

1905.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 20.

FURTHER REPORT
ON THE
GEOLOGICAL FEATURES AND MINERAL RESOURCES
OF THE
PILBARA GOLDFIELD,

BY

A. GIBB MAITLAND,
Government Geologist.

*Issued under the authority of the Hon. R. Hastie, M.L.A.,
Minister for Mines.*

With Three Geological Maps, Four Mining Plans, and 13 Figures.



PERTH:

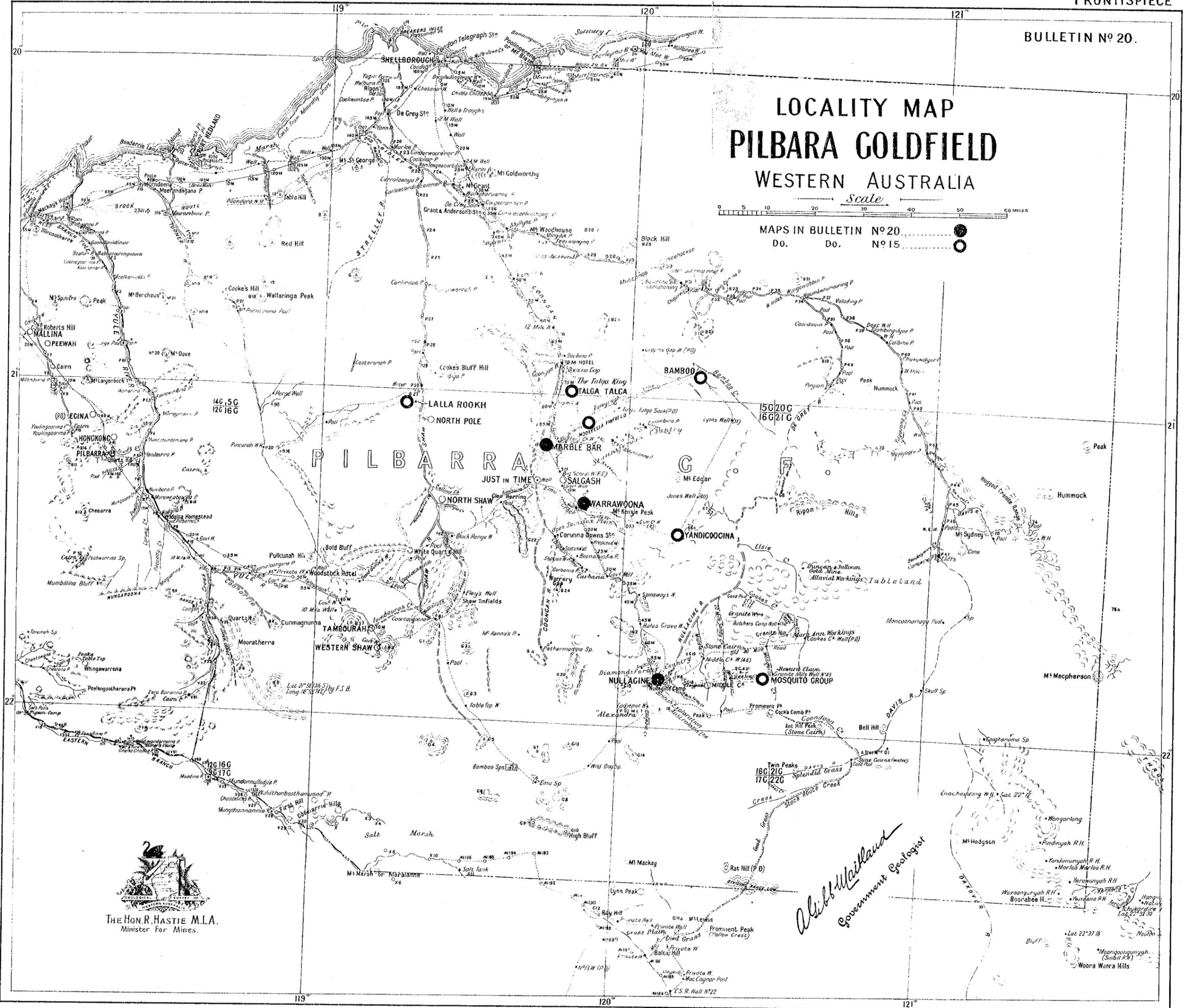
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1905.

LOCALITY MAP PILBARA GOLDFIELD WESTERN AUSTRALIA

Scale 0 5 10 20 30 40 50 60 MILES

MAPS IN BULLETIN No 20
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THE HON. R. HASTIE M.L.A.
Minister for Mines.

Alfred Hailwood
Government Geologist

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PREFATORY NOTE.

THIS report makes a further instalment to the descriptions of those mining centres of the Pilbara Goldfield referred to in Bulletin No. 15.

This report includes full details with reference to the Nullagine, Warrawoona, and Marble Bar fields, and is accompanied by geological and mining maps, without which the descriptive portions would be well-nigh unintelligible.

As in the previous season's field work, I was associated throughout with Mr. H. W. B. Talbot, Field Assistant, who rendered important assistance in the preparation of the various maps and plans.

The Index to names, places, reefs, etc., occurring in the report has been prepared by Mr. P. J. Atkins, Clerk of the Geological Survey.

A. GIBB MAITLAND,

Government Geologist.

Geological Survey Office,

Perth, 1st June, 1905.

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FURTHER REPORT
ON
The Geological Features and Mineral Resources
OF THE
PILBARA GOLDFIELD.

PART I.

Descriptive Geology.

Arriving at Port Hedland on the 30th of June in order to continue the examination of the different mining centres left untouched during the previous season, I travelled by coach as far as Marble Bar, and joined the camp, which was in charge of Mr. Talbot, on the 5th of July.

Leaving the camp at Duffer's Creek, we travelled northwards as far as the junction of Talga Creek and the Talga River. From the camp a conspicuous hill was observed 420 feet by aneroid in height and bearing 56 degrees from it. This hill forms the summit of a very long range extending northwards from the Talga Talga workings; it is composed of transmuted basic igneous rocks, intersected by laminated quartz veins. These foliated rocks dip westward at angles of from 40 to 60 degrees; associated with them are some green rocks, which weather very much like limestones; they are, however, identical with those basic igneous rocks, the original minerals of which are replaced by carbonates, so common in many parts of the district.

From this camp we travelled to a gorge known as Kitty's Gap, excavated in that laminated jaspideous quartzite, which extends from Doolena Gap to Bamboo. From camp to the gap, the whole country traversed is greenstone and its derivatives, except for about a mile of granite, which in all probability is an off-shoot from the Moolyella mass.

After getting clear of the Gap, the northern face of the range was skirted as far as Coppin's Gap. The country at the foot of the northern face of the range exposes a gneissic granite, the strike of the foliation of which is parallel to that of the laminated quartzite which makes up the range.*

* Bulletin No. 15, pp. 25, 26.

From Coppin's Gap we travelled northwards towards the point of a conspicuous range of hills which lay between us and Bamboo Creek. The highest summit of the hill rises to a considerable height above the plains, which are everywhere underlain by granitic gneiss and allied rocks. The rocks forming the hills consist of volcanic agglomerate dipping at angles of about 20 to 30 degrees to the east, and passing beneath the sedimentary beds of what there are good reasons for believing to be the equivalents of the Nullagine Series. Associated with these agglomerates are greenish grey beds of either lava or ash. Travelling across to Bamboo Creek, strata on a somewhat higher horizon are traversed; they consist of coarse conglomerates, and fine-grained sandstones, some beds of the latter of which have been quarried to a limited extent. Some of these conglomerates and grits are traversed by vertical quartz veins, some of which are of considerable horizontal extent. The general strike of these "buck-looking" quartz veins is 16 degrees. From our camp at a fine pool of water near a boundary fence (? Coppin's) to the now all but deserted township of Bamboo, the road follows the edge of the top of volcanic beds of the Nullagine Series.

The country in the more immediate vicinity of this centre having been previously fully described* need not be repeated.

From Bamboo to the foot of Mount Edgar, *via* Jones' Well, the country is made up of granite of the Moolyella type, intersected by dykes of felsite and diabase in addition to quartz veins.

Mount Edgar, one of the most prominent landmarks in the vicinity, rises to a height of about 300 feet above the base, and consists of a bluish grey basic rock [5753] in the form of a dyke. In the vicinity of Mount Edgar, the staple formation of the district (granite) is traversed by two sets of felsite dykes, one set with a general strike of north 30 degrees east, and the other north 30 degrees west. Both of these sets of dykes are traversed almost at right angles by quartz reefs, in this respect they are somewhat analogous to the system of quartz reefs and dykes of the Charters Towers Goldfield in Queensland, with which I am familiar.

From Mount Edgar, we steered across country for Warrawoona, crossing *en route* a very conspicuous greenstone dyke, at the foot of the northern side of which the Talga River flows.

This dyke, which has a general bearing of 334 degrees and 163 degrees, rises to a considerable altitude above the plain, and forms a very conspicuous feature in the landscape. So far as can be seen, the dyke is vertical and attains a thickness of about 20 feet; it traverses granite country. Several other parallel dykes of a somewhat similar nature can be seen in the vicinity.

Between this point and Warrawoona, two other parallel dykes are crossed. The granite country ends about a mile or so north of Warrawoona, and gives place to those beds, a detailed description of which is given on a later page.

* Bulletin No. 15, pp. 26, 51-61.

The mapping and examination of Warrawoona, having been completed, we struck camp and travelled in the direction of Yandicoogina as far as Gum Well. The country between the camp and the well is underlaid by granite, which has a rude foliation, the general strike of which is parallel to that of the schists, which forms the high ground of the range, near the foot of which the main road traverses. At a point about two miles west of the well, a very prominent diabase dyke is crossed, in addition to two others of much smaller dimensions; the larger dyke in all probability represents the extension of the one crossed between Mount Edgar and Warrawoona. The large dyke near Gum Well makes a very prominent feature in the landscape, and can be followed by the eye across country for a considerable distance. A traverse on foot was made from Gum Well to the range, and at one spot the large coarse-grained diabase dyke was shifted for a horizontal distance of 120 feet west by a fault bearing 112 degrees. This fault is now occupied by a quartz reef. A parallel diabase dyke of smaller dimensions has also been subject to the same amount of western displacement.

From Gum Well, a conspicuous Gap in the main range can be observed. The position of the Gap is fixed by the following bearings:—Gum Well, 31 degrees 30; Mount Edgar 41 degrees; Trig. Station G. 23, 276 degrees; and Horrigan's Peak, 302 degrees.

The Gap has been carved out of a bold quartz reef, which measures from 30 to 40 feet in width, and is of very considerable horizontal extent; for it has a length of about four or five miles in a direction of 118 degrees, and about a mile in the direction of 298 degrees. The quartz reef is evidently along a line of fault (?) which separates the granitic rocks from the Warrawoona Beds, which latter at this point occupy a width of about two miles. The large greenstone dyke previously alluded to abuts abruptly against the quartz reef of the Gap, but does not cross it. The Trig. Station G. 23 is formed of another large quartz reef, identical with that forming the Gap, and equally wide and persistent longitudinally. Both form remarkably pronounced features in the landscape.

The country between Gum Well and Yandicoogina is of granite intersected with numerous greenstone dykes.

From Yandicoogina, exigencies of travel rendered it necessary to travel as far as the De Grey (Nullagine) River *via* the main Elsie Road.* We camped on a creek, at an altitude of about 200 feet above Yandicoogina, which flowed in a general direction of north 70 degrees east. Advantage was taken of the short spell of daylight after arriving to examine the country in the vicinity. About three miles north 70 degrees east from camp was a conspicuous escarpment, the summit of which seemed to afford a good opportunity of examining the surrounding country, and a traverse was made in that direction.

* Bulletin No. 15, p. 27.

On the eastern bank of the creek, upon which the camp was pitched, is a good exposure of sandstones and shales (Nullagine Series) dipping at 20 degrees in a direction north 30 degrees east and traversed by several small faults. Sandy beds cover the surface of the country as far as the foot of the escarpment.

The bed forming the summit of the hill is a thin bed of quartzose conglomerate, containing pebbles and fragments of those laminated quartz veins so conspicuous in other portions of the district. The general dip of these sedimentary rocks which must, as seen from the hilltop, occupy a large area of country, is in the direction 228 degrees at angles varying from 8 to 10 degrees.

Having reached the De Grey (Nullagine) River, it was followed to the junction of Cook's Creek. At a point about six or seven miles in the river above the crossing of the Elsie Road, granite emerges from beneath the sedimentary rocks and occupies the country for some considerable distance. The granite is traversed by numerous quartz veins which have a general bearing of about 174 degrees.

Cook's Creek was followed up to the point at which it is joined by Mosquito Creek, passing the Black Range of the maps *en route*. The Black Range is a long razor-backed ridge of laminated quartz of the usual type. Having camped on Mosquito Creek some miles below the township, a visit was paid to the Parnell Mine.* The country between the camp and the township of Mosquito showed the staple formation to consist of highly-inclined grits, sandstones, and shales (or slates), with numerous quartz veins along the bedding planes (Mosquito Creek Beds).

In the vicinity of the lower (Mosquito Creek) well, two conspicuous rugged hills of granite (?) rise from amongst the sedimentary beds. From a distance these hills bear a remarkable resemblance to the granite hills of Mosquito township,† although the area these rocks occupy is not nearly so great as at the township.

From the camp at Mosquito Creek we travelled along the old 40-Mile Road to the crossing of Sandy Creek, which was followed down to its junction with the Nullagine River. The whole section down to the Nullagine River showed the staple formation to be of grits, shales, and conglomerates (Mosquito Creek Series) inclined at high angles. Where Middle Creek joins Sandy Creek is a vertical bed of fine-grained conglomerate.

The Nullagine (De Grey) River was followed up to the township of Nullagine, and the staple formation consisted of highly-inclined sedimentary rocks of the Mosquito Creek Series. On the western bank of the Nullagine River, at the junction of Taylor's Creek, is a large dyke of gabbro, striking about 230 degrees. The dyke, which in all probability has some intimate connection with that which makes such a prominent feature in the geology of the township of Nullagine, is about half-a-mile in width at this point.

* Bulletin No. 15, p. 80.

† Loc. cit., p. 78.

Having completed the mapping of Nullagine, a full description of which is given on a later page, we followed the main road to Marble Bar, passing the almost deserted mining centre of Wyman's Well *en route*. The country round Wyman's Well, originally known as Salgash, is identical in its geological features with Warrawoona, of which it merely forms the westward extension.

A twelve-acre lease, the Phoenix G.M.L. 624, owned by Messrs. Anderson and party, and a three-men's quartz claim owned by Messrs. Swanson and Morris Bros., represent the mining activity prevailing.

Marble Bar was reached on the 29th of September.

PART II.

Descriptions of Individual Mining Centres.

A.—NULLAGINE.

(With a Geological Sketch Map and Section, and a Plan of the Nullagine Conglomerates Gold Mines.)

The mining centre of Nullagine is situated 55 miles to the north-north-west of Marble Bar, upon the Nullagine River, about 90 miles above its junction with the Oakover; its relative position is shown on the Locality Map of the Pilbara Goldfield, which forms the frontispiece to this report.

Interest attaches to this district on account of the occurrence of gold in certain sedimentary rocks, which bear a close resemblance to the auriferous conglomerates of the Rand (South Africa), better known as the Banket deposits. These (Nullagine) auriferous conglomerates, which seem to form lenticular masses, occur in the basal members of the Nullagine Series* as developed in the ranges to the north-west of the township.

It being an important problem in economic geology to ascertain the extent, etc., of these auriferous conglomerates, as well as the quartz reefs in the underlying series of beds, a belt of country embracing what is, as at present understood, the productive area was mapped upon the scale of 20 chains per inch. The ground covered by this work comprises a belt of country about four miles in length and breadth, which is depicted upon the Geological Sketch Map (Plate I.).

As by far the larger portion of this area was practically a blank upon any of the existing maps, operations had to be commenced by preparing a plan of the vicinity of the mines. This work was accomplished by the aid of a plane table and tape measure; it would, however, have been a decided advantage had time permitted of a contour map of the district being prepared. The local representatives of the British Exploration Company, the principal lease owners in the vicinity, courteously placed at my disposal their topographical plan of the Conglomerate Mines; a reduced copy of this, embodying some geological additions by myself, forms Plate II.

A comparison between this map and the 40 chain lithograph, L 76, issued by the Department of Mines, discloses the fact that considerable violence had to be done to the position of the

* Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfield, by A. Gibb Maitland. Geol. Surv. Bull. 15. Perth; By Authority: 1904, p. 10.

Nullagine River. On lithograph, L 76, it will be noticed that there are two Nullagine Rivers, the most northerly approximately parallel to the Marble Bar Telegraph Line, and the other skirting the northern boundary of the extinct leases 57L and 58L. The true course of the river is that shown on the Geological map.

It is essential, in the public interest, that at any rate the principal water-courses in mining districts especially, should be traversed and their position laid down on the published maps with such a degree of accuracy as the scale employed will admit. Tacheometric methods afford a reliable, cheap, and accurate method of this class of work being carried out expeditiously. A great deal of time and labour is involved in preparing topographical maps, upon which the areas of the different formations, the geological boundaries, the trend of the outcrops of the different ore deposits, etc., could be delineated, which could be much more profitably expended by a geologist in other directions.

In both its physical and geological aspects, the district falls naturally into two distinct portions, which lie respectively to the north-west and south-east of the Nullagine River.

The north-western portion is that occupied by the sandstones, grits, conglomerates, and interbedded volcanic rocks of the Nullagine Series. This series, which presents a plateau-like appearance, exhibits a bold escarpment when viewed from the south-east, and certain of the harder beds stand out in bold relief, presenting mural faces at different levels. The tableland has been carved out into deep canon-like gorges and ravines, of which Beaton's Creek, and the One Mile Creek, are typical examples. The course of many of these creeks, and their tributaries appears to have been in the main determined by the trend of the system of master joints, by which the Nullagine Series has been intersected. An excellent example of this rectangular system of jointing occurs in Beaton's Creek about a mile and a-half above its junction with the Nullagine River, just within the western border of the geological map.

The greater part of the country lying to the south-east is formed of an open rolling plain, the monotony of which is broken by a very conspicuous serrated ridge of gabbro (?). This dyke lies about two miles to the west of the township of Nullagine. The Nullagine River cuts through the ridge at a point about three miles below the township. This gabbro dyke rises to a considerable height above the level of the surrounding country and forms a very conspicuous feature in the landscape. This plain is underlaid by the rocks of the Mosquito Creek Series, which formation carries all the auriferous reefs yet worked in the district.

The whole of the country lies within the watershed of the Nullagine River and its tributaries; the two most important of which are Beaton's and Kadjebut Creeks.

History.

Very little appears to have been officially recorded of the early history of the Nullagine district. It seems, however, that the first discovery of gold at Nullagine was made by Mr. N. W. Cook, in the year 1886, as a reward for which he received, two years later, a sum of £250 from the Government.

The spot at which the original find was made lies at the western extremity of a long, narrow, laterite tableland, in close proximity to several quartz reefs; the position of this spot is indicated on the Geological Sketch Map of Nullagine. (Plate I.)

The erection of a ten-head battery in 1895 at Nullagine, where the first crushing of 184 tons yielded 210ozs. 16dwts. of gold, appeared to have given a great impetus to mining, for the Warden of the field, writing in July of that year, reported:—"Quite a boom in leasing has commenced."*

The following year, the Inspector of Mines for the Northern Goldfields stated:—"At the Nullagine, quartz reefing (which has only been inaugurated during the past 18 months) is making rapid advances, crushings having yielded from 2ozs. to 8ozs. per ton, while the acquisition of a large area of conglomerate holdings by an English company marks a new era in the history of the district.†"

The progress of Nullagine during the year 1897 is thus alluded to by the Warden in his Annual Report to the Minister for Mines:—"Besides alluvial digging and quartz reefing, gold is obtained from conglomerate lodes with payable results. There is one ten-head battery, and two more are in course of erection. Water is obtained at an average depth of 50 feet. The yield of gold for the year is 982ozs. There are regular consignments of alluvial gold from Nullagine, of which I have no record; but, from information obtained from the business people, I should say that at the lowest estimate, these would amount to 600ozs. per annum."‡

Writing on the advances made on the Pilbara Goldfield during 1898, the Warden thus alludes to the progress of Nullagine:—"The North-West Australian Goldfield, Ltd., at Nullagine, are showing their confidence in their conglomerate lodes by supplementing their crushing machinery and laying down tramways, and thus, by working on a large scale, endeavour to decrease expense and make their properties pay."§

No mention is made of the progress of Nullagine during 1899, 1900, and 1901 in the reports of the Warden, as published in the annual reports of the Mines Department; for 1902, however, it is

*Supplementary Report on the Department of Mines, 1st October, 1895. Perth: By Authority, 1895, p. 4.

† Pilbara and West Pilbara Goldfields, 1896. S. J. Becher. Report of the Department of Mines for the Year 1896. Perth: By Authority, 1897, p. 36.

‡ Report of the Department of Mines for the Year 1897. Perth: By Authority, 1898, p. 23.

§ Report of the Department of Mines for the Year 1896. Perth: By Authority, 1899, p. 19.

stated:—"A large amount of good and useful development work is being done in the Nullagine District, where a further ten-head of stamps is being erected on the British Exploration and Development Company's property, which, when completed, will enable them to run 15 head, and for which purpose they are carrying out a water scheme which, when completed, will bring water a distance $1\frac{1}{4}$ miles from the river to the mine. Later on another 20 head is proposed to be erected."*

The year 1903 was a very quiet one in Nullagine in so far as any mining was concerned, and no mention is made of its progress in the Annual Departmental Report for that period.

General Geology.

The following represents in tabular form the geological formations in the district embraced by the area of the map. The stratified rocks are arranged in geological sequence:—

Alluvial deposits.

Laterite.

Nullagine series. Quartzites, grits, conglomerates and interbedded igneous rocks.
Unconformity.

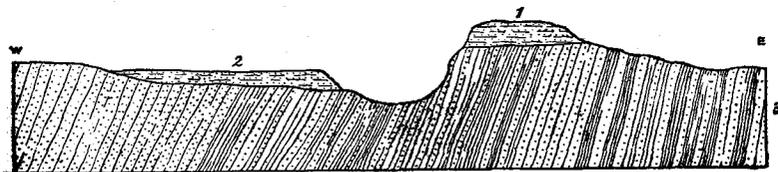
Mosquito Creek beds.—Sandstones, fine conglomerates and shales.
Greenstone dykes.

Alluvial Deposits.

The banks of the Nullagine River and its tributaries are skirted by a variable width of alluvium, the full extent of which has been shown on the geological map. The greatest width attained by the alluvium is about 50 chains, but in no case does it reach any great thickness.

The south-eastern banks of the Nullagine River show a considerable extent of alluvium at a much greater elevation than that of the present water-courses. This is depicted in Fig. 1. This

FIG. 1.



SECTION ACROSS THE NULLAGINE RIVER NEAR TOWNSITE, PILBARRA.

1. OLDER ALLUVIUM. 2. NEWER ALLUVIUM. 3. SANDSTONES, GRITS AND SHALES.

section shows the remains of an older alluvium laid down at a time when the Nullagine River flowed at a slightly higher level than now.

* Report of the Department of Mines for the Year, 1902. Perth: By Authority, 1903, p. 44.

Writing in the year 1890, Mr. H. P. Woodward says, with reference to the alluvial deposits of Nullagine, that * :—

“Three classes occur; 1st, the alluvium of existing creeks; 2nd, the alluvium of older creek beds, but in conjunction with the present streams; 3rd, older alluvial deposits or deep leads bearing no relation to existing streams or configuration of the country. . . . The older alluvial deposits are found in the river flats, where the auriferous gutters are crossed and recrossed by the present streams. The sinking here is about 10 feet, and very hard work, owing to the fact that the deposits that overlay the dirt are cemented masses of quartz and boulders of other hard rocks. . . . The deep leads are cut across by the present valleys, and can be traced from hill to hill. Here the sinking is very variable in depth, the whole gutter in some places appearing on the side of a cliff where the work merely consists in driving, while in other places shafts up to 60 feet or 70 feet have to be sunk to work the same lead. Up to the present only one of these leads has been discovered, but there cannot be the least doubt that more will be found when the small hills between the conglomerate range and the creek are thoroughly prospected. All three of these deposits are very rich, but no one can estimate the quantity of gold with any degree of accuracy, as so much leaves the colony without ever being reported; but there is no doubt that more has been taken from this field than from any other in the colony.”

It is not quite clear from what can at present be seen in any of the sections exposed in the neighbourhood of Nullagine, that what are described above as “deep leads” are such; the impression left upon my mind is that they merely represent weathered outliers of the basal members of the Nullagine Series.

Table showing the Yield of the Alluvial and Superficial Deposits of the Nullagine District generally.

Year.	Gold.
1897	ozs. No data.
1898	1,000·00
1899	729·79
1900	27·00
1901	831·02
1902	390·67
1903	288·30
1904	403·24
Total	3,670·02

* Annual General Report of the Government Geologist for the Year 1890. Perth :
By Authority, 1891, p. 25.

Laterite.

A very noticeable geological feature of the area, is the occurrence of several isolated tablelands of laterite; the area which these occupy has been accurately delineated upon the map of the district. One very important feature which the map, owing to the lack of contour lines, fails to bring out, is the uniform level at which this laterite invariably occurs.

The most conspicuous tableland is that which lies to the south-west of the township, and about a quarter of a mile west of the river bank. The tableland has a length of about a mile and a quarter, and an average width of about 10 chains; it presents a steep bluff, several feet in height, which extends with scarcely any interruption all round the plateau.

This tableland is breached by that tributary of the river which flows into it near Suburban Water Right No. 5. The laterite continues from this point as a narrow strip far beyond the limits of the map. Three other outliers occur to the north of Beaton's Creek, the most conspicuous being that which lies adjacent to the township of Nullagine.

An inspection of the geological map demonstrates that the laterite traverses successively all the geological formations, with the single exception of the modern alluvium.

In its lithological characters, the deposit presents all gradations from ferruginous claystone to pure limonite; the rock itself is very porous, and weathers readily into caverns and cavities of all sizes; in some places the surface of the rock is covered with a glaze of hydrated oxide of iron. When seen in section, it is noticed that the laterite passes by insensible gradations into the underlying strata without any sharp line of demarcation.

Mr. Woodward refers to what is evidently the laterite series as follows: "Another line of flat-topped hills, but lower, extends along the side of the creek, but these are of much more modern formation,* and it is in these that the deep leads are met with. The beds which form these hills rest directly upon the indurated slates,† and pipeclay, soft white sandstone, gypsum, and boulder beds. The wash is often very ferruginous and hard, necessitating crushing. The whole of these beds are capped by a ferruginous sandstone containing large quantities of fossil wood." ‡

It may be noted in this connection that I saw nothing which could be described as fossil wood anywhere in the series, as exposed in the vicinity of Nullagine, this, however, may possibly be due to the fact that at the time the district was visited, work was in full swing, and Mr. Woodward may have had better opportunities for observation than were open to me.

* The beds of the Nullagine series.—A. G. M.

† The Mosquito Creek Beds.

‡ *Ibid.*, p. 35.

The Nullagine Series.

Sedimentary Rocks.

The Nullagine Series is largely developed in the Pilbara Gold-field, and consists of a great thickness of sandstones, grits, conglomerates, and limestones, some of which are magnesian, together with a series of lavas and ashes and agglomerates of as yet unascertained thickness.

The formation, the base of which is rarely seen, makes a prominent feature in the landscape of the district, and plays a very important part in the geology of the north-west, in addition to being of some economic value by reason of the basal members of the series having been proved to be auriferous in at least two localities many miles apart.

Previous reference to the Series.—In Bulletin 15 full descriptions have been given of the different sections which illustrate the relationship of the Nullagine Series to those beneath,* and therefore need not be repeated.

Mr. H. P. Woodward, in the year 1890, makes the first brief official mention of the auriferous conglomerate of Nullagine in the following terms:—"To the west of this field are hills of nearly horizontally-bedded conglomerate rocks, probably of Devonian Age, in which reef gold occurs in small veins of quartz and ironstone, which follow and indeed fill in all interstices between the larger boulders. They are very rich in places, in fact so rich that it pays to 'dolly,' and the gold in the flat close by is evidently derived from these veins. This deposit is of very great interest, as nothing like it has before been found, for the gold, although occurring in an alluvial deposit, is reef gold and not alluvial, for it has been deposited subsequently to the formation of these boulder beds."†

On a later page of the same report, in the description of the country traversed from Geraldton to Nullagine, Mr. Woodward gives a few particulars with reference to the auriferous conglomerate and its relation to the older strata in the following terms:—"In this conglomerate the gold is alluvial in character, but it is true reef gold, being deposited there subsequently to the deposition of the boulders between which it has been infilled with silica and iron, probably by thermal action. These beds dip at an angle of 12 degrees to the north-west. They vary greatly in character from quartzite to boulder conglomerate, but it is only in the ferruginous beds that the gold is found. This formation is probably of Devonian Age, resting unconformably upon the edges of the clay slates and quartzite conglomerate beds with quartz reefs of the metamorphic series."‡

The latter portion of this description shows that the violent unconformability separating the beds of the Nullagine Series from those of the Mosquito Creek beds was at least recognised, though not emphasised, by Mr. Woodward fifteen years ago.

* pp. 18, 20, 21, 22, 23, 24, 25, 27, 28, 30, and 31. † Annual Report of the Government Geologist for the Year 1890. Perth: By Authority, 1891, pp. 25-26. ‡ *Ibid.*, pp. 34-35.

Writing in the year 1895, the Acting Inspector of Mines, Mr. S. J. Becher, informed the Minister for Mines that:—"Nullagine, one of the oldest and best districts of the whole field (Pilbara Goldfield), lies about 80 miles south-east of Marble Bar. Geologically, it is perhaps unique. The general character of the country is that of table-topped hills about 200 feet high, intersected by deep ravines, gullies, and valleys, widening out into flats and plains in all directions. In the immediate neighbourhood of the township the main characteristic features are:—First and centrally, flat-topped hills having ironstone formations, as 'crust,' overlying decomposed conglomerate matter; secondly, hills more rounded on top consisting of red and white cement and conglomerate deposits of varying thickness, some of the waterworn quartz being quite boulders in size. The conglomerate contains a great quantity of ferruginous matter, and this apparently carries most of the gold, which occurs in a fine state."

"The central hills seem to have been the result of denudation and decomposition of the material of the surrounding conglomerate and other formations. For the past six or seven years, there has been a steady output of alluvial gold from this field. Every gully has been systematically worked, the wash being screened and then carted down to the pool in the river for puddling and washing. The screenings, etc., have even been reworked at a profit by dry-blowers. It was noticed that the 'runs' of gold extended up the hill sides from out of the creeks and gullies. These runs were followed up the surface rubble for a few inches in depth, being all put through the dry-blowing machines, until the run ceased, when it was found that the original source of the gold was a seam or perhaps a big lode of conglomerate, whose outcrop was on the contour line where the run of gold ceased extending up the hillside. Though alluvial work is still carried on, more attention is now paid to the conglomerate lodes, which are being extensively worked and put through the battery with payable results."

"Of late, too, some very rich reefs have been found a few miles out, in what is locally known as the 'claypan' country. Crushings from the outcrops and superficial works on these reefs are returning from 2 to 4 ozs. per ton, and their prospects of permanency in depth are, it is said, good."

"The conglomerate lodes have attracted the attention of English Capitalists, and there will soon be extensive works thereon in operation. . . . " *

In 1898, Mr. S. J. Becher describes the conglomerates of Nullagine in the following terms:—"In the immediate vicinity of Nullagine township or mining camp, range upon range of conglomerate hills lie to the north-west. . . . The course of the river . . . follows the outskirts of the conglomerate country, keeping on the farther side of the slate country and its

* Report of the Department of Mines for the Year 1895, Appendix 5. Perth: By Authority, 1896, p. 29.

quartz reefs, and forms a marked line of division, as it were, between the characteristic topographical features of the district.

Coming then to the conglomerate ranges, which average in height about 100 to 150 feet above the level of the river flat we find that the hills in the forefront, upon which the chief mine workings are at present situated, appear to be mostly round-backed and strewn with rounded boulders and pebbles. On closer examination, one finds that they consist of bed upon bed of conglomerate, merging into intermediate layers of kaolin. The beds dip universally to the north-west, and strike north-east and south-west. The dip is flat, averaging perhaps 15 degrees. Therefore as one approaches from the south-east the hill-sides exhibit longitudinal sections of the country, and in some cross gorges very complete studies may be made of cross-sections; whilst, where the rounded weathered hill sides slope to the flat, one may notice somewhat regular lines of round boulders and pebbles roughly marking the outcrops of the conglomerate beds. By these indications, and also by following up the runs of alluvial gold until they stopped all along certain horizontal lines, the auriferous conglomerates were originally located and worked by prospectors by means of drifts and tunnels."

"Some of the conglomerate beds contain boulders up to three or four feet in diameter, while others carry nothing bigger than a man's head. These boulders consist of rounded masses of fragments of quartz, trap rocks, and other conglomerates. A peculiar feature about the shape of these is that they are very often somewhat flattened like curling stones. This flattened shape might suggest glacial action, but the writer saw no striæ. These have, the writer understands, proved to be less auriferous than the other beds whose component particles are small. The best gold seems to be obtained from ferruginous veins. The ore now being crushed by the mining companies varies in value, the writer believes, from 10dwts. to 2ozs. per ton, the treatment being by battery and amalgamation alone. The gold is worth £3 17s. 6d. to £4 per ounce. At the time of the writer's visit, in the year 1896, only the decomposed portion of the beds had been worked, but he is given to understand that a vertical shaft has since cut a bed in depth below the zone of decomposition, and that the character of the rock is a very hard greenstone conglomerate, carrying much iron pyrites, samples of which have yielded returns by assay up to 13dwts. per ton."

"Behind these round-backed series of hills, to the westward, the topographical features vary again, and the conglomerate ranges assume an appearance of being terraced, the reason of which becomes evident upon examination. Following up into these ranges an affluent of what is known as the main creek, one enters a gorge with precipitous sides rising to 50 feet in height, and here a very fine cross section of the country may be examined. Here it may be seen that, interbedded conformably with the beds of conglom-

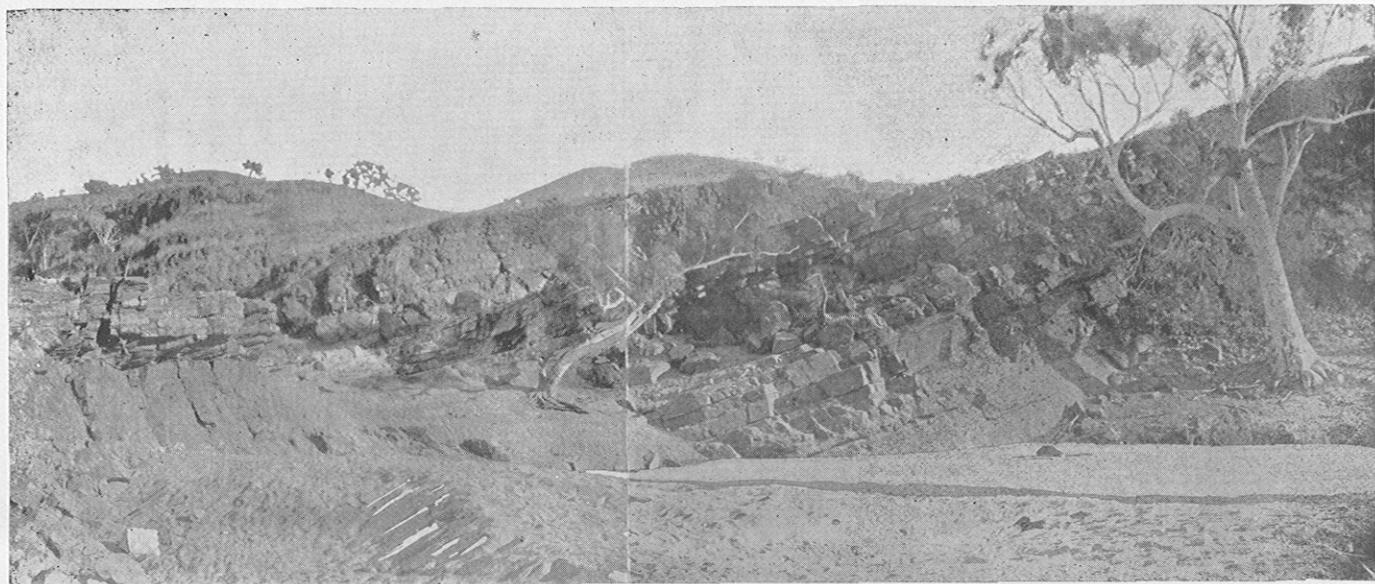


PHOTO.: S. J. BECHER.

Beaton's Pool, showing the Conglomerates and Interbedded Ashes, Nullagine.

erate, there are indurated slates and grits. The former, where long exposed to the action of the atmosphere and water, split off into flags."

"Compared with the above-mentioned series, little or no decomposition has taken place beyond surface-weathering, which accounts probably for the fact that no free gold (to speak of) has been obtained in the gullies, and that the terraced series is not at present recognised as auriferous. Time may prove this. The terracing is due to the unequal effect of weathering on the exposed longitudinal edges of these otherwise undecomposed beds of varying durability."

"As to the age and origin of these interesting Nullagine beds, nothing definite is yet known. . . . "*"

Professor David, writing in 1902 on the Permo-Carboniferous glaciation of Western Australia:—"There is . . . in my possession a photograph (Fig. 5) taken by the late Mr. Becher of the Geological Survey of Western Australia, of a remarkable conglomerate at Nullagine, Pilbara, Western Australia, which so closely resembles in general appearance the Cambrian glacial beds of South Australia as at once to suggest a possible glacial origin for the West Australian beds. They are also associated with a very finely-laminated shaly altered rock, not unlike the Tapley's Hill shales, which overlie the Cambrian (?) glacial beds of South Australia. These Nullagine beds are probably of older palæozoic age (? pre-Cambrian), and should well repay further investigation." †

The finely-banded rock, to which Professor David thus alludes, is probably either one of those lavas or ashes, which lie near the base of the series and are well exposed in Beaton's Creek, and the Nullagine River itself.

In the more immediate vicinity of Nullagine there are several cliff sections which show the mutual relationship of the various members of the series. (Photograph "A.")

In Beaton's Creek, a tributary of the Nullagine River, which it joins at the foot of McFie Street, is a very good section, showing the relation of the interbedded character of the volcanic rocks, forming the basal members of the series.

A portion of this section is shown in Fig. 2.

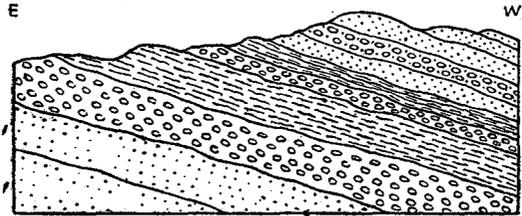
The cliffs near Beaton's Pool expose two beds of ash dipping to the westward at an angle of 17 degrees from the horizon. The uppermost bed attains a thickness of five feet six inches, and is separated by six feet of conglomerate from another ash bed 12 feet thick. In the geological map, owing to the smallness of the scale, this deposit has been treated as one bed. The mapping shows that the bed is merely an attenuated lenticular patch of no very great horizontal extent.

* The Nullagine District, Pilbara Goldfield, Western Australia. Trans. Inst. Min. Engineers (Newcastle-upon-Tyne), 1898. Vol. 16, Pt. 1, pp. 44-52.

† Report of the Glacial Committee. Austral. Assoc. for the Adv. Sci., Vol. 9, 1902, p. 201.

A little distance below the pool is another much thinner bed of somewhat greater horizontal extent; it can be followed northwards as far as the southern angle of G.M.L. 2L. (216) "The Trinity," where it is cut off by the fault which traverses this portion of the district. A good section of the ash is to be seen in the gully to the south of "The Trinity," at a considerable altitude above the level of Beaton's Pool, for the strata rise very rapidly in this direction.

FIG. 2.



SECTION AT BEATON'S POOL PILBARA G.F.
 1 SANDSTONE. 2 CONGLOMERATE. 3 ASH.

The uppermost bed of ash [5796], which forms a fall over which the waters of the creek drop into Beaton's Pool, extends about 50 chains to the northward, where it also is truncated by the fault previously alluded to. In the vicinity of the fault, the bed has a slightly increased dip of 20 degrees to the west. A small attenuated portion of it is to be seen on the downthrow side of the fault near the head of one of the branches of Beaton's Creek. It is possibly this bed which occupies the topmost stratum of the synclinal trough occurring on M.L. 1L. There is however no great thickness of ash in this section, the bed evidently thinning out rapidly in this direction.

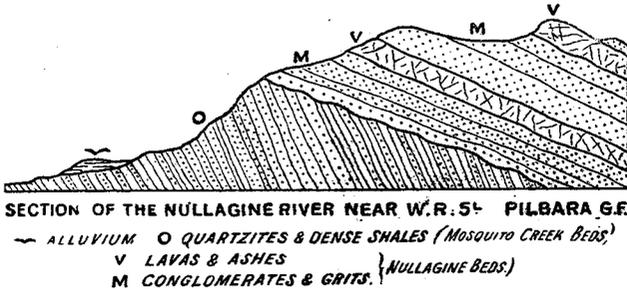
A traverse up Beaton's Creek for about a mile or so above the pool shows the beds overlying the ashes to consist of conglomerates [5797] and grits disposed in a series of gentle folds, with dips varying from 5 to 8 degrees from the horizontal. The cliffs rise to considerable elevations above either bank of the creek, and show good sections of the strata. The beds are traversed by a series of rectangular joints which have proved to be the dominant factor in determining the general direction of the watercourse.

An important section is to be seen on the southern bank of the Nullagine River at a point about 40 chains south-west of Suburban W.R. 5L, which discloses the violent unconformability separating the Nullagine from the underlying series (Fig. 3) :—

The basal member of the Nullagine Beds in this section consists of a few feet of grit and conglomerate, overlaid by about 3 feet of ash, the whole dipping at an angle of about 18 degrees to the south-west. These rest upon the upturned edges of the quartzites and

dense shales forming the Mosquito Creek Beds, which latter dip at angles averaging about 70 degrees in a south-west direction.

FIG. 3.



Some distance higher up the river the conglomerates and grits of the Nullagine Beds are overlaid by acidic lava [5795]. These volcanic beds occupy the country as far as Wild Dog Camp, Res. 3328,* about 16 miles above the township, and entirely conceal the sedimentary rocks beneath. In the neighbourhood of Wild Dog, the lavas are somewhat amygdaloidal [5808]. In certain portions of the district, the irregularities of the old surface upon which the beds were laid down is such that the volcanic beds often overlap the older rocks.

About four and a-half miles eastward, the volcanic rocks rest directly upon granite, at an altitude of about 200 feet above the well at Wild Dog Camp, the sedimentary rocks beneath being absent. This granite country is traversed by several quartz reefs. A very prominent reef, having a general trend of 248 and 63 degrees with a horizontal extent of a few miles, does not appear to be a fissure vein, as generally understood, but merely a gradual replacement of the surrounding granite by silica along a main line of weakness.

The bedded lavas, which are sometimes vesicular, were followed westwards some miles beyond Trig. Station G 13, on the head waters of the Coongan River; and from their mode of occurrence in the field, it is evident that they rest in this locality upon a very uneven surface.

No opportunity presented itself of tracing the boundary of the Nullagine Series to the south of Wild Dog Camp, but so far as may be judged from Mr. Woodward's descriptions, the formation would appear to extend to a point a few miles to the westward of Bamboo Spring (Res. 1927) on the head waters of the Shaw River, for it is stated "the rocks (near Bamboo Spring) are quartzite and basalt, with veins of chalcedony and inferior opals; the chalcedonies are

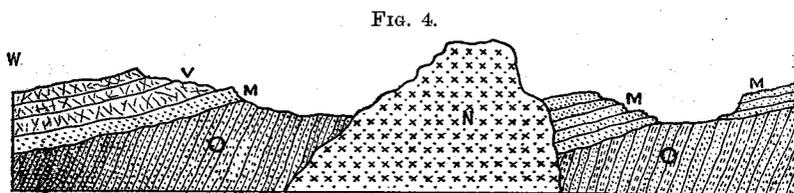
* Lands Department Lithograph 16 G.

often finely banded, and should be of considerable commercial value, as they can be obtained in large blocks.”*

From a personal knowledge of the country, I have very little doubt as to the identity of the strata to which Mr. Woodward refers with those already described.

The road from Nullagine to Wild Dog Spring passes, after getting clear of the town, near Kadjebut Spring, a watering place on the creek of that name. In the vicinity of the spring, there are several sections which give a fair idea of the relation existing between the various rock formations.

The Fig. 4 gives a generalised section of the country in the vicinity of what is known as the rock hole, near Kadjebut Spring.



SECTION IN THE VICINITY OF KADJEBUT SPRING. PILBARA G.F.

V. LAVA & ASHES } NULLAGINE SERIES O. SANDSTONES, CONGLOMERATES & SHALES. MOSQUITO CR. SERIES
M. GRITS & CONGLOMERATE } N. GABBR0.

On the western side of the large dyke, which at this point attains a considerable thickness, the Nullagine Series is represented practically by lavas and ashes, with a thin bed of conglomerate underlying. The beds rest with a violent unconformity upon the upturned edges of the Mosquito Creek Series. The Nullagine conglomerates and grits abut directly against the dyke along its eastern wall. So far as can be seen, there is no evidence of alteration of the sandstone and conglomerate anywhere along the line of contact between them and the dyke, nor so far as I could detect were there any pebbles of the gabbro contained in the conglomerate. The evidence so far as it goes seems to point to the junction between the two formations being in this locality a line of fault. In no place, however, did this dyke pierce the Nullagine conglomerates, though some miles northward in the vicinity of the One-mile Creek, a narrow dyke of a similar character does rise to the level of the Nullagine Series, and can be followed across country north-west and south-east traversing in turn each individual bed.

The basal conglomerate is made up of rounded, ellipsoidal, or subangular fragments of the strata forming the older underlying series (the Mosquito Creek Beds). These often include pieces which may reach a length of three or four feet, but the bands containing the larger fragments are merely local. Photograph "B"

* *Loc. cit.*, p. 34.

B.

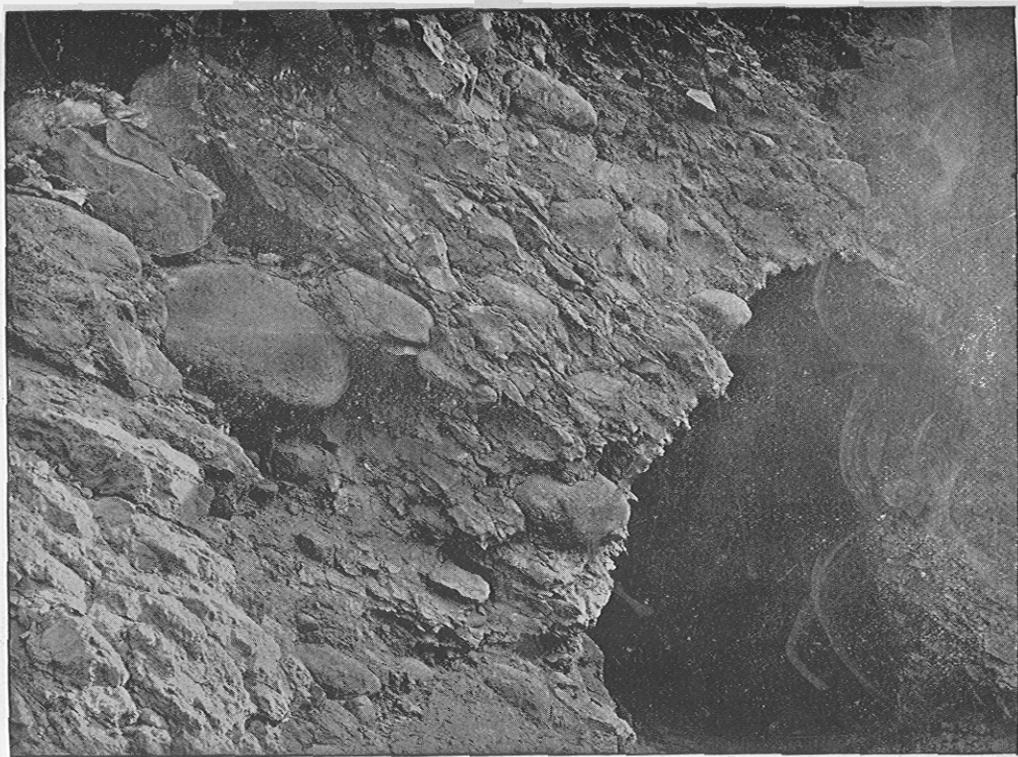


PHOTO.: S. J. BECHER

A portion of the Auriferous Conglomerate, Nullagine.

shows a portion of this conglomerate at the entrance to one of the mine workings. The conglomerate consists chiefly of fragments of the existing conglomerates, cherts, grits, and shales; reef quartz, identical in character with that forming the auriferous deposits in the underlying strata, being a very common constituent. The pebbles are embedded in a matrix, which is principally sandy, though sometimes aluminous.

Some portions of the conglomerate contain flattened and striated pebbles [5805] of fine-grained sandstone and sandy shales, identical in character with the beds of the Mosquito Creek Series; to these striated pebbles a glacial origin has been assigned by the late Mr. S. J. Becher, and subsequently by Professor David. These pebbles, however, would, in the light of the evidence now available, seem to have had their striation induced previous to their taking part in the formation of the Nullagine Series. The beds upon which the series rest with a violent unconformability and to the denudation of which the pebbles owe their origin, having been subject to intense mechanical deformation, it would only be natural to find slickensided fragments and pebbles in the newer rocks. Earth movements have caused the Nullagine Beds to be thrown into a series of undulatory folds, well shown in the geological map and section, but the deformation thus engendered has not been of sufficient intensity to cause any striation of the component pebbles.

The conglomerates or consolidated shingles are of distinctly sedimentary origin, and owe their occurrence to the disintegration of pre-existing strata, which will be fully described on a later page. From the angularity of many of the pebbles, which make up the mass of the basal members of the series, it may be reasonably inferred, that the coast-line which furnished them was not far distant. No outliers of the series occur anywhere in the vicinity of the country embraced by the Geological Map of Nullagine. From this fact and the angularity of many of the conglomerate pebbles it may be inferred that the present boundary of the series approximately marks the original shore-line. The evidence available from a careful study of the district over which the series extends, shows that the surface upon which the beds were laid down was extremely irregular. This irregularity was particularly apparent in the neighbourhood in which the basal shingles have been mined. The auriferous strata occur through a thickness of about 300 feet of grits, sandstones, and conglomerate, forming the lowest portion of the series: those portions of the strata which have been proved to be gold-bearing are those which are largely impregnated with the oxides or sulphides of iron, and which lie between the fault north of Beaton's Creek and the greenstone dyke (possibly along a fault-line also) crossing the One-mile Creek in the vicinity of Mineral Lease 5L. As may be seen by the table below, the gold contents of the conglomerates are small, not amounting to more than at the rate of .62 ozs. for the total tonnage crushed since mining first commenced.

Table showing the Yield of the Auriferous Conglomerates of the Nullagine Series.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	357·60	434·70	1·21
1897	246·00	228·00	·92
1898	893·00	1,001·20	1·12
1899	753·40	533·35	·70
1900	382·00	149·90	·31
1901	1,458·00	647·53	·44
1902	300·00	128·51	·42
1903	777·00	94·10	·12
1904	Nil	Nil	...
Total	5,167·00	3,217·29	·62

Igneous Rocks associated with the Series.

From the geological maps and the descriptions given in this and Bulletin 15, it will be seen that a great series of bedded lavas, ashes, and agglomerates form an integral, and no small, portion of the series as developed in different portions of Pilbara Goldfield.

Wherever these beds have been examined it has been invariably found that they consist of acidic lavas, the composition of some of these [5392, 5404, 5384] which may be regarded as typical of the series have already been published in Bulletin 15 and need not be repeated.

The greater mass of the rocks consist of separate lava-flows, each of no very great thickness. Some of the lavas are distinctly amygdaloidal, the cavities being filled with chalcedony.

Some of the finer-grained ashy beds [5796] differ very little in general appearance from many of the banded lavas, with which they are associated, but their distinctly fragmental character can readily be made out by the microscope, and in some cases with the aid of a pocket lens.

So far no evidence has been obtained which would throw any light upon the sources from which the lavas emanated.

In the neighbourhood of Coppin's Gap, the volcanic rocks of the Nullagine Beds are represented by coarse agglomerate, dipping at angles of about 20 to 30 degrees to the east, and passing beneath the sedimentary rocks of the series. Associated with these are beds of greenish grey lava. The sedimentary rocks of the series which occur at a somewhat higher horizon consist of coarse conglomerate and fine-grained sandstone. The hills of conglomerate rise to considerable heights above the surrounding plains, which in this particular locality are underlaid by granitic gneiss and allied rocks.

On the Coongan River, some distance below the township of Marble Bar, a mass of volcanic agglomerate forms a very conspicuous irregular-shaped hill, which presented every appearance of being the focus from which the surrounding lavas emanated.

There are several acidic dykes visible in different portions of the district, which may possibly represent another phase of that volcanic activity which was rife.

In the neighbourhood of the townsite of Nullagine, a mass of quartz felsite [5798] was met with in the well on W.R. 2L. This well has been carried down to a vertical depth of 108 feet, through quartz felsite the whole way. This rock, the position of which is shown on the map of the Nullagine Conglomerates Gold Mines forming Plate II., makes its appearance on the western bank of the creek, and rises to about the level of the floor of the battery site, where it seems to have diffused itself through a portion of the coarse auriferous conglomerate forming the base of the formation in this locality. The quartz felsite is very much decomposed, the alteration extending as far down as the bottom of the well, which is the deepest point at which it has been pierced. Examined under the microscope, the rock is found to consist of quartz and plagioclase, set in a partially devitrified matrix.

Age.

The recognition of the position of the Nullagine Beds in the stratigraphical succession is a point of considerable importance; the absence of fossils throughout the series, wherever it has yet been studied, however, renders correlation extremely difficult.

The earliest investigator of the district, Mr. H. P. Woodward,* assigned a Devonian Age to the series, though the evidence does not seem to be conclusive. The next observer, Mr. S. J. Becher, writes that of "the age and origin of these interesting Nullagine Beds nothing definite is known." †

Professor David infers that the beds are "probably of older Palæozoic Age (? pre-Cambrian) and should well repay further investigation." ‡

The limestones of the series having yielded no fossils, petrographical resemblance seems to be the only method by which any clue can, in the present state of our knowledge of the series, be arrived at with respect to its age.

In a previous report § the difficulty of correlating the Nullagine Beds with any of the formations described in the official publications on the geology of Western Australia was fully set out, and

* Annual Report of the Government Geologist for the Year 1890. Perth: By Authority, 1891, pp. 25 and 26.

† The Nullagine District, Pilbara Goldfield, Western Australia. Trans. Inst. Mining Engineers (Newcastle-on-Tyne), 1898. Vol. 16, Pt. I, pp. 44-52.

‡ Report of the Glacial Committee. Austral. Assoc. for the Adv. Sci. Vol. 9, 1902, p. 201.

§ A. Gibb Maitland. Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfields. Bull. No. 15. Perth: By Authority, 1904, p. 10.

the lithological resemblance to the quartzites, etc., of the King Leopold Range, in Kimberley, was emphasised. If this petrographical resemblance should prove to possess greater significance than at present appears, the Cambrian Age of the Nullagine Series would seem to have strong claims for consideration.

The Nullagine Beds have a very wide distribution in the North-West Division, and the Volcanic Series would seem to occupy a large area of country in the southern portion of the district. It may be noted that, in a bore put down by the Government at Onslow, near the mouth of the Ashburton River, to a depth of 1,729 feet, there was passed through a thin bed of a volcanic rock ("basalt" of the bore journal) identical in its characters with some of those igneous rocks forming part of the Nullagine Beds as developed elsewhere. It may thus be that these strata were pierced in the lower portion of the Onslow bore-hole.

Undoubted Permo-Carboniferous fossiliferous rocks are known to occupy a large area of country in the watersheds of the Gascoyne, the Minilya, and the Lyndon Rivers; hence an examination of the (geologically unknown) country lying between Onslow and the Lyndon River should afford some valuable information as to the mutual relations of the Permo-Carboniferous and the Nullagine Beds; hence it is from this district that the most important clue to the age of the Nullagine Series may be ultimately hoped for.

Mosquito Creek Beds.

The Mosquito Creek Beds, which underlie the strata of the Nullagine Series, comprise one of the oldest of the sedimentary formations as developed in Pilbara. The formation is abundantly represented, and occupies the surface of a very large area of country. The series, which consists of grits, shales, and fine conglomerates, takes its name from the district of Mosquito Creek, 24 miles due east of Nullagine, where these beds were first noticed.*

In that report attention was directed to the difficulty of separating the schistose rocks, which make up a large portion of the district, from these sedimentary rocks, and further observations have only served to emphasise that difficulty. As will be noted in the description of the geology of the Warrawoona field, which is made up of a mass of sedimentary strata, and associated igneous rocks, converted into crystalline schists, by metamorphic agencies operating on a regional scale, there seems good reason to believe that in the Mosquito Creek district the same conditions prevail.

The old 40-mile road from Mosquito Creek to Sandy and Middle Creeks follows an open longitudinal valley occupying the summit of a very broad anticlinal fold, which forms a very important structural feature in the district. It is upon the northern

* Preliminary Report on the Geological Features and Mineral Resources of the Pilbara Goldfield. A. Gibb Maitland. Bull. 15, Perth: By Authority, 1904. p. 78.

and southern flanks of this arch that all the auriferous quartz reefs of the Nullagine-Mosquito and Middle Creek zones occur.

A traverse from Nullagine township, south-eastward for about six miles to the cairn G. 16, on the summit of South Dromedary,* discloses a succession of highly inclined grits, sandstones, and shales with quartz veins. The whole series which forms the low ground underlies to the westward.

The two hills, the North and South Dromedary, which form the most conspicuous features in the landscape, rising as they do to a considerable elevation above the general level of the surrounding country, expose what appears to be the base of the Mosquito Creek Series.

The South Dromedary forms a ridge which has a general trend of north 50 degrees east, and a length of about half-a-mile. It is made up of vertical beds of conglomerate of considerable thickness. The conglomerate is very much cleaved, and the cleavage planes are seen to cut clean through the centre of many of the quartz and other pebbles. It may be noticed that the conglomerate contains numerous pebbles of laminated quartzite (chert), belts of which form such a conspicuous feature in other portions of the district, and are described in the previous report (Bulletin 15).

About two miles and a-half to the south-east of Quartz Claim 32* is a cairn, forming the summit of a tortuous ridge of laminated quartzite (chert). This quartzite underlies at an angle of about 40 degrees to the west, and with an average strike of north 70 degrees east. A few feet to the west of this is a remarkably conspicuous vein of quartz of considerable horizontal extent. From the position of this laminated quartzite, it would appear as though the beds in which it is enclosed belong to an older formation than that which comprises the strata of the North and South Dromedaries.

Between this hill and the South Dromedary (G. 16), sandy and micaceous beds (? sandstones or grits) of the Mosquito Creek type prevail. These strata are traversed by numerous quartz veins, lying parallel to the planes of bedding (? cleavage).

Farther to the eastward, a normal granite makes its appearance. This granite, which is clearly intrusive into the strata just described, is traversed by pegmatite veins which have, when viewed on the whole, a general strike of north 80 degrees east. In addition to the pegmatite veins, the granite is also seamed with an approximately parallel series of quartz reefs, which may merely represent another phase of the pegmatitic intrusions.

No estimate in the present condition of our knowledge of even the approximate thickness of the Mosquito Creek Series can be made, though the apparent enormous thickness of the formation may, in all probability, be due to the repetition of the beds by folding.

* Vide Mines Department Lithograph, L. 76.

No trace of fossils having been met with anywhere in the series, so far as it has been examined, any definite data as to the age of Mosquito Creek beds is unavailable.

Observations, fully set out on an earlier page, demonstrate that they lie unconformably beneath the Nullagine Beds, and as in certain portions of the district the Mosquito Creek Series have been subjected to more or less intense dynamic metamorphism, a considerable period must have elapsed between the deposition of the two series.

The Mosquito Creek Beds are of economic importance, by reason of the fact that they form the matrices of the numerous auriferous quartz reefs which outcrop along a belt of about 24 miles in length, and have been more or less perfunctorily worked. A full description of the reefs occurring in the Mosquito, Sandy, and Middle Creek districts has already been given in Bulletin No. 15, pp. 78-101, and need not be repeated. In this report, particulars will only be given (under the heading of Economic Geology) of those reefs, etc., embraced within the area covered by the Geological Map of Nullagine (Plate I.), and to which no previous reference has been made.

As may be seen by a reference to the table below, the gold contents of the reefs are high, having an average of nearly 3ozs. for every ton of stone mined and milled, though the actual quantity of ore raised has, up to the present time, been very small.

Table showing the Yield of the Auriferous Quartz Reefs of the Mosquito Creek Series.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	339·50	1,126·20	3·31
1897	151·00	450·95	2·98
1898	605·50	1,174·55	1·94
1899	12·70	79·60	6·27
1900	101·00	478·90	4·74
1901	28·25	187·10	6·62
1902	<i>Nil</i>	<i>Nil</i>	...
1903	<i>Nil</i>	<i>Nil</i>	...
1904	<i>Nil</i>	<i>Nil</i>	...
Total	1,237·95	3,497·30	2·82

Greenstone Dykes.

Apart from the igneous rocks which form an integral portion of the Nullagine Series, the greenstone dykes make a conspicuous feature of the country in the more immediate vicinity of Nullagine.

Lying to the west of the township of Nullagine, and distant about two miles, is a very prominent greenstone [5799] dyke, which

attains its greatest development along the eastern bank of Kadjebut Creek. The summit of this dyke is formed of a very rocky ridge, made up of large rounded and subangular blocks of greenstone, producing in places a surface of indescribable roughness. This dyke has a general north-east and south-west strike, and extends some miles in a northerly direction far beyond the limits embraced by the Geological map. It has a width of about 1,500 feet, and wherever seen in section the dyke has a decided tendency towards verticality. So far as could be seen, there appeared to be very little, if any, appreciable alteration of the enclosing rocks on either wall of the dyke. In two places along its course the dyke sends out tongues into the surrounding rocks. It is quite possible that there may be some underground connection between the main dyke and those two smaller ones which occupy a portion of the surface to the east of the Great Eastern line of reef. These two dykes, the position of which is shown on the Geological map, have a horizontal extent of about 15 and 50 chains respectively.

This large, or what may be called main, dyke is nowhere seen to pierce any other strata than those of the Mosquito Creek Series.

At a point about 20 to 30 chains to the west of this larger dyke is another approximately parallel one, first making its appearance between the Victory and the Day Dawn groups of leases, and traversing the country to the northward in the vicinity of M.A. 4 L until it disappears beneath the alluvium of the Nullagine River. Although it rises to a considerable height above the general level of the surrounding plain and forms a prominent surface feature, it nowhere exceeds a width of two chains. This dyke also does not pierce any other strata than those belonging to the Mosquito Creek Series.

On the north side of the Nullagine River, and in the vicinity of the One-mile Creek, is another greenstone [5794] dyke, trending generally north-west and south-east. It has been followed across country for a mile and a-half, and extends far beyond the limits of the map. This dyke, which traverses both the Mosquito Creek and the Nullagine series, does not make any very pronounced feature in the landscape, though it can be readily followed. Its width nowhere exceeds two chains in width, and when seen in section is vertical, or nearly so.

There seems very good reason for believing that this dyke may be the prolongation of that disappearing beneath the alluvium of the Nullagine River, in the vicinity of M.A. 4L. The course of the dyke north of the One-mile Creek is approximately parallel to that fault which lies to the north of Beaton's Creek, and it is quite conceivable that the One-mile Creek dyke may occur along a line of fracture also, although no obvious dislocation of the strata is apparent. Whatever may be the exact age of these dykes it is quite clear that the one last described is newer than the series of strata it penetrates.

The rock [5799] of which this dyke is formed is of medium grained, crystalline structure. The only minerals which are readily recognisable with the aid of a lens are felspar, pyroxene, and occasionally an iron ore.

Under the microscope, relatively large proportions of crystals of augite, some of which are changed into a pale green dichroic mineral, stand out very prominently. All the felspars, which seem to be plagioclase, and make up the greater part by volume of the rock, present in all cases that turbid, mealy aspect due to alteration. The iron ore seems to be either magnetite or ilmenite, though pyrites is present in some portions.

The rock [5794] forming the largest and most conspicuous dyke in the field is a very fresh, fairly cross-grained rock, consisting of pyroxene, with a metalloïd lustre, together with a white, and in some cases, almost colourless felspar, plagioclase. The felspar forms by far the larger proportion of the rock, and, when examined under the microscope, is found to be very much altered. A little quartz can be detected in some portions of the slide. The specific gravity of the rock is 2.82.

An analysis of a fresh, unweathered specimen [5794] made in the Survey Laboratory, showed its chemical composition to be —

Silica, SiO ₂	54.92
Alumina, Al ₂ O ₃	14.27
Ferric Oxide, Fe ₂ O ₃	1.28
Ferrous Oxide, FeO	5.25
Magnesia, MgO	10.32
Lime, CaO	6.42
Soda, Na ₂ O	2.50
Potash, K ₂ O ... ..	.64
Combined Water, H ₂ O	2.96
Hygroscopic Water, H ₂ O ... ..	.12
Carbonic Anhydride, CO ₂ ... ..	.38
Titanic Oxide, TiO ₂ ... ..	.90
Iron, Fe } FeS ₂ ... ..	.10
Sulphur, S } ... ..	.12
Manganese Protoxide, MnO... ..	trace.
	100.18

This apparently differs but little from that last described [5799], except in the coarseness of grain.

So far as any observations have at present been carried in the district, these dykes appear to have no apparent connection with any visible deep-seated rock of similar composition.

Economic Geology.

The Nullagine District comprises three distinct types of auriferous deposits, viz. :—Alluvial and other Superficial Deposits; Quartz Reefs; and Auriferous Conglomerates. The respective yields of each is shown in the table below.

Synoptical Table showing the Total Gold Production of Nullagine up to the end of 1904.

Nature of Deposit.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Alluvium and Superficial Quartz Reefs	1,237·95	3,670·02	2·82
Auriferous Conglomerates	5,167·00	3,217·29	·62
Total	6,404·95	*6,714·59	1·04

* This total does not include that of the alluvial gold.

From this table it will be noted that, in so far as the number of ounces is concerned, the alluvial and superficial deposits have proved to be the most important, whilst the yield from the quartz reefs has exceeded that from the auriferous conglomerates by 108·84 ounces, although the average grade of the quartz proves to be more than four times greater.

Considering the number of years this mining centre has been in existence, it must be candidly admitted that the gold yield is disappointing.

In addition to the above totals, 1,638·50oz. of gold have been obtained from the cyaniding of nearly 3,000 tons of tailings. It is, however, not possible to separate the yield of the tailings from each centre, but as they were all cyanided at Lambert's Treatment Works, M.A. 4L, it is probable that most of the ore was obtained from the more immediate vicinity of Nullagine itself.

Table showing the Yield of the Tailings Cyanided at Lambert's Treatment Works, M.A. 4L.

Year.	Tons treated.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1902	1,960·00	1,259·05	·64
1903	840·00	379·45	·45
Total	2,800·00	1,638·50	·58

This return thus brings the total gold yield of Nullagine up to 12,023·11ozs., as recorded at the close of 1904.

Alluvium and Superficial Deposits.

The alluvium and the other superficial deposits call for no special notice, beyond the fact that there seems good reason to believe that no small portion of the "alluvial" gold was obtained from the numerous creeks draining that portion of the escarpment of the Nullagine Series lying between Beaton's and the One-mile

Creeks. Over this area, which is that occupied by the ferruginous basal conglomerates, skilful dryblowers are still able to obtain a certain quantity of gold, derived, in all probability from the residual concentration of the gold set free from the conglomerate. Owing to the circumstance that a considerable proportion of the gold so obtained is probably never officially reported, the actual yield from this source cannot be set out in figures.

Quartz Reefs.

Quartz reefs occur in great abundance in the country lying to the westward of the Nullagine River. These reefs outcrop over a belt about four miles in length, which emerges from beneath the beds of the Nullagine Series near Suburban Water Right 5L, and extends in a general north-easterly direction across the whole area of the geological map. So far as any observations have been made it seems that the productive area of the Mosquito Creek Beds, as developed in the more immediate vicinity of Nullagine, consists of a broad belt about a mile in width, with a general strike of north-east and south-west, which latter coincides with the general trend of the series.

The position of most of the quartz reefs has been accurately laid down upon the Geological Sketch Map of Nullagine (Plate I.). They exhibit, when viewed on the whole, a general parallelism, which is coincident with the plane of bedding of the enclosing rocks. The reefs invariably occur along the bedding planes, or, at any rate, cut them at a very low angle. Few of them attain any very great horizontal extent, nor, so far as could be judged by a careful inspection of the surface, did they reach, as a whole, any great thickness.

The quartz of which the reefs of Nullagine are composed is generally of a whitish colour, contains little, if any, pyrites, and of such a character as render it readily amenable to battery amalgamation and cyanidation.

Several of the reefs have been opened up and worked to relatively shallow depths.

THE MINES.

No work of any description was being carried on at the date of my visit to the district, and none of the mines were accessible.

I have extracted a good deal of information from the manuscript reports of the different Inspectors of Mines, and the following notes may serve the purpose of giving some idea of the state of development of the mines and other cognate points at the time these officers visited the district. These notes, however, make no pretensions to being more than a mere general account. It is much to be regretted that no better official record has been kept of the statement of development of the district, a condition of affairs which virtually obtains over the whole of such portions of the Pilbara Field as have yet been visited.

For convenience of description the various properties are dealt with in geographical order, commencing at the north-easternmost end of the field. The location of each of the properties described will be found on the Geological Sketch Map of Nullagine. (Plate I.)

FISHER'S REWARD, G.M.L. 65L.—This, the most northerly of the leases in the country to the east of the Nullagine River, is traversed by two small parallel quartz reefs of no very great horizontal extent. A very little desultory work has been done upon the property, which was held for a period of about four months during a portion of the years 1896 and 1897. A few tons of quartz were raised and crushed in 1897; the official figures show that 20 tons of ore crushed yielded 56.6 ounces of gold, or at the average rate of 2.83ozs. per ton.

TRY AGAIN, 66L.—This lease adjoins that last described, on the south, and was at one period of its history known as the Turkey Mary. There are two distinct vertical reefs on the property, the easternmost having the greatest horizontal extent. The lease appears to have been held for a period of about five months only, during a portion of the years 1896 and 1897. Two small shafts have been sunk, but although the reef proved to be small, it is stated to have been rich. There are no crushings recorded from the property.

PROMISE, G.M.L. 331 (25L).—This six-acre lease lies some little distance to the west of the Try Again and about 35 chains to the east of the Nullagine River.

The property appears to have been held for about 18 months, having been surrendered in July, 1897.

There are two short reefs outcropping near the north-western boundary of the property, and three others, the position of which is shown on the plan, adjoining. A vertical shaft, 20 feet in depth, was put down, but the Inspector of Mines' report states that there was no reef exposed in it. A second shaft, 25 feet vertical, was continued on the underlay for 25 feet farther, in a south-easterly direction, on a small quartz vein; this, in the eastern shaft, the Inspector of Mines' report states, attained a thickness of two feet. There appears to be no record of any crushings from this property in the official statistics, unless such are included with those from sundry claims. The field note book, however, of the late Mr. S. J. Becher, at one time Inspector of Mines, contains the statement that "about 30 tons crushed over 90ozs., and that the first five tons went 10ozs. per ton." From this it would seem that some very rich ore must have been met with.

SUNRISE, G.M.L. 58L (480).—This lease is situated in the triangular piece of ground, bounded by the Nullagine River, Kadjebut Creek, and the gabbro dyke, shown on the geological map. A fairly well-marked quartz vein outcrops for some distance along the eastern boundary of the lease; and has been opened out by means

of a shallow shaft. Little or nothing, however, can be seen at the present time. The lease was abandoned in 1897; there are no crushings from the lease in the official statistics, unless any such are included under the heading of the yield from sundry claims.

SUNRISE No. 1, G.M.L. 57L (429).—This property, which adjoins the Sunrise on the north-east, appears to have been taken up in September, 1896, and abandoned in the month of January of the following year. A small quartz reef, probably a continuation of the Sunrise, occupies a portion of the surface, near the south-eastern boundary of the property. The only work done on the property appears to have been raising the few tons of quartz which are shown in the official returns. These demonstrate that, previous to 1897, 28 tons of ore crushed yielded 14ozs. of gold, or at the rate of 50ozs. per ton.

THE GREAT EASTERN GROUP of leases lie about a mile to the south of the Sunrise, and are situated on the eastern bank of Kadjebut Creek, almost due west of the Nullagine township.

GREAT EASTERN, G.M.L. 59L.—The Great Eastern Reef makes a very pronounced outcrop, forming as it does the highest point of a low, though conspicuous ridge, which rises some 15 or 20 feet above the level of the surrounding country. The general strike of the reef is north-easterly, and, as measured at the surface, has an underlie of 70 degrees to the south-west; from this it would seem that the reef is much steeper at the surface than underground. The country rock of both walls of the reef is slate; the reef measures about four feet in thickness, and the quartz is white, with ferruginous portions, due to the oxidation of pyrites. A fair quantity of stone from the outcrop had been raised to a depth of from 15 to 20 feet from the ground level. Mr. Inspector Gladstone's report mentions a vertical shaft 40 feet in depth, which had been continued on the underlay for a distance of 80 feet. At 30 feet in the shaft, a level is referred to 35 and 40 feet in length, driven respectively north-east and south-west, whilst at 90 feet a north-easterly level had been driven for a horizontal distance of 40 feet. There is no information in Mr. Gladstone's report as to the dimensions or character of the reef in the mine, and the workings were inaccessible to me.

The following figures give the yield of the reef in so far as it may be gained from official data:—

Table showing the Yield of the Great Eastern Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	20·00	33·80	1·69
1898	150·00	168·95	1·12
Total	170·00	202·75	1·19

ENTERPRISE, G.M.L. 76L.—This is an isolated lease about three-quarters of a mile to the north-west of the Great Eastern Group. It embraces a part of the old Union Jack Lease 40L. A fairly well-defined reef, which can be followed more or less interruptedly across the surface to the south-west for a distance of 2,500 feet, traverses the lease. Several shafts have been sunk to depths of which there is no information. Water is said to have been met with in two of them at 35 feet. These shafts have been utilised as a source of water for the Battery and Cyanide Plant at one time erected on M.A. 4L, which embraces part of the lease. There have been no crushings recorded from the property, unless they are included in the yield from sundry claims.

In the vicinity of this lease there are several other parallel reefs of smaller size, upon which a little work has been done at one time or another, but there are no particulars available in respect to the yield of any of them.

About 800 feet to the south-west of the Enterprise Reef is another parallel vein, which can be followed more or less interruptedly across the surface for about 3,000 feet, and it is quite possible that the reef, disappearing beneath the alluvial flat of the Nullagine River to the north-west of the Day Dawn Group, may represent an extension of it.

SCOTTISH CHIEF, G.M.L. 64L.—This is an old abandoned twelve-acre lease, adjacent to the Day Dawn Group on the north. There are three well-defined though small reefs traversing the property, and upon two of them, the north and south reefs, shafts have been sunk; these, however, are inaccessible, hence no particulars are available. There do not appear to have been any crushings recorded from the property.

DAY DAWN, G.M.L. 278 (17L).—Upon this property there are several well-defined parallel reefs outcropping. The reefs have an average strike of north-east, with an underlie of about 40 degrees to the south-east. The main reef, viz., that upon which the bulk of the work has been carried out, averaged on the surface about two feet in thickness. It consisted of a white, and, in places, very ferruginous quartz, and is stated by Mr. Inspector Becher to have contained very coarse gold. Mr. Becher notes that the reef had been opened by means of an underlay shaft 45 feet in depth, which was also connected with the surface by a vertical shaft of 20 feet. A little driving had been done along the reef to the south-east. At a later date, 1898, Mr. Inspector Gladstone notes that the shaft had been carried down to a depth of 69 feet, and that driving to 252 feet had been carried out. No particulars as to the nature of the reef underground is to be found in the reports of the inspectors, which is much to be regretted, as the workings are at the present time inaccessible. Only 266 tons of stone have been crushed during the three and a-half years the lease was in existence, particulars of which are shown in the table below. In addition to these figures, Mr. Becher notes that 18 tons of *débris*, with which the surface of the lease was covered, yielded 18oz. of gold.

Table showing the Yield of the Day Dawn Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	174·00	600·00	3·45
1898	92·00	102·70	1·11
Total	266·00	702·70	2·64

DAY DAWN NO. 1 SOUTH, G.M.L. 388 (43L).—A twelve-acre lease, adjoining that previously described, which was held for a little over twelve months and abandoned in December, 1897. Two short reefs, one of which may represent the extension of the Day Dawn, occupy a portion of the south-western corner of the ground. Very little work appears to have been done upon the property, and there is no record of any crushings from it.

DAY DAWN NORTH, G.M.L. 418 (52L).—No work of any moment appears to have been done upon this lease.

THE VICTORY GROUP of leases, only one of which, however, is now extant, occupies an extent of country about a mile in length, over which several small quartz veins outcrop.

VICTORY, G.M.L. 134L.—This lease embraces the greater portion of what was originally the Victory East Extended, G.M.L. 56L (424 or 99L), Walter's Folly; the original Victory, G.M.L. 383 (42L), to which it is desirable the name should be still applied, is situated some little distance southwards along the line. Five shafts have been sunk upon the lease, and, judging by the condition of the dumps, a good deal of work must have been done. None of the shafts, however, were accessible to me, and there appear to have been no plans of the workings. Mr. Inspector Gladstone mentions two underlay shafts, each 135 feet deep, and connected with drives from which 172 tons of ore had been crushed for a return of 625ozs. of gold, and a main shaft, which at the date of his visit had been carried down 70 feet. According to the official records of the mine, given in the table below, the gold yield seems to have been high.

Table showing the Yield of the Victory (East Extended) Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	12·50	50·90	4·07
1897	42·00	195·25	4·65
1898	116·00	388·30	3·34
1899	<i>Nil</i>	<i>Nil</i>	...
1900	89·00	414·35	4·65
1901	25·50	181·00	7·09
Total	285·00	1,229·80	4·31

VICTORY No. 1 EAST, G.M.L. 53L (419).—Known later as the New Victory Extended, G.M.L. 70. The reef, traversing the adjoining property previously described, extends more or less interruptedly along the south-eastern boundary of the lease. It has been opened up by an inaccessible vertical shaft, of a depth of which there appears to be no record. There are no returns of any crushings from this lease.

VICTORY, G.M.L. 383 (42L).—What is known as the main Victory reef traverses the south-eastern boundary of the property, though it makes very little show on the surface. An inaccessible underlay shaft had been carried down, according to Mr. Becher's notes, to a depth of 81 feet, on a quartz reef underlying at an angle of 60 degrees, and attaining a thickness of from three to four feet. The walls of the reef, as described by Mr. Becher, are "perfect," and are made up of a soft, fine-grained, solid, white sandy shale, which is stated to harden on exposure. The quartz is very highly coloured by oxide of iron, and, according to Mr. Becher, showed gold freely at the bottom. A vertical shaft was being put down at a spot 50 feet distant from the mouth of the underlie shaft, designed to intersect the main reef at about 80 or 90 feet, but there is no official record as to whether this was accomplished. At the time Mr. Becher was at work in the Nullagine district, a small crushing of 25 tons of stone from the reef in the inclined shaft is reported to have yielded 130ozs. of gold, or at the rate of 5·20ozs. per ton of ore crushed. A small trial crushing of a few tons by former holders of the property yielded gold at the rate of 3ozs. per ton. The official yield of this lease is given in the table below.

Table showing the Yield of the Victory Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	75·00	337·50	4·50
1897	46·00	83·60	1·81
Total	121·00	421·10	3·48

VICTORY EXTENDED, G.M.L. 51L (417).—A small six-acre lease adjoining G.M.L. 383 on the south-east, and traversed by a reef which was thought to be the southern extension of the Victory. So far as can be judged, however, it seems probable that it is a parallel reef. An underlie shaft had been carried down on the reef to a depth of 30 feet, when it cut out. The shaft, however, was carried down another 20 feet, at which point a crosscut had been put in 20 feet to the north, with the object of testing the country, and another crosscut to the south had been commenced at the date of Mr. Becher's visit. His notes, however, give no par-

ticulars as to whether the reef had been picked up below the depth at which it cut out. In 1897 22 tons of ore are officially recorded as yielding 63ozs. of gold, or at the rate of 2·86ozs. per ton.

MARQUIS, G.M.L. 62L.—A disused and inaccessible shaft is situated at a point 13 feet from the north-east angle of the lease, and is traversed by a small reef parallel to that in the adjoining property on the north. About 100 feet south from the north-east angle is a well-defined reef, shown on the geological map, underlying at a high angle to the north-west, but no work has been done upon it.

There are one or two other abandoned leases and quartz claims in the vicinity of Kadjebut Creek to the west of the South Dromedary G. 16. The position of these properties is shown on the 40 chain lithograph L 76, issued by the Department of Mines.

GOLDEN EAGLE, G.M.L. 77L (formerly Alexandra, G.M.L. 71L).—A great deal of desultory work has been carried out upon what were evidently distinct veins, but all the workings are inaccessible at the present time. According to the official records, small crushings from this lease took place annually from 1897 to 1901, but although the total quantity of gold, under 500ozs., so obtained was small, the average per ton was over four and a-half ounces. There would thus seem to have been some very rich shoots met with in the course of the work.

Table showing the Yield of the Golden Eagle Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897	21·00	52·50	2·50
1898	57·50	290·20	5·04
1899	12·70	79·60	6·26
1900	12·00	64·55	5·38
1901	2·75	6·10	2·22
Total	105·95	492·95	4·65

REWARD CLAIM, 33L.—A small abandoned lease on the eastern bank of Kadjebut Creek, and lying about three-quarters of a mile to the south-east of the Golden Eagle. An east and west vertical reef has been opened up by a shaft which is inaccessible at the present time, hence no information as to the character and behaviour of the reef underground can be obtained. There appear to be no records of any crushings from this property, unless they are included under the heading of the yield from sundry claims.

The following synoptical table gives the total gold yield of the reefs of Nullagine, in so far as such may be obtained from official statistics:—

Synoptical Table showing the Yield of the Nullagine Reefs up to the end of 1904.

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Day Dawn	266·00	702·70	2·64
Fisher's Reward	20·00	56·60	2·83
Golden Eagle	105·95	492·95	4·65
Great Eastern	170·00	202·75	1·19
Great Eastern Extended	190·00	224·40	1·18
Promise	30·00	90·00	3·00
Sunrise No. 1	28·00	14·00	·50
Victory	121·00	421·10	3·48
Victory East Extended ...	285·00	1,229·80	4·31
Victory Extended	22·00	63·00	2·86
Total	1,237·95	3,497·30	2·82

Auriferous Conglomerates.

Mining operations have, up to the present, been confined exclusively to the outcrop of the conglomerates and to very limited and shallow depths; but work, however, has been carried sufficiently far to enable some idea of the conditions governing the gold deposition being ascertained. The conclusions to be drawn from these data may have some influence upon the practical development of the field. The gold contents of the conglomerate are small, not amounting to more than 3,217·29ozs. derived from the milling of 5,167 tons of ore, or at the rate of ·62oz. per ton.

Of the different areas in which the conglomerate has been worked, the largest quantity of gold, so far as may be judged by the official figures, appears to have been obtained from the workings now embraced by the Grant's Hill Lease 122L. (*vide* the plan of the Nullagine Conglomerate Gold Mines, Plate II.) The returns from this demonstrate that 3,433 tons of ore yielded 1,780·24ozs. of gold, or at the rate of ·52oz. per ton.

The auriferous conglomerate, which has already been shown to be of sedimentary origin, is made up of rounded and subangular fragments of the strata identical in character with that forming the underlying Mosquito Creek Series. Certain portions of the conglomerate are marked by the presence of abundant iron pyrites, and its oxidation products [5802, 5806]. It is, however, in the oxidised zone of the conglomerate that any mining has, up to the present, been carried on.

In 1897, samples of the auriferous conglomerate were examined in the Survey Laboratory and have been thus described: -

"A specimen [190] typical of the finer-grained portions of the rock in its upper decomposed portions. It consists of subangular fragments of quartz, ironstone and shale, cemented together by ironstained kaolin, containing numerous cuboidal cavities at one time filled by pyrites crystals, as shown by the numerous pseudomorphs of limonite contained by them. . . . It assays 1oz. 6dwts. of gold. . . . A similar but less ferruginous variety, [191], showed no cavities vacated by pyrites, and is much coarser in grain, some of the fragments of quartz being 3 inches in length; it assays 2ozs. 1dwt. of gold per ton."*

Another variety [192] made up of large pieces of felstone, with smaller fragments of quartz embedded in a kaolinic matrix, assayed 10dwts. of fine gold and 5ozs. 4dwts. of coarse gold per ton.

A noteworthy feature in the conglomerate is the occurrence of pyrites and its oxidised representatives. In the unoxidised portions [3718, 5801, 5802] the pyrites occurs both as crystals, grains, and rounded or pebble-like forms. A photograph of a small but characteristic form [5802] is shown in Photograph "C." Some of the pyrites nodules measure an eighth of an inch in diameter, though from the size of some of the hematite pebbles there must be some which reach as much as three-quarters of an inch in diameter. A photograph of one of these hematite pebbles [5801] forms Photograph "D."

Considerable interest attaches to the occurrence of these rounded pebbles and pellets of pyrites and hematite in that they have been held to indicate a detrital character as well as ascribing a similar origin to the gold, which seems invariably to be associated with the occurrence of the ores of iron in the conglomerate.

A radiate fibrous structure can be detected in some of the oxidised conglomerates [5801] when the hematite pebbles exhibit fractured surfaces.

In some portions of the conglomerate [190] these hematite fragments make up fully one-half of the rock. The gold [1509, 3167] in the conglomerate almost invariably occurs in or lining the sides of these cavities which have been left by the removal of the iron ore. All its characters point to the gold having been left where it is now found by the oxidation of the pyrites.

The evidence, so far as it goes, respecting the origin of the gold in the Nullagine conglomerate seems to indicate that it is a secondary, and not an original constituent, and further that the primary source of the gold is the quartz reefs which occur in the underlying formation.

From the known occurrence of auriferous quartz reefs, which furnished no small portion of the pebbles of certain portions of the

* Annual Progress Report of the Geological Survey for the Year 1897. Perth:
By Authority: 1898, p. 48.

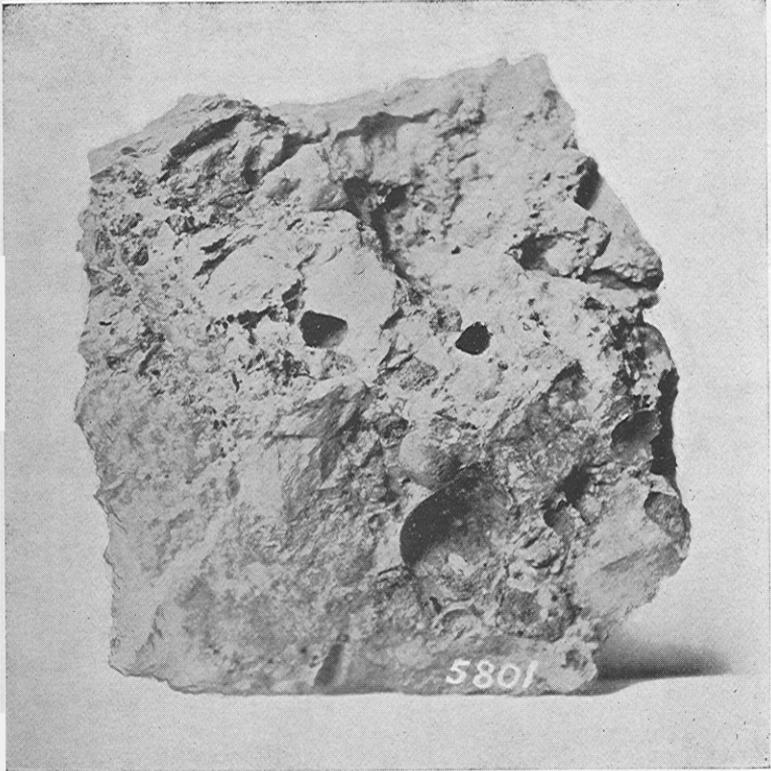


PHOTO. : E. S. SIMPSON.

Rounded Hematite Pebbles in Conglomerate, Nullagine Series.

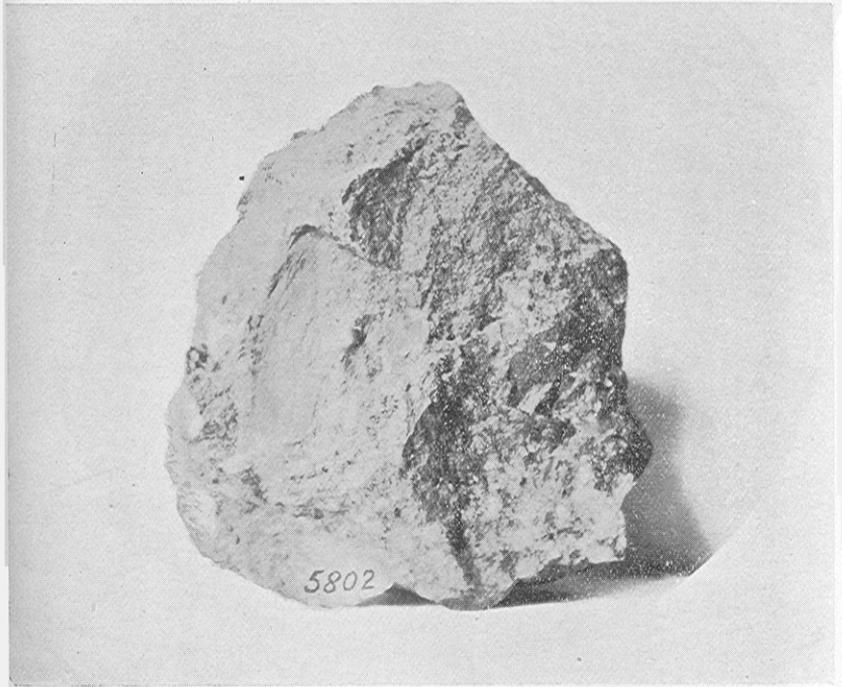


PHOTO.: E. S. SIMPSON.

Rounded Pyrites Pebble in Conglomerate, Nullagine Series.

deposit, it is of course quite conceivable that a certain amount of detrital gold forms part of the conglomerate, but there are obviously no means of ascertaining what is the proportion of primary to secondary gold.

There seems, however, good reasons for believing that by far the bulk of the gold, together with the pyrites, was introduced by solutions percolating down the most porous portions of the conglomerate, this condition being facilitated by the downward inclination of the bed-rock, and, possibly, accentuated in part by the folding which the strata have undergone.

The intrusion of felsite into the lower portion of the conglomerate (Plate II.), and the volcanic phenomena of which it formed a part, may possibly have resulted in the formation and circulation of the mineralising solutions, and also the deposition of the gold.

There is no evidence that the diabase dyke and the fault (Plate I.) have had any beneficial effect upon the gold contents of the conglomerate, but the fact remains that it is only in that portion of the formation lying between these two lines of fracture that any gold has hitherto been found. It is also noteworthy that the base of the Nullagine Series has only proved auriferous in those places where it lies upon that portion of the underlying formation which carries auriferous deposits. It may be noted, also, that over that portion of the formation from which the conglomerate crushings have been obtained numerous dryblowers have been at work for a number of years, and have obtained a considerable quantity of gold, of which the published figures afford no clue, for much of it in the early days was probably never officially reported.

Probably one-half of the alluvial gold from Nullagine, shown in the figures on page 16, may be legitimately claimed as having been derived from the escarpment of the conglomerate.

The high assays [190, 191, 192] alluded to are the exception, and merely indicate the occurrence of unusually rich shoots in portions of the conglomerate.

No attempt was made to sample any portion of the conglomerate workings, with the view of arriving at the value of the deposits, but six samples (which seemed to be characteristic of the type of deposit), collected during the course of the fieldwork, were assayed in the Departmental Laboratory, with the following results:—

- [5800].—Grant's Hill Lease 122L. Oxidised Conglomerate in which the iron had been entirely leached out. Gold, 6dwts. 23grs. per ton.
- [5801].—Grant's Hill Lease 122L. Oxidised Conglomerate, with abundant hematite kernels. Gold, 2dwts. 11grs. per ton.
- [5806].—Dean's Hill, Mineral Reward Claim 6L. Oxidised Conglomerate with hematite kernels (some portions of this conglomerate show free gold). Gold, 4dwts. 2grs. per ton.

- [5802].—Freak of Nature, G.M.L. 121L. Pyritous sulphide conglomerate. Gold *nil*.
 [5803].—North-west of the Success, G.M.L. 119. Very slightly pyritous conglomerate. Gold *nil*.
 [5804].—North-west of the Success, G.M.L. 119. Non-pyritous conglomerate. Gold *nil*.

To arrive at the value of the deposits, as can be readily understood, is an exceptionally difficult matter, but the figures of the output afford some idea of the yield of those isolated portions of the conglomerate which were deemed worth working.

The records of production of the conglomerates, given in the table on an earlier page (p. 26), seem to indicate a general decrease in the yield, the latest crushing of 777 tons returning gold at the rate of 12oz. per ton.

Fluctuations in the gold yield per ton are, of course, only to be expected, but it cannot be said that the average of all the crushings recorded is any index to the value of the whole of the conglomerate series, if worked upon a large scale. It would probably prove to be a very low grade, and possibly so low as to render remunerative working, unless under the most favourable economic conditions, impossible.

The known occurrence of such an extensive formation as the Nullagine Series has, proved, by mapping, to be and the fact that it has been shown to contain considerable quantities of gold in localities where the requisite and qualifying conditions for deposition obtain, would seem to encourage efforts in the direction of carefully prospecting other parts of the basal members of the series in the district.

Such prospecting should be a relatively easy task, seeing that it has already been shown that the auriferous portions of the conglomerate have invariably proved to be those which are the most ferruginous, hence the search for ironstained conglomerates near the base would seem to be the lines upon which such efforts should tend.

THE MINES.

GRANT'S HILL, G.M.L. 122L.—A considerable amount of *bond fide* work has been done upon the western angle of the lease, as may be seen by an inspection of the plan of the Nullagine Conglomerates Gold Mines (Plate II.)

Fairly extensive workings on the south side of the tramline which connects with the battery have been carried on in a bed of coarse conglomerate, the exact thickness of which does not appear to have been determined. The conglomerate (or boulder bed) contains large boulders of flat-sided quartz, siliceous conglomerate, and other rocks occurring in the vicinity. This portion of the workings lies in the oxidised zone of the conglomerate which contains cellular portions from which iron pyrites has weathered out [5800]. This sample assayed in the departmental laboratory 6dwts. 23grs. of gold per ton.

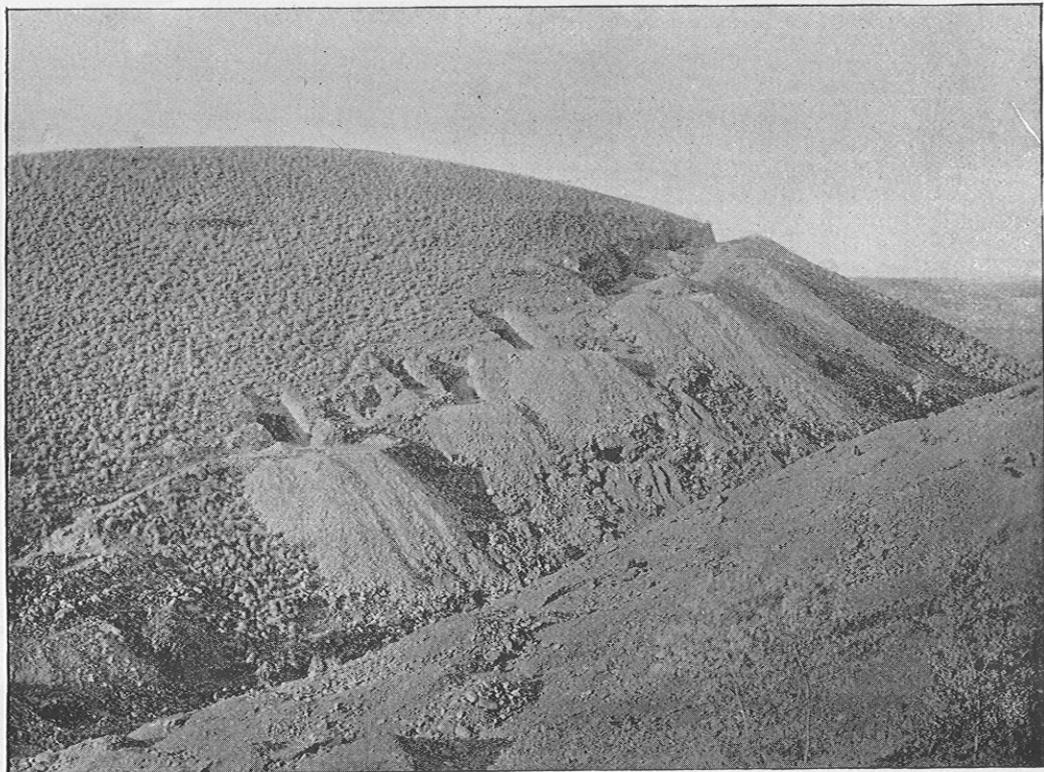


PHOTO.: S. J. BECHER.

Workings on the Grant's Hill Conglomerate, Nullagine

The larger portions of the workings, however, occur on the southern slopes of Grant's Hill, which lies on the north side of the creek which drains the gully in a westerly direction. (Photograph "E.")

A good deal of ore must have been taken out at one time or the other, for the workings extend for some considerable distance round the slope of the hills. The larger portion of the work has been carried out on a bed of conglomerate, underlying generally west-north-west, rising gradually up and along the hillside at an angle of about 40 degrees, and as the plan (Plate II.) and statistics show, a good deal of ore must have been taken out.

A fault with a very small displacement occurs in one portion of the workings, and it appears to be parallel to the main fault shown on the geological and mining maps (Plates I. and II.)

A thickness of only from three to four feet of the conglomerate has been worked. So far as can be gathered from the official statistics, the returns from what is now Grant's Hill are set forth in the table:—

Table showing the Yield of the Grant's Hill Conglomerate.

Year.	Ore	Gold	Rate
	crushed.	therefrom.	per ton
	tons.	ozs.	ozs.
Previous to 1897	109'00	147'00	1'35
1897	<i>Nil.</i>	<i>Nil.</i>	—
1898	275'00	382'35	1'39
1899	462'00	343'25	'74
1900	152'00	70'50	'46
1901	1,358'00	614'53	'45
1902	300'00	128'51	'42
1903	777'00	94'10	'12
1904	<i>Nil.</i>	<i>Nil.</i>	—
Total	3,433'00	1,780'24	'52

To what may be called the Grant's Hill conglomerate should be added the small crushing of 85'40 tons, which yielded in 1899 40'70ozs. of gold, or at the rate of '47oz. per ton, from what was originally known as the Trinity No. 1 South, G.M.L. 422, and subsequently Grant's Hill South, G.M.L. 68L.

This old twelve-acre lease adjoined the present Grant's Hill lease on its southern boundary, and apparently included the ground now occupied by the "Residence" shown on the plan of the Nullagine Conglomerates Gold Mines (Plate II.). The conglomerate from which the crushing was taken occupied the crown and the north-western slope of the hill lying to the east of the main fault. This hill formed a very rich field for dryblowers in the early days of Nullagine.

This additional crushing brings the total return from the Grant's Hill conglomerates up to 1,820·94ozs., obtained from the milling of 3,518·40 tons of ore, or at the rate of ·51oz. per ton.

FREAK OF NATURE, G.M.L. 121L.—What is now the Freak of Nature Lease includes the ground originally embraced by the Freak of Nature, G.M.L. 208, the Freak of Nature Extended, G.M.L. 21, and the Exchange, G.M.L. 18.

The most easterly working near the eastern angle of Grant's Hill was originally known as Neale's No. 3 Underlay. Work in this shaft had been confined to a bed of conglomerate, 3 feet in thickness, underlying to the north-west at angles varying from 18 to 20 degrees. The late Mr. Inspector Becher sampled this conglomerate, and reported the prospects to be "fair."

It would seem that this conglomerate is on the same horizon as that exploited in the adjoining Grant's Hill Lease.

The next working, on a slightly lower horizon, was known as Hewett's Shaft, and a little work was done upon a conglomerate from 2 feet 6 inches to 3 feet 6 inches in thickness; from this locality Mr. Becher also obtained "fair" prospects. This conglomerate appeared to be much more kaolinic than that in Neale's shaft.

Another shaft, shown upon the plan, had been put down upon a conglomerate, on a lower horizon, but no particulars respecting it are available.

There appears to be no record in the statistics of any crushings having been made on the old Exchange Lease; should any have been recorded they may be included in the yield from sundry claims, etc. It does not, however, appear from the conditions of the workings that any very large body of ore can have been taken out. From that portion of the present Freak of Nature Lease, which embraces the old Freak of Nature, G.M.L. 208 (1L), practically no work seems to have been done.

At a point on the northern bank of the main creek, near the north-eastern boundary of the lease, is a cliff of unoxidised pyritous conglomerate, which is distinctly banded.

A typical sample [5802] of this pyritous conglomerate, when assayed in the departmental laboratory, yielded, however, no trace of gold.

On the south-eastern portion of the lease, lying to the south of the pyritous conglomerate previously described, and in the ground originally embraced by the old 5-acre lease, Freak of Nature Extended, a big tunnel (Plate II.) has been put in, upon a boulder conglomerate. Judging by the present condition of the workings there seems to have been a good deal of work done, and a fairly large quantity of stone taken out. Mr. Becher's note-book indicates that the result of his sampling was that the prospects were "poor."

There are no official records of the yield of this portion of the property.

SUCCESS EXTENDED, G.M.L. 120L.—This 24-acre lease embraces part of the old Rejected, G.M.L. 414, Success, G.M.L. 352, and the Freak of Nature, G.M.L. 208. It is, however, only in the old Success and the Rejected that any mining work has been done.

The small patch lying between the 80 and 90 feet contours, in the northern portion of the ground, form the Rejected workings; in reality merely an open work on the outcrop of a bed of conglomerate.

Operations, however, have been principally confined to the old Success ground, and the extent of the open-work is indicated on the mining plan which forms Plate II. So far as may be gathered at the present time the auriferous conglomerate, which did not differ from any of the other auriferous beds, varied in thickness from 18 inches to two feet. The table below gives the total gold yield, so far as can be gathered from the official figures; the 547 tons of ore crushed were in all probability obtained from this portion of the lease.

Table showing the Yield of the Success Extended Conglomerate.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	32·00	42·00	1·31
1897	<i>Nil</i>	<i>Nil</i>	...
1898	305·00	349·25	1·14
1899	110·00*	115·00	1·04
1900	<i>Nil</i>	<i>Nil</i>	...
1901	100·00	33·00	·33
Total	547·00	539·25	·98

* The 96 tons yielding 34·40z. from the Cook's Hill workings, credited in the official return to the Success Lease, are not included in this total, but are included in the yield of M.B.C. 6L.

SUCCESS, G.M.L. 119L.—This 24-acre lease, as it now stands, includes within its boundaries the old Barney's Hill United, G.M.L. 276 (upon which most of the work has been done), and a portion of the Success, G.M.L. 352.

The conglomerate worked on Barney's Hill lies at about the highest altitude of any of the beds at present opened up, being about 100 feet vertically above that in Grant's Hill. The workings lie pretty nearly upon the summit of the hill and along its southern slopes; the bed has been stripped along its outcrop for some distance round the southern and western slopes, and a vertical shaft 25 feet in depth has been sunk, intersecting a drive put in along the conglomerate for some distance from the outcrop.

Over three hundred tons of ore have been raised from the Barney's Hill workings. The figures given in the table as being

the yield of the present Success Lease were derived from ore obtained exclusively from the Barney's Hill workings.

Table showing the Yield of the Success Conglomerate.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	80·00	100·15	1·25
1897	246·00	228·00	·92
1898	12·00	23·10	1·92
Total	338·00	351·25	1·03

BARNEY'S HILL No. 1 NORTH, G.M.L. 24L (330).—This six-acre lease, which was abandoned in 1897, embraces the workings (Plate II.) lying near the western angle of G.M.L. 119L. Operations have been confined to a bed of very coarse ferruginous conglomerate, containing very large ellipsoidal boulders. At a slightly lower level on the north side of a gully flowing southwards from the south-west angle of G.M.L. 119L is a vertical shaft, 50 feet in depth, in which five or six feet of water were standing. This shaft, which was inaccessible, had been carried down through conglomerate of the usual type, and, judging by the material at grass, it contained a little pyrites. A characteristic portion of the pyritous conglomerate [5803] yielded no gold on assay in the official laboratory.

The only returns from the Barney's Hill United Lease appear to have been previous to 1897, when a small crushing of 20 tons yielded 25ozs. of gold, or at the rate of 1·25ozs. per ton. These figures indicate that portions of the conglomerate, in this part of the field, are auriferous.

MINERAL REWARD CLAIM, 6L.—This Reward Claim, which comprises an area of 320 acres, includes within its boundaries the old leases:—Golden Crown, G.M.L. 365 (31L); Beaton's Hill, G.M.L. 373 (37L); Cook's Hill, G.M.L. 412 (47L); Rejected No. 2, G.M.L. 416 (50L); together with parts of Golden Promise No. 1, G.M.L. 67L, and Central No. 1, G.M.L. 69L.

Near the easternmost angle of G.M.L. 119L, and to the north of Dean's Hill, are a series of extensive workings upon what was originally the Golden Crown G.M.L. 365, at an altitude of over 200 feet above the low ground at the base of the formation. All the ground on the flanks of the hill below these workings has been dryblown, and, during Mr. Inspector Becher's term of office, the average winnings from this source are stated to have amounted to about 18dwts. per man per day. The conglomerate, which lies in the locality practically horizontally, is of the usual ferruginous type, containing large pellets of hematite. A typical sample of this highly ferruginous variety from the open-work [5806] assayed in the

departmental laboratory gold at the rate of 4dwts. 2grs. per ton. The total returns from the Golden Crown workings, as shown in the table below, gives the yield as 189·90ozs. obtained from the milling of 223·60 tons of ore, or at the rate of ·84oz. per ton.

What is known as the Cook's Hill workings are situated due east of W.R. 2L. Cook's Hill is said to have derived its name from Mr. Nat. Cook, who is credited with being the first discoverer of gold at Nullagine in 1836. A good deal of work must have been done at one time or another, but as operations have been abandoned for some considerable time there is little to be seen.

By far the larger portion of the hill appears to have originally been covered with a gritty and ferruginous sand (the residual decomposition product of a sandstone) underlaid by a kaolinic deposit which carried waterworn boulders. It is noteworthy that while the material from the hill was being crushed several small diamonds were met with in the battery boxes; reference however will be made to this subject on a later page. The Cook's Hill deposit lies not very far from the base of the Nullagine Series. The total returns from the Cook's Hill workings, as shown in the table below, give the yield as being 140·10ozs. obtained from the milling of 348 tons of ore, or at the rate of ·40ozs. per ton. In this return an effort has been made to credit Cook's Hill with the yield actually obtained from the ore raised.* The return from the Diamond Reward Claim, M.R.C. 6L, as shown in the general table at the end, is really the result of the ore obtained from the Cook's Hill workings, and there seems to be good reason for believing the 1899 return from the Success Lease 27L includes 96 tons of ore from this same source. This latter yielded a return of 34·40ozs. of gold, or at the rate of ·36ozs. per ton. The workings on Beaton's Hill, which lie to the west of those last described, the hill upon which work has already been carried out, comprises about four acres, and is covered by a deposit of laterite stated to be about ten feet in thickness. Beneath the laterite occurs a more or less variable thickness of almost horizontal beds of sandstone and conglomerate. The bed which was worked lies near the base of the hill, and is said to rest directly upon a bedrock of slate, and the gold is said to have been traced thereto by the alluvial workers in the adjacent gully on the north.

Two shafts, now inaccessible, have been sunk to depths stated to be 35 and 40 feet respectively, and levels driven therefrom.

Mr. Beaton, one of the original holders of the ground, and after whom the hill is named, is stated to have worked a considerable distance in under the hill, and to have taken out a large quantity of gold by crushing the material roughly by hand, screening it, and sluicing it at the river. There appears, however, to be no official

* The late Mr. Becher's note-books, 1896, state that "since first worked Cook's Hill has yielded about 4,000ozs. of gold." There is no reason for doubting the accuracy of this statement, but it is quite clear that this amount has not been officially recorded in the statistics, and may possibly never have been reported to the Government.

record of the yield from the old Beaton's Hill Lease, and in all probability any returns therefrom have been included in that from sundry claims.*

Table showing the Yield of the Conglomerates of the Mineral Reward Claim 6L.

Year.	Name of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total Ore crushed.	Total Gold therefrom.	Average rate per ton.
Previous to 1897	Golden Crown, G.M.L. 31L	tons. 32·60	ozs. 50·90	ozs. 1·56			
1898 ...	Do. do. ...	191·60	139·00	·72			
1898 ...	Cook's Hill, G.M.L. 47L ...	22·00	26·30	1·19	223·60	189·90	·84
1899 ...	Do. do. ...	96·00	34·40	·36			
1900 ...	Do. do. ...	230·00	79·40	·34			
					348·00	140·10	·40
	Total ...				571·60	330·00	·49

GOLDEN PROMISE, G.M.L. 380 (39L, and subsequently Golden Promise No. 1, 67L.)—The abandoned workings upon what was originally embraced by this lease are coterminous with the north-western boundary of the Mineral Reward Claim, 6L (Plate I.), and at an altitude of about 180 feet above the general level of the plains. A vertical shaft, 20 feet in depth, had been put down through conglomerate and intersected the open-works at a lower level. The auriferous portion of the conglomerate was a ferruginous band varying from 15 inches to 2 feet in thickness.

The following table gives the yield of the crushings:—

Table showing the Yield of the Golden Promise Conglomerate.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897 ...	84·00	68·65	·81
1898 ...	88·00	81·20	·92
Total ...	172·00	149·85	·87

SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.—In addition to the returns given above in connection with sundry claims, which it is impossible to specify individually, there have been recorded over 6,000ozs. of gold. These figures are given in such

* The late Mr. Becher's note book, 1896, states:—"Return, September, 1896, 1 ton, yielding 2ozs. 2dwts. 12grs. Since Beaton's Hill was first worked it has yielded about 3,000ozs. of gold." This amount does not appear to have been officially recorded in the statistics, and may possibly never have been reported to the Government.

detail as is possible in the table below. There are, however, no means of ascertaining what proportion of these figures are to be credited to that portion of Nullagine embraced by the geological map (Plate I.); it is, however, possible that they include returns from the Elsie, Mosquito Creek, Nullagine, and 20-mile Sandy, which centres are included in the "Nullagine District," as defined by the Mines Department.

*Table showing the Yield from Sundry Claims,
Nullagine.*

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1897	...	...	...	100·00	143·65	1·43
1898	...	...	...	92·00	213·90	2·32
1899	...	...	...	1,066·70	{ 2,695·95 *38·45	2·52
1900	...	...	...	1,008·60	{ 2,433·30 *11·00	2·41
1901	...	...	...	248·25	336·54	1·35
1902	...	...	...	293·05	343·67	1·17
1903	...	...	...	145·90	609·30	·41
1904	...	...	...	830·65	{ 1,308·65† *23·75†	1·57†
Total	...	...	...	3,785·15	8,158·16	2·15

* Specimens. † Fine ozs.

Diamonds.

The occurrence of small diamonds at Nullagine having been brought under the notice of the Government, a report was obtained on the subject by the then Premier from Mr. Fred. F. Groom in the year 1896.* From Mr. Groom's report it appears that the greater number of the most valuable diamonds were washed out of the conglomerate forming Brook's Hill, which was being treated for gold, and others were found in the stamper boxes after crushing a few tons of the conglomerate. Mr. Groom states: "There is no doubt, in my opinion, that the diamonds are enclosed in the conglomerate, . . . and such as have been found by diggers in washing for gold have been released by the gradual decay of the rock . . . On the last day of my stay in Nullagine, I was present at the cleaning up of the battery after crushing about two tons of stone taken from the hill . . . On carefully panning off the gravel left in the stamper boxes nine small stones were found, varying from the size of a pin's head to a pepper-corn, or from $\frac{1}{16}$ to $\frac{1}{2}$ carat in weight. I put the lot into the scales, they weighed $1\frac{1}{2}$ carats, and it took the four largest to weigh one carat. I was informed that

* Report of a visit to Nullagine, Pilbara District, to examine the country reported to be diamond-yielding. Appendix 4. Report of the Department of Mines for the Year 1895. Perth: By Authority, 1896, p. 27.

Mr. Brooks found one diamond for which he obtained £76, another he sold for £28. These, with one other, valued by the finder at £12, were all the diamonds I could hear of as having been of any value; the last-mentioned stone was described as being bright yellow."

During the course of my examination of the district no diamonds came under my notice, there are, however, in the collection of the Western Australian Museum (a.) four small diamonds presented by Messrs. Brook Bros. in 1896, and (b.) four small diamonds taken from the battery boxes when cleaning up a crushing of conglomerate, one from Cook's Hill, presented by Mr. Inspector S. J. Becher in 1896. The returns of a crushing of 230 tons of conglomerate from the Mineral Reward Claim 6L in 1900 show, in addition to 79·40ozs. of gold, twenty-five small diamonds, the value of which, however, is not stated. From the particulars given above it seems perfectly clear that the presence of diamonds in the conglomerates near the base of the Nullagine Series is authentic. The occurrence of such renders it possible that they are not isolated instances, though the interest is at the present time more scientific than commercial.

Table showing the Yield of the Auriferous Quartz Reefs at Nullagine.

Name of Lease.	Number of Lease.		Owner.	Remarks.	Previous to 1897.		1897.		1898.		1899.		1900.		1901.		1902.		1903.		1904.		Total.				
	Marble Bar Number.	L. Number.			Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	
Day Dawn	278	17	Doherty and Party ..	Abd., 14/8/99 ..	tons. 174.00	ozs. 600.00	..	..	tons. 92.00	ozs. 102.70	..	..	..	..	..	..	..	..	..	..	..	..	..	..	tons. 266.00	ozs. 702.70
Do. No. 1 S.	388	43	J. Isdell	Abd., 24/12/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Do. North	418	52	Do.	Ftd., 24/12/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Promise	331	25	Farley & White ..	Surr., 19/7/97 ..	*30.00	90.00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fisher's Reward ..	..	85	Fisher & Martin ..	Abd., 31/3/97 ..	..	..	20.00	56.60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30.00	90.00
Try Again .. ..	..	86	Walters Nicholls ..	Abd., 21/4/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20.00	56.60
Victory	383	42	Geo. Holcombe ..	Surr., 3/5/96 ..	75.00	337.50	46.00	83.60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	121.00	421.10
Do. Extended ..	417	51	Do.	Surr., 3/5/98 ..	..	..	22.00	63.00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22.00	63.00
Golden Eagle ..	..	77	Johns & Smythe ..	Late 71L, Alexandra	..	..	21.00	52.50	57.50	290.20	12.70	79.60	12.00	64.55	2.75	6.10	..	..	..	..	..	..	..	..	105.95	492.95
Do. No. 1 E.	419	53	Royer, Ahern, etc. ..	Ftd., 9/4/97. Later 70L, New Victory Extended	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Victory East Extd.	424	56	W. Extd. Volunteer Pros. Association	Ftd., 14/7/99 ..	12.50	50.90	42.00	195.25	116.00	388.30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	170.50	634.45
Walter's Folly ..	..	99	Alfred Royer	Voided, 6/9/01. Late 56L	..	..	..	..	..	..	..	..	89.00	414.35	25.50	181.00	..	..	..	..	..	..	..	..	114.50	595.35
Victory .. ..	..	134	Aikman & Giles ..	Late 99L .. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Marquis .. ..	..	62	Maher, Wiberg, etc.	Ftd., 25/8/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sunrise No. 1 ..	429	57	Turner & Travis ..	Abd., 18/1/97 ..	28.00	14.00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28.00	14.00
Sunrise	430	58	Aikman & Higgs ..	Abd., 29/1/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gt. Eastern No. 1	423	55	Garland & McKenna ..	Abd., 18/9/96 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gt. Eastern Extd.	..	61	Doherty & Jenkin ..	Abd., 19/1/99 ..	..	..	..	..	190.00	224.40	..	..	..	..	..	..	..	..	..	..	..	..	..	..	190.00	224.40
Great Eastern ..	..	59	Isdell, McKenna, etc.	.. ..	20.00	33.80	..	..	150.00	168.95	..	..	..	..	..	..	..	..	..	..	..	..	..	..	170.00	202.75
Do. No. 1 .. ..	..	72	Isdell, Connolly, Hol- combe	Abd., 1/12/97. Part in 75L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scottish Chief ..	..	64	Eatch, Townsend, etc.	Abd., 20/1/97 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Enterprise .. ..	..	76	Jenkin, Garland, etc.	Ftd., 13/10/99. Part of 40L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total					339.50	1,126.20	151.00	450.95	605.50	1,174.55	12.70	79.60	101.00	478.90	28.25	187.10	1,237.95	3,497.30

* From Inspector of Mines MS. notes.

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Table of the Yield of the Auriferous Conglomerates at Nullagine.

Name of Lease.	Number of Lease.		Owner.	Remarks.	Previous to 1897.		1897.		1898.		1899.		1900.		1901.		1902.		1903.		1904.		Total.	
	Marble Bar Number.	L. Number.			Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.	Ore crushed.	Gold therefrom.
Freak of Nature ..	208	1	N.W. Australian G.F's., Ltd.	Now 120, 121	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.	tons.	ozs.
Success Extended ..	..	120	British Exploration of Australasia, Ltd.	In force. Late 1, 21, 27, M.L. 1, and M.L. 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
The Trinity (Grant's Hill) ..	216	2	N.W. Australian G.F's., Ltd.	Now 122, 121 (small portion)	109.00	147.00	..	..	275.00	382.35	462.00	343.25	152.00	70.50	..	..	..	..	..	..	..	..	998.00	943.10
Grant's Hill ..	..	122	British Exploration of Australasia, Ltd.	In force. Nearly all 2L, and part of M.L. 1	..	..	..	..	..	..	..	..	..	..	1,358.00	614.53	300.00	128.51	777.00	94.10	..	..	2,435.00	837.14
Exchange ..	279	18	N.W. Australian G.F's., Ltd.	Greater part in 121 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Freak of Nature ..	..	121	British Exploration of Australasia, Ltd.	Portion of 1, 2, 18, 21 M.L. 1, and whole of Q.C. 6L. In force in 120 and 121 ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Freak of Nature Extd. ..	310	21	N.W. Australian G.F's., Ltd.	Late 219-5L. In 119 and 120	32.00	43.00	..	..	305.00	349.25	206.00	149.40	..	..	100.00	33.00	..	..	..	..	..	..	643.00	574.65
Success ..	352	27	N.W. Australian G.F's., Ltd.	In force. Portions of 27L and M.L. 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Do. ..	..	119	British Exploration of Australasia, Ltd.	Abd. 5/8/97. N.N.W. of 27L	80.00	100.15	246.00	228.00	12.00	23.10	..	..	..	..	..	..	..	..	..	..	..	..	338.00	351.25
Barney's Hill United ..	276	16	A. S. Roe ..	Abd. 5/8/97. N.W. of 16L	20.00	25.00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20.00	25.00
Barney's Hill No. 1, N. Rejected ..	414	48	Do. ..	Abd. 5/8/97. S.W. of 16L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rejected, No. 1 ..	415	49	Do. ..	Abd. 5/8/97. N.W. of 48L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Golden Crown ..	365	31	Conglomerate G.F's. of W.A., Ltd.	Cancelled, 14/10/98. S.E. of 27L. In M.R.C. 6L	32.60	50.90	..	..	191.00	139.00	..	..	..	..	..	..	..	..	..	..	..	..	223.60	189.90
Beaton's Hill ..	373	37	Conglomerate G.F's. of W.A., Ltd.	Cancelled, 14/10/98, 5 chns. S.E. of 69L. In M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Golden Promise ..	380	39	Eatch, Lynch, Reyes, etc.	S. of 31L. Later 67L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Golden Promise, No. 1 ..	..	67	Conglomerate G.F's. of W.A., Ltd.	Late 39L. Cancelled 14/10/98. Part in M.R.C. 6L	84.00	68.65	..	..	88.00	81.20	..	..	..	..	..	..	..	..	..	..	..	..	172.00	149.85
Cook's Hill ..	412	47	Conglomerate G.F's. of W.A., Ltd.	Includes 36L. S.E. of 21L. In M.R.C. 6L	..	..	..	..	22.00	26.30	..	..	..	..	..	..	..	..	..	..	..	..	22.00	26.30
Trinity No. 1 South ..	422	54	Owen Connolly ..	Later 68L. S.E. of 2L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Grant's Hill South ..	..	68	Conglomerate G.F's. of W.A., Ltd.	Later 54L. Cancelled, 17/2/99	..	..	..	..	..	..	85.40	40.70	..	..	..	..	..	..	..	..	..	..	85.40	40.70
Nullagine Central ..	..	45	Butler, Ramsay, and Skinner	Later 69L. S.E. of 31L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Central No. 1 ..	..	69	Conglomerate G.F's. of W.A. Ltd.	Late 45L. Cancelled, 14/10/98. Part in M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rejected No. 2 ..	416	50	A. S. Roe ..	Abd., 5/8/97. Adjoins 47L on East. Later part in 73L. In M.R.C. 6L	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Diamond Reward Claim ..	..	M.R.C. 6L	British Exploration of Australasia, Ltd.	Takes in 31L, 37L, 47L, 50L. Part of 67L and 69L	..	..	..	..	..	..	..	..	230.00	79.40	..	..	..	..	..	..	..	..	230.00	79.40
Total					357.60	434.70	246.00	228.00	893.00	1,001.20	753.40	533.35	382.00	149.90	1,458.00	647.53	300.00	128.51	777.00	94.10	5,167.00	3,217.29

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B.—WARRAWOONA.

(With a Geological Sketch Map and three Mine Plans.)

General Geology.

The mining centre of Warrawoona lies about 15 miles from Marble Bar, and embraces the south-eastern extension of that belt of auriferous rocks which form the Marble Bar, Yandicoogina, and Mount Elsie Zone, to which reference has been made in a previous report.*

The district of which Warrawoona is the centre is formed of a lofty serrated razor-backed ridge (with several minor parallel ones) trending generally north-west and south-east. It is upon the southern slopes of the main ridge, and what perhaps may be conveniently called the foothills, that all the auriferous quartz reefs occur. The general trend of these ridges has been determined by the outcrop of the siliceous rocks of which they are everywhere made up.

Several important watercourses occupy the longitudinal valleys (carved out of the softer strata) between the different ridges, whilst those creeks which breach them almost at right angles to the general strike of the schists afford many excellent sections. They thus shed light upon many obscure points in connection with the geological features of the district. The plateau which extends for miles on either side of what may be called the main axis owes its relatively smooth and rounded contour to the general homogeneity and practically equal weathering of the rocks by which it is underlaid, *e.g.*, granite, etc.

The geological formations of the area embraced by the Geological Sketch Map of Warrawoona (Plate III.) are represented by a series of sedimentary rocks, quartzites, and conglomerates, many of which have been converted into quartz schist, mica schist, etc., by dynamic agencies. Associated with these undoubted sedimentary strata are a series of igneous rocks which have likewise been rendered partly schistose by the same causes. The exact relation these igneous rocks bear to the sedimentary series has not been worked out, a problem which would perhaps be difficult in this particular portion of the district. The southern portion of the district is occupied by granite, which appears to have been brought into position by a fault, trending generally north-west and south-east.

Somewhat akin to the southern granitic mass are those dykes and masses of felspar-porphry which occupy the northern limits of the map; in all probability these latter have some intimate connection with the large area of granite which occupies the country to the north of that embraced by the Warrawoona Map. There seems however to be strong reasons for believing the granite to be intrusive into what may conveniently be termed the schists, and that portions of it have been affected by earth movements of varying degrees of intensity after the intrusion took place.

* Bulletin No. 15, p. 33 *et seq.*

In addition to these rocks, the field is traversed by a remarkably persistent series of north-west and south-east greenstone dykes. These dykes, which have been mapped with some degree of accuracy, traverse the centre of the auriferous portions of Warrawoona, approximately at right angles to the general trend of what may be called the auriferous zone. Besides these relatively newer greenstone dykes, there are others which are intimately associated with the older rocks of the district. These older dyke rocks are often rudely cleaved and foliated, and seem to occur in intimate connection with, or parallel to, the principal structural lines of the district, viz., north-west and south-east. These older cleaved or foliated dykes can be seen in many places to be pierced almost at right angles to their general trend by the newer or uncleaved series.

Within the area embraced by the map, there is a large development of those laminated or banded quartz veins which form such conspicuous features in this district. These, owing to their economic importance, have been laid down upon the map with a considerable degree of accuracy. One conspicuous band traverses the whole length of the district, viz., six miles, and forms the centre of the main auriferous zone, which latter is of considerable longitudinal extent, though averaging only about 20 or 30 chains in width.

Of the different rocks occurring in the Warrawoona area, not much can be said, in the present state of our knowledge, of their relative ages, nor their true position in the geological time scale.

The following is a list of the various rock groups arranged in tabular form:—

Warrawoona Beds. Age undetermined (? Archaean)	(a.) Altered Sedimentary Series (quartzites, conglomerates, quartz, and mica-schist, etc.)
	(b.) Metamorphic Igneous Rocks (greenstone, magnetite, and serpentinous schist, and more or less allied sheared basic igneous rocks)
Granite and Felspar Porphyry.	
Basic Dykes	(a.) Newer
	(b.) Older

Warrawoona Beds.

The strata of the Warrawoona Series form part of that auriferous zone which includes Marble Bar, Yandiccoogina, and Mount Elsie, and to which reference has already been made in a former report.* In the Warrawoona neighbourhood, however, much better opportunities for investigating the strata present themselves than in any other portions of the district yet examined.

An examination of the district, which is of great importance by reason of its gold yield, shows that the Warrawoona Beds can be separated into two distinct portions sharply differentiated from each other, viz., an acidic and a basic series. The acid series is made up of highly siliceous beds, dipping at varying angles to the

* Bulletin No. 15, p. 33 *et seq.*

north-east and trending generally north-west and south-east. The beds, which there are very good reasons for believing to be of sedimentary origin, consist of fine-grained flaggy quartzites, sheared conglomerates which still retain traces of their original character, mica and quartz schists, together with certain other fine-grained siliceous rocks which seem to have lost all trace of their original character. There are, in intimate association with these, certain other acidic rocks, which may eventually prove, on closer examination, to be highly-sheared felsites; it has however not been found possible, owing to the small scale of the map, to delineate the area over which these doubtfully acidic igneous rocks extend; it is, however, but small.

In hand specimens, this doubtful rock [5788] is in reality a quartz-sericite schist, with eyes or lenticules of a fairly soft mineral around which the finer foliation of the matrix sweeps in very graceful curves. The mineral forming these eyes has been examined both chemically and microscopically by Mr. E. S. Simpson, who reports that "they appear at one time to have been single crystals of probably potash-felspar, but are now completely altered into a mixture of at least three minerals, viz., free quartz; a non-hydrous crystalline silicate of alumina, probably andalusite; and a hydrous silicate of alumina and alkalis, probably a mica. The specific gravity of these 'eyes' is variable but averages 2.85. Their average composition is:—

Silica, SiO_2	76.0
Alumina, Al_2O_3	21.4
Ferrous Oxide, FeO} ... ..	.3
Lime, CaO	Nil
Magnesia, MgO	Trace
Potash, K_2O} ... ..	.4
Soda, Na_2O} ... ..	.3
Combined Water, H_2O	1.6
	100.0

Examined under the microscope these porphyritic crystals are found to be shattered and broken, and their edges present that peculiar peripheral granulation so characteristic of crystals and fragments which have been subject to intense crushing. A micro-photograph of one of these shattered and broken crystals forms Fig. a, Photograph "H" (facing page 72.) The matrix in which the larger crystals are embedded presents a fine mosaic of quartz, felspar, and a little sericitic mica through which are streams of numerous yellowish brown crystals. These crystals which occur in the form of short, and sometimes geniculated, pear or kite-shaped prisms with straight extinction under crossed nicols, are in all probability rutile. It is difficult, with the evidence at present available, to be sure of the exact nature of the original rock, but it may possibly have been produced by the crushing of a felspar porphyry. Unaltered felspar porphyries do occur in the country just to the north of this, hence it is possible that this rock may be merely a transmitted variety of them.

The specimen, a quartz sericite schist [5760], is another variety of a rock identical in many respects with that last described, except that there are no large porphyritic crystals. Streams of rutile are common, in addition to numerous colourless acicular crystals of what seem to be apatite.

A quartz schist [5761] from near the Ironclad Battery, M.A. 1, consists microscopically of a mass of irregular interlocking grains of quartz, with irregular patches arranged in the form of bands, of what under crossed nicols is neither more nor less than a fine quartz mosaic. The quartz exhibits undulose extinction. A little sericitic mica occurs in places.

Another quartz schist [5762] from a different portion of the mass, when examined under the microscope consists of a very fine-grained mass of quartz, showing undulose extinction, together with a little sericitic mica, the foliæ of which are often very much distorted.

A fairly fine-grained quartzite [5764] which under the microscope is found to contain numerous fairly large angular and sub-angular quartz grains set in a much finer-grained quartz mosaic. This rock contains numerous brown patches and strings of mica (?) together with a little pyrites.

Associated with these quartzites and quartz schists is a very calcareous rock [5765] which outcrops near the Ironclad Battery. In hand specimens the rock is of a pale salmon colour, is distinctly banded, weathers very much like a limestone, and effervesces briskly upon the application of dilute acid. An analysis of this rock is given in the table on page 66. Very little can be made out by microscopic examination, even with a $\frac{1}{4}$ -inch objective, and it is not quite clear whether the rock is a limestone or merely an extreme phase of the alteration of one of the igneous rocks of the district. The field relations however seem to point to its being distinctly interbedded with the quartzites and quartz sericite schists.

A short distance north of the Seven Dials, just outside the limits of the geological map, is a conspicuous hill forming the western extremity of a bed of metamorphic grit (or quartzite) and conglomerate, dipping at angles averaging about 50 degrees to the north-east; the quartzite rests upon greenstone schist, and has been affected by the same foliation which affects the latter. The quartzite is traversed by bands of laminated quartz of the type prevailing in the district. Most of the pebbles in the conglomerate are flattened out almost beyond recognition, though in some places they are well shown on the weathered surface of the rock.

Among the quartz schists which form the summit of what may be called the main range of Warrawoona is a bed which here and there contains what at first glance appears to be fossil wood [5766]. A characteristic specimen of this silicified wood (?) has a length of about $4\frac{1}{4}$ inches; cross sections of it are ellipsoidal in shape, the major axis being about three-quarters, and the minor axis about five-eighths of an inch in length. Microscopical sections both transverse and longitudinal were prepared, and were submitted

along with the specimen to Mr. Etheridge of the Australian Museum, Sydney, who was unable to detect any trace of organic structure in them. It is, however, quite possible that the dynamic metamorphism which these rocks have undergone may have entirely obliterated all traces of organic structure, and that some form of plant life existed at the time these beds were deposited.

Adjoining Lease 479, the Juneau, is a schist forming part of the main series which presents many points of interest.

In hand specimens the rock [5787] is of a very light brownish colour, and is distinctly foliated. In addition to quartz, which forms no inconsiderable portion of the rock, there are numerous elongated crystals of a clear glassy mineral, the cleavage faces of which are very distinctly marked, and which give a distinctive character to the rock. Under the microscope the rock is found to be made up of clear and unaltered fragments of felspar, very few of which however are twinned, quartz polarising in brilliant colours, a little colourless mica and a reddish brown substance, which may result from the alteration of some mineral rich in iron. The rock is clearly a felspathic schist, the field relations of which point to its being of clastic origin.

The greenstone schists and other allied rocks of Warrawoona occupy a large area of country, and vary very much in the width of their outcrop. It is of course possible that this may in part be due to differences in the folding (?). A feature in the physical structure of the greenstone schists which may have some significance is what may be called an anticline of foliation, the centre of which trends generally in the same direction as the main structural lines of the district. This is well exposed at a point a little distance to the south of the Gauntlet No. 3 North-West Lease.

A very important feature of these greenstone schists is the presence among them of unfoliated basic rocks, which sometimes occur in the form of lenticular belts of (in certain places) considerable horizontal extent. Several excellent sections in the district show these basic rocks passing by scarcely perceptible gradations into the greenstone schists.

It is possible that as the strike of these belts of massive basic rocks more or less coincide with that of the general foliation of the district, they may occasionally be mistaken for some of the older basic dykes, which have a parallel strike.

In one or two localities are belts of magnetic-schist, in the centre of some of which are uncrushed "eyes" (of large dimensions) of greenstone occurring in such a way as to indicate that the margins only of the mass have been crushed down into schist. Many of these schists contain very large quantities of magnetite, such as give a very distinctive character to the rock.

The foliated or sheared greenstones on the Gauntlet Lease contain large brown crystals [5767], a combination of cube and octahedron of iron ore, viz., limonite pseudomorphs after pyrites.

Many of these crystals are about an inch in length. In other portions of the field, the surface of the unfoliated greenstone is strewn with similar limonite crystals. Some of the greenstones are very much decomposed, and some of the constituent minerals are largely replaced by carbonates, giving the rock a very characteristic weathered surface at first sight, very suggestive of the weathered surface of some limestone.

The chemical composition of several of these greenstones and their allies is given in the table of analyses, page 66.

In mineralogical constitution the rocks present very many points of similarity.

The country rock [5755] of the Golden Gate Reef is a soft green talcose-chloritic schist, the chemical composition of which is shown in the table on page 66. The crystals of talc which are often of considerable length, have been as may be seen under the microscope, broken and torn apart by the stresses and strains to which the rock has been subject. The exact relation of this schist to the surrounding greenstone cannot be precisely determined, as access to the underground workings of the mine was not obtainable.

The rock [5777] which forms the matrix of the Imperialist Reef is a fine-grained talc-chlorite schist, identical with that of the Golden Gate. The analyses of the two rocks present also many points of similarity.

The Tom Thumb Reef is enclosed in a fine-grained chlorite schist [5756] which, when examined under the microscope, is found to be made up of quartz, felspar, chlorite, and epidote (?). The chemical composition of this rock is given in the table on page 66.

The country rock [5768] forming the matrix of the May-be reef is of a somewhat similar character, and, as its field relations indicate, owes its origin to the compression of a massive greenstone. Its mineralogical constitution does not appear to differ in any very essential feature from the other schistose greenstones; its chemical composition is given in the table quoted above.

The Gauntlet Lease is traversed by a band of chlorite schist [5779] in many respects identical with that forming the Tom Thumb Reef. The chemical composition of this rock agrees very closely with some of the massive diabases of other portions of the field.

At a point about 10 or 12 chains to the north-east of G.M. Leases 531 and 593 is a lenticular mass of a serpentinous rock [5757], the chemical composition of which is set forth in the table of analyses on page 66. The mass has a length of about 20 and a maximum width of about five chains, whilst its longer axis is in a direction of north-west and south-east, parallel to the main structural features of the district.

A very large quartz reef outcrops in the centre of the mass, but does not extend into the surrounding rocks. The serpentine is enclosed in the mass of acidic rocks, but in such a condition that its original condition is not quite clear; there seem, however,

grounds for believing it to have been brought into its present position by a fault.

The massive greenstones vary very much in grain; they all contain more or less hornblende (sometimes fibrous) and its alteration product chlorite, quartz, feldspar, and calcite, together with an iron ore. Some, however, are very calcareous, and effervesce briskly on the application of acid.

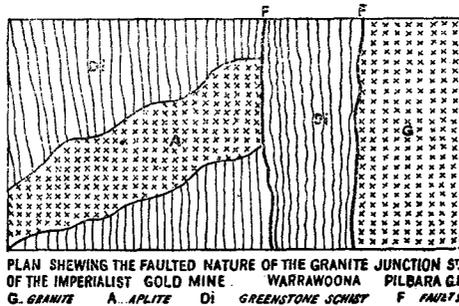
Detailed petrographical examination of all these rocks has not yet been made, but it is hoped to approach this subject at a later date, as opportunity offers.

Granite and allied Granitic Rocks.

The granite, which is of the normal type, occupies a rudely triangular patch on the southern boundary of the map, about 200 chains in length and about 40 chains in maximum width. It, however, extends for many miles far beyond the limits of the map. There seems good reason for believing that the granite is intrusive into the greenstone schists, though its northern boundary, to the south of the Imperialist Reef, is marked by a fault.

The exposure on the hillside, a plan of which forms Fig. 5, reveals the relationship of the granite and greenstone schists to each other.

FIG. 5.



In this section the greenstone schists abut sharply against a smooth wall of granite, which is inclined at an angle of from 45 to 55 degrees to the north, this angle being practically coincident with the dip of the foliation planes of the schists. A few inches of schist separate an aplite dyke of four feet in thickness from the main granite mass. The dyke traverses the schists in a direction almost at right angles to their general strike. A quartz reef occurs along the faulted junction some distance east of this point, in close proximity to the newer greenstone dykes, which traverse the centre of the field. There is no very clear evidence of a marked banding or foliation in the granite anywhere in the southern portion of the district. In that large granite mass on the north, just outside the limits of the map, it possesses a rude foliation or

banding, which is parallel to the general strike of the foliation of the schists forming the higher ground to the south.

Whether this banding has any connection with the general foliation of the district, or is an original feature of the granitic magma, has not been satisfactorily determined. If this banding in the granite is not an original feature, then it would seem to indicate that both it and the Warrawoona beds were subject to the same set of stresses and strains which were set up in the interval separating the beds of the Nullagine from the older series.

The north-east angle of the map is made up of felspar-porphry [5792] sometimes occurring in the form of dykes. The rock, when a freshly broken and unweathered surface is examined, is found to be of a grey colour, with numerous crystals and fragments of a cloudy white felspar (some of which show twinning) set in a fine-grained matrix.

Examined under the microscope, the rock is found to be made up of a micro-crystalline ground mass of quartz, together with a small proportion of orthoclase, in which are embedded large crystals and fragments of felspar but no quartz. A relatively large quantity of biotite of a brownish colour occurs in many cases, arranged in bands which sweep round the porphyritic felspar in a manner paralleled by the flow structure developed in some volcanic rocks. The brown colour of the mica often passes gradually into a bright green, the result, probably, of alteration. The porphyritically developed felspar has not been optically determined, but the characteristic cross-hatched twinning in some parts would point to its being an orthoclase. The relatively large proportions of lime and soda as disclosed by the analysis [5792] shown in the table on page 66, would seem, on the other hand, to indicate that the felspar belongs to the lime-soda series. This felspar-porphry is practically identical in its character with the Duffer's Creek porphyry referred to in the analysis [5392] of the rocks from Pilbara, on page 12 of Bulletin No. 15. There are few if any large porphyritically developed felspars in this latter rock, which perhaps may be held accountable for the smaller percentage of potash and lime, as shown in the analysis; in all other respects the two rocks are identical.

There does not seem, so far, to be any intimate relationship subsisting between this porphyry and the main granite mass, as developed on either side of the main axis of Warrawoona. The fact that it shows no signs of even a quasi-foliation, which characterises some portions of the granite, would seem to indicate that the porphyry is of later date than the granite. It may, perhaps, have some connection with the volcanic activity which prevailed during the period of the deposition of the Nullagine Series.

The geological age of the granite cannot, as yet, be exactly determined; it is, certainly, newer than the Warrawoona Beds, into which it is intrusive. The granite passes beneath the Nullagine

Series, which the evidence* so far available seems to point to being of Cambrian Age; in this case the granite would be Pre-Cambrian.

Basic Dykes.

The basic dykes of Warrawoona belong to two different periods; the district, however, furnishes no satisfactory evidence as to the exact age of each set.

The newer basic dykes traverse the whole width of the field in a general north-east and south-west direction, and extend for very many miles to the north and south of the country examined. The system of newer dykes intersects the auriferous belt between the Bow Bells and the Gauntlet groups of reefs almost at right angles to the general trend of the series. In no case do these dykes attain any great thickness, and their breadth varies greatly in different parts; the thickness, as shown on the Geological Map of Warrawoona (Plate III.), has been somewhat exaggerated, in consequence of the small scale employed. Such few cross sections as may be seen of them indicate that they approach very closely to the vertical.

The rocks of which they are composed are basic compounds, an analysis of the most typical [5773] is shown in the table on page 66.

In hand specimens these dyke rocks vary from coarse to medium grain, and are seen to consist of a greenish grey felspar, together with a ferro-magnesian constituent and an iron ore. Under the microscope the rock is found to consist of allotriomorphic crystals of a plagioclastic felspar, many of which present that turbid mealy aspect so characteristic of alteration, together with brown or almost colourless augite, and a little enstatite (?) passing into bastite (?). The place of some of the augite is taken by a pale green fibrous decomposition product which may be chlorite. The iron ore, which is often represented by skeleton crystals, is probably ilmenite. The rock is therefore a diabase.

The regular continuity of the system of dykes has been interrupted in the vicinity of their intersection with the auriferous series. From the position in which this interruption occurs, it would seem that these newer dyke rocks had undergone considerable movement since their injection. The somewhat curved and distorted fragments or isolated patches all point to a series of later movements along lines parallel to that of the main trend of the auriferous belt of Warrawoona.

The older series of dykes have a general trend approximately at right angles to that of those previously described, and are in some cases intersected by them. Like the newer dykes they are all basic compounds. In some cases they have been crushed and sheared into a schistose greenstone, which occasionally takes the form of a schist which has a characteristic weathered outcrop, very suggestive of a calcareous schist. These sheared dykes are all indicated upon the map.

* *Supra*, p. 27.

Table of Analyses of Rocks from Warrawoona.

By E. S. SIMPSON.

Geological Museum No. ...	5755	5756	5757	5765	5763	5773	5777	5778	5779	5780	5781	5792	5793
Specific Gravity ...	2.94	2.88	2.91	2.76	2.79	3.00	2.93	2.82	2.62	2.84	2.58	2.73	3.07
Silica, SiO ₂ ...	43.25	43.47	30.63	17.63	41.88	50.48	43.90	45.68	55.00	48.54	65.75	69.14	50.20
Alumina, Al ₂ O ₃ ...	9.98	14.87	1.68	4.28	10.13	23.18	9.13	8.94	24.30	13.67	19.39	14.71	17.95
Ferric Oxide, Fe ₂ O ₃ ...	1.93	3.35	5.94	1.97	Nil	3.07	1.20	2.23	3.93	2.13	.51	3.47	9.49
Ferrous Oxide, FeO ...	10.04	14.93	4.72	Nil	9.59	8.86	10.48	5.91	7.53	10.04	3.05	.78	4.20
Magnesia, MgO ...	22.48	12.64	32.30	14.74	7.20	.64	19.17	12.25	2.30	4.54	2.36	1.09	2.26
Lime, CaO ...	5.31	1.18	Trace	24.63	13.06	7.47	7.46	12.56	.18	6.46	Nil	4.83	7.76
Soda, Na ₂ O ...	.49	.55	.41	.92	1.30	2.17	.57	1.82	2.43	3.58	.93	4.24	1.01
Potash, K ₂ O ...	Trace	.13	.11	.43	.10	.83	.09	.12	Trace	.04	4.66	1.00	.14
Combined Water, H ₂ O ...	4.74	6.82	.52	.70	3.51	1.71	4.68	1.92	3.14	2.74	1.78	.08	3.04
Hygroscopic Water, H ₂ O ...	.20	.26	.15	.05	.07	.10	.04	.07	.27	.04	.10	.04	.10
Carbonic Anhydride, CO ₂ ...	.17	Nil	23.03	34.94	11.60	.55	2.46	8.34	.98	7.14	.16	.40	1.12
Titanic Oxide, TiO ₂ ...	.50	1.48	.52	.20	1.15	.38	.30	.40	Trace	1.12	.66	.30	1.42
Pyrates, FeS ₂ { Fe	.03	.05	.09	Nil	.16	.14	.02	.04	Trace	.12	.11	Trace	.14
{ S ...	.04	.06	.11	Nil	.18	.16	.03	.05	...	.14	.12	...	.16
Manganese Protoxide, MnO ...	.54	.10	.11	Trace	.32	Trace	.05	.09	Trace	Trace	Nil	.21	.37
Total ...	99.70	99.89	100.32	100.49	100.25	99.74	99.58	100.42	100.06	100.30	99.58	100.29	99.36

- 5755.—Talc-chlorite schist. Golden Gate Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5756.—Chlorite schist. Tom Thumb Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5757.—Serpentine schist. Near Moolyella Gap, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5765.—Carbonated schist. Near Ironclad Battery, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5768.—Chlorite schist. May-be Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5773.—Newer Diabase Dyke. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5777.—Talc-chlorite schist. Imperialist Lease, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5778.—Older Greenstone Dyke. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5779.—Foliated Greenstone. Gauntlet Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5780.—Greenstone. Bow Bells Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5781.—Schist. Bow Bells Lease, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5792.—Felspar-Porphry. North side of Main Range, Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.
- 5793.—Greenstone. Warrawoona, Pilbara Goldfield. Analyst, E. S. Simpson.

Fissures, Faults, etc.

A very marked feature in the structure of Warrawoona is the occurrence of those bands of laminated quartz which traverse the whole length of the field, these being locally spoken of as "dykes."

These bands often rise in the form of rough serrated ridges, which, by virtue of their power of resisting denuding agencies, stand out in bold relief, and can be followed across country for, in some cases, miles. They are, wherever seen in section, either vertical or inclined at high angles to the north east. In the case of the crosscut from the south drive in the tunnel workings of the Bow Bells Mine (Plate IV.), a dip of 65 degrees was observed. Although this vein, as seen underground, proved to be ten feet in thickness, there did not appear to be any distinct line of demarkation between it and the country rock, the whole section in the crosscut suggesting a gradual replacement of the original rock along lines of maximum compression or foliation.

Similar cases of a gradual transition between the quartz and the country rock can be noticed in several cases along the summits of the ridges in the district.

Of these bands there are twelve in all, the most conspicuous and the most important being that which traverses the whole line of

leases across the field in a north-westerly direction. This particular vein is locally spoken of as "The Dyke," and it may be that it represents an old line of weakness along which disturbance has taken place at several distinct periods.

The other veins, it will be noticed, all taper off gradually along a line which is, approximately, parallel to the dyke, and are disposed somewhat in the shape of a fan, the ribs of which open out gradually to the west.

The mode of occurrence and ending off of these quartz veins is very suggestive of this line being a fault; to which the interruption in the continuity of the newer diabase dykes in the vicinity would seem to lend additional colour. There is, however, no sign of any such fault on the surface, and, in fact, owing to the nature of the surrounding rocks, any such might readily escape detection.

These laminated quartz veins have been subject to a certain amount of faulting, and all those which have any effective throw have been laid down upon the map. As all the veins have a very high underlie, a considerable vertical displacement might easily take place without having any very marked effect upon the outcrop.

When examined under the microscope, typical specimens of these laminated quartz veins [5758, 5759] present no features of any particular moment.

In addition to the laminated quartz veins previously mentioned, there is another type of fracture developed on the field, which makes itself manifest in two well defined bands, trending approximately parallel to them. These bands, which form a very pronounced feature in the landscape, are represented by a "sheeting" or "zoning" of the country rock, the width of which varies within very wide limits. The photographs "F" and "G," taken by the late Mr. S. J. Becher, give a graphic idea of the nature of these zones, which in reality result from the powerful compression to which the rocks have been subjected. There are, occurring in these bands, more or less extensive lenticules or "eyes" of quartz, parallel to the foliation; and many of these quartzes have a characteristic and distinct greenish hue [5759]. Fig. 6 shows a section across one of these compression fractures, with the characteristic quartz lenses, traversed by a reef of much newer formation. This newer reef is from 12 to 14 inches in thickness. The country rock traversed by this fracture has been silicified along the lines of compression, whilst the vertical slickensided faces indicate subsequent movement, which, however, may not have been very great. One of these bands of compression or shearing traverses the whole length of the Klondyke Boulder Lease (Plate VI.), parallel to the reef of the "Leader" type; it forms a very marked feature on the surface and stands out in bold relief. The foliæ, however, are not, in this section, vertical, but inclined at a very-high angle to the north-east.

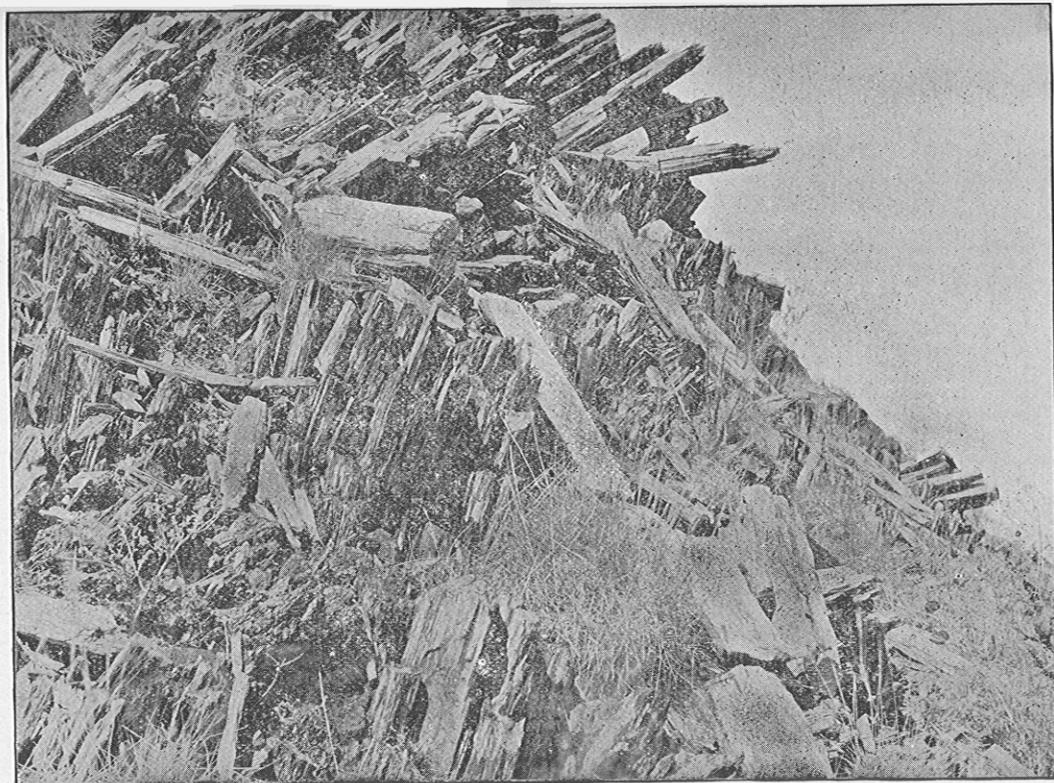


PHOTO.: S. J. BECHER.

Enlarged view of Sheeted Zone in country rock, Warrawoona, Pilbara Goldfield.

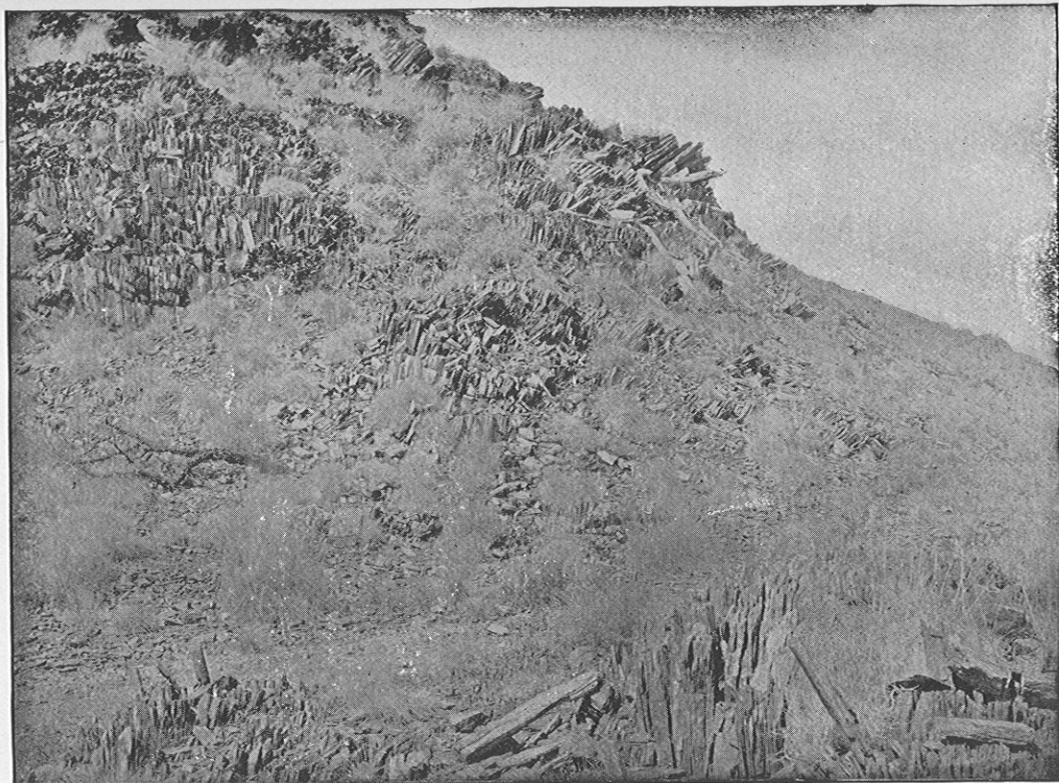
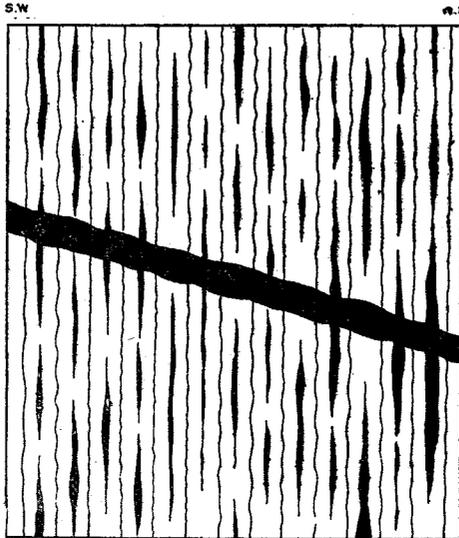


PHOTO.: S. J. BECHER.

Sheeted Zone in country rock, Warrawoona, Pilbara Goldfield.

The faults which many of the reefs have undergone are referred to below under the heading of the Auriferous Deposits, and the position of those which can be actually observed and those the

FIG. 6.



SECTION ACROSS A COMPRESSION FRACTURE TRAVERSED BY A QUARTZ REEF, WARRAWOONA,
PILBARA G.F.

existence of which is inferred are shown upon the mining plans which form Plates IV., V., and VI.

Economic Geology.

Auriferous Deposits.

The auriferous deposits of Warrawoona are quartz reefs, which outcrop over a belt about six miles in length and about 20 chains in width.

There are no alluvial deposits of any extent anywhere within the limits of the area examined.

In addition to what may be called the main belt of Warrawoona, there are several minor outlying virtually isolated reefs, which have been worked in a more or less desultory fashion.

The position of all the quartz reefs has been laid down upon the Geological Map of Warrawoona (Plate III.) with such a degree of accuracy as the scale employed and a plane table survey would permit. No considerable body of ore, which is obvious to anyone making a fair and reasonable inspection of the surface, has been overlooked. The reefs exhibit, when viewed on the whole, a general

parallelism to the trend of the main structural features of the district. A careful examination of all the reefs, both on the surface and below ground, wherever such was possible, showed that they could be divided into two totally different types, which are sharply differentiated from each other.

The first type may, for convenience, be called the Normal or Fissure Vein Type, whilst the "Kidney" shaped lenticular quartz reefs of the second are locally spoken of as the "Leader."

Both types have been more or less opened up, and their relative importance as gold producers well established, as may be seen by a reference to the tables below.

Tables showing the yield of—

(a.) THE NORMAL QUARTZ REEFS, AND

(b.) THE LEADER TYPE OF DEPOSITS OF WARRAWOONA.

The Normal Quartz Reefs.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	626·85	3,143·72	5·01
1899	...	...	...	1,194·75	3,679·56	3·08
1900	...	...	...	1,854·31	4,973·74	2·68
1901	...	...	...	355·75	874·25	2·45
1902	...	...	...	396·55	774·80	1·95
1903	...	...	...	429·85	1,080·64	2·51
1904	...	...	...	105·45	236·44	2·24
Total	...	...	...	4,963·51	14,763·15	2·97

The Leader Type of Deposit.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	78·55	276·75	3·52
1899	...	...	...	167·10	470·62	2·81
1900	...	...	...	87·40	314·45	3·59
1901	...	...	...	46·25	126·60	2·73
1902	...	...	...	49·70	147·26	2·96
1903	...	...	...	71·50	166·25	2·32
1904	...	...	...	49·00	125·38	2·55
Total	...	...	...	549·50	1,627·31	2·94

The data embodied in these two tables have been drawn up from the official statistics, but, of course, could not have been tabulated without a personal examination of the different reefs in the district. The figures demonstrate conclusively that whilst the

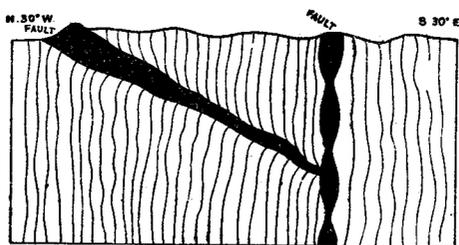
average value of the two types of deposit is about equal, it is, however, the normal quartz reefs that have, up to the present, been most extensively worked, and the reason is not far to seek.

The reefs of the Leader type are in every respect identical with those described* as forming the important deposits in the mining centre of Edjudina.

At Warrawoona, the "Leader," which forms a continuous band, so far as prospecting operations have shown, of about two and a half miles in length, occurs along a line of rupture, which is forcibly shown by the powerful slickensided surfaces exhibited almost everywhere underground. These faces are often coated with fine films of gold. The "reef" is represented by "kidney" or damper-shaped lenses of quartz which vary from a few inches in width to a foot or two in length along the vein. The interval between each lens of quartz naturally fluctuates within very wide limits. Sections are visible in some of the workings fully described on a later page, which show the "casing" of the lens to be quartz of a somewhat different type; cases of this kind, which are of frequent occurrence along the "Leader" line, seem to point to the quartz lenses being portions of a pre-existing quartz reef which has been shifted in segments, as it were, along a vertical line of dislocation. Until these quartzes have been submitted to microscopical examination it is impossible to determine whether they exhibit optically any signs of mechanical strain, as would be naturally expected.

There seem very strong grounds for believing that the reefs of the "Leader" type are of later formation than those of the true fissure veins. Fig. 7 shows a section of a fissure vein abruptly cut off by the "Leader."

FIG. 7.



SECTION OF THE REEFS IN THE OPEN CUT NEAR THE SOUTH EASTERN BOUNDARY OF G. M. L. 503 WARRAWOONA PILBARA G. F.

From the very nature of the Leader it is naturally somewhat difficult to work, as the stopes must be kept within the narrowest possible limits, and merely the auriferous quartz lenses extracted.

* Notes on the country between Edjudina and Yundamindera, by A. Gibb Maitland, Bulletin 11. Perth: By Authority, 1903, pp. 14, et seq.

A feature of many of the normal reefs, notably those on the Bow Bells lease, is the folding which they have undergone; this characteristic is particularly well exemplified in the case of the Horseshoe vein, and is shown on the plan which forms Plate IV. It will be noticed that in those cases in which the folding has taken place, there is almost invariably a relatively large pocket of ore at the apex of the arch. The fold in the Horseshoe vein of the Bow Bells lease merely differs from the saddle reefs as depicted in many geological manuals in the fact that in this particular case the legs are horizontal. Mining operations, however, have hardly been carried sufficiently far to determine whether or not the apices of the folds contain any higher grade ore than what may be called the legs of the reef. The fact that rich chutes are known to prevail in intimate connection with the apices of the folds in other mining districts where the quartz reefs have been violently contorted is a circumstance which should commend itself to the attention of those engaged in the exploitation of the reefs in question. All the evidence available points to the fact that the folding of the reefs is the result of great lateral pressure acting upon the country rock after the formation of the reefs themselves. The folding and puckering of some of the quartz veins is well illustrated, even in many hand specimens, notably in the quartz schist [5789] on the Gauntlet East, G.M.L. 560, a micro-photograph of which forms Fig. b. Photograph "H." This lateral pressure has not only folded but has faulted many of the reefs. Wherever possible the faults which have any effective throw have been mapped and shown in both the geological and mining plans as well as in some cases in the sections by which they are accompanied. The high inclination of the majority of the veins is such as of course might permit of a considerable displacement without any marked effect upon the outcrop, hence many faults, unless disclosed during the course of mining operations, might easily escape detection. In the case of the main reef on the Gauntlet lease, the rich shoot for which the mine is famed is coterminous with the fault which traverses the whole breadth of the lease. It is, however, not yet clear whether this fault fissure formed the channel along which the mineralising solutions percolated.

In addition to these normal vertical faults, there are also reverse faults at thrust planes, which are either horizontal or are inclined at a very low angle to the horizon. Typical instances of these are to be found in the workings on the Gauntlet and the Klondyke-Boulder leases; in the first of these cases the actual horizontal displacement measures only a few inches.

The reefs of both types are composed of a hard, translucent and crystalline quartz, which, in addition to the gold, contains in subordinate quantities pyrites, chalcopyrite, limonite, malachite, ferruginous wad, and a muscovite mica which is partly chromiferous.

In some cases the gold can be seen contained in cavities, evidently left by the oxidation of pyrites.

(a.)

Bulletin 20.

H.

(b.)

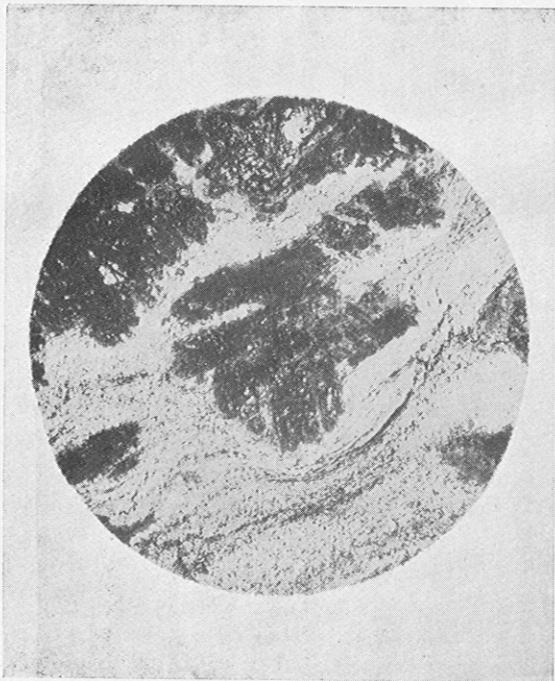


PHOTO.: E. S. SIMPSON.
Broken Crystals of Feldspar (?) in sheared Feldspar-Porphyr
[5788], Warrawoona. Enlargement, 11 diameters.

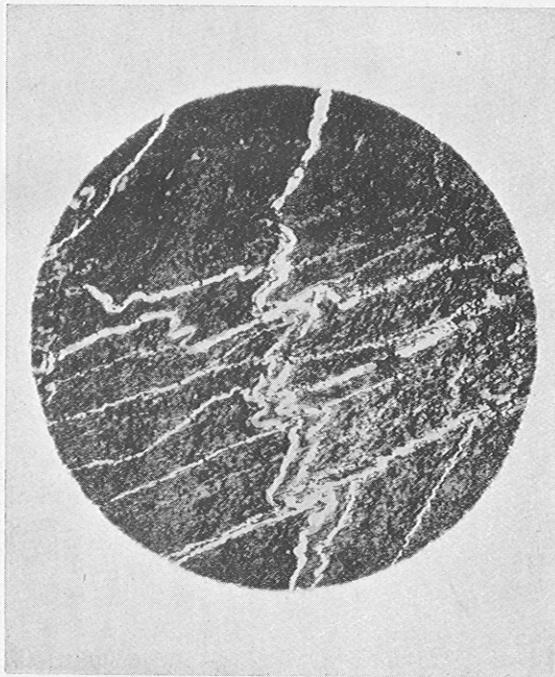


PHOTO.: E. S. SIMPSON.
Section of Quartz Schist [5789] showing contorted quartz
laminae in relation to stratification and cleavage foliation,
G.M.L. 560, Warrawoona. Enlargement, 11 diameters.

Cases have been observed of the occurrence of calcite [5776] carrying a trace of gold; possibly the parent source of the calcite is to be looked for in the lime-soda felspars which enter into the composition of the greenstone and its allies, the country rock of many of the quartz reefs.

Although the total gold yield of Warrawoona has been 17,294.18ozs., recovered from the milling of 5,700.01 tons of ore, thus giving an average value of 3.03ozs. per ton, and many of the reefs have been opened up, these, however, have only been worked to very shallow depths.

All the mines which were open to inspection were visited, and full descriptions of them are given in the following pages. In the case of three properties—the Gauntlet, the Bow Bells, and the Klondyke Boulder, the reefs on which are instructive examples of the normal type as developed on the field—detailed surveys on a large scale of the various ore bodies, faults, etc., were made in the hope that they might in some measure furnish a guide as to the general behaviour of the reefs of this class in the locality. The result of these surveys has been embodied upon plans on the scale of 100 feet per inch accompanying the report, Plates IV., V., and VI.

For convenience of description, the mines and other workings are described in geographical sequence, commencing at the north-westernmost end of the field.

THE MINES.

PRINCEPT, G.M.L. 517.—This is the most north-westerly lease on the Warrawoona Belt. The ground is now abandoned, and so far as may be seen very little work has been done upon the property. The surface of the lease is occupied by greenstone-schist of the prevailing type.

Near the north-western boundary of the lease is a shaft of unknown depth, sunk upon a vertical reef of about 12 inches in thickness. The reef has a general north-eastern and south-western strike. So far as may be judged by the stone lying at grass the quartz [5754] contains oxide of iron, green carbonate of copper, carbonate of iron, together with a little red copper oxide. An assay of a characteristic sample [5754] of the ore yielded in the Survey Laboratory gold at the rate of 1dwt. 15grs. per ton.

In addition to this there are two other reefs on the property, situated near the south-eastern boundary, and lying about 300 feet apart. The westernmost and most conspicuous of these forms the summit of a very prominent rise on the ground, and, as measured at the top, is from 20 to 25 feet in thickness. So far as may be seen the reef is vertical, and strikes a little to the west of north. About three feet to the west of this is a parallel reef of ice-like quartz, but of no horizontal extent. The eastern reef, about 300 feet distant, extends some considerable distance southwards, beyond the confines of the property.

The following table gives the yield of this property. The gold was entirely derived from the reef in shaft above mentioned :—

Table showing the Yield of the Princept Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1899	tons. 2'15	ozs. 5'00	ozs. 2'32

CUTTY SARK, G.M.L. 521.—Messrs. Skogsberg and Svensen. This property is an old lease, the Cutty Sark, which has been resurveyed, and part of it is now held as Q.C. 142. The reef worked on this lease has an average strike of 305 degrees, and appears to be the same as that which enters the property near the north-east angle of the lease.

A vertical shaft 74 feet in depth has been sunk by the present holders of the property, and the stone stoped out from a depth of 60 feet; the reef is said to have been four feet in thickness. From the bottom of the shaft crosscuts six feet in length have been put in east and west respectively. Owing to the state of the country rock it is stated that work had to be abandoned at this level. At the date this property was visited, access could not be obtained below 33 feet from the surface; at this depth is a large body of quartz five to six feet thick, it is however merely a somewhat larger bulge on the reef than usual.

There are about 18 to 20 tons of quartz raised and awaiting crushing. The quartz at grass shows gold freely, it contains the red oxide, and the blue and green carbonates of copper in relatively small quantities, in addition to a little galena.

The only crushings from this reef were recorded in 1898 and 1904.

Table showing the Yield of the Cutty Sark Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 4'75	ozs. 10'10	ozs. 2'12
1904	31'30	49'00	1'56
Total	36'05	59'10	1'64

TOM THUMB, Q.C. 128 (141).—Trangmar. This property was originally embraced within the boundaries of G.M.L. 519, the Carnoustie.

A good deal of work must have been done upon this property by the previous owners of the ground, but most of these workings are inaccessible at the present time.

A vertical shaft 94 feet in depth has been sunk through almost vertical beds of chlorite schist [5756].

At 65 feet is a level, which has been put in along the strike of the country for a distance of 40 feet to the west. The face of the drive connects with the old workings, the end of the rich chute being at this point, and the stone, merely thin lenticular veins along the foliæ, being stoped out to the surface from the westernmost old shaft.

The quartz lenticules, of a totally different type to those occurring in Kopecke's leader, are said to attain a thickness of 12 inches in places. At the foot of the main shaft a quartz reef was met with and a fairly large body of water was encountered, at the point at which the stone was first intersected. The water is standing in the shaft at 85 feet from the surface. From stone shown to me, it appears that the quartz lenticules must be very rich in places.

Table showing the Yield of the Tom Thumb Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1903*	34.40	155.57	4.52
1904	2.15	9.09	4.22
Total	36.55	164.66	4.50

* Previous to 1903 the yield was included under the heading of Sundry Claims. In 1898, however, the official statistics show that 45.40 tons of ore crushed from the Carnoustie reef yielded 178.11ozs., or at the rate of 3.92ozs. per ton. This, however, in all probability was obtained from the reef outcropping just outside the north-east angle of the claim, as shown in the Geological Sketch Map of Warrawoona.

GOLDEN GATE, G.M.L. 607 (now Q.C. 137).—The unsurveyed quartz claim, 137, originally embraced by the Golden Gate Lease, G.M.L. 607, lies some little distance to the south of the Tom Thumb. The workings, however, are inaccessible; the main shaft is reputed to have reached a depth of 76 feet, and the reef stated to have consisted of lenticular quartz veins occurring along the planes of foliation of the talc-chlorite schist [5755].

Table showing the Yield of the Golden Gate Reef.

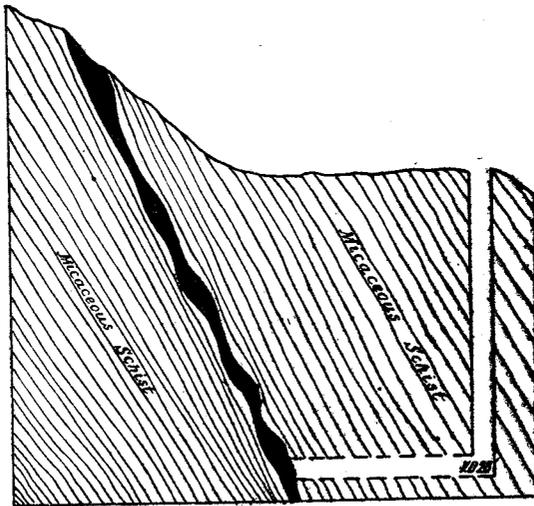
Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1901	6.00	{ 16.40 *6.00	2.73
1902	13.00	29.10	2.24
1903	40.45	73.00	1.80
Total	59.45	118.50 *6.00	1.99

* Dollied and Specimens.

SEVEN DIALS, G.M.L. 605.—The Seven Dials property, now abandoned, lies at the north-western extremity of what may be called the Bow Bells-Gauntlet Zone, as may be seen by an inspection of the Geological Sketch Map of Warrawoona. (Plate III.)

The reef prospected enters the property near the north-western boundary, and, after a somewhat sinuous course, leaves it by the south-eastern boundary, not far from the north-east angle of the lease. So far as may be seen in an opencut on the surface, the reef underlays to the north-east at 65 degrees, and varies from two to three feet in thickness. The reef appears to be somewhat faulted along the outcrop, though the horizontal displacement is not more than three or four feet in each case. A vertical shaft (Fig. 8), 28 feet in depth, has been sunk at a point 34 feet north-east from the outcrop. The shaft has been carried down through a narrow belt of a fine micaceous schist.

FIG. 8.



SECTION ACROSS THE SEVEN DIALS REEF G.M.L. 605 WARRAWOONA
PILBARA G.F.

CHANCE, G.M.L. 534.—This lease, now abandoned, occurs a few feet to the north-west of G.M.L. 531.

Work has been concentrated upon a somewhat similar deposit to that occurring in G.M.L. 531. At the outcrop the section across the vein from west to east is as follows:—Quartz, six inches; formation, eight inches; quartz, 12 inches; formation, 12 inches; quartz, three feet six inches. An underlay shaft has been put down to an unknown depth, but being inaccessible, no particulars as to the nature and behaviour of the reef underground are available.

The quartz [5769] is almost pure white, and contains oxide of iron, small quantities of green carbonate of copper, and chalcedony.

Lying in the vacant triangular piece of ground between this lease and G.M.L. 531 is an underlay shaft, which has been put down to an unknown depth, upon a thin vein of quartz underlying northwards. Workings along the outcrop further down the hill show the vein to attain a maximum thickness of 12 inches.

The returns of a small crushing in the year 1898 are shown in the table below.

Table showing the Yield of the Chance Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 4'00	ozs. 8'35	ozs. 2'08

MAY-BE,^E G.M.L. 531.—This lease is abandoned, and no work had evidently been done upon it for some considerable time past. As may be seen by an inspection of the geological sketch map, it will be noticed that the northern portion of the property is traversed by the main laminated quartz vein, which forms what may be called the backbone of Warrawoona; this quartz vein has been traversed by three faults which have had the effect of shifting the outcrop a few feet in each case. All the work on the lease centred on the quartz reefs occurring on the south side of the laminated quartz vein. On the summit of a hill near the south-west angle of the lease is an open cut, 20 feet in length, exposing about an inch of quartz encased in a banded (partly silicified) greenstone [5768], the foliation planes of which underlie at an angle of 60 degrees northerly. The quartz leader lies along a compression fracture, which from its geological position may represent the north-western extension of Kopeke's leader.

Bow BELLS BLOCK No. 1, G.M.L. 524.—This is an old abandoned lease adjoining G.M.L. 523 on the north-west; it embraces a narrow strip of the northern portion of Bow Bells No. 1 West (*q.v.*). A few tons of stone have been crushed from this lease in 1898, as shown in the table; it is probable that this stone was raised from the reef in the inaccessible vertical shaft, of which mention is made in the description of the reefs on G.M.L. 593.

Table showing the Yield of the Bow Bells Block No. 1 Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 12'00	ozs. 10'50	ozs. 87

BOW BELLS No. 1 WEST, G.M.L. 593.—An abandoned 24-acre lease adjoining the Bow Bells on the north-west. As may be seen by an inspection of the geological map, there are seven quartz reefs traversing the lease in addition to the main laminated quartz vein. The principal work has been done upon a reef outcropping near the northern boundary of the lease. A vertical shaft, now filled up, had been put down to an unknown depth on the slope of the northern wall of the valley, traversing the ground, and connects with the surface lower down by a tunnel about 100 feet in length, driven on a bearing of 35 degrees. The face of the tunnel is filled with *débris* falling down the shaft, so that nothing whatever can be seen of the reef. The mouth of the vertical shaft shows a good solid body of quartz, varying from two to four feet in thickness. This stone in all probability represents the continuation of the large reef outcropping to the north of main shaft on the Bow Bells lease, distant about 400 feet. At the mouth of the tunnel is a heap of quartz [5770] showing free gold, in addition to muscovite, which is partly chromiferous and partly stained by limonite, iron pyrites, and chalcopyrite.

Another reef outcropping 18 feet north of the laminated quartz vein, forming the southern wall of the valley. The shaft is inaccessible, but as measured to the surface of the water at present standing in it, is at least 32 feet deep.

A little stone has been raised, and now lies at the mouth of the shaft. It contains [5771] muscovite, which is partly chromiferous, ferruginous wad, and limonite. The reef varies from one to three feet in thickness, and has such a strike as would carry it into the laminated quartz vein some distance to the west.

BOW BELLS, G.M.L. 505.—The Bow Bells lease comprises an area of 12 acres, and was originally taken up by Messrs. Royer, Barnes, and Burroughs in the year 1898; it eventually passed into the hands of the present holders, The British Exploration Company of Australia, in 1901.

The lease, as may be seen by the Geological Sketch Map of Warrawoona, lies in the same zone as that which embraces the Gauntlet Mine, G.M.L. 483, from which it is distant about 100 chains to the north-west. The surface of the lease is occupied by greenstone schists and allied rocks, and the southern boundary of the property is traversed by the band of laminated quartz, which extends across the lease from end to end.

As shown by the large scale plan of the mine (Plate IV.), there are seven reefs upon the property.

The Northern Reef (No. 3 shaft), extends along the surface for a distance of about 80 feet, and underlies at a high angle to the north-east; the thickness of the reef as showing at the surface is

12 inches. The shaft by which the reef is worked is 39·63 feet above the level of the main (or Horseshoe) shaft, and has been carried down to a depth of 45 feet 9 inches. The shaft was inaccessible, but I was informed by the Manager (Mr. Hanemann) that at the bottom the reef proved to be small and poor. At a point about 50 feet north of the shaft, and along the outcrop of the same reef, is a shallow shaft, showing about 12 inches of quartz. No. 2 tunnel, 1·08 feet above the main shaft and 70 feet from it, was started with the object of intersecting the reef in No. 3 shaft, but after being carried in 8 or 10 feet, through country rock, it was apparently abandoned, and is now used as a store.

What may be called the *Horseshoe Reef* is worked from the main shaft, which has been sunk at the most convenient spot in the fork of the reef. The northernmost leg of the reef, as may be seen by the plan of the reefs (Plate IV.) can be followed for a distance of about 260 feet northwards, at which point it gradually tapers out to a thin vein of quartz, considerably less than an inch in thickness. At the bend of the horseshoe, the reef is about five feet in thickness. The southern leg of the reef can be followed, with a varying thickness, traversing No. 2 shaft, for a distance of about 150 feet, to a point at which it turns southerly, continuing on that course for a further distance of 50 feet, whence it gradually disappears. The main shaft, which has been carried down 106 feet 2 inches vertically, intersects the southern leg of the reef at No. 1 level, put in at a depth of 91 feet 6 inches; this reef is about three feet in thickness. The northern leg of the reef is represented by the 12 inches of quartz, intersected in the northern drive at a point about 40 feet from the shaft. An eastern drive about 50 feet in length has been put in practically along the country rock forming the foot-wall side of the reef. A narrow quartz vein, however, occupied the centre of the drive, and may possibly represent the small vein showing on the surface, for about 30 feet west from the mouth of No. 2 shaft. The eastern drive has been carried south on a bearing of 171 degrees for a distance of 18 feet, through massive greenstone. It is contemplated continuing this with the object of intersecting the rich chute worked in the reef in No. 1 shaft, and hauling all the stone to be milled from the main shaft.

The Tunnel Workings.—The workings at No. 1 tunnel and No. 1 shaft, are the most extensive, and appear to be the most important on the property. The mouth of the tunnel is 18·94 feet above the level of the main shaft, and has been carried in for a distance of 85 feet from the mouth to a point at which it intersects the reef, followed down from the surface in the workings from No. 1 shaft. Forty-five feet back from the face of the tunnel is a quartz reef two feet six inches in thickness, which in all probability represents the northern leg of the main reef. On the surface at the mouth of No. 1 shaft the two legs of the reef are 20 feet apart, whilst in the tunnel, 59 feet vertically below, they are 40 feet apart,

Twenty-three feet from the mouth of the tunnel is a small reef of six inches underlying to the north-east, and which in all probability represents the feather edge of the middle or lens-shaped mass of quartz (the Middle Reef) shown on the plan (Plate IV.) as lying midway between the Main and the Horseshoe Reefs. From the face of the tunnel, drives have been carried north and south for distances of 60 and 60 feet respectively; and for a length of 40 feet northwards from the face of the tunnel the reef has been stoped out to the surface, and has produced, up to the end of 1903, 483.70 tons of quartz, officially recorded as yielding 855.69ozs. of gold, or at the rate of 1.76ozs. per ton. The reef can be followed with more or less interruption northwards, but to the southwards it appears to be represented by a mere thread of quartz. At a point about 60 feet south from the tunnel a crosscut has been put in 40 feet south from the drive, through more or less foliated greenstone, with thin films and threads of quartz along the foliation planes. At the face of the crosscut the laminated quartz vein has been pierced and proved to be 10 feet in thickness, with an underlie of 65 degrees to the north-east. There does not seem to be any distinct line of demarcation between the country rock and the vein; the whole appearance suggesting a gradual replacement of the original rock along lines of maximum compression or foliation. On the footwall side of the vein is a body of quartz of as yet unknown thickness; in its general appearance, this quartz closely resembles some of the auriferous quartz of other portions of the field, and on that account seems worthy of being, at least, opened out and prospected. From the foot of the main shaft, and at the face of the tunnel, a winze, No. 1, has been carried down on the reef 77 feet 6 inches; this winze, which was inaccessible below 24 feet from the drive, has been put down on the footwall side of the chute followed above. No. 2 winze, however, about 20 feet to the north has been put down in the centre of the chute, and carried down 83 feet. The chute, which underlies north, leaves the winze at about 40 feet. The reef in this winze is very strong, and in places large, attaining as much as eight to 10 feet in thickness; at the foot of the winze, owing to a large bulge in the reef, its exact width had not been ascertained at the time of my visit. An intermediate level connects the two winzes at 24 feet six inches below the drive; about 200 tons of ore have been taken out above, and now await crushing. The quartz [5782] has a very ice-like appearance, and contains small scales of sericitic (?) mica, and irregular patches of serpentine. A sample of it assayed gold at the rate 1dwt. per ton. It is contemplated intersecting this chute from No. 1 level in the main (Horseshoe) shaft by a crosscut put in from the face of the eastern drive, as may be seen in the section (Plate IV.). The width of the chute appears to be about 35 or 40 feet.

There are many points of similarity between the geology and economic features of this property and the Gauntlet. The ore deposits in each case belong to one and the same type, and both occur in the same mineral zone.

So far as may be seen by a careful inspection of the surface it appears as though a considerable amount of faulting has gone on. The inferred position of these faults has been indicated upon the plan which forms Plate IV.

The following table gives the yield of the reefs on this property:—

Table showing the Yield of the Bow Bells Reefs.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	55·00	152·40	2·77
1899	...	...	...	183·00	342·30	1·87
1900	...	...	...	104·20	175·29	1·68
1901	...	...	...	<i>Nil</i>	<i>Nil</i>	...
1902	...	...	...	141·50	185·70	1·31
1903	...	...	...	<i>Nil</i>	<i>Nil</i>	...
1904	...	...	...	<i>Nil</i>	<i>Nil</i>	...
Total	...	...	...	483·70	855·69	1·76

Adjoining the Bow Bells Lease on the north, and on the ground taken up for a battery site, is another very conspicuous quartz reef. This bold reef, which outcrops at about 40 feet from the boundary of the Bow Bells lease, measures about 20 feet in its widest part, and can be followed along the surface for about 484 feet. The eastern end of the reef bifurcates, and both horns of the fork gradually dwindle out to threads of quartz. The western end of the reef is about 50 feet from the north-west angle of G.M.L. 505.

GREAT WESTERN, G.M.L. 502.—An abandoned 12-acre lease lying in the main belt some distance to the south-east of the Bow Bells. Some desultory work has been done upon a well defined reef, varying from 1 to 5 feet in thickness. The reef occurs in a very much crushed greenstone. The quartz in places contains veins and eyes of banded bright green serpentine [5772] which present every appearance of having been produced by shearing. The reef is in all probability along (or parallel to) the same line of fracture which carries the Main Bow Bells Reef. The quartz is of a white colour, and practically destitute of any other mineral, except a very little pyrites, closely associated with the green serpentine previously referred to. A parallel reef occurs near

the south-eastern angle of the lease, but no work has been done upon it.

In 1898, when the property was visited by the then Inspector of Mines, Mr. Gladstone, about 100 tons of quartz had been raised from the first lease, and awaited treatment. No separate crushings from this lease appear in the returns; any returns are in all probability included under the heading of the yield from sundry claims.

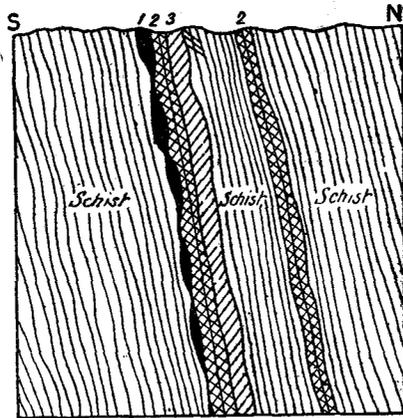
A tunnel had been put in 55 feet on a bearing of 223 degrees, on the vacant ground lying between this lease and that adjoining G.M.L. 595; the tunnel had been carried through decomposed schist underlying to the north-east. At about 35 feet from the mouth of the tunnel there is about from six to eight inches of quartz exposed, which represents the continuation of the reef opened up in G.M.L. 502; the face of the tunnel exposes a thin vein of quartz of from two to three inches in thickness.

GAUNTLET No. 3 NOR'-WEST, G.M.L. 595 (*late Gift*).—This abandoned 24-acre lease is traversed by two principal reefs which have been worked at one time or another by three shafts. The most northerly shaft, which is inaccessible, has been sunk to a depth of 15 feet on a reef having a general strike of 107 degrees, with a high underlay to the north. A little stone has been taken out from the reef, which, judging from the ore at grass, had a maximum thickness of 12 inches. So far as may be seen in the sides of the shaft the reef is represented by three or four quartz veins about a couple of inches in thickness. The same reef has been opened up at intervals along the outcrop for a distance of about 100 feet eastwards from the shaft; in one place the reef measures from two to three feet across. A very little stone has been raised and is now stacked; the quartz is of a pure white colour and contains small quantities of iron ore; a sample [5774] of it assayed gold at the rate of 1dwt. 15grs. per ton.

The principal workings on the lease, however, are on the vein lying to the south-west of the laminated quartz vein and about 148 feet from it. Two shafts, 94 feet apart, have been put down upon the vein. The south-eastern shaft (No. 2) is inaccessible, and no information is available; the vein has been opened up along the surface for a distance of 38 feet along the outcrop south-east from this shaft, but owing to the condition of the workings little is to be seen of it. No. 1, or the westernmost shaft, is distant 94 feet from No. 2, and the stone has been worked right to the surface between the two but from what depth cannot be ascertained. This shaft, the depth of which is unknown, has water standing in it to about 35 feet from the surface, and is now used as a well. Owing to the influx of water, it is asserted, the property had to be abandoned.

Fig. 9 gives a section across the reef, which lies along a line of fault, the hanging wall of which is marked by a somewhat puckered and greatly slickensided vein of quartz.

FIG. 9.



SECTION ACROSS THE GIFT REEF G.M.L. 595.
WARRAWOONA PILBARA G.F.
1 Gift Reef along line of Fault 2 White Quartz 3 Black Quartz.

This vein is the continuation of Kopcke's Leader.

The following table gives the yield of this reef so far as can be ascertained from official data.

Table showing the Yield of the Gift Reef.

Year.	Ore Crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1898	11.80	23.50	1.99
1899	32.25	50.00	1.55
Totals	44.05	73.50	1.66

GOLDEN GAUNTLET, G.M.L., 506.—This lease adjoins the Gift, on the east; a fair amount of work has been done at the north-west end of the property, on a reef which occurs, as may be seen by an inspection of the geological map, in close proximity to where the main laminated quartz vein is traversed by the greenstone dyke [5773].

A tunnel has been put into the face of the hill on a bearing of 240 degrees, for a distance of about 75 feet. At 34 feet from the mouth of the tunnel, the laminated quartz vein has been met with,

and passed through at 47 feet, giving a thickness of 13 feet; the vein underlays to the north-east at 85 degrees. At the face of the tunnel the decomposed rock is much less foliated than that exposed in the rest of the tunnel, thus indicating a gradual decrease in foliation as one approaches, and receded from the quartz vein. There does not appear to have been much obtained from this tunnel, which would seem to have been driven for the purpose of exploring the laminated quartz vein at some depth below its outcrop. Two shafts, now inaccessible, have been put down on a large reef situated a little distance to the north of the tunnel which has an average strike of 146 degrees. The most northerly shaft, 35 feet deep, is distant 95 feet from the southernmost; from the foot of the northern shaft a drive has been put in along the reef in both directions, but no particulars are obtainable. The thickness of the reef as measured on the outcrop, close to the northern shaft, is 20 feet, and probably merely represents the widest portion of a bulge in the reef. The quartz is of a bluish white colour, and appears to contain no accessory minerals. A fair quantity of outcrop stone has been stacked and awaits crushing.

Table showing the Yield of the Golden Gauntlet Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1899	tons. 3'00	ozs. 4'60	ozs. 1'53

GAUNTLET, G.M.L. 483.—The Gauntlet Lease was originally taken up in the year, 1898, by Mr. R. H. Mackenzie; it comprises an area of 12 acres, and has been responsible for a yield of 3,693ozs. of gold, or 2'86ozs. for every ton of ore milled up to the close of 1903.

The surface of the lease is occupied by greenstone schists and allied rocks, whilst skirting the southern boundary is a continuous and conspicuous band of laminated quartz about 10 feet in thickness. The foliated greenstone contains large crystals of iron ore, identical with those weathering out of the massive variety.

There are practically four principal reefs, *i.e.*, reefs upon which any work has been done, on the ground, the longest having a length along the outcrop of at least 400 feet, and the shortest about 100 feet (Plate V.). When the position of the reefs is accurately laid down upon a plan, it is noticed that they exhibit, with minor variations, a rude parallelism, the general strike being north-west and south-east, which coincides with that of the foliation and dominant structural features of the district. About 45 feet north of the band of laminated quartz is a fairly continuous quartz reef outcropping for about 500 feet from the north-western boundary of the property. This reef attains a thickness of about two feet in

places, though as a rule very thin, it is perhaps the one which exhibits the greatest linear persistence on the lease.

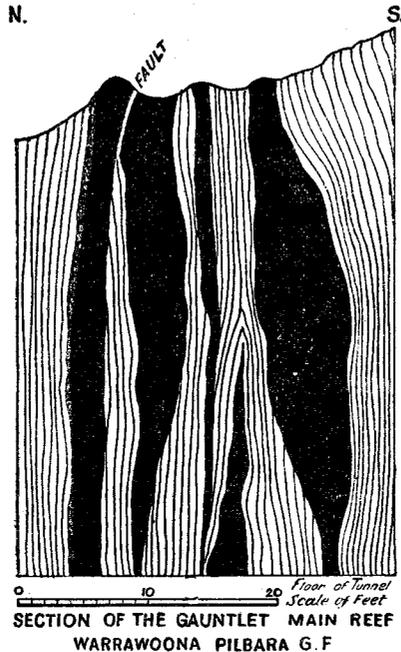
The South Reef.—The South Reef, which has been opened up by means of a tunnel and several small open-works, can be traced across the surface for about 140 feet. The tunnel has been driven about 31 feet in a southerly direction; at its mouth the reef, merely an exceptionally large lenticular mass of quartz, the maximum thickness of which measures 2 feet 3 inches, has been exposed. The country rock in the tunnel is decomposed schist, with small lenticular “eyes” of quartz developed along shear planes. The open-works on this line merely expose a similar succession of quartz lenticules. In view of the fact that their mode of occurrence is identical with those on that important line, Kopcke’s Leader (*q.v.*), and that they are said to be appreciably auriferous, this line would seem to merit a certain amount of judicious prospecting.

The Main Reef.—As developed to the south of the main shaft, from which it is distant 40 feet, the main reef has a continuous outcrop of 132 feet; the eastern end of the outcrop originates as a mere thread of quartz, which gradually increases in size until it reaches a maximum thickness of 10 feet. At the western extremity, where it is truncated by a fault, to which reference will be made later, the reef is about six feet in thickness. As shown in the large open cut at the surface, the main reef is intersected by two faults, making an angle of about 55 degrees. What may be called the main or cross fault has a general strike of 163 degrees, and the strike fault, 110 degrees. Fig. 10 shows what may be called the “compound” nature of the reef as exposed in the open cut, the tunnel, and the lowest portion of the workings at the present time. There is a total thickness of about 16 feet of quartz exposed in the open cut, 14 feet in the tunnel, and about 12 feet at the bottom workings. The main reef has been opened up by means of a vertical shaft (the main shaft) 126 feet 6 inches in depth and a tunnel 168 feet in length. The shaft, which is eight feet by four feet, intersected the reef at 101 feet from the surface, and had been carried down through a foliated green rock. East and west drives, 95 and 201 feet respectively, have been put in at 101 feet; at 116 feet in the shaft is water level, of which there is 10 feet standing.

The tunnel has been put in at a point 85 feet west of the main shaft, about 20 feet vertically below it, and intersects the bottom of the open cut previously alluded to. At about 32 feet from the mouth of the tunnel a winze has been carried down along the plane of the fault to the western end of the drive from the main shaft 87 feet vertically below the level of the floor of the tunnel. Fig. 10 is a section of the reefs, etc., seen in the tunnel at the foot of the open-cut. From this point the tunnel has been carried through foliated country rock, with quartz leaders; on nearing the face of the tunnel the schist becomes much more siliceous, suggesting the proximity of the laminated quartz vein which occupies the surface of the southern boundary of the lease.

The whole of the stone has been taken out from the floor of the tunnel to the surface, 38 feet vertically above it, and from this spot practically the whole of the 3,693ozs. of gold, as shown in the return

FIG. 10.



appended, was obtained. From what can be seen in this portion of the mine, it appears that the ore chute lies in, or in close proximity to, the acute angle formed by the two principal faults alluded to previously; the positions of these are delineated on the plan of the reefs and underground workings (Plate V.).

The main reef has been met with in the west level, opened out from the end of the crosscut, 38 feet in length, south from the main shaft. The reef first makes its appearance as a mere thread of quartz at a point in the drive 23 feet east from the centre of the crosscut; at this spot it measures from six to eight inches in thickness, and gradually increases towards the face. At one point in the drive the reef measures fully eight feet of solid quartz; powerfully slickensided faces on the foot-wall demonstrate that the reef occurs along a line of fault. The slickensides hade in the same direction as the underlay of the reef, to the northwards. The end of this level intersects the winze from the tunnel overhead, and has been carried down 16 feet 6

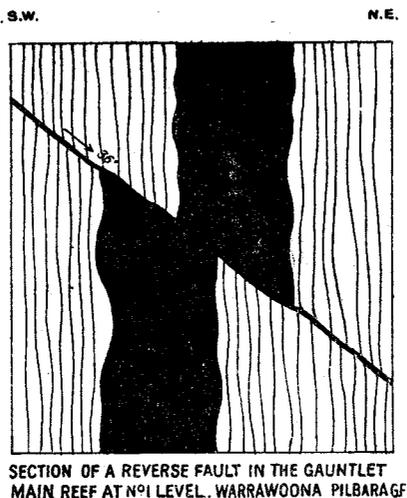
inches from the floor of the drive. At the mouth of the winze the main reef measures three feet nine inches; whilst at its foot it is four feet eight inches, with a thin band of schist. Thirteen feet from the north face is a second reef of 24 inches, separated from a third of three feet by ten inches of schist. This section agrees in the main with that occurring in the tunnel at the foot of the open cut, in that there are three bodies of quartz separated by varying thicknesses of schist. The main fault leaves the south drive at a point 26 feet from the foot of the winze on the eastern wall, and does not appear to have been followed. The drive is continued about 22 feet from this point on the western wall of the fault through schist containing thin ribbons of quartz and small cubical crystals of pyrites. An important feature in this winze is an almost horizontal fault, or thrust plane, hading to the north at about five degrees, with a horizontal displacement of from 12 to 18 inches to the rise. The fault fissure measures less than six inches filled with quartz, which may merely represent a flat leader of secondary origin. The floor of the drive, as ascertained by a trench put in across the mullock with which it had been filled, showed that the reef occurred below the horizontal fault. Free gold is showing freely in the solid stone [5785]. The bottom of the winze is at water level.

The main fault traverses the whole breadth of the lease, and abruptly truncates a bold reef lying some distance north of the north-eastern boundary of the property. There seems to be good reason to regard the reef lying to the west of the fault, and about 120 feet from the mouth of the tunnel, as being the western extension of the main reef. This reef lies near the centre of the lease, and makes a bold outcrop of nearly 300 feet in length; it is, in places, of considerable thickness, and the general mineralogical character of the quartz agrees very closely with that which forms the main reef itself. This possible extension of the main reef, more especially where it is truncated by the fault, has not been prospected. I understand appreciable quantities of gold have been obtained there. There are two other smaller reefs, shown on the plan (Plate V.), in close proximity to this one; these also have not been prospected.

The East Reef.—The East Reef, as showing on the surface, has an outcrop of 275 feet in length, and a width of about eight feet in its widest part; both ends of the outcrop are represented by thin threads of quartz. The reef has been opened up both from the main shaft and the east shaft, which is 95 feet in vertical depth, and has been sunk on the reef the whole way. The reef makes its appearance in the eastern drive from the main shaft at a point about 50 or 60 feet from the eastern shaft, where it is represented by a thread of quartz, which gradually increases in thickness until it occupies the full width of the roof of the drive, and attains a maximum thickness of eight feet. There is at this level a blank space of about 50 feet between the end of the main and the east reef, though at the surface the

extent of dead ground is not so great. At the surface the two extremities of the reef are about 14 feet apart in a direction at right angles to the underlay, and, underground, at 100 feet vertically below, the distance is barely 10 feet. Beyond the stone taken out of this reef in sinking the shaft, driving the level, and a little from the small open cut on the surface, no further work has been done. The foot of the eastern shaft also exposes a reverse fault, Fig. 11, which has a throw of about two feet, and a hade of 35 degrees to north 75 degrees east.* The quartz exposed in the shaft averages about three feet in thickness.

Fig. 11.



The North Reef.—The North Reef lies on the opposite side of the valley which traverses the central portion of the Gauntlet lease longitudinally, at a considerable elevation above the lowest portion of the ground. The reef outcrops at an average distance of about 90 feet from the north-eastern boundary of the lease, and occupies the surface for a distance of about 440 feet. The north-western end of the outcrop of the reef bifurcates, with an extension of the reef to the north-east of about 40 feet. At this point the stone, which is about four feet thick, is abruptly truncated by a fault, which also cuts off a larger reef, 160 feet in length, at a point about 200 feet to the south-east. This latter reef makes a very pronounced outcrop, and is of considerable thickness. A vertical shaft, 29 feet deep, has been sunk at a point near the thickest portion of the north reef, but beyond this no other work has been done upon it.

* By an error Fig. 11 gives the section as being in the main reef, whereas it should be the east reef.

The following table gives the yield of this lease, the gold having been entirely derived from the stone occurring at the faulted extremity of the main reef:—

Table showing the Yield of the Gauntlet Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	106·20	430·90	4·05
1899	...	...	...	150·10	736·15	4·90
1900	...	...	...	872·00	2,269·00	2·60
1901	...	...	...	136·50	238·05	1·74
1902	...	...	...	24·50	19·45	·79
1903	...	...	...	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Total				1,289·30	3,693·55	2·86

RANGATIRA, G.M.L. 491.—An abandoned lease, adjoining the Gauntlet, on the south. The property is traversed by two reefs, upon which a little desultory work has been done. A small crushing, particulars of which are given below, has been obtained from this lease.

Table showing the Yield of the Rangatira Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1899	...	...	...	8·50	5·15	·60

GAUNTLET EAST, G.M.L. 560.—The north-western boundary of this lease is traversed by what may be the faulted extension of the East Reef of the Gauntlet. An inaccessible vertical shaft has been sunk upon it, but nothing can be seen of the reef and its behaviour underground. To the eastward and not far to the west of the Treble Event boundary, a tunnel 55 feet in length has been driven on a bearing of 296 degrees, through a fine-grained quartz schist [5789] traversed by a deposit of the leader type. Nothing, however, beyond this has been done on the property.

There do not appear to have been any crushings recorded from this lease, unless such are included in the yield of those from sundry claims.

IMPERIALIST, G.M.L. 564.—The Imperialist reef lies about 400 feet to the south of what may be called the main reef series of Warrawoona. The reef can be followed more or less interruptedly along the surface for a distance of at least 2,200 feet south-east, and as may be seen by an inspection of the Geological Sketch Map (Plate III.), there seems to be good reason to believe that it may extend much further than this.

The Imperialist has been exploited by three principal shafts, all of which are situated near the western extremity of the outcrop. No work was being carried out at the date the property was visited and the main shaft had been dismantled.

The westernmost shaft (now filled in) is situated near the western extremity of the outcrop of the reef, which at this point strikes 101 degrees. Judging by the condition of the dump and the workings a fair amount of work must have been done from this shaft. Between this point and the Central shaft, 114 feet distant, the reef has been opened out at one or two places, and about 12 inches of quartz exposed. A considerable amount of work has obviously been done from the Central shaft; this shaft, which exposes from 6 to 12 inches of quartz, is inaccessible. The main shaft bears 97 degrees from the Central, and is 83 feet distant from it. Water stands in the shaft at 80 feet from the surface. The quartz lying at the mouth of the shaft contains fragments of serpentine [5775]—a sample of this quartz yielded, on assay in the Survey laboratory, gold at the rate of 1dwt. 15grs. per ton—and large veins of calcite [5776], some of which are 12 inches in thickness. The calcite yielded a minute trace of gold per ton. The country rock of the reef is [5777] a talc-chlorite schist. The quartz of the Imperialist, so far as may be judged by the stone in the dump, seems to be a replacement of the country rock.

Near the north-east angle of the lease is another parallel reef of from six to eight inches in thickness, upon which a fair amount of work has been done. The reef has been stoped out to the surface from a depth of 20 or 30 feet; the workings, however, are inaccessible. The country rock is schist of the prevailing type. The quartz is traversed by a small vein of calcite. There are three other more or less parallel reefs in the vicinity of the Imperialist, but no work appears to have been done upon any of them.

The following table gives the yield of the Imperialist reef:—

Table showing the Yield of the Imperialist Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
1899	...	...	...	tons. 163·75	ozs. 214·01	ozs. 1·30
1900	...	...	...	367·50	389·20	1·05
1901	...	...	...	17·50	26·30	1·50
1902	...	...	...	Nil	Nil	...
1903	...	...	...	147·00	181·07	1·23
Totals				695·75	810·58	1·16

TREBLE EVENT, G.M.L. 573.—This six-acre lease adjoins the Dodger on the west. Two apparently deep shafts have been put down upon what appears to be the north-western extension of the

Dodger Reef. Nothing, however, can be seen of the reef at the present time. A small trial crushing, of a little over three tons, has been recorded from this reef in 1902, with the results as shown in the table below:—

Table showing the Yield of the Treble Event Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1902	tons. 3·25	ozs. 4·00	ozs. 1·23

DODGER, G.M.L. 587.—Two shafts have been sunk on a reef, which lies a short distance to the north of the laminated quartz vein, and parallel to it, but at the present time nothing can be seen of the nature of the reef and its behaviour underground.

KLONDYKE BOULDER BLOCK, G.M.L. 577.—No work has apparently been done upon this property, which was evidently taken up with the object of intersecting the Klondyke Boulder Group of reefs at depth on the underlie.

PRINCESS OF ALASKA, G.M.L. 489.—This is an old abandoned lease which included within its boundaries the three leases 573, 587, and 577. Two small crushings have been recorded from this in 1898 and 1899, but there is, however, nothing to indicate at the present time whether the stone was obtained from the Treble Event, G.M.L. 573 (*q.v.*), or the Dodger, G.M.L. 587 (*q.v.*).

Table showing the Yield of the Princess of Alaska Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 11·00	ozs. 33·56	ozs. 3·05
1899	29·00	37·05	1·27
Total	40·00	70·61	1·76

KLONDYKE BOULDER, G.M.L. 604 (late 476).—This 12-acre lease, which has turned out 2,356ozs. of gold, or at the rate of 2·40ozs. per ton of ore milled, was originally granted to Messrs. Hall and Cook in the year 1898, and was numbered 476. The lease was subsequently re-numbered 604 on its being conditionally surrendered in 1901.

A considerable amount of work has been done upon the property since it was first exploited, but at the date the locality was visited, the lease being under exemption and the main working

full of water, access underground could not be obtained; there appear to be no plans of the workings, hence no information as to the nature and behaviour of the reef below surface is available.

As may be seen by an inspection of the Geological Map (Plate III.), it will be noticed that the surface of the lease is occupied by greenstone schist; the north-eastern portion of the ground is traversed by a narrow but persistent band of very much sheared greenstone, which forms a very pronounced feature on the surface. This band lies about an average distance of 100 feet south of the conspicuous laminated quartz vein which traverses the field.

All the reefs lie to the south of the laminated quartz vein; they, however, do not occur in that zone which embraces the Bow Bells and the Gauntlet reefs. The Klondyke Boulder reefs present many features in common with those of the two properties mentioned above. The position of the reefs, etc., is shown on the plan which forms Plate VI.

There are two distinct types of ore deposits on the property, the most persistent being that which may be conveniently termed the leader, which trends generally north-west and south-east, and has an outcrop of not less than 650 feet; the second type being that of the main reef, which has a much more westerly trend than that of the leader.

The Leader has been opened up at six or seven places on the lease, but in only one spot (E) does any very serious attempt appear to have been made to exploit it. At this spot a vertical shaft had been put down on a shear plane underlying at a very high angle to the south-west. The shaft proved to be inaccessible; but from what could be seen on the south-eastern wall the reef consisted of eye-shaped masses of quartz encased in slickensided faces of older quartz, about three to four inches in thickness. There is every geological reason for believing that this reef is merely the north-western extension of Kopcke's leader (*q.v.*).

The Main Reef consists of a vein of quartz, having an outcrop measuring about 130 feet in length; it has been worked by means of two shafts, B and C. Shaft B measures 25 feet in depth, and from it is an open cut 83 feet in length, in which a somewhat tortuous quartz reef is exposed; little, however, is to be seen of it at the present time, though in one place there is about 12 inches of quartz exposed. At the south-west end of the open cut, and about three feet from the main reef and on the north side of it, is a large lenticular mass of bluish-white quartz several feet in thickness. Its position is shown on the plan of the reefs forming Plate VI. There seem good reasons for believing the main reef and this lenticular mass of quartz to be separated by a fault hading to the north. Between this lens and shaft E is another boomerang (kylie) shaped mass of quartz about 80 feet in length. Shaft C, 21 feet northwards from B, is also inaccessible. Water is standing in the shaft;

to the top of the water is 84 feet. About 55 feet north-west from the shaft B is another vertical shaft 44 (?) feet deep, sunk with the intention of working the small reef, shown on the plan, outcropping for about 50 feet, and lying a little distance to the south.

To the north-west is a tortuous reef, which occupies the surface for about 140 feet. The reef, which is well seen in the open cut, along its outcrop is traversed by two faults, as shown on the plan (Plate VI.). The southernmost fault is continuous in a south-easterly direction and probably extends as far as that which truncates the reef outcropping at A, referred to later on.

At A is a quartz reef of three feet ten inches in thickness and 70 feet in length, cut off by an almost north and south fault. This fault, which is exposed in a shallow shaft nine feet deep, underlies in a direction north 65 degrees east at an angle of 24 degrees. A section is given on Plate VI. showing this fault; it is, however, taken across the reef and not in the direction of the true dip. There seem good grounds for believing this to be a reverse fault.

The main shaft workings are inaccessible, hence there are no data as to the nature, thickness, and other cognate points of the reef.

The following table shows the yield of this property:—

Table showing the Yield of the Klondyke Boulder Reef.

Year.			Ore crushed.	Gold therefrom.	Rate per ton.
			tons.	ozs.	ozs.
1898	...	...	90.45	379.14	4.19
1899	...	...	262.45	526.28	2.00
1900	...	...	253.71	436.55	1.72
1901	...	...	92.50	287.60	3.10
1902	...	...	81.05	159.65	1.97
1903	...	...	198.00	567.00	2.86
1904	...	...	38.00	94.71	2.49
Total	...	...	1,016.16	2,450.93	2.41

WHEEL OF FORTUNE, G.M.L. 611 (formerly G.M.L. 571, and Dawson City, G.M.L. 477).—There are two well-defined reefs on the property, both of which lie some distance to the north of the conspicuous laminated quartz vein which occupies the southern boundary of the lease. Several shafts have been put down, to depths not known to me, upon that well-defined quartz reef, which lies about 100 feet north of the laminated quartz vein. In August, 1898, Mr. Inspector Gladstone mentions the depths of three of these shafts as being, respectively, 50, 35, and 50 feet, the latter one

being on a reef three feet in thickness. The reef, as exposed at the surface, is of that bluish-white colour, which characterises the reefs of Bow Bells and Gauntlet types.

Some of the quartz [5791] contains quantities of the red oxide and the green carbonate of copper, together with films of sericitic mica and a little serpentine. A sample of the characteristic cupriferous variety [5791] assayed in the Survey laboratory: gold, 4dwts. 2grs. per ton, and copper 1·23 per cent. There have been four crushings recorded from this property, details of which are given in the table below:—

Table showing the Yield of the Wheel of Fortune Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	25·60	6·90	·27
1899	...	...	...	Nil	Nil	...
1900	...	...	...	96·50	99·95	1·03
1901	...	...	...	16·50	11·50	·70
1902	...	...	...	67·75	131·60	1·94
Totals				206·35	249·95	1·21

NELSON, G.M.L. 514.—A shallow shaft has been sunk upon a prominent east and west reef, situated near the north-west angle of the property, but very little work appears to have been done upon it. A small trial crushing was obtained from this reef in the year 1898, with the result as shown in the table.

Table showing the Yield of the Nelson Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	1·25	5·29	4·23

KLONDYKE No. 1 WEST, G.M.L. 578 (formerly Klondyke No. 1, G.M.L. 474).—The leader, lying to the south of the laminated quartz vein, traverses the whole length of the property, and all the work done on the lease appears to have been concentrated on it. Two inaccessible shafts have been put down on the leader, but at the present time there is nothing to be seen of anything underground.

Writing in 1898 Mr. Inspector Gladstone mentioned that the one shaft then sunk had attained a depth of 60 feet, and exposed “a rich leader with three-foot lode formation.”

The official returns shown in the table below demonstrate that the leader was rich, crushing nearly at the rate of $4\frac{1}{2}$ ozs. per ton.

Table showing the Yield of the Klondyke No. 1 West Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	5'00	37'77	7'55
1899	...	...	...	14'95	63'20	4'22
1900	...	...	...	23'05	88'70	3'84
Total				43'00	189'67	4'41

KLONDYKE BLOCK, G.M.L. 507.—This 18-acre lease lies north of, and adjoins the Klondyke property. Six well-defined reefs traverse a portion of the property, but no serious work seems to have been done upon any of them. Two of the reefs are of the bluish colour which characterises the quartz of the Bow Bells and Gauntlet reefs.

A crushing of 37 tons has been recorded in the year 1898, the yield of which being shown in the table below :—

Table showing the Yield of the Klondyke Block Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	37'00	764'00	20'65

KLONDYKE, G.M.L. 473 (now called the Klondyke Queen, G.M.L. 627.)—The Klondyke Lease comprises an area of six acres, and was originally taken up by Messrs. Poutt and Corboy in the year 1898; it eventually passed into the hands of the present owners Messrs. Royer and Elliott some time during the year 1903. This lease, as may be seen by the geological map, occupies the same zone as that which embraces the Klondyke Boulder mine, G.M.L. 604, from which it is distant 28 chains to the south-east. The surface of the property is occupied by the quartzitic rocks, and is traversed by the conspicuous vein of laminated quartz which forms the backbone of the district.

Judging by the condition of the surface a fair amount of work must have been done upon the lease; according to the official records 706'75 tons of ore have been raised, which yielded 4,700'76ozs. of gold, or at the rate of 6'65ozs. per ton of stone crushed.

When the property was visited the lease was not being worked, and owing to there apparently being no plans of the workings, very little information as to the nature and behaviour of the deposits is available. The Klondyke reef, as may be seen by the geological map, lies a little distance to the north of the leader.

The Main Reef enters the lease on its eastern boundary, where it has been open cut for about 27 feet; there is about a foot of quartz now showing. To a point about 117 feet east of this the reef has hardly been touched, it measures, however, four feet across; at this point is the mouth of a tunnel, put in along the reef for a distance of at least 300 feet. Seventy-two feet from the mouth of the tunnel is a winze, inaccessible at the present time, and said to be 90 feet; at this point there is 12 to 14 inches of quartz exposed over-head in the tunnel. The chute of gold followed from the mouth of the tunnel and by the winze is said to be 40 feet wide, with an underlay to the west. The reef has been practically stoped out to the surface to a point from the floor of the tunnel, about 129 feet from its mouth.

A vertical or main shaft connects with a point a few feet to the south of the drive, at a distance of 258 feet from the entrance to the tunnel. Judging from the condition of the workings, the tunnel did not follow the main reef, but merely a thin spur going off to the west.

Free gold is showing in the stone on the outcrop at a point about 50 feet west from the main shaft.

The following table shows the yield of the Klondyke Reef:—

Table showing the Yield of the Klondyke Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	63·00	836·00	13·27
1899	...	...	...	347·00	1,758·86	5·06
1900	...	...	...	144·50	1,566·20	10·83
1901	...	...	...	86·75	294·40	3·39
1902	...	...	...	65·50	245·30	3·74
1903	...	...	...	Nil	Nil	...
1904	...	...	...	25·00	83·64*	3·34
Total				731·75	4,784·40	6·53

* Includes 7·33ozs. obtained by cyaniding 9 tons of sands, the balance being returned from what is now known as the Klondyke Queen, G.M.L. 627.

KLONDYKE No. 1 EAST, G.M.L. 480.—This six-acre lease adjoins the Klondyke on the east, and is traversed by the leader, which crosses the whole length of the property.

A tunnel has been put in eastwards from the level of the creek, for an unknown distance, on a reef which bears 287 degrees

30 minutes. Further east along the outcrop is a vertical shaft 32 feet in depth, designed to connect with the tunnel below. The reef, as exposed on the surface, is about two feet in thickness. From its relative position there are good grounds for believing this reef to be the eastern extension of the Klondyke. There do not seem to have been any crushings from this property, unless such are included in returns from Sundry Claims.

BROUGHT TO LIGHT, G.M.L. 516.—This three-acre lease lies within that zone which includes the Bow Bells and Gauntlet Reefs. There are four well-defined reefs outcropping on the property, but upon one only has any work been done, viz., that near the north-west angle of the adjoining lease number 515. This reef has been opened out along the outcrop for a distance of 50 feet, and in the open cut a vertical shaft 21 feet in depth has been sunk on the reef, which is about 12 inches in thickness. So far as can be seen the reef appears to have petered out at the foot of the shaft.

A small crushing of a little over eight tons has been recorded from this reef, and its yield is shown in the table below.

Table showing the Yield of the Brought to Light Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1899	tons. 8·75	ozs. 7·96	ozs. ·90

THE EARLY MORN, G.M.L. 515.—There are two or three well-defined reefs outcropping on this property, but upon none of them has any work been done.

KLONDYKE No. 2 EAST, G.M.L. 481.—This lease adjoins the G.M.L. 478 on the north-west, and, like it, is traversed along its whole length by the leader. This, which occupies the southern portion of the property, has been opened out in one or two places.

A tunnel, the mouth of which is 35 feet north of the leader, and at a slightly higher level, has been put in, through vertical decomposed schists, for a distance of 84 feet, on a bearing of north 35 degrees east. With the exception of a few irregular quartz leaders, nothing of any importance seems to have been met with. A vertical shaft, designed to intersect this tunnel, was commenced, but after being carried down 10 feet work was abandoned. A second tunnel, 20 feet in length, has been put in at some distance from the longer one, but so far nothing is to be seen. There are two other reefs lying to the north of the leader, but nothing has been done upon them.

There seems to have been no crushings recorded from this lease, unless any such are included in the returns from Sundry Claims.

ADMIRAL DEWEY, G.M.L. 500.—This twelve-acre lease is situated due south of and adjoins G.M.L.s 478 and 481. There are several reefs traversing the property, the most conspicuous and persistent being that which outcrops along the southern boundary of the lease. The outcrop of the reef is interrupted in two places, as may be seen by an inspection of the plan. The country rock of these reefs is greenstone schist of the prevailing type. The only work carried out on this property is near the centre of the northern boundary, where a trench 16 feet long has been put in across the summit of a narrow ridge to a depth of four or five feet, in which an irregular network of quartz veins and leaders is exposed. The strike of the leaders is parallel to the enclosing schists.

There appears to have been only one crushing recorded from this lease, as shown in the return.

Table showing the Yield of the Admiral Dewey Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
1898	...	...	...	tons. 8.45	ozs. 4.55	ozs. .53

KLONDYKE KING BLOCKS No. 1, G.M.L. 511.—This lease lies due north of and adjoins G.M.L. 578; it is traversed by two well-defined reefs, which lie within that zone, embracing the Gauntlet and the Bow Bells reefs.

No work of any kind, however, has been done upon these reefs.

KLONDYKE KING, G.M.L. 478.—This six-acre lease adjoins the Klondyke Queen on the west, and, like it, is traversed by the leader, as well as two other reefs of minor importance on the north. The property, however, has long since been abandoned, though a fair quantity of work has apparently been done upon it.

A tunnel 44 feet in length has been put in on a bearing of 27 degrees through the schists to the leader, which has been connected with the surface by a shaft 31 feet deep. The workings from the tunnel are connected with another shaft 24 feet deep, and situated 48 feet to the west.

The leader, so far as it can be seen, does not present any essential points of difference to that in other portions of the field.

KLONDYKE QUEEN, G.M.L. 488.—The leader traverses the whole length of the lease on the southern flanks of the laminated quartz vein, but the former does not appear to have been opened out at all. The only work done upon the property is the sinking of a vertical shaft 32 feet deep on a very short east and west reef situated at a point 54 feet north of the laminated quartz vein. An open cut extends south from the vertical shaft and exposes decomposed country rock of the prevailing type.

The only crushing recorded from this lease must have been taken from the east and west reef, previously alluded to. The returns are shown in the table below:—

Table showing the Yield of the Klondyke Queen Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 9'90	ozs. 13'75	ozs. 1'38

KLONDYKE QUEEN EXTENDED, G.M.L. 503.—A small three-acre lease, adjoining the Dead Camel, on the north-west. The property is traversed by the north-western extension of the leader, a fair amount of work having been done along its outcrop, but only to a very shallow depth. There appear to have been no crushings recorded from this property, unless such are included in the returns from Sundry Claims.

To the south of G.M.L. 503 is a faulted inlier of quartzite, in the form of a large attenuated lens, of considerable length but no great breadth. This, however, is too small to be shown on the geological map accompanying the report.

DEAD CAMEL, G.M.L. 475.—The "leader" is continuous through this property, and has been worked for about 100 feet along the outcrop.

A vertical shaft 91 feet in depth has been sunk at one point on the outcrop. Below a depth of 84 feet nothing can be seen of the leader, owing to the shaft being filled in. At the foot of the shaft, so far as can be at present seen, the reef is of the usual lens-shaped type: the lenses being up to eight inches in thickness, and up to 18 inches in depth.

Free gold is showing in the stone, in addition to pyrites and galena [5786] and serpentine.

In addition to the leader there are two other quartz reefs on the property situated on the north side of the laminated quartz vein, but no work has been done upon them.

The returns from this reef are shown in the table below.

Table showing the Yield of the Dead Camel Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 2'50	ozs. 9'10	ozs. 3'64
1899	16'25	54'40	3'34
Total	18'75	63'50	3'38

SAINT GEORGE No. 1 WEST, G.M.L. 498.—The reef outcropping in the Saint George traverses the eastern portion of this lease, but little is to be seen. Mr. Inspector Gladstone reports that “an open cut has been worked on the reef. Two shafts have been started and are down* about 10 feet. The reef here is two feet six inches thick.”

SAINT GEORGE, G.M.L. 493.—The 12-acre lease, the Saint George, lies some distance to the north of the leader, and has evidently been abandoned for some considerable time. There has evidently been a good deal of work done on the reef at one time or another. Little or nothing, however, can be seen at the present time. Mr. Inspector Gladstone’s report, previously alluded to, makes reference to this property in the following terms:—“This is one of the best of the eastern leases on the line. One shaft is down 45 feet, with an open cut about 20 feet. The reef varies from 10 to 15 inches and is very rich in gold. The first crushing gave 110ozs. of gold from 11 tons of quartz.” The quartz as showing in the face of the open cut near the shaft is pure white and about one foot in thickness.

The following table gives the yield of this reef:—

Table showing the Yield of the Saint George Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1898	tons. 20'00	ozs. 124'00	ozs. 6'20

SAINT GEORGE No. 1 EAST, G.M.L. 499.—Very little work has been done on the reefs traversing this property. There are about three shallow pot-holes, from which about 3 tons of reputedly rich stone have been unearthed.

LAST CHANCE, G.M.L. 540.—An abandoned lease. A fairly well-marked reef, from 12 to 18 inches in thickness, traverses the lease in a north-westerly and south-easterly direction, but beyond opening out the outcrop very little work appears to have been done upon it. The quartz is bluish-white, and contains a little pyrites.

BAND OF HOPE, G.M.L. 533.—An abandoned six-acre lease adjoining G.M.L. 540 on the east. The main reef traversing the adjoining property crosses the northern portion of the Band of Hope; there are also two other veins to the south of it on the ground, trending approximately in the same direction, but no serious work of any kind has been done upon them.

* August, 1898.

CUBAN, G.M.L. 492.—A similar condition of affairs prevails on this property as on the Britannia.

The leader, which traverses the whole length of the lease, has been worked to a shallow depth along practically the whole length of the outcrop. At the present time no work is going on, and there is little or nothing to be seen. Mr. Inspector Gladstone's report of 1898 mentions a vertical shaft 20 feet deep, and alludes to a trench 120 feet in length along the outcrop of the leader.

The following table shows the yield of the leader traversing the lease, as obtained from official sources.

Table showing the Yield of the Cuban Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	5'00	17'08	3'41
1899	...	...	...	18'20	74'33	4'08
1900	...	...	...	28'10	124'00	4'41
Totals				51'30	215'41	4'19

BRITANNIA, G.M.L. 484.—An abandoned six-acre lease, adjoining the Reward and G.M.L. 522 on the west.

A good deal of work has been done along Kopcke's leader, but little can be seen at the present time. Mr. Inspector Gladstone, writing in 1898, mentions a vertical shaft 27 feet in depth, and a trench 160 feet in length: none of these are accessible at the present time, hence no description can be given.

The following table gives the returns from this lease:—

Table showing the Yield of the Britannia Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	9'50	19'85	2'09
1899	...	...	...	9'50	8'85	'93
Total				19'00	28'70	1'51

KOPCKE'S REWARD BLOCK, G.M.L. 522.—There are four short though well-defined reefs outcropping on this lease, but no work of any kind has been done upon them.

REWARD CLAIM 94.—A good deal of work seems to have been done upon this lease. The leader has been worked for a length of 320 feet along the outcrop. There are two vertical shafts 80 feet apart. The western shaft attains a vertical depth of 50 feet, and has been put down on the western end of a slope, along the footwall of the vein. At the foot of the shaft is a quartz lenticule about three inches in thickness; on the hanging wall side of the vein is about eight to twelve inches of laminated quartz, passing gradually into the softer decomposed (aluminous) country rock. The eastern shaft has been carried down to a vertical depth of 130 feet, but has been filled up to a depth of 100 feet. The largest of the quartz lenses exposed attains a maximum thickness of 12 inches, and a minimum of a quarter of an inch. The quartz contains a little pyrites, green carbonate of copper, and a little galena, which latter occurs pretty well all along the leader. Free gold is showing in the stone at grass, of which there was about 40 tons awaiting crushing. The charges for crushing (30s.) and cartage (10s.) amount to about £2 per ton.

The following table gives the yield of this lease :—

Table showing the Yield of Kopcke's Reward Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1898	31·00	160·59	5·18
1899	67·85	210·06	3·09
1900	36·25	101·75	2·80
1901	46·25	126·60	2·73
1902	49·70	147·26	2·96
1903	71·50	166·25	2·32
1904	49·00	125·38	2·55
Total	351·55	1,037·89	2·95

WHENNA-PAI, G.M.L. 532.—A small three-acre lease traversed by the leader, upon which a little work has been done, but the workings are inaccessible.

DAYLIGHT, G.M.L., 496.—An abandoned six-acre lease adjoining the Juneau on the west.

A good deal of work has been done at different points along the outcrop of the leader, which traverses the whole length of the property. A tunnel 45 feet in length has been put in eastward, close to the eastern boundary of the lease, and exposes quartz lenticules of the usual type. Mr. Inspector Gladstone, writing in

1898, noted the sinking of a vertical shaft 25 feet deep, but such was not accessible to me.

JUNEAU, G.M.L. 479.—An abandoned six-acre lease adjoining the Criterion on the west. The only work done is an open cut about 120 feet in length put down to a maximum depth of 15 feet upon the line of lenticular quartz veins, the leader. As exposed in the open cut the width of one of these quartz lenses in two inches, and its depth 12 inches. About 100 feet south of the leader is a large ice-like quartz reef parallel to it, and outcropping for about 100 feet along the surface.

Two small crushings have been recorded from this lease, particulars of which are given in the table below.

Table showing the Yield of the Juneau Reef

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1898	5.75	5.55	.96
1899	8.10	9.78	1.20
Total	13.85	15.33	1.10

CRITERION, G.M.L. 508.—This property, now abandoned, lies at the south-eastern extremity of the long line of leases which extend across Warrawoona. A tunnel has been driven for a distance of 74 feet on a bearing of 208 degrees through decomposed schist inclined at a high angle to the north. At the face of the tunnel the main band of laminated quartz has been pierced. About a foot north from this is a quartz vein made up of small lenticules. Near the mouth of the tunnel is a vertical shaft measuring 29 feet in depth, but inaccessible at the present time. In addition to this and the tunnel, there are other workings, but as these are likewise inaccessible, no description can be given.

Near the south-eastern boundary of G.M.L. 508 (? on Lease 527, the Lucknow) is an open cut 60 feet in length, varying from 5 to 10 feet in depth, from which a vertical lenticular shaped quartz reef (or succession of quartz lenticules) has been extracted. This vein is the eastern extension of Kopecke's Leader. This open cut exposes a quartz reef underlying at 30 degrees in a direction of south 30 degrees east; there is a length of about 15 feet 4 inches exposed. At the surface the reef is 12 inches in thickness, and at

the bottom of the open cut, where it abuts against the leader, it has dwindled to four inches.

Table showing the Yield of the Criterion Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1898	...	...	...	8'00	3'30	41
1899	...	...	...	4'20	4'50	1'07
Total				12'20	7'80	63

LONE HAND, G.M.L. 512.—The most easterly of all the leases embraced within the limits of the geological map. This property has been abandoned for some considerable time. Operations appear to have been confined to opening up a large and well-defined reef, which traverses the northern boundary of the property. The reef has been opened up in three places, along the outcrop, and where exposed, it varies in thickness from one to two feet. The quartz [5783] is white, and contains the following minerals, the numbers in parentheses indicating their relative frequency:—muscovite (3), limonite (3), malachite (2), pyrites (2), chalcopryrite (1), chalcedony (1), gold (1). In addition carbonate of iron is present in some parts. The reef which underlies to the south has a fairly long outcrop.

SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.—In addition to the yield of the reefs described above, there are several others which it is impossible to specify, and the returns from which are given in the table below:—

Table showing the Yield from Sundry Claims, Warrawoona.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons	ozs.	ozs.
1897	...	...	...	5'00	28'93	5'78
1899	...	...	...	187'60	{ 200'82 *50'00	1'07
1900	...	...	...	12'20	32'50	2'66
1901	...	...	...	5'00	5'00	1'00
1902	...	...	...	22'50	35'02	1'55
1903	...	...	...	84'85	{ 332'57 ‡433'30	3'91
1904	...	...	...	70'45	‡138'45	1'96
Total				387'60	\$773'29	1'99

* Alluvial. † Specimens. ‡ Fine gold. § Alluvial an
specimens not included in total gold.

*Synoptical Table showing the Yield of the Warrawoona
Reefs up to the end of 1904.*

Name of Reef.	Ore	Gold	Rate
	crushed.	therefrom.	per ton.
	tons.	ozs.	ozs.
Admiral Dewey	8.45	4.55	.53
Bow Bells	488.70	855.69	1.76
Bow Bells Block No. 1	12.00	10.50	.87
Britannia	19.00	28.70	1.51
Brought to Light	8.75	7.96	.90
Carnoustie	45.40	178.11	3.92
Chance	4.00	8.35	2.08
Criterion	12.20	7.80	.63
Cuban	51.30	215.41	4.19
Cutty Sark	36.05	59.10	1.64
Dead Camel	18.75	63.50	3.38
Gauntlet	1,289.30	3,693.55	2.86
Gift	44.05	73.50	1.66
Golden Gate	59.45	124.50	2.09
Golden Gauntlet	3.00	4.60	1.53
Imperialist	695.75	810.58	1.16
Juneau	13.85	15.33	1.10
Klondyke	731.75	4,784.40	6.53
Klondyke Block	37.00	764.00	20.65
Klondyke Boulder	1,016.16	2,450.93	2.41
Klondyke No. 1 West	43.00	189.67	4.41
Klondyke Queen	9.90	13.75	1.38
Nelson	1.25	5.29	4.23
Princept	2.15	5.00	2.32
Princess of Alaska	40.00	70.61	1.76
Rangatira	8.50	5.15	.60
Reward Claim 94	351.55	1,037.89	2.95
St. George	20.00	124.00	6.20
Tom Thumb	36.55	164.66	4.50
Treble Event	3.25	4.00	1.23
Wheel of Fortune	206.35	249.95	1.21
Sundry Claims	387.60	{ 773.29 *50.00 +433.30 }	1.99
Cyaniding ... ..	...	†6.56	...
Total	5,700.01	17,294.18	3.03

* Alluvial. † Specimens. ‡ Nine tons of sands.

C.—MARBLE BAR.

(With a Geological Sketch Map and Section.)

Marble Bar is the official centre of the Pilbara Goldfield, and the headquarters of the Warden, the Acting Inspector of Mines, and other officials. The relative position of the centre may be seen by a reference to the locality map which forms the frontispiece to this report. The locality derives its name from the picturesque "bar" of jasper which crosses the Coongan River, about two and a half miles to the south-west of the township. The district has had

a somewhat chequered career, and the feverish activity which at one time prevailed has given place to more prosaic conditions.

The mining centre of Marble Bar forms the westernmost extension of that auriferous zone referred to as the Marble Bar, Warrawoona, Yandicoogina, and Mount Elsie Group.*

A geological sketch map, to which is attached a generalised section across the field, designed to illustrate its salient structural features, accompanies this report (Plate VII.). As was the case in most of the other mining fields of the State, by far the larger portion of the area was practically a blank upon any of the existing maps, operations had to be commenced by preparing a plan of the more immediate vicinity of the mines.

Marble Bar lies close to what may be called the Main Range, which presents a fairly bold front to the eastward, and the country is drained by the Coongan River and its tributaries—Duffers and Sandy Creeks.

The Marble Bar centre presents features which link it geologically with Warrawoona and Yandicoogina.

Since the first discovery of the field, about 16 years ago, Marble Bar † has yielded 16,306·74ozs. of gold, resulting from the milling of 8,407·20 tons of ore; these figures give an average of 1·93ozs. of gold per ton. In addition to these figures there have been officially recorded 2,082ozs. from unknown tons, and 82ozs. of specimens, thus bringing the total yield up to 18,470·74ozs.

The various formations represented consist of a series of schists and allied rocks, granites, greenstones, and certain volcanic rocks, which may possibly represent the Nullagine Series as referred to in the earlier pages of the report.

The auriferous reefs of the more immediate vicinity of Marble Bar are embraced within a comparatively narrow belt of greenstone schist, running north and south, and which, as may be seen by an inspection of the Geological Sketch Map (Plate VII.), has a length of a little over three miles.

The district has been subjected to a considerable amount of faulting, and wherever possible the position and extent of these faults have been laid down upon the map.

General Geology.

The different rock masses have as far as possible been mapped, but it has not been found possible to do this in the same detailed way with regard to all the other rocks lying between Marble Bar and the Coongan River.

* Bulletin No. 15, p. 33 *et seq.*

† *i.e.*, the Marble Bar District as defined by the Mines Department.

Alluvial Deposits.

Most of the watercourses in the district are occupied with a more or less width of alluvium, but in no case did these deposits attain any great thickness, nor are they of any economical importance.

Schists.

By far the largest portion of the district embraced by the geological map is made up of schists, both acidic and basic, which bear a very strong resemblance to those occurring at Warrawoona.

Some of the schists in the vicinity of Hospital Hill, and adjoining the road to Nullagine near the crossing of Sandy Creek, are associated with beds which have every appearance of being transmuted quartzites and conglomerate. Much more detailed investigation, however, than was possible at the time I visited the district is necessary before it can be definitely asserted that these acidic schists are of sedimentary origin. So far, however, as can at present be seen, it appears that these schists are arranged in synclinal trough, as shown in the generalised section at the foot of the Geological Map.

These schists are of economic importance by reason of the fact that they almost invariably form the matrices of the auriferous quartz reefs.

The schists are traversed by two bands of laminated quartz or jasper, the position of which is indicated on the geological map. The most conspicuous, however, is that known as the Marble Bar, which crosses the Coongan River about two and a-half miles south-west of the township. A view of this forms Photograph "I."

The "Bar" is a long razor-backed ridge (Photograph "J.") of laminated quartz or jasper, which rises to a considerable height above the general level of the surrounding country. The width of this band is naturally variable, but in one place near the Coongan River it measures as much as 220 feet from wall to wall. As seen in section, the banded jasper is inclined at an angle of 50 degrees to the north-west. The rocks forming this band can be followed across country for a considerable distance, and form a belt parallel to those similar beds described in Bulletin No. 15. The jaspers [609, 3593, 3695] present a brilliant appearance, due to the inter-lamination of red, white, and dark-coloured bands (Photograph "K") with intermediate varieties, the differences in colour being due to the occurrence of iron in the form of either limonite, hematite, or magnetite. Some portions of the rock contain small but perfect crystals of magnetite.

When carefully examined the banded jasper is found to be much fractured and faulted, Fig. 12 [609], some of the cracks thus formed being filled with secondary silica. The occurrence of these cracks filled with secondary silica is such as to cause the stone to break up into slabs and blocks of an extremely irregular size.

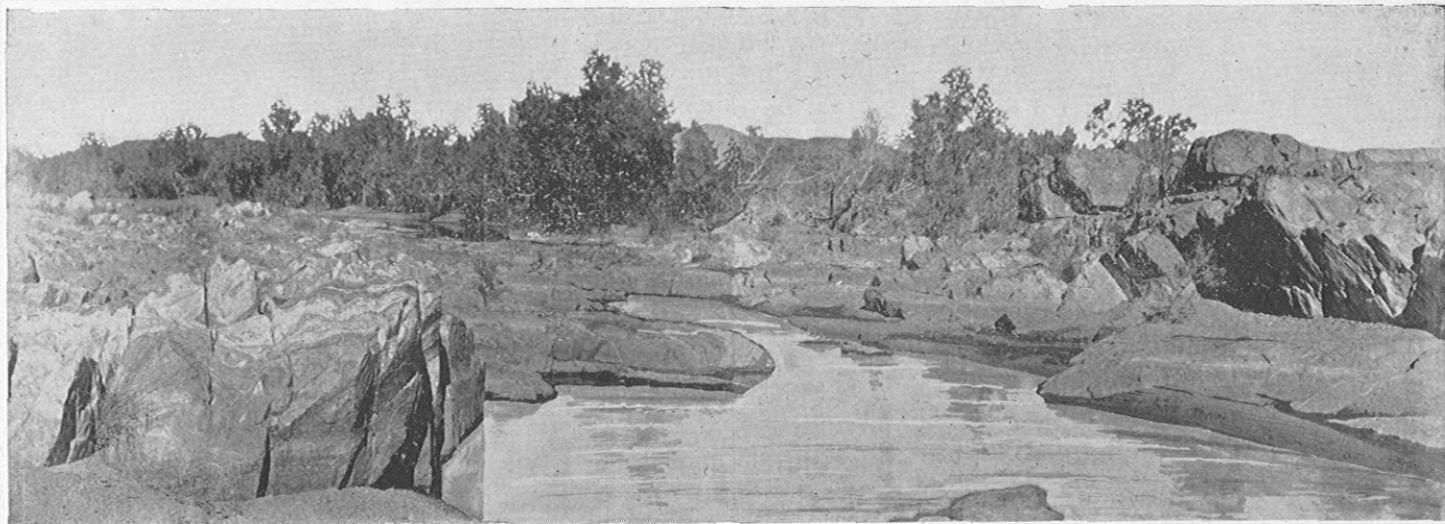


PHOTO.: S. J. BECHER

The Marble Bar, Coongan River.

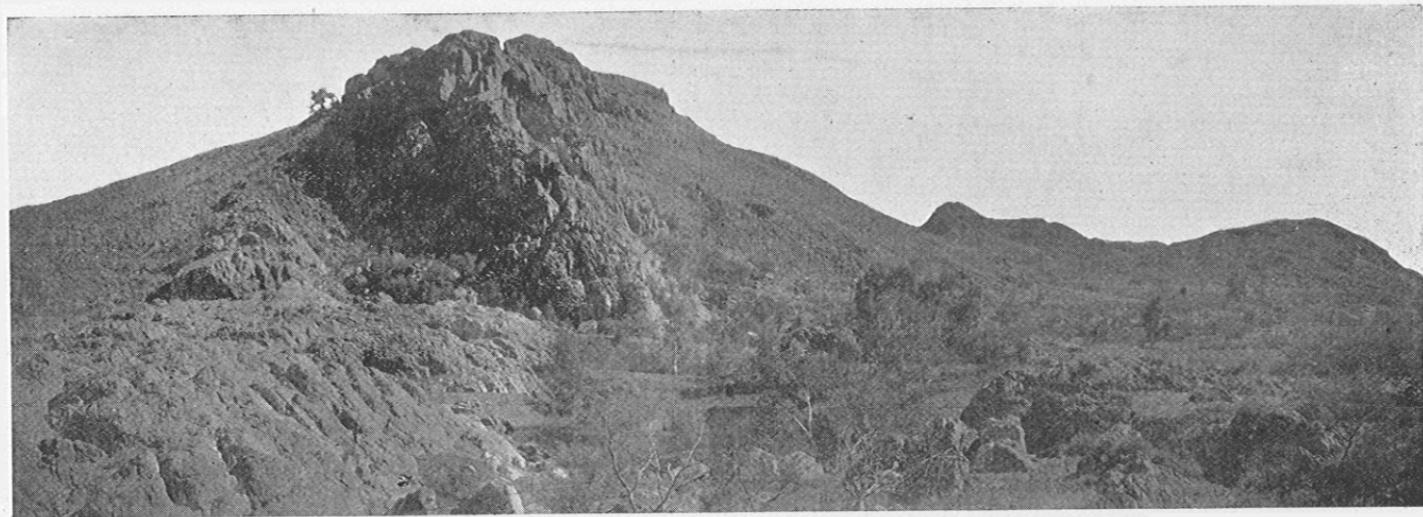


PHOTO.: S. J. BECHER.

Laminated Jaspideous Quartzite, Coongan River, near Marble Bar.

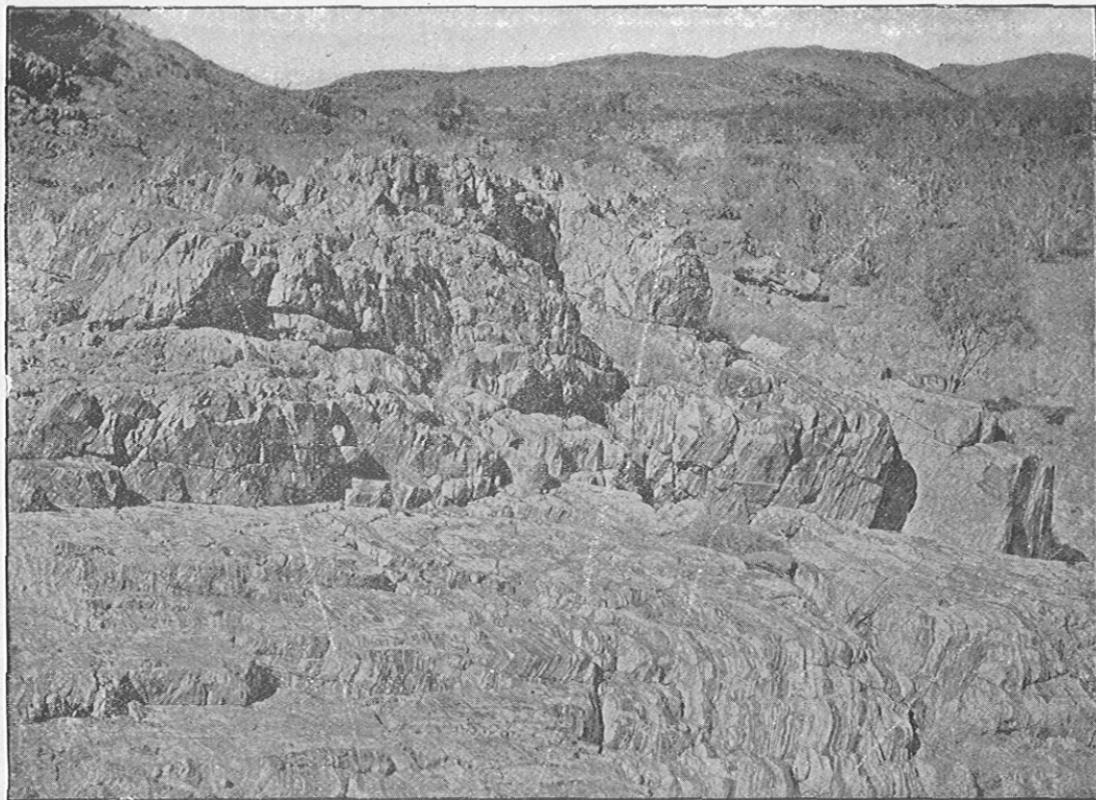
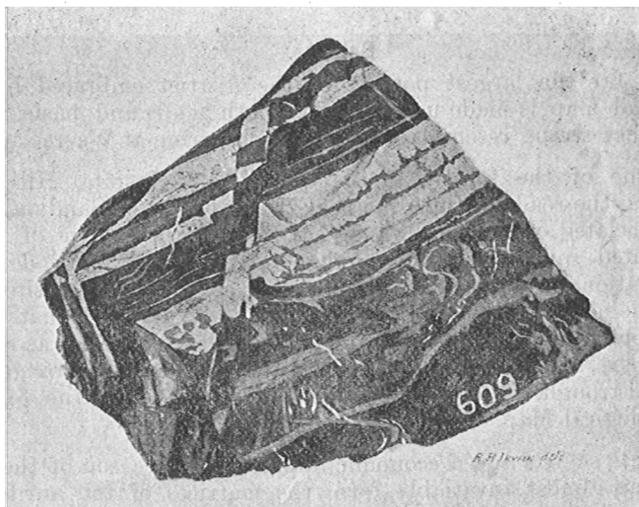


PHOTO: S. J. BECHER.

Banded Jasper, near The Marble Bar, Coongan River.

The jasper takes an excellent polish and those portions of the rock which may be found free from flaws, etc., could doubtless be

FIG. 12.



Faulted Jasper. Marble Bar.

used for ornamental purposes were its geographical position somewhat more accessible. A typical sample [3695] of this banded jasper which was cut and polished in Europe for use at the Paris and Glasgow Exhibitions is now in the Museum of the Geological Survey.

Granite.

A very large area of country to the east of the township of Marble Bar is occupied by granite. The mass presents in places a very rugged surface, which rises in two conspicuous hills of considerable elevation about due east of the town. The granite presents the same general features throughout its whole extent. In its lithological characters it consists of quartz, felspar, and a little mica. The mass forms one extremity of that granite which embraces the Moolyella Tinfield described in Bulletin No. 15.

Porphyry.

The granite has been invaded by dykes of porphyry [5392, 5812], whilst a very extensive area occurs in the vicinity of Duffer's Creek. In their lithological character these porphyry dykes resemble those of Warrawoona very closely. An analysis of a typical porphyry [5392] is given on page 12 of Bulletin No. 15. These dykes agree very closely with those porphyries of Warrawoona, described in the earlier pages of this report.

Gabbro.

Adjoining that tributary of Duffer's Creek, close to the eastern boundary of the geological map, is a fairly extensive area of a dark green basic rock [5809] which consists of felspar (saussurite?), a ferro-magnesian constituent, which appears to be hypersthene and its alteration products, a little quartz, and an iron ore. Another similar area occurs a little to the south of the Ironclad Mine, G.M.L. 2.

Diabase Dykes.

A very important feature in the geology of Marble Bar is the number of basic dykes, which an examination of the geological map shows have a general easterly trend. The dykes are all readily distinguished by their dark greenish colour, a rusty and in places exfoliating weathering, and in the majority of cases a tendency to verticality. The dykes have proved in the vicinity of Marble Bar of considerable value in working out the geological structure of the district. An inspection of the map demonstrates that only in one case do they intersect those sheared greenstones which form the auriferous series.

Owing to the marked features which many of these dykes exhibit on the surface, the mapping of them proved a relatively easy task. These basic rocks form part of that system of dykes which make such a marked feature in certain portions of the Pilbara Goldfield, and to which allusion has been made in the earlier pages of this report, and in Bulletin 15.

An examination of the geological map will show that many of these dykes have been faulted, but in no case does the horizontal shifting appear to have been very great. There are no data, however, by which any estimate of the amount of vertical displacement can be arrived at. The hade of the majority of the faults, however, is to the west, as may be seen in one or two sections. The dykes are all of a fine grain.

Economic Geology.

THE MINES.

Although practically none of the mines at Marble Bar were open to my inspection, the following information extracted from the field notebooks of the late Mr. S. J. Becher give some idea of the condition of affairs prevailing, and other cognate points at the time this officer visited these properties.

In order to facilitate description the mines are described in geographical order, commencing at the northern end of the leases. The position of the various properties is shown upon the geological sketch map attached (Plate VII.).

WESTERN SHAW No. 1 NORTH, G.M.L. 291.—The most northerly of all the leases embraced within the area of the map, and traversed by four small quartz reefs, which underlie west. No work, however, appears to have been done upon them. The reefs

are enclosed in the belt of sheared greenstone, which forms the main auriferous series of the district.

IRONCLAD NORTH, G.M.L. 299.—The lease is traversed by a well-defined quartz reef, which extends along the whole length of the eastern boundary of the property, and underlies to the west.

The developments on the property consisted of two vertical and one underlay shaft. One shaft had been carried down to a vertical depth of 25 feet, and continued for a short distance on the reef. A drive had been put in to the north from the foot of the vertical shaft to a point 35 feet distant, where the reef pinched out. Another drive had been continued to the south for 74 feet, and the reef is said to have averaged three feet in thickness, but only crushed, however, 8dwts. to the ton.

The second vertical shaft was 55 feet in depth, but no particulars appear to be obtainable regarding it. The underlay shaft had been carried down 35 feet.

The yield of this reef may have been included under the heading of "Sundry Claims."

IRONCLAD, G.M.L. 2.—The ore deposits on the Ironclad Lease consist of five well-defined reefs, which lie within the belt of greenstone, as shown on the map. The surface of the western half of the lease is occupied by granite, beneath which the sheared greenstone passes. At one time a fifteen-head battery was erected on the property. Near the north-west angle of the lease is the well, near the old battery site, which had been carried down to a vertical depth of 92 feet. In this well the granite extends to a depth of 40 feet, at which point it gives place to schist. The water level is said to have been at 75 feet, and the amount of water which the well made was estimated at 600 gallons per hour.

The northernmost shaft on the field is an underlay put down on the reef at a point about five chains from the northern boundary, but this is at the present time totally inaccessible.

The principal work on the lease has been carried out upon what may be called the main Ironclad reef, which outcrops boldly along a low ridge near the eastern boundary of the lease.

The stone which forms the main reef consists of white quartz, with very ferruginous patches.

A tunnel has been driven in from the side of the hill, along the strike of the reef on a bearing of 141 degrees for a distance of 145 feet, thence 14 feet on a bearing of 182 degrees to a point at which the main reef is first intersected. From this point a drive has been carried along the reef for a distance of at least 138 feet. The reef, as exposed at the first bend in the tunnel, measures three feet in thickness. These workings connect with the surface by two vertical shafts, one being 24 feet deep, and the reef stopped right up to the surface. In this portion of the workings the average thickness of the reef is four feet. The second vertical shaft, 128 feet west, had been carried down to a depth of 87 feet, and intersected the main

Near the south-east angle of the lease are three inaccessible shafts, not indicated on the map; the northernmost of the group being an underlay put down on the reef to a depth of 120 feet. The reef is said to have attained an average thickness of five feet. A second underlay, some little distance to the south on the same reef, is said to have been carried down to a depth of 40 feet. West of this is a vertical shaft 34 feet deep.

The following table gives, so far as can be ascertained from official sources, the yield of the Ironclad Reef:—

Table showing the Yield of the Ironclad Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1893	297·00	774·30*	2·60
1894	94·00	163·00	1·73
1895	1,097·00	258·00	·23
1896	531·00	239·02	·45
1898	21·50	7·25	·34
Total	2,040·50	1,441·57	·70

* Of this amount, 418ozs. has been obtained from a crushing of unknown tons.

IRONCLAD SOUTH, G.M.L. 108.—This is a 24-acre lease, adjoining the Ironclad. There are three small but distinct reefs upon the property, but very little work of any description appears to have been done upon them. An opencut has been put in along the reef, averaging about 12 inches in thickness, which may represent the southern extension of the Ironclad. Three underlay shafts, 34, 54, and 20 feet respectively, have been put down, but these are inaccessible. The principal workings are an underlay shaft, 65 feet in depth, from which drives have been put in east and west for distances stated to be 60 and 20 feet respectively. The only separate record of any crushing from this mine is one in 1895 of 61 tons, which yielded 24ozs. of gold, or at the rate of ·39ozs. per ton.

IRONCLAD BLOCK, G.M.L. 113.—The surface of the Ironclad Block Lease is occupied by granite, and a vertical shaft has been put down at a point seven chains from the south-east angle of the lease, and designed to intersect the main Ironclad Reef at about 200 feet. This shaft had been carried down to a vertical depth of 117 feet through granite. The relative position of this shaft is shown in Fig. 13, *supra*.

IRON DUKE, G.M.L. 387.—This lease embraces part of an area which included the old leases, G.M.Ls. 63 and 8.

A shaft, not shown on the plan, has been put down to a depth of 40 feet, upon an approximately north and south reef, which is

stated to have been of very variable thickness, but to have reached as much as three feet. The reef which underlays west is of white quartz.

In 1896, 40 tons of quartz raised are stated to have yielded 25·70ozs., or at the rate of 64ozs. per ton.

KEEP-IT-DARK, G.M.L. 296.—This old lease embraces a portion of the abandoned M.L. 8, The General.

A considerable amount of desolatory surface work has been done.

Two vertical shafts, 20 feet in depth, had been sunk upon the eastern extremity of the east and west reef, adjoining the main fault which traverses the property, but these were long ago abandoned. Two other underlay shafts, one of them 12 feet deep, had also been put down, but these were also inaccessible. A crushing of 32·5 tons in 1896 yielded 73·65ozs. of gold, or at the rate of 2·26 ozs. per ton.

The general reef outcrops upon what was originally M.L. 8 (G.M.L. 485) now embraced by G.M.L. 296.

The general reef which outcrops just outside the northern boundary of G.M.L. 296 is a well-defined body of quartz; striking north and south and underlying at an angle of between 40 and 50 degrees to the east. This reef has been extensively worked by the previous holders of the lease. The reef has been followed down from the surface for a distance of over 180 feet. A vertical shaft (Fig. 14) about 50 feet in depth intersected the reef, which was followed down for a further distance of 150 feet. The reef was abruptly cut off by a fault underlying west, but the shaft was continued for a further distance of 30 feet through country rock. A good deal of work appears to have been done underground, but there was very little to be seen at the present time. The fault seen at the bottom of the shaft is also visible in the workings at the eastern end of No. 1 level; the fault also underlies to the west. There are several faults in the vicinity of the reef, some of which are shown on the geological map (Plate VII.) so far as the small scale will admit.

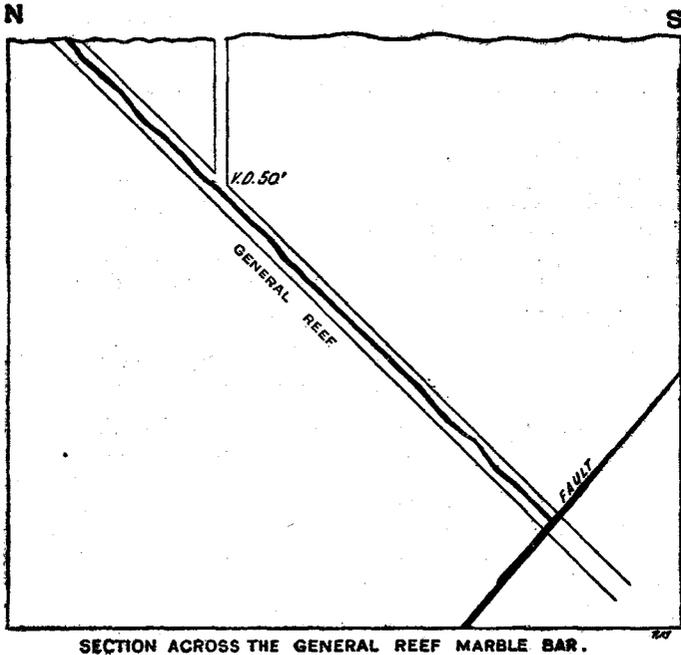
HOMEWARD BOUND, G.M.L. 613.—This lease embraces a portion of the ground embraced by the old Homeward Bound Lease, G.M.L. 579.

There is one fairly large-sized reef cropping out near the northern portion of the property, and trending generally north and south with an east and west arm. This reef is almost flat.

Upon the old Exhibition, G.M.L. 286, which includes the northern portion of the Homeward Bound, little else than surfacing seems to have been done.

Upon the greater portion of the western half of the Homeward Bound, lie all the old "Rejected" workings. Several shafts have been sunk, and much surface work done by previous owners upon an interrupted line of reef, which has a southerly underlay and a general east and west strike.

FIG. 14.



The reef is said to lie fairly flat and with an average thickness of about 12 inches, with, however, big bunches here and there.

An underlay shaft had been sunk on the reef to a depth, on 17th September, 1896, of 50 feet on a good body of stone.

The Rejected No. 1 Reef (on old G.M.L. 84) does, however, appear to be upon exactly the same line as that just described. The reef outcropping has been worked by a main vertical shaft 40 feet in depth, which, up to the end of September, 1896, had been continued on the underlay for a further distance of 81 feet. Two reefs are said to have been exposed in the workings, separated by a horse of country. The lower reef is said to have possessed good, well-defined walls, which had an underlie of about 35 degrees to the south. The upper reef, reputed to have been the most regular of the two, had an average thickness of about two feet. Near the foot of the underlay shaft, the reef varied from 18 inches to five feet in width.

So far as can be ascertained from the official figures, the yield of the reefs on the present Homeward Bound Lease appears to have been as shown in the following table:—

Table showing the Yield of the Homeward Bound Reef.

Year.	Name of Lease.	Ore crushed.	Gold therefrom.	Rate per ton.	Total Ore crushed.	Total Gold therefrom.	Average rate per ton.
Previous to 1897	Rejected, G.M.L. 105 ...	tons. 1,208'00	ozs. 1,827'00	ozs. 1'51	tons.	ozs.	ozs.
1897 ...	Do. do. ...	65'00	67'00	1'03	1,273'00	1,894'00	1'48
1898 ...	Homeward Bound, G.M.L. 615	249'75	261'15	1'04			
1901 ...	Do. do. ...	198'75	242'25	1'22	455'50	526'30	1'15
1902 ...	Do. do. ...	7'00	22'90	3'72			
Total					1,728'50	2,420'30	1'40

SHAMROCK, G.M.L. 160.—An old six-acre lease upon which a fair amount of work must have been done at one time or another. Near the north-eastern angle of the lease is an underlay shaft put down to a depth of 100 feet, on the reef outcropping on the crown of the hill. This reef was intersected by a vertical shaft, No. 1, and farther south-west by shaft No. 2, at depths of which there is no precise information. A third shaft had been sunk at a point 35 feet west of No. 1 to a depth of about 30 feet, but no particulars are available beyond the fact that a quartz reef five inches in thickness had been met with.

The following is a list of the crushings from this property, so far as are disclosed by the official statistics:—

Table showing the Yield of the Shamrock Reef.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
1895	tons. 52'25	ozs. 120'10 *	ozs. 2'29
1896	8'00	22'70	2'83
Total	60'25	142'80	2'37

* Includes 33ozs. from unknown tons.

TRUE BLUE, G.M.L. 157.—An old six-acre lease adjoining the Shamrock on the east. A considerable amount of open cast work has been carried out. The northernmost shaft on the lease is an underlay shaft 90 feet in depth, connecting with a vertical shaft 24 feet in depth, which had been continued for a further distance of 24 feet on the underlay of the reef. The reef averages two feet in thickness, and underlays about 30 degrees to the south-west. There

is another parallel reef below this one, which attains a thickness of about two feet.

The figures in the table below give the result of the crushings, so far as may be gathered from the official records :—

Table showing the Yield of the True Blue Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1893	...	...	...	*	61·20	...
1894	...	...	...	35·50	42·00	1·18
1895	...	...	...	92·50	168·82	1·82
1896	...	...	...	55·25	38·00	·68
Total	...	...	...	183·25	310·02	1·69

* Unknown.

MARBLE BAR, G.M.L. 288.—An old twelve-acre lease adjoining the Coongan Star Extended on the north, from which in the year 1898, 11 tons of ore yielded 15·70ozs. of gold, thus giving an average of 1·42ozs. of gold per ton.

COONGAN STAR, G.M.L. 92.—Upon this six-acre lease a good deal of *bonâ fide* work has apparently been done in times past upon a north and south reef, inclined at a very low angle to the west, but which makes no very pronounced outcrop on the surface. An old disused main shaft has been put down upon the summit of a low hill, and the reef worked out about 50 or 60 feet on the underlay.

A vertical shaft had been put down to a depth of 20 feet at a point 150 feet from the summit of the hill, but no particulars are obtainable respecting it.

Adjoining this is another 25 feet in depth, from the bottom of which a drive had been put in 40 feet to the south-east, whilst a third shaft near by had been sunk to an unknown depth. In addition to these old workings is a vertical shaft 33 feet in depth, at which point the reef is met with; this has been followed on the underlay for a further distance of 37 feet. About 100 tons of quartz have been raised and awaited crushing.

Table showing the Yield of the Coongan Star Reef.

Year.				Ore crushed.	Gold therefrom.	Rate per ton.
				tons.	ozs.	ozs.
1894	...	...	...	184·50	310·15	1·68
1895	...	...	...	75·50	131·80	1·74
1896	...	...	...	71·25	157·00	2·20
Total	...	...	...	331·25	598·95	1·80

COONGAN STAR EXTENDED, G.M.L. 287.—Near the south end of the lease, adjoining the south-east angle of the Coongan Star property, a shaft 25 feet deep had been put down upon a small but good quartz vein, from which a small trial crushing is asserted to have yielded an average of about 2ozs. per ton.

A quartz reef in granite country outcrops near the north-west angle of the lease, but no work appears to have been done upon it. A water shaft of unknown depth is to the west of the reef.

AUGUSTA, G.M.L. 615.—This lease, as at present constituted, embraces by far the larger portion of what was originally included in the Stray Shot, G.M.L. 3, the Excelsior, G.M.L. 21, and the Augusta, G.M.L. 7.

The Augusta reef makes a fairly distinct and well marked outcrop on the surface; the reef, however, has been interrupted near the southern angle of G.M.L. 280, by a north and south fault, which has but a slight throw.

The outcrop of the reef is traceable all round the north-east, east, and south-east sides of the hill, and averages about three feet in width, it extends westwards as far as the Stray Shot, where it is worked by several shafts. There seems, however, good reason to believe that the reef in the Surprise Lease, G.M.L. 167, adjoining the Stray Shot on the west, is the continuation of the Augusta, interrupted, however, by a small fault, lying parallel to that alluded to above. Along the eastern outcrop of the main Augusta reef stone has been broken out in several places.

The Augusta Reef has been worked by a main shaft which has been carried down on the underlie of the reef which is very flat for a considerable distance.

At the 75 feet, 150 feet, and the 266 feet levels drives have been put in for varying distances, but in the absence of an adequate plan of the mine any intelligible description of the reef underground is well nigh impossible, more especially as the majority of the workings are inaccessible.

Overlying the reef is a dyke [5819] of a fine-grained rock, which, under the microscope, seems to consist principally of felspar and an altered dichroic ferro-magnesian constituent.

In the underlay shaft at the 75 feet level the main Augusta Reef is said to have attained a maximum thickness of seven feet, but in the lower levels of the mine it averages only about 12 inches. It is stated that where the reef is wide the good stone is confined to certain bands, chiefly, however, of highly-mineralised bands; in the lower levels of the mine, where the reef is smaller, most of the stone is said to have been worth crushing.

The main Augusta Reef extends right through the Excelsior and the Stray Shot, below the level of the Stray Shot Reef. A great number of shafts have been sunk at relatively short distances apart on the slope of the hill and a considerable amount of surface

work done. The quartz is of a darkish hue, and contains relatively small quantities of the sulphides of iron, copper, and lead.

Table showing the Yield of the Augusta, Stray Shot, and Excelsior Reefs.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Previous to 1897	3,349'00	{ 9,219'00 *2,082'00 }	2'75
1897	1,661'70	1,818'28	1'09
1898	291'70	363'49	1'24
1899	230'00	322'40	1'40
1900	72'00	{ 30'96 †195'00 }	·43
1901	15'00	26'60	1'77
Total	5,619'40	†11,780'73	2'09

* From unknown tons. † From tailings. ‡ Does not include ounces from unknown tons and from tailings.

SUNDRY CLAIMS FROM THE DISTRICT GENERALLY.—In addition to the yield of the reefs described above, there are several others which it is impossible to specify and the returns from which are given in the table below :—

Table showing the Yield from Sundry Claims, Marble Bar.

Year.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
1897	94'50	119'17	1'26
1898	206'00	{ 444'15 *1,000'00 }	2'15
1899	104'30	{ 244'62 *1,770'00 }	2'34
1900	15'00	14'00	·93
1903	24'00	24'00	1'00
1904 ... ..	...	†916'35	...
Total	443'80	†845'94	1'90

* Alluvial. † Alluvial and dollied. ‡ Does not include alluvial and dollied.

It is, however, not quite clear from the manner in which the returns are presented whether or not these sundry claims include the yield from reefs in other centres not embraced within the limits of the Geological Map of Marble Bar.

*Synoptical Table showing the Yield of the Marble Bar
Reefs up to the end of 1904.*

Name of Reef.	Ore crushed.	Gold therefrom.	Rate per ton.
	tons.	ozs.	ozs.
Augusta	5,619.40	14,057.73	2.50
Augusta No. 1 South	66.00	149.60	2.26
Coongan Star	331.25	598.95	1.80
Excelsior	Included under Augusta.		
General	Included under Homeward		Bound.
Homeward Bound	1,728.50	2,420.30	1.40
Ironclad	2,040.50	1,441.57	.70
Ironclad South	61.00	24.00	.39
Iron Duke	40.00	25.70	.64
Keep-it-Dark	32.50	73.65	2.26
Marble Bar	11.00	15.70	1.42
Pillendinnie	1.00	342.00	342.00
Rejected	Included under Homeward		Bound.
Robert Bruce	112.00	116.92	1.04
Shamrock	60.25	142.80	2.37
Stray Shot	Included under Augusta.		
Sundry Claims	443.80	4,532.29	10.21
Trafalgar	30.00	90.00	3.00
True Blue	183.25	310.02	1.69
Total	10,760.45	24,341.23	2.26

General.

In the latter end of last year, while in the North-West, a communication was received from Mr. J. Isdell, M.L.A., the Parliamentary representative of the district, containing a request that the tailings in the Marble Bar District be experimented upon by the Department, with the view of suggesting a method by which the large quantity of gold reported to have been lost in previous years could be recovered.

In accordance with instructions, attention was devoted to the question while at Marble Bar, and the heap of accumulated tailings at (a.) the Ironclad Mine, and (b.) on M.A. 1, were sampled by myself and Mr. Talbot, the Field Assistant.

These, on being received in Perth, were dealt with in the official laboratory, and reported on by Mr. E. S. Simpson, as follows :—

“The following are the results of extraction tests made on two samples of tailings collected by you at Marble Bar :—

“G.S.L. 687, IRONCLAD MINE.—These tailings consisted mainly of quartz sand, with a small percentage of clay and iron oxides, a very small amount of pyrites and a minute trace of copper. No antimony was present. The samples carried 28 per cent. of slimes. Percolation was easy and rapid. Cyanide consumed 0.63 lbs. per ton. Assay value of tailings, 4dwts. 15grs. per ton; of residues, 1dwt. 9grs. per ton. Extraction, 70.3 per cent. after three days leaching.

“There are no metallurgical difficulties whatever in the way of treating these tailings by the cyanide process. The question of their successful treatment resolves itself into one of economics solely, viz., whether or not 13s. 9d. (the value of the gold which it is possible to extract) will, under local conditions, do more than pay for the cost of extraction.

“G.S.L. 688, M.A. 1.—These tailings also consist mainly of quartz sand, with a small percentage of clay and iron oxides, a trace of pyrites, a slight trace of antimony, and copper carbonates equal to 0.15 per cent. of copper. The sample contained 28 per cent. of slimes. Percolation was very good. Cyanide consumed was very high, viz., 4.19lbs. per ton, probably owing to the copper present. Assay value of tailings, 3dwts. 6grs. per ton; of residues, 1dwt. 22grs. per ton. Extraction 41.0 per cent., after three days leaching.

“It would appear to be impossible to treat these tailings successfully. In the first place they are not rich in gold; in the second, the copper present causes the extraction to be very low, and the consumption of cyanide so high as to be prohibitive.”

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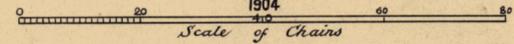
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GEOLOGICAL SKETCH MAP OF NULLAGINE

PILBARA G. F.
BY
G. Gibb Maitland
GOVERNMENT GEOLOGIST

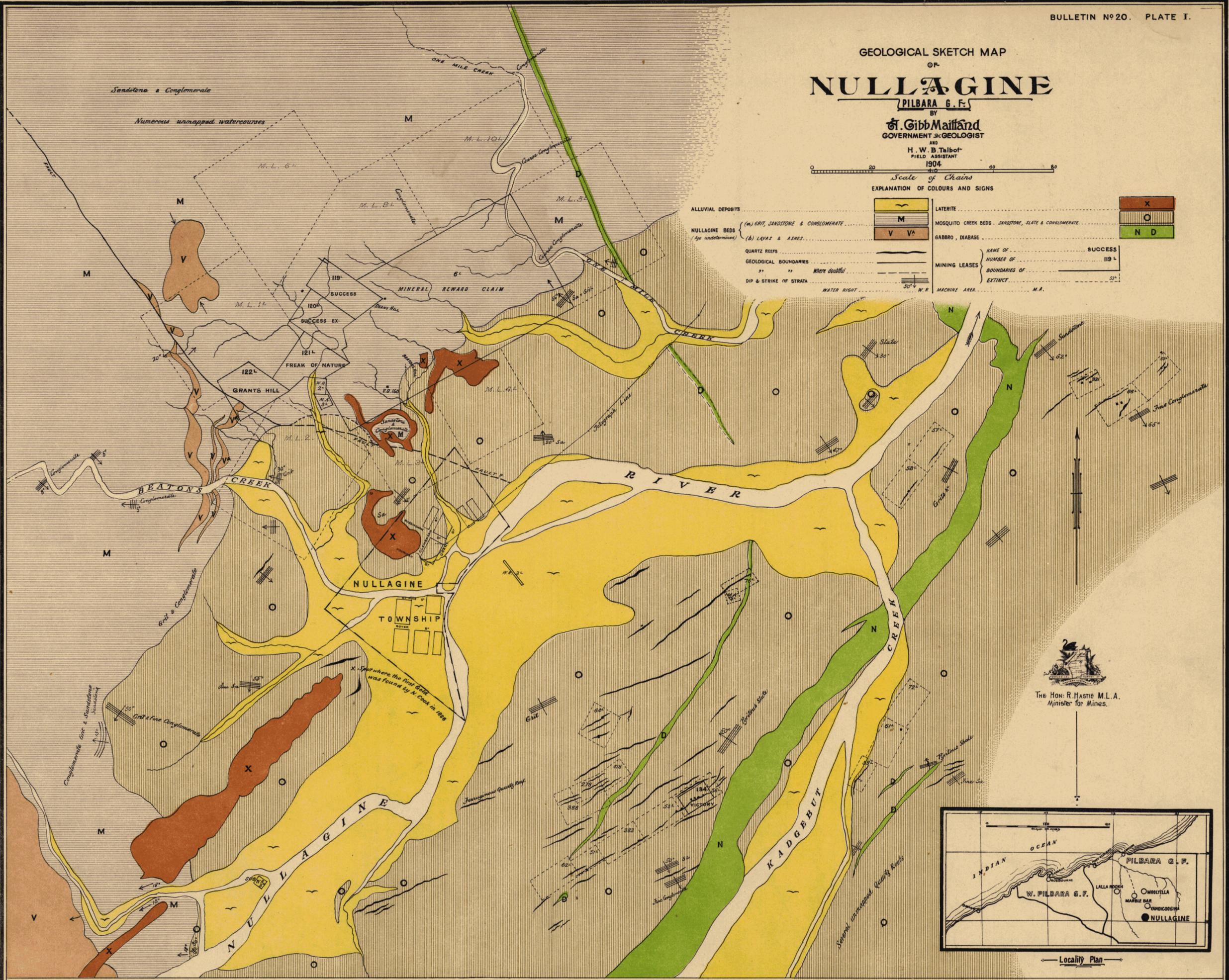
H. W. B. Talbot
FIELD ASSISTANT

1904

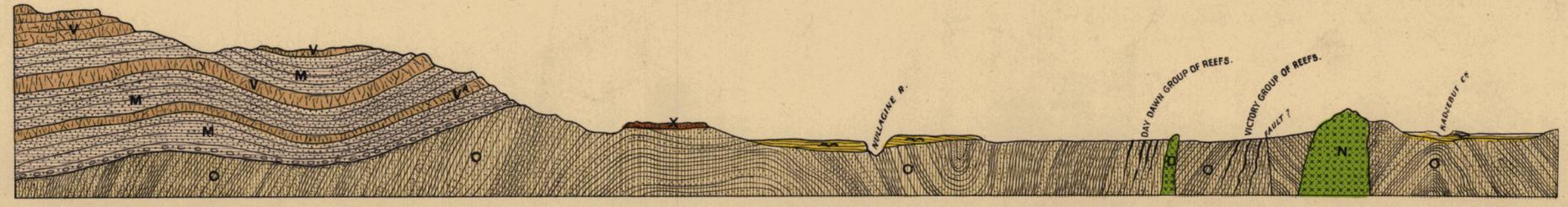
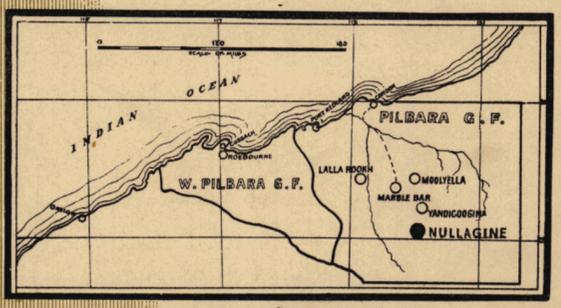


EXPLANATION OF COLOURS AND SIGNS

ALLUVIAL DEPOSITS	(a) GRIT, SANDSTONE & CONGLOMERATE	LATERITE	X
NULLAGINE BEDS (Age undetermined)	(b) LAVAS & ASHES	MOSQUITO CREEK BEDS - SANDSTONE, SLATE & CONGLOMERATE	O
QUARTZ REEFS		GABBRO, DIABASE	N D
GEOLOGICAL BOUNDARIES		NAME OF	SUCCESS
DIP & STRIKE OF STRATA	Where doubtful	NUMBER OF	119 L
		BOUNDARIES OF	
		EXTINCT	59 L
		MACHINE AREA	M.A.

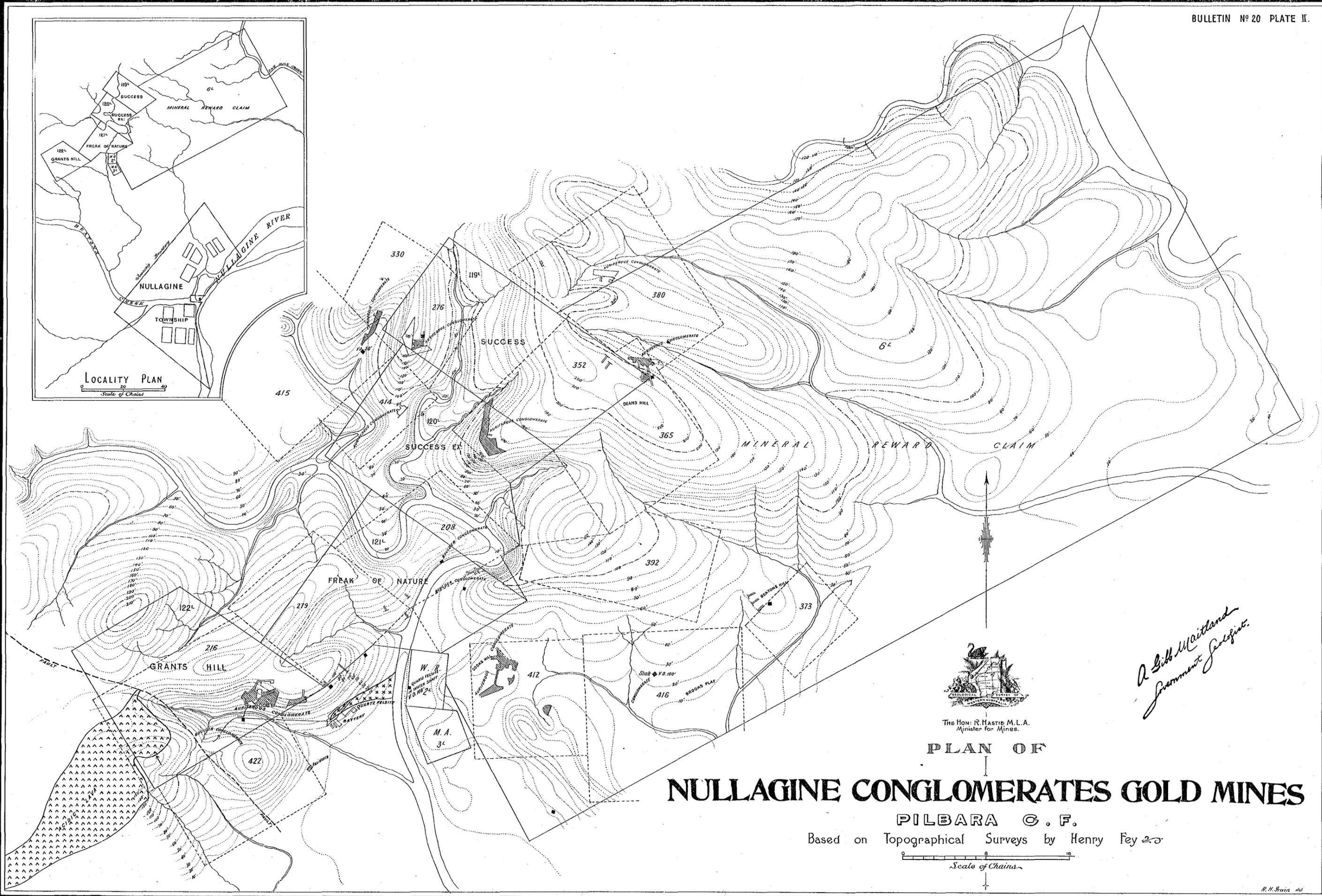
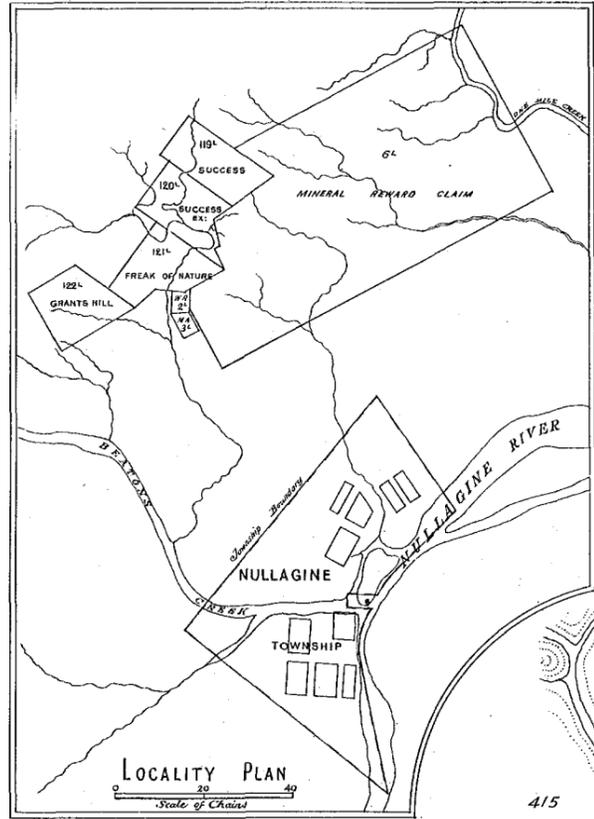


The Hon. R. HASTIE M.L.A.
Minister for Mines.



GENERALISED SECTION ACROSS THE VALLEY OF THE NULLAGINE RIVER SHEWING (a) THE NULLAGINE SERIES WITH INTERBEDDED IGNEOUS ROCKS, AND (b) THE MOSQUITO CREEK BEDS WITH INTRUSIVE IGNEOUS ROCKS.
LENGTH OF SECTION ABOUT FOUR MILES. NOT DRAWN TO SCALE.

R.H. Irwin del.



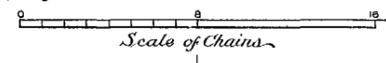
*A. G. Maitland
Government Geologist.*



THE HON. R. HASTIE M.L.A.
Minister for Mines.

**PLAN OF
NULLAGINE CONGLOMERATES GOLD MINES
PILBARA C. F.**

Based on Topographical Surveys by Henry Fey 20



R. H. Smith del.



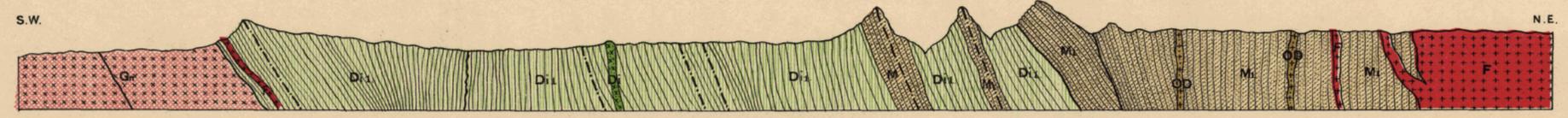
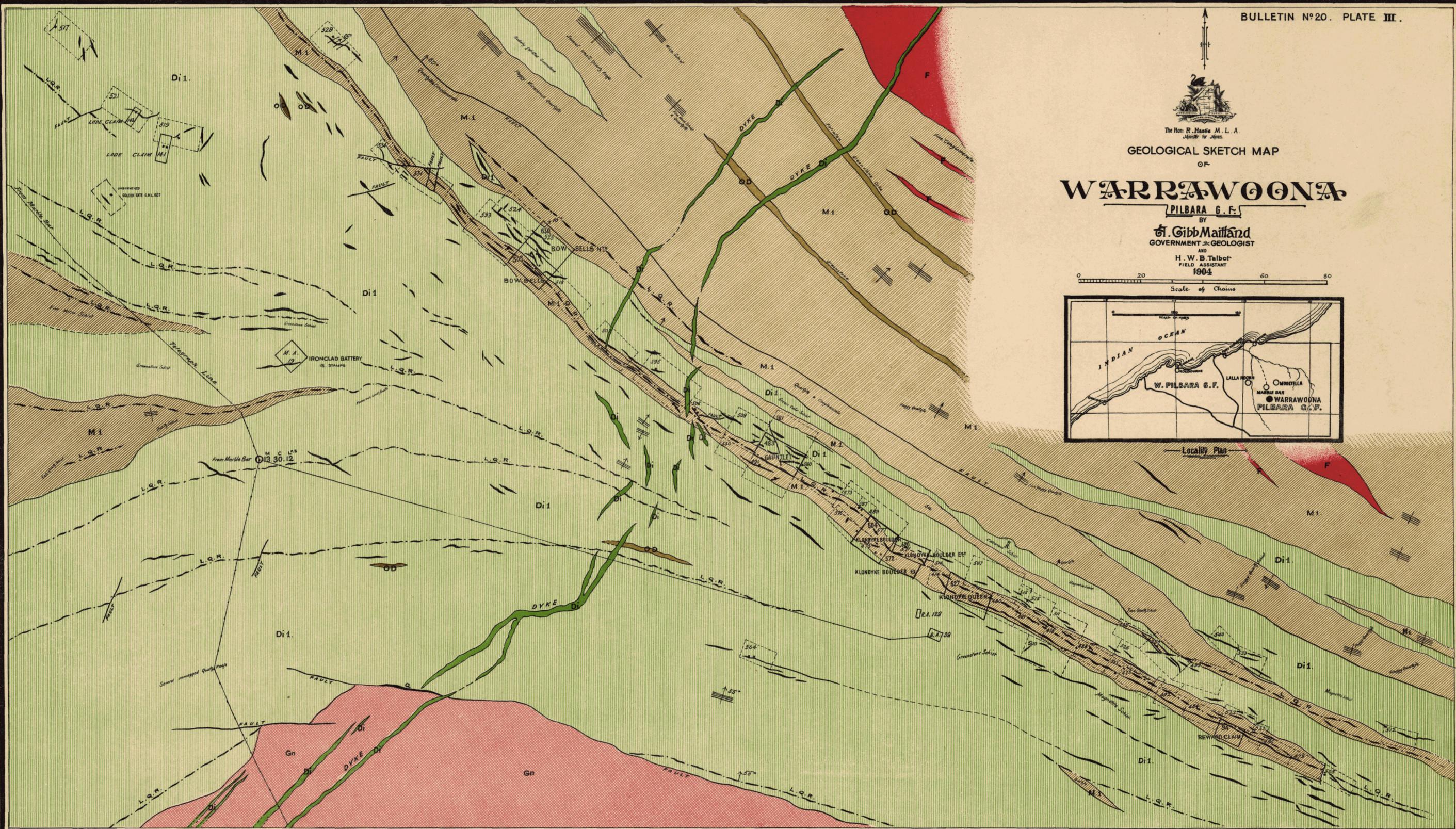
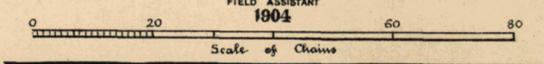
The Hon. R. Hannie M. L. A.
Minister for Mines
GEOLOGICAL SKETCH MAP
OF

WARRAWOONA

PILBARA G. F.

BY
G. Gibb Maitland
GOVERNMENT GEOLOGIST

H. W. B. Talbot
FIELD ASSISTANT
1904



GENERALISED SECTION ACROSS WARRAWOONA
LENGTH OF SECTION ABOUT THREE AND A HALF MILES. NOT DRAWN TO SCALE.

EXPLANATION OF COLOURS AND SIGNS

- QUARTZITE, CONGLOMERATE, QUARTZ SCHIST, MICA SCHIST & ALLIED SEDIMENTARY ROCKS. M1
- GREENSTONE, MAGNETITE, SERPENTINOUS SCHIST & ALLIED IGNEOUS ROCKS. Di 1
- GRANITE Gn
- FELSITE & FELSPAR PORPHYRY F
- BASIC DYKES D1 (NEWER) D2 (OLDER)
- Quartz Reefs Laminated Quartz Reefs Faults OD
- Mining Leases No. of Boundaries of Extinct Leases No. of Boundaries of
- Machine Area M.A. Business Area B.A. Residence Area R.A.
- Dip of Strata Geological Boundaries



GEOLOGICAL SKETCH MAP

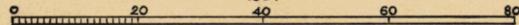
MARBLE BAR

PILBARA G. F.

BY
G. Gibb Mailland
GOVERNMENT GEOLOGIST

H. W. B. Talbot
FIELD ASSISTANT

1904

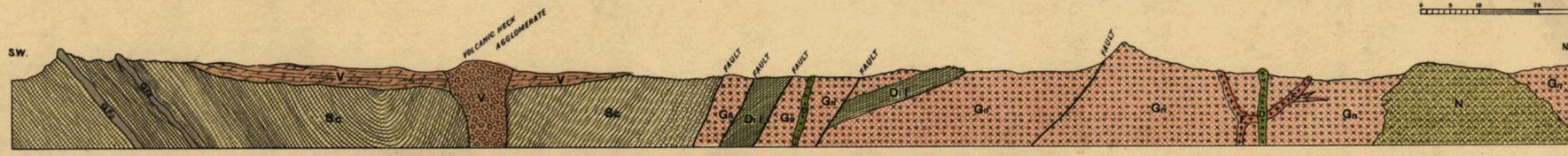
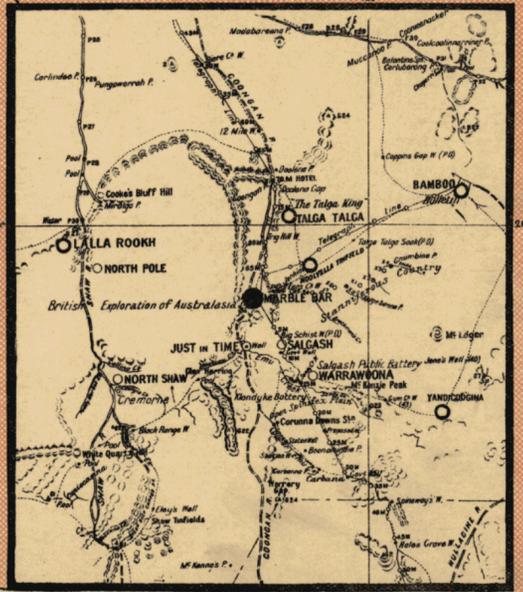
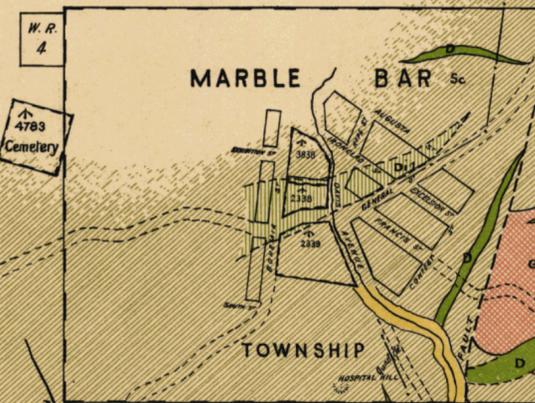
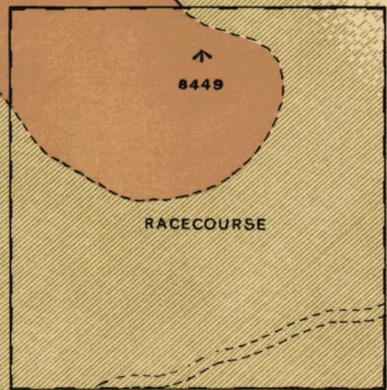
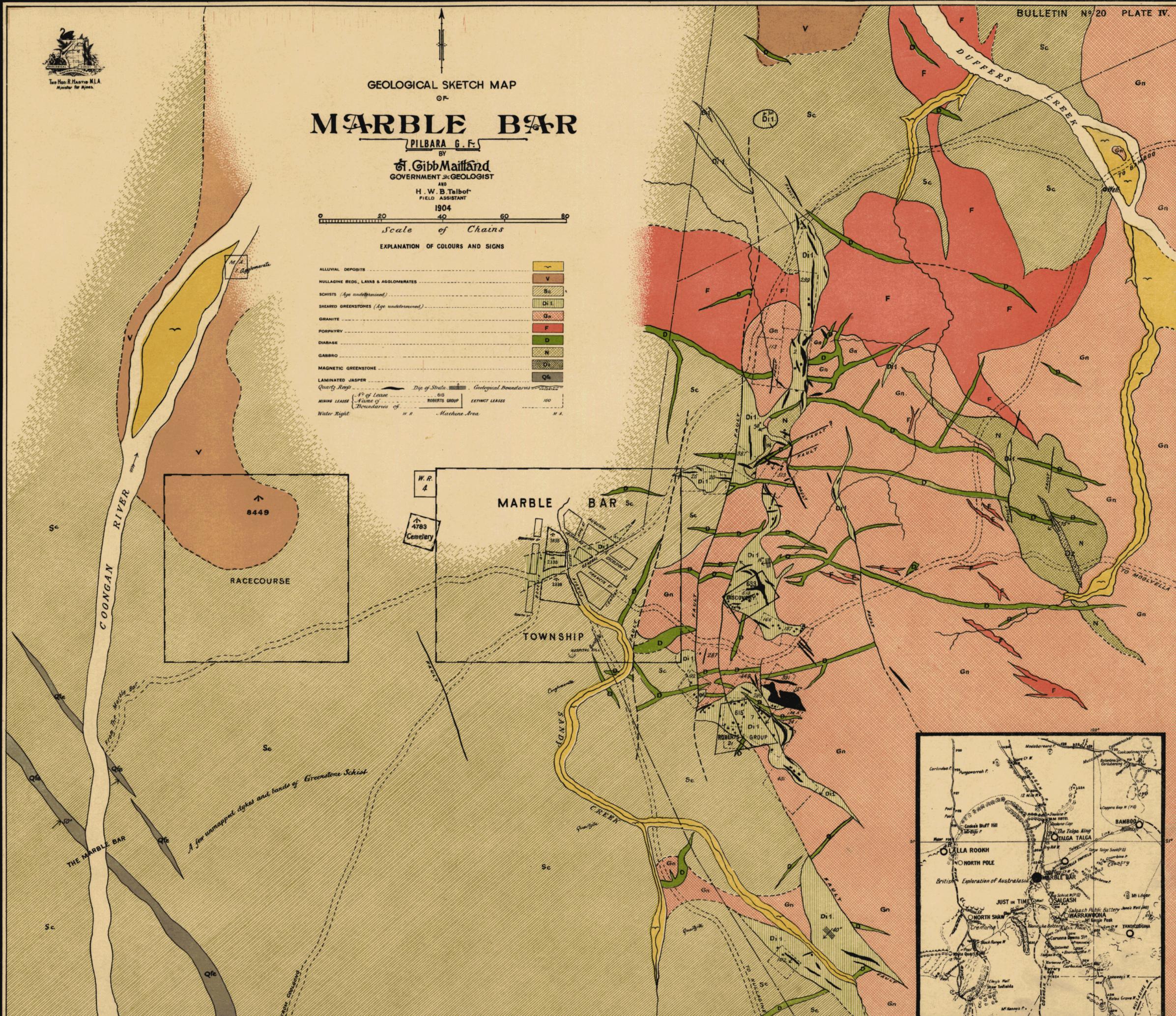


Scale of Chains

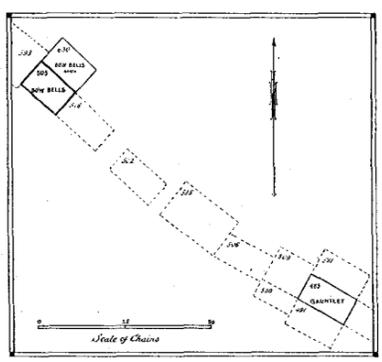
EXPLANATION OF COLOURS AND SIGNS

ALLUVIAL DEPOSITS	V
NULLAGINE BEDS, LAVAS & AGGLOMERATES	Sc
SCHISTS (Age undetermined)	Di 1
SHEARED GREENSTONES (Age undetermined)	Gn
GRANITE	F
PORPHYRY	D
DIABASE	N
GABBRO	Di
MAGNETIC GREENSTONE	Qc
LAMINATED JASPER	Qj

Quartz Reqs. $\frac{1}{2}$ " of Lease Dip of Strata Geological Boundaries
 Mining Leases Scale of 625 ROBERTS GROUP EXTINGUISHED LEASES 100
 Boundaries of W. R. Machine Area M. A.



GENERALISED SKETCH SECTION ACROSS MARBLE BAR.
LENGTH OF SECTION ABOUT FIVE MILES. NOT DRAWN TO SCALE.



Locality Plan



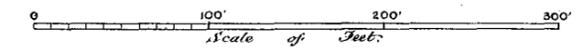
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Minister for Mines.

PLAN & SECTIONS OF THE BOW BELLS GOLD MINE

CHAMBERLAIN GROUP, WARRAWOONA.

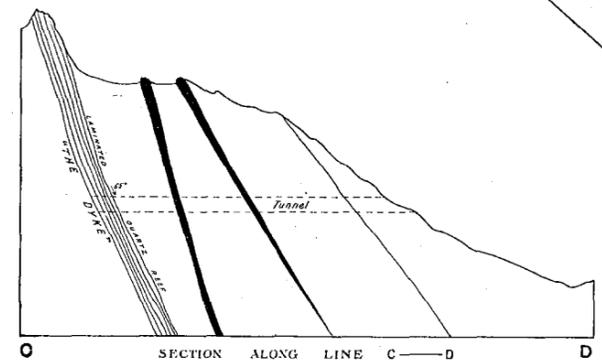
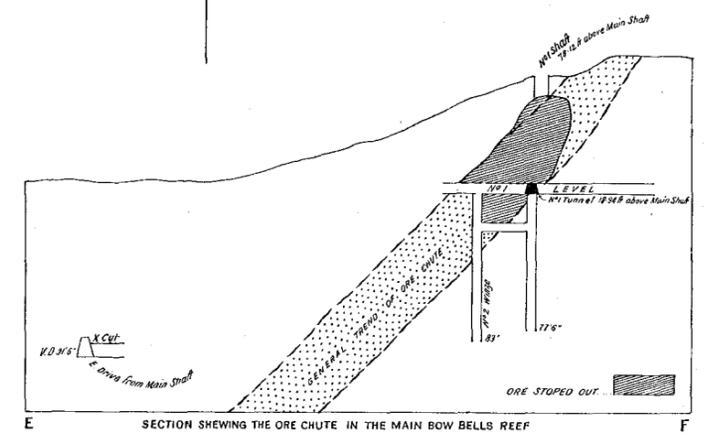
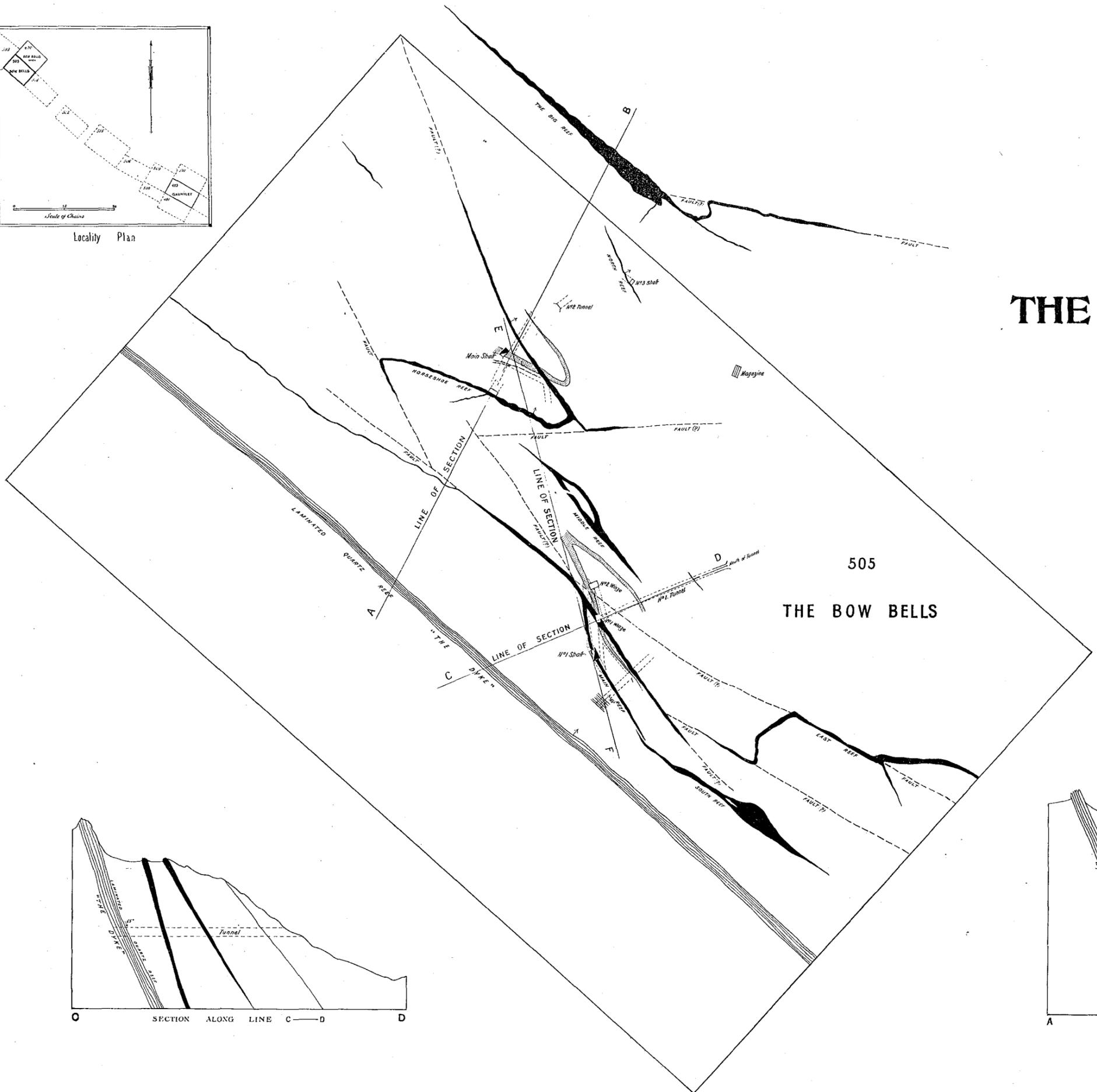
PILBARA G. F.

BY
G. Gibb Mailland
GOVERNMENT GEOLOGIST

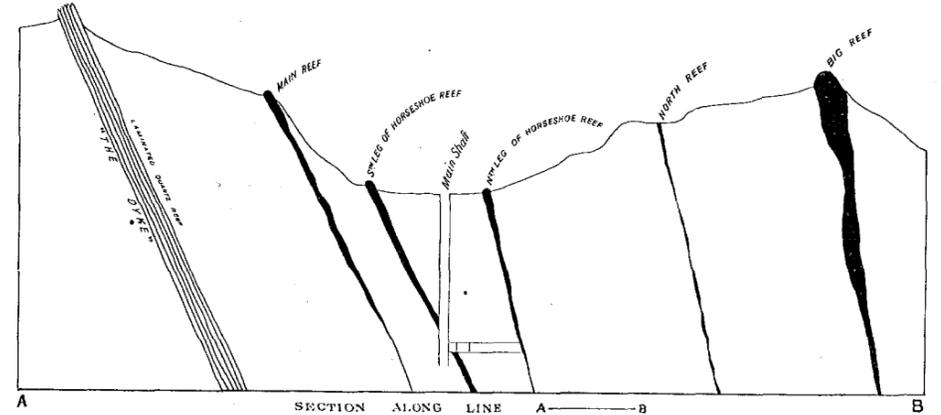


EXPLANATION

REEFS (outcrop)	LAMINATED QUARTZ REEF
" AT N°1 LEVEL	FAULTS
	THE DYKE



SECTION ALONG LINE C—D



SECTION ALONG LINE A—B

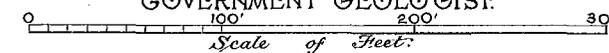
R. N. Irvine del. 22/1/04.

PLAN & SECTION OF THE GAUNTLET GOLD MINE

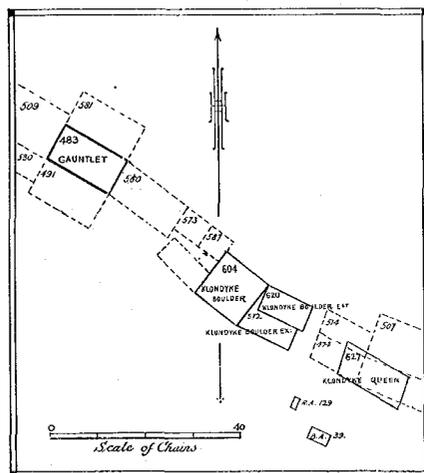
BADEN POWELL GROUP, WARRAWOONA.

PILBARA G. F.

BY
A. Gibb Maitland
GOVERNMENT GEOLOGIST



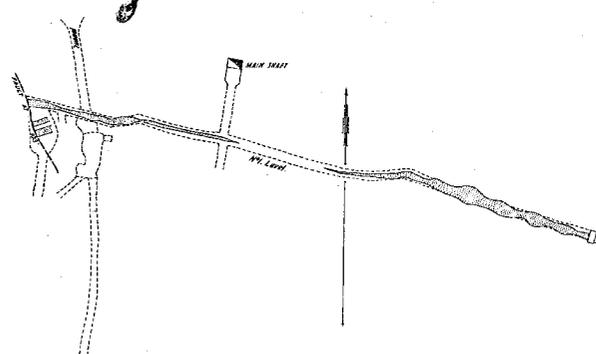
EXPLANATION	
REEFS (outcrop)	
AT N°1 LEVEL	
LAMINATED QUARTZ REEF	
FAULTS	
THE DYKE	



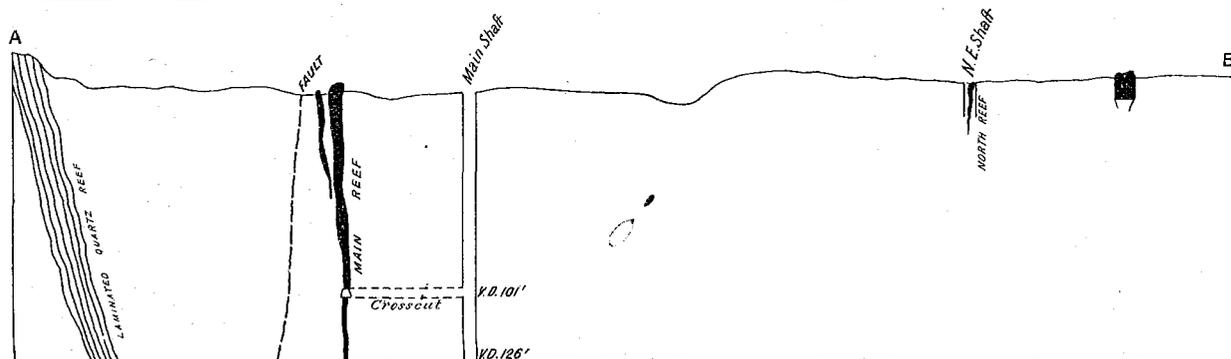
Locality Plan



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PLAN OF MAIN REEF AT N°1 LEVEL



SECTION ALONG LINE A—B

R. D. Irvine del.



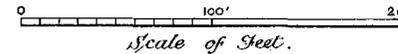
THE HON. R. HASTIE M.L.A.
Minister for Mines

PLAN OF THE KLONDYKE BOULDER GOLD MINE

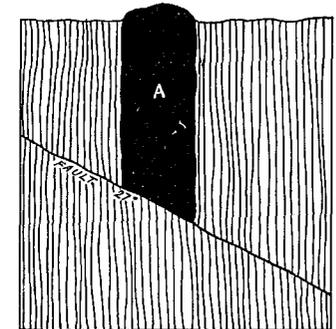
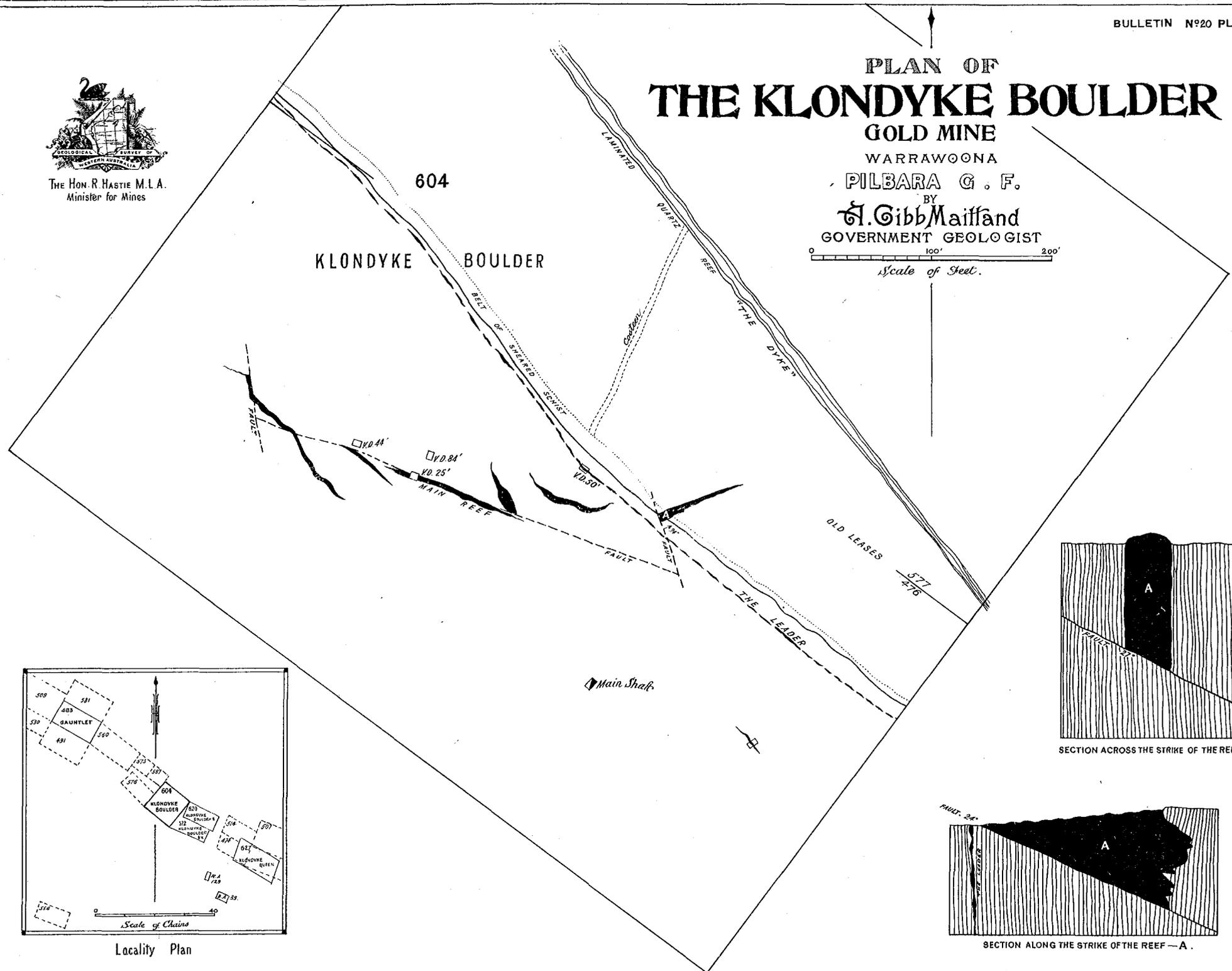
WARRAWOONA

PILBARA G. F.

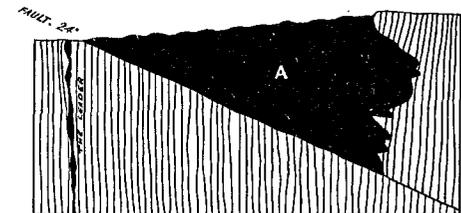
BY
H. Gibb Maiffand
GOVERNMENT GEOLOGIST



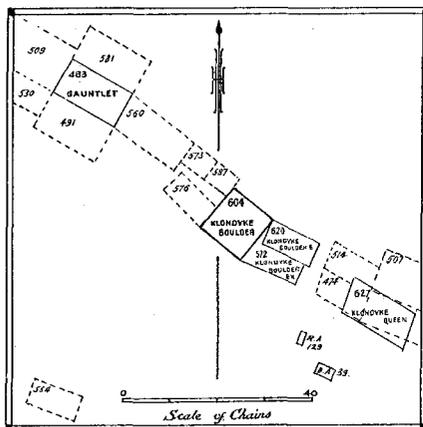
Scale of Feet.



SECTION ACROSS THE STRIKE OF THE REEF - A.



SECTION ALONG THE STRIKE OF THE REEF - A.



Locality Plan

P. H. Swin, del.