

W. Ellis.

1936.

WESTERN AUSTRALIA.

# ANNUAL PROGRESS REPORT

OF THE

# GEOLOGICAL SURVEY

FOR THE

YEAR 1935

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# Annual Progress Report of the Geological Survey of Western Australia for the Year ended 31st December, 1935.

*The Under Secretary for Mines.*

I have the honour to submit for the information of the Hon. the Minister for Mines my report on the operations of the Geological Survey for the year 1935.

## STAFF.

The staff was strengthened by the appointment at the beginning of February of two field geologists, Messrs. R. A. Hobson and R. S. Matheson, and a junior clerk, Mr. J. Outtrim. The staff now consists of four field geologists, a technical assistant, a junior clerk and a messenger.

## FIELD WORK.

*Government Geologist.*—On the 15th January I accompanied the Acting State Mining Engineer to Collie to advise on a faulting problem which had arisen in the Co-operative Colliery.

In February I attended, as a member, a meeting of the Executive Committee of the Aerial, Geological and Geophysical Survey of Northern Australia which was held in Melbourne. At this meeting final arrangements were made for the appointment of staff and the commencement of field work in the various territories to be examined by the Survey.

From the 16th April to 7th May I accompanied the newly appointed field staff of the Aerial, Geological and Geophysical Survey of Northern Australia to the Pilbara Goldfield, where operations were to commence, and in the company of Mr. K. J. Finucane, the senior field geologist, carried out a reconnaissance of the mining centres which it was proposed to examine during the first field season. Returning to Perth overland from Nullagine, I spent several days in an inspection of the field work then in progress at the Abbots mining centre, Murchison Goldfield.

In June I inspected the progress of field work at South Burracoppin (Burgess' Find), and also paid a brief visit to Leonora to tender advice to assisted prospectors in that district. At the end of June I visited Yellowdine (Palmer's Find) and sampled for departmental information the Yellowdine Gold Development Company's mine.

In July I reported on mining developments at Donnybrook and sampled, with negative results, a reef recently opened up on Dee's Block, Margaret River. Before returning to Head Office, I accompanied the Assistant Conservator of Forests on a visit to various areas in the southern districts in which the Forestry Department were operating, with

the object of gaining an insight into their problems and finding in what ways geological investigations could be of service in their solution. Immediately on my return to Perth I visited Mundaring to discuss problems which had arisen in connection with the Forestry Department's pine plantation at Mundaring Weir.

During August I made an extended tour of many of the central goldfields in company with Professor Clarke, of the Department of Geology, University of Western Australia. Many of the centres visited had not been seen by me previously, and I was able to take full advantage of Professor Clarke's wide experience as a former member of the field staff of the Survey. The results of this trip were a better understanding of many problems in the regional geology of the State and a better appreciation of the need of geological survey work in many districts.

In September I inspected the progress of field work on the re-survey of the southern portion of the Yilgarn Goldfield; and in the company of the Chairman of the Executive Committee and Executive Officer of the Aerial, Geological and Geophysical Survey of Northern Australia, I inspected the progress of the work being undertaken in the Pilbara Goldfield. Before returning to Perth I accompanied Mr. Finucane on a reconnaissance of the West Pilbara district in order to formulate plans for additional field work in that district during 1936.

In October I accompanied the Hon. the Minister for Mines and the Under Secretary for Mines to an interstate mining conference in Melbourne, and at its conclusion attended a meeting of the Executive Committee of the Aerial, Geological and Geophysical Survey of Northern Australia, also in Melbourne.

In November, at the request of the Engineer for Country Water Supplies, I chose a number of bore sites for water in the Wialki-Bonnie Rock district in the north-eastern wheatbelt.

In December I commenced an examination of the lode system on the Ora Banda Amalgamated Co.'s property at Grant's Patch, the completion of which has had to be deferred. On my way back to Perth I visited Londonderry to obtain specimens for a proposed exhibit of the State's commercially valuable mineral deposits and inspected the progress of field work at Marvel Loch, Yilgarn Goldfield.

The remainder of my time was fully taken up in administrative and routine duties at Head Office.

*F. R. Feldtmann, Field Geologist.*—During the year Mr. Feldtmann has been solely occupied in the preparation of a report on the western portion of the Boulder Belt. A breakdown in health necessitated his taking long service leave during the period between the 5th August and the 4th November.

*H. A. Ellis, B.Sc., A.O.S.M., Field Geologist.*—During January and February Mr. Ellis was engaged on field and office work in connection with a gold discovery at Mullewa, and water supply problems at Edwards' Find, Cave Rocks, Logan's Find, and Spargoville.

In March he carried out investigations on building stones from Moora for the Public Works Department, ore and rock specimens for the general public, and the preparation of field-sheets and the compilation of information preparatory to undertaking a detailed geological survey of the Abbotts Mining Centre, Murchison Goldfield.

During April and May he made a detailed geological survey of the Abbotts Mining Centre, embracing an area of about 40 square miles, and whilst in the Murchison district, located bore and well sites for pastoral and mining interests.

During June and July he prepared reports and plans on the Abbotts survey and water supply work, and made preparations for the re-survey of the southern portion of the Yilgarn Goldfield.

From August to November Mr. Ellis was engaged on field work in the Yilgarn Goldfield; and on completion of annual leave on December 18, compiled maps and collected information for a proposed journey to the vicinity of the Petermann and Rawlinson Ranges near the South Australian border.

*R. A. Hobson, B.Sc. (Hons.), Geologist.*—From his appointment on the 28th February until near the end of May, Mr. Hobson was engaged at Head Office mainly on the preparation of field sheets and compilation of data for field work at South Burracoppin (Burgess' Find) and the southern portion of the Yilgarn Goldfield. He also prepared a Summary of Petroleum Exploration in Western Australia.

From 21st May to the end of July he was engaged in field work at Burgess' Find and the preparation of maps and a report on this centre.

From 24th July to 15th December he was engaged in field work on the re-survey of the Yilgarn Goldfield.

The remainder of Mr. Hobson's time was taken up by office work in connection with the Yilgarn survey and the preparation of a progress report on centres examined by him during the course of the field work.

*R. S. Matheson, B.Sc., Geologist.*

Mr. Matheson was appointed on 1st March and for a month was engaged compiling base maps and other information for the Abbotts survey. In addition, he assisted with routine work in the office.

During April and May he assisted in the detailed survey of the Abbotts Mining Centre.

In the early part of June he assisted with the field work at Burracoppin, and during the remainder of June he was engaged in miscellaneous drafting work and the examination of bore cores.

From August to December Mr. Matheson assisted with the Yilgarn re-survey, and on his return to Head Office late in December, prepared a progress report covering centres examined by himself in the Yilgarn Goldfield.

#### HEAD OFFICE.

*Miss B. M. Bowley, B.Sc., Technical Assistant.*

Miss Bowley's duties have been heavy during the twelve months under review owing to the continual increase in volume of inquiries from the general public, and the great increase in clerical work brought about by intensive field work by other members of the staff. She has kept up to date the various technical records of the Branch, and as time permitted made progress with a reorganisation of the geological museum.

Reports following on the field work of the staff are attached, except where such were made for purely departmental purposes.

In conclusion, I take this opportunity to express my appreciation of the work and loyal support of each member of the staff during the past year.

F. G. FORMAN,  
Government Geologist.

#### YELLOWDINE GOLD FIND.

By F. G. FORMAN, B.Sc.

Since my first inspection of the Yellowdine find (November, 1934) development has been sufficient to enable a better idea to be obtained of the shape and size of the reefs on the principal prospecting areas, P.A. 3546 (Whindfield's) and P.A. 3547 (Egan's).

P.A. 3546.

In my first report it was suggested that two parallel reefs existed near the north-east corner of this area. Two shafts, No. 2 and No. 3, have since been sunk, respectively on the western and eastern exposure of quartz. The shafts are 67 feet apart and are connected at a depth of 50 feet by a crosscut which has exposed a width 56 feet of quartz carrying high values. At a point 26 feet from No. 2 shaft and 41 feet from No. 3 shaft prospecting drives have been put in north and south from the crosscut.

The northern drive is in quartz for a distance of 27 feet at which point the contact between the quartz and the country rock is dipping south at an angle of 65 degrees. The eastern wall of the drive from about ten feet back from the face is in country rock (quartz-mica schist) which separates the main quartz body into two portions in this space.

The southern drive has been put in a distance of 53 feet, the quartz again split near the face by a well-shaped mass of quartz-mica schist. At the wedge-face of the drive the western body of quartz turns sharply to the west, its contact with the country rock dipping south at an angle of 50 degrees. The behaviour of the quartz on the eastern side of the drive cannot be judged until further driving is done.

What was described in the first report as two parallel reefs is therefore a solid mass of quartz fifty-six feet in width from west to east and eighty feet from north to south. The eastern and western walls of the quartz mass are both dipping inwards at steep angles while the dips of 65 degrees on the northern end and 50 degrees on the southern end indicate an increase in size with depth in this direction with a general southerly pitch.

In No. 9 shaft, 136 feet south of No. 2 shaft, a quartz reef 11 feet wide at a depth of 44 feet from the surface has been driven on for a distance of about 20 feet to the north. Judging by its strike and the position of a body of quartz exposed in a costean between Nos. 2 and 9 shafts, this quartz is almost certainly a southern leg or extension from the large quartz bulge exposed between Nos. 2 and 3 shafts. This reef is probably the same as that exposed in No. 4 shaft, 70 feet south of No. 9, but No. 4 shaft was not examined during this visit.

P.A. 3547.

The main reef on this area, referred to in the previous report as Egan's reef, is being prospected by two shafts, Nos. 1 and 8, approximately 80 feet apart. No. 8 shaft was not inspected during this visit but is said to be down 51 feet. The quartz cut out in this shaft at a depth of 16 feet but is said to have been picked up again in the bottom of the shaft by crosscutting east.

No. 1 shaft has been sunk in solid quartz to a depth of 50 feet and drives north and south have been started. The quartz in this shaft contains a large amount of arsenopyrite and is similar to the quartz observed in the open-cut near No. 8 shaft during the last inspection.

North of No. 1 shaft a number of parallel and likely looking quartz reefs have been exposed in costeans, but no information as to values was obtainable.

#### INSPECTION OF GOLD PROSPECTING OPERATIONS AT DONNYBROOK.

By F. G. FORMAN, B.Sc.

The prospecting operations are on the site of the former workings two miles south of Donnybrook townsite, and on both sides of a creek flowing from south to north, a tributary of the Preston river.

Gold was first discovered at Donnybrook in 1897 by prospectors searching for alluvial gold, and soon after gold bearing quartz veins were disclosed. A crushing of 173 tons of ore giving a return of 501 ozs. of gold led to the proclamation of an area of 1,020 square miles as a goldfield in 1899. The goldfield was cancelled in 1906 after the production of 841.76 ozs. of gold from the milling of 1,653.3 tons of ore.

A short account of the geology and a description of the mine workings as they then were is given by Mr. T. Blatchford in the Geological Survey Annual Reports of 1898 and 1899.

The creek, which divides the field into two parts, flows in a narrow alluvial flat which effectively hides the nature of the underlying rocks. On the eastern side of the creek, Blatchford describes the rocks as being massive hornblendites and gneissic granites intersected by a narrow belt of hornblende rock pass-

ing in a north and south direction throughout the length of the field. Examination of dumps from shafts sunk since Mr. Blatchford's visit shows that the rocks in this locality consist of quartzites and slates interbedded with gneisses and basic rocks resembling hornblendites and gabbros. The appearance of the gneisses suggests that they are derived from sediments as every gradation can be seen between normal quartzites and fully developed gneiss.

The western side of the creek is occupied by sedimentary rocks of Permo-Carboniferous age, which include the Donnybrook sandstone, well-known in Perth as a building stone. Outliers of the Donnybrook sandstone on the tops of several of the hills on the eastern side of the creek indicate that the sediments at one time extended right across the valley and formed a sedimentary contact with the underlying metamorphic rocks. The contact of the two series is therefore not along a fault plane as has been suggested in the past.

The first workings inspected were in the sandstones to the west of the creek where Payne and party have obtained some rich prospects in old workings at a depth of about 20 feet. Here and elsewhere in the sandstone, the gold is associated with fracture zones filled with chalcedonic silica, and in places the country rock has been altered to a quartzite. The quartz veins in these fracture zones have the appearance of having been precipitated from cold solutions in fractures or joints in the sandstone, due probably to the circulation of cold surface waters.

It was mentioned by Blatchford and was also observed by the writer that the gold is of a peculiar arborescent form—obviously the result of secondary deposition. In my opinion the gold has been derived by solution from primary deposits in older rocks underlying the Donnybrook series, and has been re-deposited in the sandstones. Assay of this gold\* has shown it to be of a very poor quality, gold 49.29 per cent., silver 50.71 per cent.

The present workings on the east side of the creek are situated about 300 feet south of Camellari's shaft, and of the main shaft of the former Donnybrook Gold Mining Company. These workings are situated on the old metamorphic rocks and consist of two shafts connected by a drive at a depth of about 40 feet, in what appears to be a true lode channel. Samples taken by Mr. Desmond Brown and myself from the drive where a crushing was recently obtained, and from the crosscut at the bottom of one of the shafts, returned only traces of gold, from which it appears that the values occur only spasmodically. This fact and the presence of heavy iron oxides in the lode channel, combined with the undoubted presence of secondary gold in the sandstones to the west, suggest that this eastern line of lode is also affected by secondary enrichment, and that any primary deposits would be likely to be of lower grade than the ore obtained near the surface.

In these circumstances, an optimistic view cannot be taken of the present developments at Donnybrook. No doubt rich patches of secondary gold will continue to be found along the fracture zones in the sandstones to the west, and similar patches are also to be expected along the lode channel to the east, but there is little hope of the development of large payable deposits in the district.

\* G.S.W.A. Bull. 6, by E. S. Simpson, page 9.



## THE MULLEWA GOLD FIND.

By H. A. ELLIS, B.Sc., A.O.S.M.

### INTRODUCTION.

Early in January, 1935, a gold find was reported in the vicinity of Mullewa, which town is situated 65 miles east of Geraldton on the Geraldton-Wiluna Railway, and 331 miles north of Perth by the Perth-Wongan Hills-Mullewa Railway. The writer was instructed to examine and report on the find, and an examination of the area was made on January 6th and 7th, 1935.

### LOCALITY.

The find is situated about one mile south of the Mullewa Railway Station in undulating granite country at the head of a northerly trending drainage area in Railway Water Reserve No. 905, which feeds the Mullewa Railway dam.

The country in the vicinity is lightly timbered with Jam and Karara, and carries a fair growth of natural grasses.

### HISTORY OF FIND.

From information obtained locally, it appears that the locality was the scene of a small gold find some 25 years ago, and a short line of old shallow surface workings, consisting of costeans and excavations, bears evidence to this fact.

The quantity of gold obtained then is variously stated, but the maximum amount does not seem to exceed 25 ounces. No value can be placed on any such estimate, however, as the nature of this type of gold-winning is naturally likely to lead to indefinite statements.

In December of 1934, T. Johnsen, of Mullewa, found a small piece of haematite-bearing quartz carrying free gold, lying on the surface about 40 feet away from a shallow excavation on a narrow quartz reef. This specimen stone was in such a position that it could not have been shed from the original gold-bearing formation and placed by natural processes where found.

Intensive search failed to locate the origin of this specimen, but investigations in the old workings nearby revealed a small patch of quartz amounting to a few pounds weight only, carrying free gold.

Immediately subsequent to this discovery the area was extensively pegged, and early in January some 45 Prospecting Areas had been applied for.

It is here suggested that the specimen stone found on the surface was ejected from the original formation in the old workings nearby, during blasting operations by the original prospector. At present one prospector is working on the Prospecting Area on which the find was made, but no work is being done on the other areas.

### NATURE OF OCCURRENCE.

The formation on which the old workings are situated consists of a vertical quartz reef varying in width from a few inches up to 18 inches, in hard gneissic granite striking N. 30 deg. E. magnetic bearing, and parallel to the bands in the enclosing gneiss.

The reef outcrops for not more than 100 yards and is a quartz filling in a composite fracture and brecciated zone in the granite. This is evidenced by the occurrence of clean walls to the reef in some places, and by the presence of brecciated granite completely surrounded by quartz in others, in which case the walls are not well-defined. No gold-bearing quartz was seen by the writer, and the mode of occurrence of the gold in the reef was not therefore ascertainable. From the nature of the old workings, however, it would appear that small quartz leaders crossing the main formation probably carried the gold at or near their junction with the main reef. Three roughly circular holes now about 6 feet deep and much wider than necessary to mine the main formation, suggest this to be the case, and presumably, from the shallow nature of the excavations, the gold-shoots were very short but comparatively rich.

Numerous samples from the reef in the vicinity of these old workings failed to reveal any minerals other than a trace of iron pyrites when "dollied."

Three samples taken from the reef where exposed in three separate places in the old workings located over a length of 110 feet of outcrop, gave the following returns:—

No. 1.—Gold, trace; silver, trace.

No. 2.—Gold trace; silver, trace.

No. 3.—Gold, trace; silver, trace.

Assays by the Government Chemical Laboratory, Perth:—

Nos. 214/35, 215/35, and 216/35.

The gneissic granite in the vicinity of the old workings carries numerous thin barren quartz veins, some running with the grain of the gneiss, others cutting across it, and still others showing a branching habit. There is also an extensive development of large white pegmatitic quartz reefs throughout the surrounding square mile of country.

About 8 chains north of the most northerly hole on the reef which carried the gold, a quartz vein about 2 inches thick striking N. and S. magnetic bearing, and dipping steeply to the east, had been uncovered by trenching and had been sunk on. This work seems to have been done at the same time as that done on the other old workings, but the shaft is now only about 15 feet deep with the quartz vein showing in the south side of the shaft only.

A sample from this vein gave the following returns:—Gold, trace; silver, trace.

Assay by Government Chemical Laboratory, No. 213/35.

A small quantity of iron pyrites occurs in the quartz of the formation containing the old workings.

The country surrounding Mullewa is composed of Pre-Cambrian granite and gneissic granite. In a railway cutting a few chains east of the Mullewa railway station the granite is seen to be highly sheared and jointed, while further to the south in the vicinity of the gold-find, it is in places a normal massive granite, and in others a gneissic granite with a pronounced development of large feldspar crystals.

About one mile south of the Mullewa railway station, the bands in the gneissic granite strike N. 30° E. magnetic bearing. Other strikes of sheared

granite in this locality varied between N. 20° W. and N. 30° E. magnetic bearing. Here the granite is invaded by a series of narrow dykes of fine-grained basaltic dolerite and one larger dyke of medium-grained quartz gabbro.

These basaltic dolerite dykes are parallel to the direction of the schistosity in the sheared granite, and to the bands in the gneiss, and though the orientation of the larger quartz gabbro dyke could not be so easily determined, it has every appearance of having a similar or nearly similar strike. These dykes are jointed, but are not in any way sheared, and the finer grained basaltic dolerite type carries sparsely distributed blebs of iron pyrites in fine granular aggregates.

Both dyke-rock types appear remarkably fresh in hand specimen and in thin slice.

An extensive development of white quartz reefs associated with the final products of consolidation of the granite is a conspicuous feature of the country in this locality.

Another interesting feature is the occurrence in the vicinity of the gold-find of a band of highly contorted hornblende schist devoid of quartz reefs and about 20 feet wide, which follows the strike of the sheared granite. This is only about 200 feet long, and at its northern end gradually passes into gneissic granite. In places it is a typical crenulated hornblende schist, and a thin slice observed under the microscope is seen to consist of a bladed form of blue hornblende, granular epidote, albite feldspar, and a little platy quartz.

This occurrence is conceivably a remnant of a once much more extensive formation, the balance of which has been assimilated by the invading granite.

The abnormal appearance of the gneissic granite in the immediate vicinity tends to support this view.

The development of this hard gneissic granite is restricted to a narrow belt east of this schist formation; elsewhere the granite is more of the normal type, massive and sheared.

Some mica schist seen in the dump of the Mullewa well west of the railway station may be another remnant of a formation of which the hornblende schist was part, or it may on the other hand be an intensely sheared granitic formation.

#### PROSPECTS OF THE AREA.

In an area of about one square mile of country surrounding the find, no conditions simulating those obtaining in the immediate locality of the old workings were noticed. There are no other known gold-bearing formations in the district, and the one in which the gold has been found is very small.

Narrow leaders carrying gold may still be found in the immediate neighbourhood of the present known formation, but it is almost certain that they will be of a similar nature to the gold shoots already found and worked out.

There is consequently not much likelihood of any further extensive finds in this locality.

## REPORT ON THE DOMESTIC AND BATTERY WATER SUPPLIES AT SPARGOVILLE, LOGAN'S FIND, CAVE ROCKS, COOLGARDIE GOLDFIELD, W.A.

By H. A. ELLIS, B.Sc., A.O.S.M.

### INTRODUCTION.

Spargoville, Cave Rocks and Logan's Find are gold-mining centres situated south of Coolgardie and in the following relative positions:—

*Spargoville.*—About 20 chains west from a point situated about 28 miles S.E. from Coolgardie on the Coolgardie-Norseman road.

*Logan's Find.*—About nine miles in a direct line S.S.W. from Spargoville.

*Cave Rocks.*—About six miles E.N.E. in a direct line from Spargoville, and about 2½ miles E. from Yilmia Trig. Station.

There are no existing natural domestic and mining water supplies at any of the localities, and investigations, the results of which are embodied in this report, were made by the writer with the object of ascertaining the possibilities of obtaining such supplies locally. At Spargoville domestic water is brought from Coolgardie, a distance of 28 miles.

At Logan's Find, domestic water is brought from Larkinville railway siding, a distance of seven miles, or from an uncovered surface dam five miles east of Logan's Find.

At Cave Rocks, domestic water is obtained from Coolgardie, a distance of 31 miles.

### SPARGOVILLE.

At the time investigations were made here (January 17, 1935) the population at this locality was 30, and mining operations were being carried out on an auriferous shear zone in sericite schist.

The property is being developed by the Spargo's Find Gold-mining Syndicate by sinking, driving, and crosscutting on the auriferous formation, which is of a low grade nature. An estimate made by the management of the value of about 50,000 tons of ore at grass and developed in the workings is 8 dwt. per ton. The deepest shaft was 70 feet deep as on January 17, 1935, and the formation has been traced over a length of about 400 feet horizontally, but not sufficient development work has been done to determine the nature of the distribution of the ore-shoots nor their quality. The mine in its present stage of development does not give the impression that it is likely to turn into a big producer.

### PROSPECTS OF OBTAINING LOCAL DOMESTIC WATER SUPPLY.

Spargoville is situated on relatively high, heavily timbered country at the head of one of the drainage systems entering Lake Lefroy from the west. The rock types throughout this area are metamorphic sediments and metamorphic basic igneous rocks of Pre-Cambrian age, with but a small development of recent alluvium and soil-filled depressions.

The rainfall of the locality is approximately 10 inches per annum, falling mostly during the winter months—April to October inclusive. The nature of the rainfall is such that the quantity falling at any



one time is small, and insufficient to enable a reasonable proportion of it to enter the ground-water zone. The heavy forest growth makes big demands on the water entering the soil, and this, combined with the effects of evaporation and the general impervious nature of the underlying rocks, leads to only a small proportion of the rainfall entering the ground-water zone.

In areas such as that under discussion where we have only a small rainfall of a seasonal and generally scattered nature, a high annual evaporation rate, a heavy growth of forest trees and scrub, and a general impervious nature of the underlying rocks, the underground water is almost invariably saline and scanty in quantity.

For the occurrence of fresh or moderately fresh underground water suitable for domestic purposes under such conditions as just enumerated, the following natural circumstances must exist:—

- (1) A catchment area free or nearly free from vegetation on which the rainfall can be collected and concentrated with a quick run-off.
- (2) Suitable loosely consolidated sediments into which the concentrated run-off from this area can be received and stored.

The fundamental principle connected with these conditions is the rapid collection and storage of the accumulated waters, thus rendering the agencies of evaporation and transpiration ineffective.

Bare granite and occasionally greenstone areas do provide the first requisite in some districts, but the occurrence of condition (2) is less frequent, though weathering products of granite areas are capable of providing it, and frequently do so in wide granitic terrains.

The capacity of these underground reservoirs is seldom large, depending on the porosity, shape and extent of the formation holding the water.

An extensive search in the vicinity of Spargoville failed to reveal the existence of any such structures, and there is no possibility of the occurrence of any fresh ground-water in the district unless the two conditions enumerated above exist.

#### PROSPECTS OF OBTAINING LOCAL BATTERY WATER SUPPLY.

Water necessary for treatment purposes in metallurgical plants is not so restricted as regards quality as that required for domestic uses, and consequently the geological conditions necessary for its accumulation are not so limited as those applying to the latter.

Nevertheless, a definite set of conditions is necessary, and in a low rainfall area such as in that under investigation, the limits to these conditions become narrower.

As previously mentioned, the nature of the underlying rocks at Spargoville is not such that a rapid absorption of the rain that falls can take place. The metamorphic series of sedimentary and basic igneous rocks is not a very porous medium, and access for water to the ground-water reservoirs must take place through the medium of joint-planes in the bed-rock. There is no indication of extensive jointing in these rocks in this district, and as such a condition is necessary for the admission of large quantities of

rain-water to the ground-water reservoirs, thus ensuring a reasonably shallow supply, it is fairly certain that the distance to ground-water will be moderately deep. It is also probable that the capacity of any shaft or bore-hole sunk to the ground-water will be very small.

Undoubtedly, once the zone of saturation has been reached, mining operations in the nature of crosscuts and drives will, by intersecting more water-bearing joints, improve this capacity, but for the immediate requirements of Spargoville these facts are not of use. If the future development of the formation at Spargoville leads to the extensive penetration of the upper 300 feet of the rocks enclosing the lode, it is probable that supplies of water suitable for metallurgical purposes will be found.

The extensive growth of forest over the whole of this area requires millions of gallons of water that would otherwise find its way to ground-water level, and in the course of mining operations much of this forest will be destroyed, thus augmenting the already meagre water supplies to the underground reservoirs.

While the killing of the forest trees undoubtedly promotes run-off with accompanying soil erosion, the water that does soak into the ground is free to make its way downwards, and it is generally held that the balance between transpiration and absorption as disturbed by the process of clearing the forest growth off an area is greatly in favour of absorption in the process of final adjustments.

Evaporation is also increased by the absence of the vegetation, but during the winter months, when most of the rain falls in this district, this factor is not paramount to transpiration.

The deepest shaft at Spargoville is 70 feet, and there is only a slight moisture content in the softer parts of the formation at this depth. The rocks are not extensively jointed where seen in the mine workings, and they do not show indications of having been water carriers when they do occur.

There is no prospect of obtaining useful supplies from bores of even large diameter, and for the immediate requirements of Spargoville it seems that underground sources cannot be looked to for the provision of water for treatment purposes.

#### PROVISION OF BATTERY AND DOMESTIC WATER SUPPLIES BY SURFACE DAMS.

The topography of the country to the north and west of Spargoville is such that a catchment area sufficient to supply a million gallon dam is available, and a dam site situated about 30 chains south of the mine would necessitate only a small lift to place the water in storage tanks at the mine.

The nature of the ground for holding purposes would have to be investigated, but in view of the fact that this seems to be the only method available for securing domestic and battery supplies, the water catchment area would have to be investigated from many angles, and this work would naturally fall to the Goldfields Water Supply Department if such assistance were contemplated. From a geological point of view it would be advisable to secure capacity in such a dam by depth instead of surface extent, and from the high rate of evaporation (about 12 feet per annum) it would be essential that such a dam be covered.

In securing the necessary depth, it is doubtful whether the soil and underlying rock would prove efficient holders under the increased pressure, and lining of the dam with concrete might have to be resorted to.

The nature of the water likely to be collected in such a dam can be gauged from the following analyses of water from uncovered surface dams situated not far from Spargoville:—

	Lab. No. 407.	Lab. No. 408.
	Grains per Gallon.	
Total soluble salts ..	19.6	19.3
Sodium chloride (calculated from chlorine) ..	3.2	3.2
Nitrogen as nitrite ..	nil	nil
Nitrogen as nitrate ..	.034	.046
Oxygen absorbed in 4 hours from $\text{KMnO}_4$ ..	.37	.29
Reaction pH ..	7.6	7.8

Analyses by Government Chemical Laboratory.

No. 407 was from an uncovered surface dam two chains east of the Coolgardie-Widgemooltha Road, 38 miles from Coolgardie.

No. 408 was from an uncovered surface dam five miles east of Logan's Find, which place is situated 35 miles from Coolgardie on the Coolgardie-Norseman telegraph line.

Cattle had access to both of these dams and caused organic pollution to such an extent as to render the water unfit for human consumption. The Government Analyst recommended treatment of such waters as these with bleaching powder or sodium hypochlorite before use by human beings.

From the results of these analyses it will be noticed that the amount of total soluble salts is very low, so low as to impart no appreciable taste to the water. As both of these dams were uncovered it is safe to assume that a fairly high-grade potable water of very low salinity could be obtained in dams that were adequately covered and protected from rabbits and stock of all descriptions.

The water from both of these dams has been used at intervals by the mining population of the district, but has been found to adversely affect the health of the consumers.

From the nature of the pH reactions these waters are alkaline, though not excessively so, and there is no quality exhibited in the analyses that would render such water unsuitable for metallurgical purposes.

The cleaning of the forest in the catchment areas would have the effect of increasing the run-off, but would also temporarily increase the salinity of the water, but not to such an extent as to render it unfit for domestic purposes. In the course of time an improvement in the quality of the water would be effected.

#### LOGAN'S FIND.

This locality, situated near the 35-mile peg on the Coolgardie-Norseman telegraph line and about 9 miles in a direct line S.S.W. from Spargoville, occupies much the same position topographically as does Spargoville.

At the time of inspection, January 19, 1935, the only mining work in progress here was that being done by two prospectors, though considerable work has been done in the past in this locality. Several properties here, on which shafts, the deepest of which is said to be 200 feet, have been sunk, are under exemption, and the immediate water requirements are therefore those of the two men at present on the field.

These men obtain their water from a dam situated about 5 miles east of the main workings (an analysis of this water is shown under Lab. No. 408), and also occasionally from a well at Emu Rock in the same locality. Neither of these waters is satisfactory for domestic purposes, that from the dam on account of organic pollution, and that from the well on account of its reported high salinity. When the population of this locality was greater, water was obtained from Government tanks at Larkinvale railway siding.

The country rock in this locality is composed of metamorphic sediments, and a fairly thick growth of forest covers the area.

The same facts as stated in connection with the occurrence of potable and saline underground water at Spargoville are likewise applicable to this locality, and from information obtained locally, the 200 foot shaft did not provide any appreciable supply of water, thus strengthening the evidence supporting the paucity of underground water at moderate depths in these localities.

To the north and west of Logan's Find, an excellent dam-catchment area exists, and a dam-site situated about  $1\frac{1}{2}$  miles north of the most northerly workings could be selected to impound a million gallons of water or more if desired.

As is the case at Spargoville it is suggested that the most effective and safest means of providing a domestic and battery water supply here is by means of deep covered surface dams.

#### CAVE ROCKS.

This locality is situated in somewhat generally lower country than Spargoville and Logan's Find, at the head of Merougil Creek, some six miles E.N.E. of Spargoville.

At the time of inspection, January 20 and 21, the locality was deserted, though indications existed that only a short time had elapsed since mining operations had ceased.

Extensive shallow workings on the line of the auriferous shear zone in sheared epidiorite exist at this locality, and from information obtained in Kalgoorlie the whole of these workings have been in low grade ore. There has been no systematic development of the ore-bodies, and no proof exists that bodies of ore sufficient to make a producing mine on a small scale are available. When work was in progress, water for domestic purposes was carted from Coolgardie, distant 31 miles.

As in the case of the other two localities, the conditions necessary for the accumulation and storage of domestic ground-water supplies do not exist here, though the topographical situation is more favourable to the occurrence of saline underground water than in either of the Spargoville or Logan's Find localities.



A very heavy growth of forest trees over most of the country surrounding the Cave Rocks area is a prominent feature, and this consumes many millions of gallons of water before it can reach the ground-water zone.

The prospecting areas were under exemption at the time of inspection, and several investigating companies were reported to be interested in the locality with a view to taking options.

A genuine attempt to locate underground water for battery purposes has been made in this locality by Mr. Kuring, owner of P.A. 3982. About half-way along the western boundary of P.A. 3982 in a depression down which water flows during storms, and which is at a general low level with respect to the surrounding country, a bore-hole was sunk by hand in fine-grained epidiorite to a depth of 145 feet, where a small supply of saline water was met with.

Mr. Kuring reports that the water rose in the bore-hole a few feet, but that the supply was very small and that the quality was that of fair stock water.

These facts are in keeping with the geological conditions under which this water occurred, as the bore-holes probably penetrated a water-bearing joint closed at its lower end. The water in such a joint, would establish static equilibrium by a fall of the water surface in the joint, with a corresponding elevation of it in the bore-hole.

These facts are mentioned because it might be inferred from the fact that the water rose in the bore-hole that an area of sub-artesian water had been located. Such an occurrence is not possible in impervious, sparsely jointed, metamorphic rocks.

A shaft was then sunk 10 feet west of this bore-hole in similar rock to a depth of 153 feet, and a drive was extended in the direction of the bore-hole for a distance of 10 feet. This shaft, sunk purely as a water shaft, failed to make a supply of water, though it is reported that there is some water in the bottom of the shaft at present.

It would appear that this shaft at 153 feet has just penetrated the upper portion of the zone of saturation, though on account of the paucity of jointing in this rock and its impervious nature it does not appear that there is any capacity in this portion of the ground-water zone.

The deepening of the shaft to 200 feet would increase the chances of cutting further water-bearing joints, but it is not probable that a good supply will be obtained even at this depth; unless in the event of more water-bearing joints being struck, extensive driving were resorted to in a direction at right angles to the strike of the joint system. This water-shaft could be turned into a reservoir by diverting storm waters into the mouth of the shaft in the event of its being abandoned at its present stage. Its situation would permit of this procedure, and in a locality where water is scarce such an expedient would provide storage for 22,500 gallons of water in a shaft 6 feet by 4 feet and 150 feet deep.

There was some possibility that diamond-drilling would be carried out in this area, and if such were the case every endeavour should be made to keep a check on underground water in such holes. As is the case at Spargoville and Logan's Find, the topographic conditions provide a fairly good catchment

area, and it is considered that a surface dam of one million gallons capacity could be obtained in close proximity to the leases.

This is the only means whereby useful supplies of domestic water will be procured at this locality, and although a deepening of the water shaft already in existence here will increase the small supply already in it, it is doubtful whether useful supplies of battery water will be obtained here under a depth of 300 feet and after extensive driving has been undertaken.

#### CONCLUSIONS AND RECOMMENDATIONS.

1. The areas investigated are situated in the 10-inch rainfall zone, and the rains are of the winter type, falling mainly during the months of April to October inclusive as a series of unevenly distributed showers. A thick growth of forest covers the areas, and utilises much water in its growth that would otherwise find its way to ground water reservoirs.

2. The geological conditions necessary for the collecting and storing of underground supplies of potable water do not exist at any of the three localities investigated, hence the sinking of wells and bores with the object of obtaining such supplies is useless.

3. The nature of the rocks and the distribution of their possible water-bearing structures, namely, the joint planes, is such that supplies of saline ground water sufficient for small treatment plants will not be obtained until mining development has searched a depth of about 300 feet with the necessary accompanying drives and crosscuts to intersect any water-bearing joints.

4. There is not sufficient promise shown in the metalliferous formations as at present developed to warrant the construction of a pipe-line from Coolgardie.

5. The immediate requirements of all three areas in the matter of domestic and battery water supplies could be met by the provision of surface dams.

6. In all three localities catchment areas of sufficient extent are available locally to supply at least a million gallon dam, and the quality of the water conserved in this manner would be sufficiently good to serve as a domestic supply, and the water could also be used in small treatment plants.

7. There is some good and some bad holding ground in the localities, and investigations would need to be made on the holding capacity of the ground before a dam-site was chosen.

8. As evaporation is high (as much as 12 feet per annum) any dams constructed should be sunk with the object of obtaining storage in depth rather than with increased surface area. Adequate covering for such dams would also be essential.

It is here suggested that a form of assistance to the water supply problem in these localities could consist of catchment area investigations being made and dam sites chosen by the Goldfields Water Supply Department. In this manner the run-off capacity of the respective drainage areas could be determined, and would serve as a guide to the extent to which this method of water supply could be made to serve the present and possible future requirements of the areas concerned.

# REPORT ON DOMESTIC AND BATTERY WATER SUPPLIES AT EDWARDS' FIND, YILGARN GOLDFIELD.

By H. A. ELLIS, B.Sc., A.O.S.M.

## INTRODUCTION.

Edwards' Find is a gold-mining centre situated about 25 miles nearly due south from Southern Cross and about 28 miles from that centre by road. Mining operations are being carried out here on several lines of parallel and sub-parallel quartz reefs in fine-grained greenstones, discovered on cleared agricultural country some three years ago.

At present the population of the field is 25, and the auriferous formations are being actively developed by sinking and driving, particularly on G.M.Ls. 11 and 12. Surface prospecting in the nature of loaming and costeaning is also being pushed ahead, and some promising reef outcrops have been uncovered in the area. The payable ore is carted to Marvel Loch battery some 10 miles N.E. by road, and the following returns, supplied by the owners of the claims on the field is an approximation of the ore so far treated from this locality.

### From G.M.Ls. Nos. 11 and 12—

Tonnage treated .. .. .	1,864
Gold returned (ozs.) .. ..	1,183
Gold in sands (dwts.) .. ..	4

### From Goodin, James and Nelson's Leases east of G.M.L. No. 12—

Tonnage treated .. .. .	421
Gold return (ozs.) .. .. .	553
Gold in sands (dwts.) .. ..	6

There are no existing natural domestic or battery water supplies in the field at present, water for domestic purposes being carted from Southern Cross, a distance of 28 miles. The owners of G.M.L. 12 have sunk a shaft 193 feet deep on the reef towards the southern boundary, and no supply of underground water has been met with. A shaft 100 feet deep on G.M.L. 12 perhaps slightly more favourably situated for obtaining underground water is quite dry at the bottom.

The position is now, that the provision of a battery seems justified, and the installation of such a treatment plant is being considered by the owners of G.M.Ls. 11 and 12. Investigations were made during February 20th and 21st, 1935, by the writer into the question of the possibilities of securing local supplies of water for both domestic and mining purposes, and the results are embodied in this report.

## PROVISION OF DOMESTIC SUPPLY.

The country in which Edwards' Find is situated is an unmapped extension of the greenstone belt that is shown on Blatchford and Honman's map (Plate 1, Bulletin 63), as terminating locally just north of the 20-mile peg on the Parkers Road Railway Siding-Parkers Range Road, about 18 miles south of Southern Cross.

The general topography is flat to undulating, and as the locality is in the agricultural area embracing some of the Miners' Settlement Farms, much of the country is cleared. Areas not cleared carry a thick growth of salmon, gumlet, morrel and ti-tree. Edwards' Find was made on Jilbadji Location No.

450 on a portion of the block then being sown with wheat. There is a marked absence of outcrops of any description in this locality, and the surface is composed of a slightly sandy soil underlain by a clay sub-soil seen in places to be as much as 12 feet thick.

The rainfall is in the vicinity of 10 inches per annum and is of the winter type falling during the period April to October (inclusive), with occasional summer storms. There are no bare granite or greenstone areas on which the rainfall can be collected and concentrated with a quick run-off, nor are there any suitable loosely consolidated sediments into which the run-off from such areas could be received and stored. Lacking these two essential features for the collection and preservation of non-saline groundwater in areas of low rainfall and high evaporation, the country in the immediate vicinity of Edwards' Find has no possibility of providing potable groundwater for domestic uses.

## PROVISION OF BATTERY SUPPLY.

As proved in a shaft 193 feet deep sunk on the reef towards the southern end of G.M.L. 12, which has just penetrated the ground water zone, and which is making only about 2 gallons per day, supplies of underground water are not easy to obtain in this locality. Unfortunately, this shaft is sunk on some of the highest ground of the leases, though it is doubtful whether a shaft sunk to a similar depth even at the lowest point on G.M.L. 11 would provide a useful supply of battery water.

The rock in the bottom of the 193ft. shaft is a compact, fine-grained greenstone, intersected by sparsely distributed flatly dipping joints. These joints are very tight, and cannot be expected to increase in number or become more open in depth. In several instances flatly dipping strike-faults were observed cutting the reefs above the 100ft. level and causing lateral displacement of them. Such faults may well occur again below the 193ft. level, and any such fault plane would provide a zone of more highly jointed rock which would be favourable to the downward percolation of the underground water if cut in a shaft. However, unless some such favourable structure is met with in the course of sinking, the prospects of obtaining any useful supply for battery purposes within the next 100 feet of sinking are not very good.

On G.M.L. 11 there is a shaft situated in somewhat lower ground than that on G.M.L. 12 just described, and the depth to the zone of saturation will not be as much as 180 feet here. To prove this reef at a greater depth than 100 feet it will be necessary to sink this shaft, and it is probable that this locality will be the best one in which to carry out the dual work of proving the reef at depth and endeavouring to secure a water supply for the future treatment plant. Two hundred feet may not be sufficient depth to provide a useful supply even here, and once the zone of saturation is reached, driving and any cross-cutting done would enhance the supply by cutting more water-bearing joints.

The reefs where seen at 193 feet in G.M.L. 12 and at 100 feet in G.M.L. 11 are from 2 feet to 3 feet wide and carry payable values according to information supplied by the owners. The permanency and value of the formations here as exposed in the number-



ous prospecting workings, and as revealed by the crushing returns, warrants the rapid exploration and development of the reefs above the 300ft. level. To do this, water is necessary to enable the installation of a 5-head battery to provide returns for development work.

The sinking of a shaft by hammer and drill in tough, fine-grained greenstone below the 200ft. level is uneconomical, excepting phenomenal values exist in the reef.

If sufficient water can be provided to enable machinery to be installed to permit mining operations to be extended to the stage where sufficient underground water for treatment purposes is available, then a good purpose will be served. It is considered that at 300 feet such supplies are likely to be encountered on G.M.L. 11.

At present the best solution of the water problem lies in the provision of a surface dam. It is a less costly and less risky means than that of sinking the 193ft. shaft on G.M.L. 12 in the hope of obtaining a sufficient supply in the shaft only. A bore of even large diameter and of considerable depth would not be likely to provide sufficient battery water in this locality.

#### PROVISION OF DOMESTIC AND BATTERY WATER SUPPLIES BY A SURFACE DAM.

An excellent catchment area on cleared ground traversed by numerous intersecting roads running in the right direction to act as drains to the proposed dam-site extends to the east, west, and south of G.M.Ls. 11 and 12. Second growth of gums and scrub is appearing on this area, and needs removing if the best use is to be made of the catchment. The surface is fairly hard over most of the area, and the shallow depth to a clay subsoil would increase the run-off during the period of the winter rains, as saturation of the surface soil would not be a prolonged process during the early part of this period. This fact is important, because it permits of the augmentation of the supply in the dam by comparatively light falls of rain.

A dam-site situated in a depression near the eastern boundary of G.M.L. 11 and about half-way along it, would be favourably situated to receive the maximum run-off. This locality was indicated to the owners, and at the writer's suggestion, the site was test-bored for holding capacity. The bore-holes revealed a depth of 12 feet of clayey material that would prove ideal holding ground. Dams situated in similar ground two miles S.W. of Edwards' Find were inspected, and the owner of these dams reports that they are in excellent holding ground.

It is suggested that a 3,000-yard dam (half a million gallon capacity) be sunk here for the following reasons:—

- (a) It appears to the writer that the catchment area is capable of filling such a dam and of keeping it replenished from time to time. It is not so certain in the absence of detailed catchment area investigations that a 6,000-yard dam could be economically installed.

- (b) If the dam is to be sunk before the dry season breaks, and to be of any use during the remainder of this year it must be completed before then, a 3,000-yard dam is all that can be excavated in the time available.
- (c) If water gets into a partially excavated dam in this type of holding ground excavating will have to cease, because horses or a tractor will not be able to work in the resulting clayey mixture.
- (d) The need of a water supply for both domestic and mining purposes is urgent, and it will be better to be sure of getting this in some degree of adequacy in a 3,000-yard dam than by running the risk of having an uncompleted, 6,000-yard dam when the rains come.
- (e) There is space available behind this suggested 3,000-yard dam for the excavation of another dam if experience teaches that such an additional dam can be filled.

The maximum depth to which a dam could be safely sunk here is eleven feet below the ground surface, and a smaller 200-yard settling dam in conjunction with the main one would be a wise provision to minimise the quantity of silt entering the main excavation, thus preserving its capacity as long as possible.

The provision and proper maintenance of wing-drains in parts of the catchment area not served by entrenched road surfaces is also essential.

Clearing the second growth and rolling the softer parts of the catchment area with a heavy roller when moist will also improve the run-off.

The covering of a dam where evaporation is high (as much as 12 feet per annum), as in the case of this locality, is necessary to secure the maximum capacity from the dam.

Investigations made locally concerning the contract price of such a dam, indicate that 1s. 6d. per yard is about the lowest price at which a 3,000 yard would be excavated.

It must be borne in mind that 500,000 gallons is not the total amount of water that will be conserved in a 3,000-yard dam. Periodically, during the winter, the supply will be augmented, and if the drains are kept in good order the summer storms which are a feature of the local climate can be looked to, to augment the summer supply. Again, the usual procedure of providing a tailings dam at the battery will enable a percentage of the battery-water to be used again.

#### CONCLUSIONS.

- (1) Edwards' Find, a gold-mining centre situated 25 miles south of Southern Cross, with a population of 25, carries quartz-reef formations varying in width from 4 feet to 6 feet of a distinctly promising nature both in value and depth.
- (2) There are no existing natural or artificial domestic or mining water supplies on the field at present, water for domestic uses being carted from Southern Cross, a distance of 28 miles.

- (3) Geological conditions suitable to the collection and storage of non-saline ground-water for domestic purposes do not exist in the field, hence such supplies cannot be obtained from well or bores.
- (4) The occurrence of saline ground-water in sufficient quantity for battery purposes is not likely to be met with under 300 feet, and then only after extensive driving and crosscutting has been carried out in the course of mining operations. Bores of even large diameter are not likely to provide a sufficient supply.
- (5) An excellent cleared, road-intersected catchment area, capable of supplying at least a 500,000 gallon dam, exists at the main mining centre, and a dam-site located in excellent holding ground giving a depth of 11 feet in clayey soil is obtainable.
- (6) Although the rainfall is only about 10 inches per annum and is of a scattered nature, it is considered that the excellent catchment area will provide a good run-off, and that the dam supply will be augmented periodically during the year under normal climatic conditions.
- (7) It is absolutely essential if this dam is to be constructed for use during the coming winter, that it be commenced immediately and finished in six weeks' time. The first heavy rains, and these are likely to fall in the break of the season, are those that will fill the dam quickest from this catchment area.

#### RECOMMENDATIONS.

- (1) As the water from any dam constructed here will be used for domestic purposes, and as the mines will be located on the catchment area, it will be necessary for every care to be taken to destroy putrescent organic matter on the area. Dr. E. S. Simpson, Government Mineralogist and Analyst, recommends that before being consumed by human beings, the water in such dams should be sterilised with bleaching powder or sodium hypochlorite at the rate of two pounds per hundred thousand gallons. This recommendation is important and should be conveyed to the users of the water. It is also very necessary to completely enclose with rabbit-netting any such artificial waters to prevent rabbits, kangaroos, emus, and live stock in general from having access to the water.

The addition of bleaching powder or sodium hypochlorite at the rate suggested above will not provide a sufficient concentration of nascent chlorine to interfere with treatment operations using amalgamated plates.

- (2) The prospects of this field are sufficiently good to warrant the statement that any assistance the Mines Department may consider giving to the gold-mining industry in the matter of water supplies would be justified at Edwards' Find.

#### STONE DEPOSITS—MOORA.

By H. A. ELLIS, B.Sc., A.O.S.M.

I have to advise inspecting some buildings in Moora in which stone from the above deposits has been used.

I also made a short visit to the locality from which this stone is reported to have been obtained, and forward the following notes in connection with these observations:—

#### BUILDINGS.

*Post Office.*—Date erected not known to me. The fine-grained pink ferruginous sandstone has been used for the lower two feet of the foundation of this building. The main portion of the building is not made of either of the two specimens recently reported on by the Geological Survey, but of a rock from Griffith's quarry.

The sandstone is wearing very well and has retained its colour to a large extent. It is now pale pink, and is somewhat case-hardened. The edges are quite sharp and no structural defects are noticeable, although the sandstone is carrying the weight of the whole of the walls.

*Commercial Hotel.*—Erected 1909. The bottom five feet of the walls of this building are composed of the fine-grained ferruginous sandstone reported on by us, and are in perfect order to-day. The colour is pale pink and uniform in nature, and the edges are everywhere sharp. The sandstone is carrying the whole weight of a two-storey building (brick) and is not showing any structural defects (no fretting).

*Wesleyan Church.*—Erected 1909. Foundations consist of a layer of the fine-grained banded quartzite and the fine-grained pink sandstone reported on by us. The main building is of fine-grained sandstone. Both rocks are wearing well and are not showing any defects.

The quartzite has gone a dark purple in colour and does not look so well in a building as does the sandstone. The quartzite has been used with the bedding horizontal.

#### DEPOSITS.

The localities from which this stone is reported to have come are situated in a N.S. ridge about 1.8 miles east of Moora.

There is no quarry, the material having been obtained from scattered shallow excavations. Localities situated on the S. side of the road to Berkshire Valley about 1.8 miles east of Moora Post Office, and opposite a dam situated close to the road on the N. side, indicate that both types of stone could be obtained in quantity.

Exposures seen were also very much jointed, but the deepest excavation observed was only about three feet, and less highly jointed rock may be expected at a greater depth.

Access is easy, though slopes are not steep and this would add to quarrying costs.

The localities are all thickly covered with scrub, and not much time was spent seeking other exposures which must exist here.

No stone is being quarried at the present time.

#### SUMMARY OF THE RESULTS OF THE GEOLOGICAL SURVEY OF THE ABBOTTS MINING CENTRE, MURCHISON GOLD-FIELD.

By H. A. ELLIS, B.Sc., A.O.S.M.

The gold-bearing quartz reefs of the Abbots centre have been found to occur almost exclusively in the rocks belonging to the Kyarra Schist series, which



consist of schistose derivatives of Pre-Cambrian dolerites, gabbros and tuffs, folded along axes trending north-north-east and north-north-west; the planes of schistosity being nearly everywhere vertical, or dipping at very steep angles. Such evidence as is available points to their having been formed in shear zones in this schist, and the irregular and lenticular nature of the smaller gold-bearing reefs is definitely established.

Small local concentrations of gold in thin quartz reefs have been found from time to time in the past, but as the sites of these finds were either unknown or inaccessible, the geological features associated with them were not determinable.

The two main producers, closed down since 1904 and 1908 respectively, were the Vranizan and New Murchison King mines, in which quartz reefs were worked to a depth of about 300 feet. The old workings of these mines were inaccessible below water-level, and the ore bodies above this level have been worked out. From information obtained from persons who had worked in the mines, operations ceased below water-level on account of the absence of ore-bodies at depth; the reefs being stated to split up into thin stringers at the 300ft. level. From the only mine plan available—that of the underground workings of the Vranizan—the ore-bodies are shown to be pitching to the north, and that while the dip of the reef remained moderate, it was workable, but that when the dip steepened, either the values were poor or the reef thinned out.

From observations in the accessible parts of this mine the fact was established, that, in those reefs found to contain gold and worked in the past, the ore-shoots occupied the whole extent of the reef, and that where the stoping terminated the reef had broken up into unworkable thin stringers not carrying values.

The accessible workings of the New Murchison King showed that the same feature concerning the stoping also existed there, but as the reefs had a comparatively steep dip from the surface, a change in dip is not known to have influenced the nature of the ore-bodies in this instance. It may have done so, but since no plan of the underground workings is available, and the mine was inaccessible below water-level, nothing definite can be stated.

The shear-pattern of the reef system could not be determined on account of insufficient exposures, but the definite existence of a nearly north and south shear, and another north-west system has been established, and both carry auriferous reefs.

The country forming the Kyarra Schist has been extensively prospected, and apart from the area embraced in the strip of country about one mile long by ten chains wide, in which practically all the known payable gold deposits, both large and small, have been found, it has not yielded any other payable results.

The structure of the area examined has been tentatively determined as either a uni-lateral one, consisting of a large drag fold on the easterly limb of a northerly pitching anticline, or a bi-lateral one forming a northerly pitching anticlinorium; the balance of the evidence being in favour of the former, with the auriferous reefs occurring in or near the supposed position of the axial plane of the structure. From this interpretation of the structure, it has been suggested that other possible lines of auriferous country

may occur in the Kyarra Schists, near the eastern boundary of this formation due east of Abbots Trig. Station, and in the belt of country running north-north-east from a point situated about 2 miles west of Abbots Trig. Station. A small reef in a shear zone is at present being worked in this latter locality (P.A. 2140N).

The asbestos and copper occurrences have been found to be of mineralogical interest only, and do not constitute present or possible future payable ore-deposits.

Potable underground water was found to be present at depths ranging from eight feet to one hundred and fifty feet below the ground surface, the depth to water-level being shallower in the granite than in the greenstone country.

Neither the granite nor its associated pegmatite dykes were found to be metalliferous, and no record of any pneumatolytic minerals having been found in or near them is known.

#### REPORT ON PROPOSED WATER SUPPLY FOR TUCKANARRA BATTERY, MURCHISON GOLDFIELD.

By H. A. ELLIS, B.Sc., A.O.S.M.

During the course of the geological survey of the Abbots Mining Centre, Murchison Goldfield, a request was made to the writer for assistance in the matter of obtaining a suitable water supply for the Tuckanarra battery, a privately owned gold-treatment plant.

Investigations were made on the way north to Abbots and also on the return journey on completion of the Abbots survey.

The battery is situated about 30 chains west by south from the Tuckanarra railway siding, and about five chains west of a south-westerly trending drainage channel. The general nature of the topography in this locality is flat to undulating, and the rocks are of the greenstone type not readily penetrated by surface water.

The water supply in use at the time of the first visit on April 7, 1935, was being obtained from a 7-inch borehole sunk to a depth of 102 feet situated three chains east of the creek bed that trends south-west, five chains east of the battery site. Additional supplies were also being obtained from a waterhole in the creek bed near by. A windmill had been erected on the bore and waterhole. When the bore was first drilled, water was struck at 87 feet, and the hole was continued to 102 feet but not eased. A good supply is said to have been obtained from this source until the bore apparently silted up.

Even the most favourably situated boreholes drilled in greenstone country have very little chance of providing a supply of water sufficient for battery purposes, and a well sunk as close to the bank of the creek as possible, after a borehole had determined the depth to water level, and a drive towards the main drainage channel to cut the cleavage or jointing of the country rock and provide storage, would have provided an ample water supply here.

Tenders were subsequently called for this work, but the price was fairly high, and the owner of the battery thought it less costly to arrange to get a water supply from an abandoned mining shaft three-quarters of a mile distant from the battery. This shaft is said to be 250 feet deep and to possess a large storage capacity in the nature of drives.

The cost of a pipe-line for this distance, together with the necessary pumping machinery, may well exceed that of a well and drive on the site of the old bore, and this feature was pointed out to the owner.

In cases such as this, which no doubt frequently occur in the greenstone belts of the goldfields where shallow underground water is not plentiful, a definite procedure in the search for underground water for battery purposes should be followed.

If there is a drainage channel anywhere in the locality, a small diameter bore should be sunk as close as possible to the edge of the channel at the lowest practicable point. If the creek bed is a wide flat one, then the test hole is best drilled in the creek bed itself. Considerations of elevation and position, with the view to obtaining gravity supplies, must be subordinated to the major consideration of first obtaining the water. In localities where underground water is scarce, a good principle to follow is to be concerned firstly about securing a supply, and then to adapt the means of raising it to the circumstances under which it occurs. Frequently, the order of these considerations is reversed in the minds of water-seekers. Having drilled the borehole to water-level, it should be continued for at least 20 feet into the ground-water zone when this is contained in weathered greenstone rocks. A pumping test should then be applied, and even if it falls far short of the required supply, as it almost invariably will do, it must be remembered that seepage surfaces cut in a well and in storage drives will very greatly enhance the capacity of the source of supply.

If the supply obtained in the borehole is only a very moderate one, it is still advisable to sink a well on it, if the site of the bore is the most favourable in the locality. If the general trend of the planes of schistosity of the country is known, then the maximum seepage surface will be cut by sinking the well with its greater length at right angles to this direction, i.e., "across" the "run" of the country. Twenty feet into the ground-water zone is not an excessive depth to carry the wall, and if a sufficient supply is not obtained then, it will be necessary to make drives from the bottom both for storage and increased capacity.

With the well located on either bank of the drainage channel, the storage drives should be cut directly towards the centre of the creek. In making storage drives in any well, the most efficient seepage surface will be cut in a direction at right angles to the bedding or planes of schistosity of the country rock, or, when these are not prominent, then in a direction at right angles to the trend of any joints, if these occur.

It is best to drive into the footwall side of the country when the bedding, planes of schistosity, or joints dip either flatly or steeply. By this means new possible seepage surfaces not previously cut by the vertical shaft or well are intercepted, with the additional prospects of enhanced supply.

To illustrate the points stressed above, a special case can be considered. Assume a drainage channel running north-east and south-west, with the planes of schistosity of the sheared greenstone running about north and south and dipping to the west at steep or flat angles. The best situation for a 6ft. x 4ft. well on such a creek would be as close as possible to the western bank, and sunk with the 6ft. side lying in an east and west direction. The storage drive would be driven in an easterly direction under the creek bed, thus cutting possible seepage surfaces some distance west of the actual point of intake in the creek bed.

The sinking of wells close to or in drainage channels in the goldfields of Western Australia may be regarded as risky on account of the occasional violent re-flooding of such depressions with the possibility of loss of the equipment. In the extreme case when it is necessary to locate the well in the centre of a wide drainage area, if care is taken to build a substantial compact dump inside a stout stub fence built of straight round timber, and hinged wooden or iron doors are provided as a cover for the well-mouth, the structure will stand total submergence without much damage being sustained beyond a slight silting of the well. The location of wells close to the bank on straight reaches of the drainage channel and on the inside curve of bends is a fairly safe procedure. Positions near the bank on the outside curve of bends should be avoided, as erosion at these points in flood times is extreme.

#### REPORT ON THE LOCATION OF A BORE-SITE FOR WATER AT "GNAWEEDA" STATION, MEEKATHARRA.

By H. A. ELLIS, B.Sc., A.O.S.M.

During the progress of the geological survey of the Abbotts Mining Centre, the writer's services were made available to pastoralists using Meekatharra as a centre, who were contemplating establishing new water supplies on their holdings. Owing to the depressed state of the wool market for some years past, very few improvements in the nature of new water supplies are being made by the station owners, but help was required and given to "Gnaweeda" Station in locating a bore-site in a portion of the run where underground water supplies have been difficult to obtain.

In that portion of "Gnaweeda" Station situated north-east of Gnaweeda Railway Siding on the Meekatharra-Wiluna railway, a belt of low hilly greenstone country runs N.N.E. and S.S.W., and contains, besides some auriferous deposits, some excellent pastoral land. An attempt to provide a water supply to enable some of this country to be used was made by the Gnaweeda Pastoral Company, who drilled a bore-hole in the greenstone and obtained an inadequate supply.

The situation of this bore is on the south side of a wide flat drainage channel in greenstone, 3.1 miles north along a fence which crosses the Meekatharra-Wiluna road 4.4 miles east of Gnaweeda Railway Siding. It was drilled to a depth of 140 feet through alluvium and greenstone, and water was struck at 122 feet.

The supply is reported to be 800 gallons per 24 hours, and this was not sufficient to safely water the number of sheep the paddocks were capable of carrying. An adequate supply could have been obtained here by sinking a well out in the centre of the drainage channel and making drives across the bed of the creek at a depth of, say, 150 feet. As the owners of this station possess a 6-inch percussion water-boring plant, they were anxious to find a spot somewhere not too far from the original site, where a new bore-hole could be sunk with the prospect of obtaining at least 3,000 gallons per day. It was pointed out by the writer that there was only the remotest chance of this being possible in a bore-hole drilled in greenstone country, and no structure capable of providing such a supply was noticed in this locality. Only a very exceptional structural feature would permit of this supply being obtained in a greenstone area, and it was decided to move the bore-site to granite country to the south of this locality.

A site in flat granite country situated 90 chains south and 20 chains east of the present bore in the greenstone was chosen, with the object of obtaining a supply in alluvium and decomposed granite, in what would probably be an old valley in the granite surface continuous with the drainage channel in the greenstone to the north. It is not anticipated that the depth to water level will exceed 100 feet, and the supply should prove sufficient if the bore-hole is properly cased with perforated casing after it passes into the ground-water zone. The useless procedure sometimes followed, of boring in the comparatively fresh granite when a supply has not been obtained in the overlying beds, will not be carried out in this instance, as the futility of this was explained to the owners.

Some excellent supplies have been obtained in the wide, flat alluviated granite plains in comparatively shallow bores some distance south of this locality, the bore at "Gnaweeda" homestead being a particularly good instance. The supply in this bore-hole is not accurately known, but from information supplied by the owners it exceeds 6,000 gallons per day.

There are numerous wells on this station, and many were observed to have been sunk just where water was required to serve existing fenced paddocks. The practice of fencing first and securing the water supplies afterwards, which seems to be general in the Murchison district, shows that underground water of useful domestic and stock quality is fairly general in that part of the district underlain by granite.\*

#### REPORT ON P.A. 1855N, SITUATED ON GNAWEEDA STATION ABOUT 18 MILES EAST OF MEEKATHARRA.

By H. A. ELLIS, B.Sc., A.O.S.M.

On that part of Gnaweeda Station, situated north of the Meekatharra-Wiluna road and railway line, about 18 miles east of Meekatharra, a belt of gold-bearing greenstone outcrops as a series of low hills

and ridges having a general northerly trend. This line of country probably includes Gabanintha to the south and the gold-mining leases to the north, of which the "Mistletoe" constituted a spectacular producer some years ago. An investigation of this belt was not made during the examination of P.A. 1855N, as no authority was given for an areal geological survey of this portion of the district to be made.

The brief description of the outcrops and auriferous formations contained in this report on P.A. 1855N, are the result of investigations made by the writer with the help of Mr. E. Lacey on May 14, 1935. Time did not permit of a detailed examination of the surface outcrops on the whole of the 24-acre P.A., the object of the investigations being to acquire sufficient data to enable an opinion to be formed concerning the prospects of the auriferous formations already opened up.

In the north-east portion of the prospecting area there is exposed in a low hill a belt of deeply weathered grey to brownish coloured, somewhat schistose rocks, which may be in the unweathered condition, a variety of chloritic schist. They are granitised in narrow belts which show a well-defined set of rectangular joints, and one large quartz reef, barren of gold values occurs in them. This quartz reef outcrops for about 80 feet, and is flanked on both sides by granitised schist striking N. 30 deg. E. and dipping to the east at about 60 degrees. The reef varies in width but averages about 6 feet. About 40 feet south from the southern end of this reef, a small rich shoot of gold has been found in a quartz reef which, when cut in a vertical shaft at 6 feet in depth was 11 inches wide on the north side, and 9 inches on the south side of the shaft.

This reef has been followed down for 24 feet on the underlay to the east, the dip being about 60 degrees. A shear zone about 3 feet in width contains the reef which varies rapidly in thickness, strike and dip. The formation strikes N. 40 deg. E. and dips to the east at 60 degrees. At a distance of 12 feet down the underlay shaft a big bulge of barren quartz appears on the north side, this does not cross the shaft, but continues to the bottom for 12 feet. There are no values in this formation, which appears to be a separate make of quartz to that containing the gold. A drive to the south along the thin reef for 12 feet showed the pinching out of the lens in that direction, and at 24 feet in the shaft, the original gold-bearing formation had narrowed down to 2 inches but was said to still carry gold. Some gold was obtained from the upper portions of this small formation by dollying, but no crushings are recorded as coming from it.

The general structure of this occurrence shows it to be of a decidedly lenticular nature, with the narrow shoot of gold pitching to the south. In circumstances such as those under which this shoot of gold occurred, so long as the smallest remnant of the original gold-bearing quartz persists either in length or depth and it is still carrying gold, then it is advisable to follow it. Unless the reef is showing signs of breaking up into numerous small stringers, it has always the possibility of forming another lens, and at 24 feet a quartz reef cannot be said to have been reasonably tested in depth.

\* In a private communication from Mr. Lacey, part owner of "Gnaweeda," he states that water was struck at 98ft. and that it rose in the bore hole about 8ft.

Since writing this report a letter from the station owner states that at 141ft. he struck a big supply of water, the level of which could not be lowered on bailing at the rate of 10,000 gallons per 24 hours.

At a distance of 90 feet south-west from the underlay shaft, a shaft 29 feet deep with a crosscut to the west from the bottom for 30 feet has been sunk purely as a prospecting venture. No reefs were encountered in this shaft which was inaccessible, and the country rock as seen in the sides appeared to be a very much disturbed and highly weathered schist. About 50 feet N.W. of this shaft, a large ironstone and quartz formation outcrops, and forms the summit of a low hill. The country rock is a very much oxidised schist, granitised and silicified in places, striking N. 30 deg. E. and dipping to the south-east at 70 degrees. Fine gold has been found by loaming in this formation on the north side, but no definitely gold-bearing portion of it had been discovered up to the time of inspection, May 14, 1935, at which time work was in progress.

One hundred and sixty feet west-north-west of the southern toe of this quartz and ironstone formation, a vertical shaft has been sunk in oxidised schist for 38 feet. The intervening rocks consist of very much decomposed schist, and it appears that the shaft was sunk to intercept a lode formation exposed in a shallow surface working 15 feet deep cut in brecciated quartz and decomposed green-stone schist about 20 feet N. 10 deg. W. from the shaft.

At 12 feet down the 38ft. shaft, an ironstone leader 2 to 4 inches thick, striking N. 30 deg. E. and dipping E. 30 deg. S. at 60 degrees cuts across the shaft and is said to carry gold. A network of ironstained quartz stringers is exposed in the sides of the shaft, and it is not reported that any of them carries gold.

At about 25 feet down the shaft, a defined oxidised shear zone is exposed, and the remaining 13 feet of the shaft has been sunk in this zone. At 28 feet vertical depth, a crosscut has been extended for 22 feet on a bearing of 320 degrees into banded oxidised and decomposed schists, cutting the footwall of the lode formation which here strikes N. and S. and dips east at about 60 degrees at about 2 feet in from the shaft. From the bottom of the shaft, which is still in the lode, a crosscut extends for 20 feet on a bearing of 135 degrees, and at 14 feet in this crosscut a decided change to less oxidised but still decomposed country rock is noticeable. The minimum width of the oxidised shear zone is thus about 17 feet, and numerous small bunches and thin stringers of quartz occur in it. Free gold in a very fine state of division occurs in the decomposed lode matter along the northern wall of this crosscut, but not in sufficient quantity to be payable. A sample from the walls of this crosscut showed only a trace of gold in the dish on washing, and another sample taken from the lode matter as exposed along the south wall of the crosscut returned gold 5 grains, silver 5 grains per ton, on being assayed at the Government Chemical Laboratory. A vertical sample, taken from 2 feet in the west crosscut at 28 feet from the surface, and considered to be near the footwall side of the lode, gave gold, a trace; silver, a trace; on being assayed at the Government Chemical Laboratory.

These assay returns indicate that the portion of the lode as at present exposed are definitely unpayable. Free gold in an extremely fine state of division does occur in the lode matter, but in the present state of development of the formation no payable body of ore has been exposed.

In fairly wide bodies of lode matter such as has been shown to exist here, the values are frequently confined to relatively narrow bands, and the location of these bands or shoots is only made possible by a continuous system of assaying or panning, while development work is in progress. It is possible that the shoot of gold in this fairly large shear zone has not yet been located, and the amount of exploratory work done on it to date has not been nearly sufficient to warrant the supposition that no gold shoot exists.

The formation in which the lower portion of the shaft has been sunk, and in which the crosscut to the south-east has been cut, is a strong one structurally, and is likely to persist to some depth. It is necessary to explore the portion of it already opened up in the 38ft. shaft, along the strike, *i.e.*, north and south, by means of drives, and to crosscut east and west to the walls of the lode formation at intervals along these drives.

About 100 feet of driving and 50 feet of crosscutting from the level of the bottom of the present shaft, should determine the presence or otherwise of a shoot of gold in this formation, already known to carry a small quantity of gold.

There were no obvious geological features exposed in the workings from which the direction of a possible ore-shoot could be indicated by the writer; but it is considered that in view of the soft nature of the formation which it will be necessary to mine in exploratory work, and the undoubtedly auriferous nature of the strong structural feature constituting the lode, together with the totally inadequate amount of underground prospecting work done, that the further exploration of this formation on P.A. 1855N could be undertaken with a reasonable chance of success.

A plan of P.A. 1855N showing underground and surface exploratory work compiled from compass and tape traverses by the writer accompanies this report.\*

#### REPORT ON PROSPECTING ACTIVITIES AT "WHITE HORSE," FIVE MILES SOUTH OF ABBOTTS MINING CENTRE, MURCHISON GOLDFIELD.

By H. A. ELLIS, B.Sc., A.O.S.M.

The White Horse gold locality is situated approximately 5 miles south of Abbots Trig. Station, and 15½ miles N. 28 deg. W. from Meekatharra in a straight line. A bush track usable by motor vehicles runs north to Abbots, and another running east by south joins the Meekatharra-Abbots road about 13 miles out from Meekatharra. There is a well equipped with windmill, tank, and troughing belonging to Youthapina Station close to the auriferous belt, and a good water supply is obtainable from this source.

The locality did not fall within the area examined in detail in connection with the geological survey of the Abbots Mining Centre, and on May 20, 1935, when the camp was being struck preparatory to returning to Perth, Prospector J. Farely arrived and informed the writer that he had been trying unsuccessfully at intervals for several years past to locate a gold-bearing reef that had shed some very rich "floaters" at "White Horse."

\*Plan not published.



Circumstances would permit of only a very hasty examination being made in an endeavour to help this prospector, and it was considered that the most useful help would be given by making an underground survey of the driving and crosscutting done on the area where the rich floaters were found. This work was carried out by Mr. R. S. Matheson on May 20, 1935, and as much of the surface geology as time would permit was also investigated and mapped. The accompanying plan embodies this information.\*

It appears that for the past twenty years the presence of rich gold-bearing "floaters" has been known in the flat and gently undulating country situated about 30 chains west of the windmill and well, located on a southerly trending watercourse in this locality. Extensive costeaning and shallow surface work has been done over the area of a few acres, where the floaters have been, and still are, being found.

The surface geology of the area was not worked out in detail, but the general geology is somewhat similar to that of the Abbotts centre, consisting of bands of sheared and partially sheared, fresh looking chloritic rocks, some of which are definitely of a pyroclastic origin, between which occur wider bands of the much weathered Kyarra Schist, a schistose derivative of doleritic lavas.

The country on which the "floaters" have been found consists of Kyarra Schist, is only very slightly undulating, and is covered with a varying thickness of the usually prevalent Murchison Goldfield "cement." The prospecting operations have been confined to the band of Kyarra Schist which has a general strike of N. 20 deg. E. and a vertical dip. There is a pronounced kaolinised zone flanked on either side by yellowish weathered schist, and the various prospectors who have tried this locality have practically confined their attention to this zone. No quartz reefs have yet been discovered in this kaolinised zone, and on account of the overburden of cement, Prospector J. Farely has sunk four shallow shafts 16, 17, 22, and 29 feet deep respectively, in and near the bleached zone, and has cut prospecting drives and crosscuts from the bottom of these shafts in an endeavour to locate the reef that has shed the "floaters." The presumption has been made that the reef still exists, and does occur in the kaolinised zone, and from the prospectors' point of view this is a good assumption. In country further north, rich but small quartz veins have been found occurring under somewhat similar conditions, and the kaolinisation of the rock at "White Horse" certainly suggests the action of mineralising solutions.

The "floaters" consist of limonitic-stained, somewhat cellular, milky white quartz with a pronounced dull greasy lustre, showing cubical and irregular masses of limonite, pseudomorphous after pyrite. Occasional small patches of unaltered iron pyrites may be seen on the freshly broken surface of some specimens, and a small staining of scorodite, the green hydrous arsenate of iron, also occasionally occurs. This latter mineral is probably associated with arsenical pyrites, and the "floaters" on which it is visible always carry a high gold content. Finely disseminated free gold is visible on some of the freshly broken porous limonite surfaces, and in the cavities from which limonite pseudomorphs have been removed by weathering. This gold is of a secondary nature, having been originally contained

in the iron pyrites, which, in the process of oxidation to limonite, has liberated its gold content now found redeposited in the limonite pseudomorphs. No free gold was seen by the writer as occurring in the quartz itself, but it is most likely that there is primary gold deposited in the solid quartz.

"Floaters" as large as a four-gallon kerosene tin are said to have been found here, and some weighing up to six pounds are still being found. On dollying and panning, specimens from the "floaters" reveal a rich gold content variously estimated at from two to ten ounces to the ton. The gold is mostly very fine with only occasional coarser grains visible in the tail.

The numerous costeans and shallow excavations cut across the area where the "floaters" occur have failed to reveal any reef that could have shed the gold-bearing quartz, and nothing in the nature of quartz reefs has been cut in any of the underground prospecting drives or crosscuts. The covering of tightly cemented alluvium—the Murchison "cement"—is variable in thickness, and the surface on which all the prospecting has been done is not perfectly level. It is possible that if an accurate one-foot contour map of the present surface were made, and used in conjunction with one constructed for the old land surface as revealed by the varying depth of cement covering, and the present distribution of the "floaters" correlated with both, then some idea of the direction from which the "floaters" were shed could be obtained.

It is possible that the reef did not occur in the kaolinised Kyarra Schist at all, but in the yellow oxidised country either east or west of this belt. The absence of obvious slopes in the nearly flat topography makes it impossible to say which side may have contained the reef, without the topographical detail mentioned above.

Another possibility must be borne in mind, and that is that the original gold-bearing quartz reef has been completely eroded away.

The gold-bearing reefs of the district are extremely lenticular both in the direction of strike and dip, and the shoots of gold are short and patchy. It is therefore conceivable that the gold-bearing reef that has shed the "floaters" was of this lenticular nature, and that the present land surface covers the root or roots of the original ore-body now represented by only very thin quartz stringers possibly only one-quarter of an inch or less in thickness.

In prospecting for similar elusive ore-bodies in flat country covered with alluvium or "cement," the practice of sinking shallow shafts and crosscutting the country at a depth calculated to keep the work just below the surface debris is to be recommended. Considerable attention should first be given to ascertaining the strike or "run" of the country, and the prospecting crosscuts should be driven as nearly as possible at right angles to this direction. A systematic lay-out for the shafts, either directly across the strike of the belt it is desired to prospect, or diagonally across it with the subsequent system of crosscuts appearing in plan as a series of steps, should be followed. It is necessary to take the shaft only a short distance into the oxidised zone, as any ore-body existing in the formation being prospected will almost always be encountered near the surface. This fact is mentioned because the prospectors engaged in

\*Plan not published.

this type of work in this locality thought that they may possibly have missed the reef through not sinking their shafts deep enough.

# REPORT ON JAMES, NELSON & GOODIN'S G.M.L. 13PP—EDWARD'S FIND.

By H. A. ELLIS, B.Sc., A.O.S.M.

The owners of this lease have, in the past, been working a quartz reef which has returned good crushings from the surface to about 78 feet vertical depth, where the reef was cut off by granite in the 78ft. level.

The reef strikes 330 degrees and dips to the west at 80 degrees, being practically vertical for the upper 50 feet. It has been worked in three levels from two shafts sunk to 78 and 155 feet respectively vertical depth below the brace, situated to the east of the reef and one chain apart.

In attempting to deepen the southerly shaft to get below the granite and start another crosscut to the west, the granite was met with in the side of the shaft at 115 feet vertical depth. A crosscut was driven for 14 feet in a westerly direction on the granite surface which here dipped at 40 degrees on a bearing of N. 70 deg. E., but from plans recently compiled by the writer this crosscut was not extended far enough to cut the downward continuation of the reef in this section of the mine.

Sinking of the shaft was continued with the granite showing in the western wall as a vertical face, and at 123 feet it started to cross the north and south walls of the shaft, and at 136 feet vertical depth was right across the shaft. From here on for 23 feet, the shaft has been sunk in solid granite, and at the bottom of the shaft a crosscut has been extended into the granite for six feet in a westerly direction.

The writer, in February, 1935, when engaged in reporting on water-supply problems at Edward's Find, was invited to inspect this occurrence, and at the time the slopes of the few granite surfaces exposed indicated that the intrusion had an easterly dip, and the owners were advised to continue crosscutting to the west, a procedure they had already commenced at that time. This crosscut has not been extended beyond six feet, the hardness of the granite having deterred the effort to pierce it in this direction.

The position now is much the same as it was in February of this year, and assistance from the Mines Department has been requested to enable the owners to pierce the granite.

They state that their requirements are an air compressor, jack-hammer, and air-pipe and hose with necessary power unit to be provided by the Mines Department on loan, the plant to be returned to the Mines Department or possibly purchased if the reef is found and proves to be payable. They do not seem to be interested in £ for £ subsidy.

A detailed examination of this mine was made by the writer on July 29 and 30, 1935, and a plan of the underground workings, together with longitudinal and vertical cross-sections have been compiled.

The granite intrusion has been found to have an uneven upper surface, but no indication of its total thickness in any part can be ascertained, only the upper surface having as yet been exposed in isolated places in the mine. From calculations based on the measured depth of these isolated surfaces below the collar of the 78ft. shaft, and assuming that the granite is in the form of a dyke, the upper surface is calculated to have a general dip of 63 degrees on a bearing of N. 55 deg. E. (magnetic).

Assuming that the lower surface is parallel to the upper surface, the shortest way out of the granite from the bottom of the 155ft. shaft is by sinking an inclined shaft at a depressed angle of 27 degrees from the horizontal on a bearing of 235 degrees (magnetic). This would take the workings towards the downward continuation of the reef if it persisted beyond the granite.

The granite has invaded the reef and partially replaced it in the 78ft. level, but there is no indication as to whether or not the granite has been intruded along a fault plane. The reef should persist underneath the granite if not displaced by faulting, and values should not be affected. The problem is to determine the thickness of the granite dyke.

In a reef about 20 chains west in Edward's G.M.L. 11, a granite dyke cut the main reef without either displacing it laterally or affecting values, but this dyke was very thin. In the writer's opinion it is first advisable to determine the thickness of the dyke by cutting a crosscut inclined at a depressed angle of 27 degrees to the horizontal on a bearing of 235 degrees (magnetic) from the bottom of the 155ft. shaft.

Such a crosscut would extend in the direction of the downward continuation of the reef, and if the dyke had been intruded along a fault plane, dipping north-east and the reef had been faulted, as is possible, the crosscut would have a chance of eventually cutting the reef.

In any case, once the thickness of the dyke is determined, the advisability of sinking the main shaft could be considered with the object of crosscutting at a greater depth to intersect the reef.

The values persisted down to the point where the reef was cut off by the granite, and the stope length of the shoot was 20 feet in No. 1 level (34ft. level), 120 feet in No. 2 level (54ft. level), and 170 feet in No. 3 level (78ft. level), with 35 feet of stope length 20 feet deep underfoot in the north end of No. 3 level down to the granite. The average width of the reef where stoped was about 15 inches, and the following crushing returns from ore mined from this reef were supplied by the owners and are believed to be correct:—

Tons of Ore Treated.	Gold there- from. OZS.	Gold in Sands.
63	163	5 dwt. 12 grains
133	174	6 dwt. 15 grains
55	48	8 dwt. 1 grain
155	128	7 dwt.
120	88	
Total 526 tons	601 ounces	

The gold was of a particularly high grade, being stated by the owners to be sometimes higher than standard. From the above figures the average grade of ore treated was 23 dwt. per ton, disregarding the gold left in the sands.

Since ceasing work in this mine sometime last February, a second line of reef about 5 chains west of the one under discussion has been discovered, and a rich shoot of gold of about 10 feet stope length has been followed down for about 70 feet from the surface, at which depth it has been cut off by a flatly dipping fault.

A third line further west is now being prospected from a shallow shaft and a gold-bearing quartz reef is being opened up, though values in this reef are still low.

Summarising the situation it will be seen that:—

(1) A highly payable gold reef of an average width of 15 inches where stoped, striking N. 30 deg. W. and dipping steeply to the west has been cut off by presumably a granite dyke at a depth of about 78 feet, the stope length of the gold shoot immediately above the granite being 170 feet.

(2) In an endeavour to get through the granite intrusion by sinking the main shaft and crosscutting, the owners sank the shaft 23 feet in solid granite and crosscut 6 feet west without getting out of it.

(3) The owners now require assistance from the Mines Department in the form of a loan of plant consisting of air-compressor, power unit, jack-hammer and air-lines to be problematically ultimately purchased or the hire paid for, to enable the solid granite to be penetrated in the search for the reef below the intrusion.

(4) Six hundred and one ounces of practically standard gold have been won from the mine from 526 tons of ore treated.

(5) Only the top surface of the intrusion has been exposed in isolated places in the workings, and no conception of its thickness can be obtained in the present mine workings.

#### CONCLUSIONS.

(a) The granite is probably in the form of a large dyke intruded along a fault plane.

(b) The calculated dip of the upper surface is about 63 degrees in a direction N. 55 deg. E. (magnetic), and assuming the lower surface to be parallel to the upper surface, the shortest way out of the granite is by means of a crosscut (or inclined shaft) extended on a bearing of 235 degrees (magnetic) at a downward inclination of 27 degrees to the horizontal from the bottom of the 155ft. shaft.

(c) The search for the reef below the granite is likely to be a hazardous undertaking, as faulting may also be present, and such granitic intrusions have characteristically uneven boundaries.

(d) The possibility of the intrusion being very large and its liability to alter its attitude must be borne in mind.

#### RECOMMENDATIONS.

As a prospecting venture, the inclined crosscut suggested from the bottom of the 155ft. shaft could be cut with a chance of ultimately cutting the reef below the granite, if the latter does not prove to be excessively thick.

The fact that good crushings were obtained from this reef before it was lost, and from another parallel reef subsequent to that event should be considered when the question of granting assistance to the present owners is under discussion.

#### PROGRESS REPORT ON THE GEOLOGY AND MINES OF THE YILGARN GOLDFIELD (South of the Great Eastern Railway).

By H. A. ELLIS, B.Sc., A.O.S.M.

#### INTRODUCTION.

The major part of the southern portion of the Yilgarn Goldfield and its associated accessible mines were geologically surveyed in the years 1912-1913 by Messrs. T. Blatchford and E. St. Smith; by far the greater portion of the work being done by the former. The results of this survey were co-ordinated by Mr. Blatchford and published as Bulletin No. 63 of the Geological Survey of Western Australia's geological series in 1915.

Renewed activity in the Yilgarn field led to a demand for this bulletin which could not be met, and with the object of bringing the geological and mining information up to date for incorporation in a new issue, the writer was instructed to carry out a re-survey of the whole of the southern portion of the Yilgarn Goldfield.

#### FIELD WORK.

Field work was commenced by the writer and Messrs. R. S. Matheson and R. A. Hobson towards the end of July, 1935, and was continued to mid-December, when the party was withdrawn to head office in order to do the essential office and laboratory work connected with the survey. Field work will be resumed early in 1936.

During the 1935 field season the various G.M.Ls. embodied in the following groups have been investigated by Messrs. Matheson and Hobson:—Jaccoletti, Glendower, Lennebergs, Burbidge (including with this latter group the Great Victoria, Grand National, Prince George and M.O.M. leases), Marvel Loch, Xantippe, Donovan's Find and Edward's Find.

The general geology of the area was undertaken by the writer, who is also responsible for the interpretation of the mining geology of the groups investigated by his two colleagues.

The general structural geology of the auriferous belt south from Southern Cross to Parker's Range and including the Yellowdine-Palmer's Find belt, has been studied in as great detail as the very poor exposures permit, and in subsequent paragraphs statements concerning this structure must be regarded as tentative only, being subject to modification by the results of areal mapping yet to be done.

#### MAPS.

The mapping of the geological structure of the southern portion of the Yilgarn Goldfield presents a very formidable task on account of the low relief, dense forest and thick scrub, paucity of outcrops and an ever persistent mantle of sandy soil and laterite. To complicate this feature further, it has been found that the gold-bearing formations are almost entirely of a sedimentary nature, and that if

a true picture of the structure is to be obtained, then the shape of every inferred geological boundary must be assumed to be reasonably correct when the maps are undergoing structural interpretation.

It therefore becomes evident that unless these sedimentary boundaries can be delineated with a fairly high degree of accuracy, then the geological structure cannot be unravelled. If most of the geological boundaries could be shown to be governed by the principles of transgressive igneous intrusion, then the question of boundary shapes would not assume such importance.

Continuity of outcrop for more than a few chains is extremely rare in this field, and all the inferences to be made from a study of the soil, vegetation and topography have had to be used in conjunction with the observations on actual outcrops in the compilation of the maps.

In mapping the gold mining leases, they have been taken in groups whenever possible, and mostly fall on our plane-table sheets which measure 18in. x 24in., plotted to a scale of five chains to one inch, one sheet to the group.

The actual surveying has been done with a plane table, using a telescopic alidade and staff for the tachometric measurement of distances, while all the other known methods of plane-table surveying have also been freely used in the location of points such as lease corner-pegs, shafts, surface workings, outcrops and geological boundaries. Recourse has been had to prismatic compass and chain surveys in country too thickly timbered to permit of the use of the plane table, while compass and paced traverses have been avoided. The lease plans can therefore be regarded as conforming to a standard of accuracy well within the plotting limits of the scale used.

For each group of leases, two 18in. x 24in. plans have been prepared. One is a "fact" or surface map showing topographic features, the positions of shafts, costeans, open cuts, buildings, lease boundaries and outcrops, together with geological boundaries where these can be defined with certainty. Soil covered areas are shown as such, and the distribution and nature of the vegetation is also indicated. It is hoped that this map will effectively serve the purpose of enabling a true geological picture of the surface exposures to be gained at a glance.

The other group map is a sub-surface map showing the nature of the rock underlying the mantle of soil, and has been compiled from information obtained from underground workings, surface outcrops and inferences of the existence of certain rock types, gained from a fairly sure diagnosis only of the soil type overlying this inferred rock. On it are also shown the positions of ore bodies.

There is scope for disagreement on the position of geological boundaries in this map which does not exist in the "fact" map, but it was thought advisable to take this step of producing a sub-surface map in order to indicate what we believe to be the solid geology of otherwise soil covered areas. We do not believe we are correct in every instance, but submit our interpretation in the hope that our work will form a basis for any future investigation.

#### MINE PLANS.

When procurable, copies of mine plans have been obtained from mine owners, and tracings have been made and used in underground examinations. Any underground workings of even small extent have been surveyed with prismatic compass and tape, and plans and sections on a scale of 50 feet to the inch have been prepared.

The underground geology of all producing leases and prospecting areas has been investigated and incorporated in the mine plans, which therefore form an accurate record of mine workings as well as the geology of each individual producer.

#### GENERAL GEOLOGICAL MAP.

The general geology has been recorded on Lands and Mines Department lithographs on scales of 300, 80 and 40 chains to the inch, but finality with respect to geological boundaries has not been reached on that portion already investigated, it having been found necessary to possess a more complete knowledge of the structure before boundaries can be reasonably inferred over large featureless sand and soil covered areas.

A considerable volume of structural data has been accumulated, and specimens of all rock types encountered have been collected and recorded on our field sheets.

#### GENERAL GEOLOGY.

Throughout the progress of the survey, the principal object aimed at has been to endeavour to find out why the gold is where it is, to correlate the known occurrences of gold ore with the geological structure, and to search for similar structures in areas not yet known to be auriferous.

As a result of investigations so far, no practical results have come from this endeavour, due mainly to the inability to work out correctly detailed structure owing to the paucity of outcrops and the shallow depths of the mine workings.

We have been forced to the conclusion that the original conception of the greenstones as being igneous masses intruded into a series of sediments (The Yilgarn Series) is untenable, in the light of field evidence at present at our disposal.

So far, no evidence at all in support of the intrusive nature of any of the so-called "greenstones" has been found, but a considerable body of field evidence has been collected which supports the conception that the hard, dark, green, grey and black crystalline rocks of the South Yilgarn Goldfield are lava flows, sub-aqueous tuffs, and thin and thick banded basic sediments forming part of a series conformable with the grey shales, grits, quartzites, mica schists, etc., of the Yilgarn Series which probably underlie them.

The indications are at present that the lavas occur towards the base of the basic series, and are succeeded by beds of sub-aqueous tuff, and normal water deposited basic sediments with numerous bands of acid sediments of varying thickness consisting of shales, quartzites, graphitic schists, etc.

The whole of the original "greenstone" areas of Bulletin 63 can be shown to consist largely of interbedded basic and acid sediments with the former predominating, and with a relatively small development of basic igneous rock as metamorphosed lava flows, occasionally showing pillow structure.



In the acid sediments themselves, numerous thin bands of basic sediments occur, and are so frequent in places as to necessitate their being mapped as "acid sediments with basic bands."

Practically the whole of the rocks investigated with the exception of the intrusive granite and lava are of shallow water origin, the rapid alternation of beds of different material and different grain size testifying to this.

It appears to the writer that the Yilgarn Series of recognised metamorphic rocks, together with the conformable so-called intrusive "greenstones" of Bulletin 63, now regarded as of predominantly sedimentary origin, constitute an horizon in a previously thick series of sediments, the basal and upper members of which may have been composed of grits.

This series of sediments and associated volcanic and pyroclastic rocks laid down under water in a great syncline were involved in mountain building orogenic movements, and were subjected to the processes resultant from the intrusion of a granitic magma on a large scale. Large areas were engulfed by the granite and equally large areas were converted into paragneisses and generally granitised. During the mountain making folding, these sediments were folded into major anticlinoria and synclinoria with steep northerly and southerly pitching axes and underwent regional metamorphism.

Some evidence for the existence of flat thrust faulting on a moderately small scale has been found to the south of Palmer's Find, and it is not unlikely that this structural feature has played an important part in the present distribution of auriferous belts. A second period of folding, the axes of which trend generally N.W. and S.E. and are more or less horizontal, has been imposed on these rocks. The folding during both of these periods has been intense, and close tight folds have been formed which have frequently ruptured under the great folding stresses and have produced shear zones in which many of the known auriferous deposits have been found to occur.

Still another period of folding, the axes of which have a general east-west trend, has been imposed upon this series of rocks, and the bearing that this folding has had on gold deposition may prove to be of some importance when further investigations have been made in the Great Victoria-Nevoria district.

From a knowledge of the geological structure already gained, it can be stated with some confidence that lateral prospecting from the mine workings in known auriferous areas is likely to lead to the discovery of further gold-bearing formations. It can also be stated that the continuation of a known fairly straight portion of lode need not necessarily be found in a straight line on either end of this formation, but may be found to either side, since the shape of the ore deposits is almost everywhere controlled by folding.

Brief reference to the nature and occurrence of granite and sand-plain areas will be fitting at this juncture, in view of the fact that the writer's conception of these, as in the case of the so-called "greenstones," is not in accord with previous conceptions as published in the publications of the Geological Survey of Western Australia. So far, in the course of the survey, several "granite" rocks have been investigated, and it has always been assumed in the

past that the bare rock masses which outcropped from beneath the sandplain were composed of granite, and represented monadnocks, the remnants of a previous cycle of erosion.

The sandplain country has also been assumed to overlie granitic areas, and while this is undoubtedly partially true, the nature of the rock underlying these sandy scrub-covered wastes is not considered by the writer to be entirely granitic, but in all probability consists largely of gneiss, representing the metamorphosed equivalent of a once thick and extensive series of felspathic grits, of which the Yilgarn Series with its associated basic sediments, pyroclastic rocks and lavas forms an horizon.

The true granite rocks are massive biotite granite devoid of pegmatite dykes, and appear to represent the apices of granitic intrusions. Other rocks present a distinctly gneissic structure, are seamed with intersecting pegmatite dykes, and in places produce all the characteristics of migmatites. A typical example of such a structure is to be found in the large rock situated about half a mile east from a point five miles north of Palmer's Find on the Palmer's Find-Yellowdine Siding road. It thus becomes evident that all the "granite rocks" are not true granite as was at first thought, when it was conceived that the sandplain country covered gneissic areas as well as granitic terrains.

It is possible that the main granitic intrusion was post folding, and it is established from underground inspection of numerous mines that granitic and pegmatite dykes have cut the known auriferous formations in a frequently flatly lying intrusive manner.

Assuming the origin of the gold in the lodes and reefs to have been genetically associated with a granite magma, then at least two periods of granitic intrusion are so far indicated.

Concerning the auriferous belts and their association with the dark ferro-magnesian basic sediments, pyroclastics and basic lavas and their associated fine-grained acid sediments, it seems probable that this series of predominantly stratified rocks has constituted a general incompetent series, the numerous members of which themselves show relative incompetency. Their associated beds, the coarse felspathic grits which have been assumed to overlie and underlie this series, are considered to have been the major competent beds, and the nature of their original constitution has rendered them readily amenable to regional metamorphism.

We therefore see in the so-called "greenstones" evidence of intense folding, and in that portion of the area so far examined, the narrow belt of basic and acid sediments and lavas extending south from a little east of Yellowdine Siding through Palmer's Find to Meier's Find affords ample field evidence of the severe nature of this folding.

## RESULTS OF THE RE-SURVEY.

1. Of major importance to the distribution of possible auriferous formations has been the discovery during this survey that the occurrence of the known ore bodies has not been, as previously considered, dependent upon the contacts of intrusive greenstone bodies and the intruded sediments,

2. It has been found that the whole of the gold belt so far investigated consists of a series of sediments of both a basic and acid nature, pyroclastic rocks and lava flows, all interbedded in a fairly rapidly alternating manner and that the formation of the gold-bearing deposits has been controlled primarily by the principles of intense folding.

The gold-bearing solutions have penetrated shear zones in both types of rocks, both basic and acid, and have not infrequently chosen narrow quartzite bands interbedded with thick basic sediments.

3. On account of the bedded sedimentary nature of the rocks and the intense folding they have undergone, it can be reasonably inferred that lateral prospecting from mine workings is already known gold-bearing formations is likely to lead to profitable results.

4. There is a great area of possible gold-bearing country covered with recent superficial deposits, and though this type of country is admittedly very difficult to prospect, the chances of ore bodies existing in it should not be overlooked.

5. By far the greater quantity of gold-bearing material in the South Yilgarn Goldfield is contained in lode formations as distinct from quartz reefs, the tenor of the latter being almost always higher than that of the former.

While these lode formations are structurally strong in the majority of cases, it is unfortunately true that their gold content is low. No lode formations have as yet been investigated below the oxidised zone in the South Yilgarn field, but in view of the fact that practically all the worked out and working mines in these formations show only low-grade secondary enrichment, little hope can be given for payable primary deposits in the unoxidised zone.

6. The need for the very thorough underground prospecting of any low-grade formation before the erection of a treatment plant on it is emphasised by the extremely erratic nature of the secondary enrichment, and care must be taken not to place too much reliance on anything but a very thorough systematic sampling of any low grade ore-body which it is intended to treat.

7. The auriferous quartz reefs so far seen have been frequently found to be lenticular in nature both along the strike and down the dip, and though usually carrying a higher gold value per ton than the lode matter, have not the continuity to enable them to be large producers.

8. A fairly thorough stocktaking of the mineral resources in the area so far investigated has been effected, and it has been found that this in itself will prove invaluable to future seekers of gold in the southern portion of the Yilgarn Goldfield.

9. Whilst engaged on the field work we have been called upon for advice on numerous occasions by many small mine owners and prospectors, and have frequently directed the search for the continuation of faulted ore-bodies and underground prospecting in general.

## SUMMARY OF PETROLEUM EXPLORATION IN WESTERN AUSTRALIA TO JANUARY, 1935.

By R. A. HOBSON, B.Sc. (Hons.).

### 1.—INTRODUCTION.

Prior to 1919 no acceptable evidence of mineral oil had been forthcoming from anywhere in the State. Bitumen had been recorded as being washed up on the western portion of the southern coast, and oil reported on the Princess Royal Harbour, Albany. Supposed prospective areas were examined by Maitland (1902, 1904, 1906), Montgomery (1903) and Woodward (1915). These examinations failed to disclose any favourable conditions for the formation and retention of oil. It was shown that the bitumen was found only on the beach and not inland, and that it was distributed over a considerable length of the south coast of Australia. It was not considered an indication of the presence of mineral oil inland. Any oil in Princess Royal Harbour, Albany, was considered to have been derived from shipping. Maitland (1906) further found other conditions unfavourable.

The general position was reviewed by Maitland (1913), who showed that no evidence had been forthcoming at that date of the existence of mineral oil anywhere in the State.

In 1917 attention was drawn to the Nullabor Plains. The geology of this area was reviewed by Maitland (1918), whose work is summarised in a later section of this report. He evidently formed an unfavourable opinion of the area.

In 1919 Harry Price, a well-sinker, reported (Blatchford, 1927) that he had recognised traces of oil in a bore being sunk in search of water on Gogo Station, Kimberley Division. The bore was located on the west side of a southern extension of the Rough Range. About the same time Walter Okes reported the finding of glauconitic pitch close to the junction of the Ord and Negri Rivers. Both these discoveries were confirmed by Blatchford (1921) and descriptions published. Thus attention was drawn to the Kimberley Division and geological work followed immediately.

### 2.—SCOPE OF REPORT.

An attempt has been made to summarise the work of various geologists in various districts. Only reports relating to petroleum exploration have been examined. A brief resumé of the geology of each area as found in the various reports is given and also the conclusions arrived at by the various authors. No attempt has been made to give a complete summary of the geological knowledge of the various districts. Accompanying this report is a map\* which is to be used in conjunction with a geological map of this State. The map shows the areas of the State covered by sedimentary rock of Palaeozoic or younger age, and areas whose oil prospects have been considered. In some instances the map shows the area covered by plates or maps accompanying reports and in others the area reported upon. This latter is usually an oil prospecting lease. The report is also accompanied by an Appendix and Bibliography.

### 3.—SEDIMENTARY AREAS IN W.A.

Four main Artesian basins are recognised in Western Australia:—The Desert Basin, the North-West Basin, the Coastal Basin, the Eucla Basin, together

\* Map not published.

with two smaller ones in the East Kimberley. Other smaller areas of sediments exist *e.g.*, the Upper Fortescue River Area (Cainozoic), the Collie Coal Basin (Permo-Carboniferous), and an area of Permo-Carboniferous rocks in the south-west corner of the State. These latter however are not important when considering the oil prospects of the State.

The four main Artesian basins mentioned above, cover most of the area of sediments shown on the accompanying map.\*

#### 4.—GEOLOGICAL SURVEYS AND REPORTS IN CONNECTION WITH PETROLEUM IN WESTERN AUSTRALIA.

These are best considered according to the various districts in which they have been carried out. They will be discussed under the following heads:

##### I. Kimberley Division.

- i. The Desert Artesian Basin.
  - (a) Fitzroy Valley Area.
  - (b) Southern portion of the Basin.
- ii. The Ord River Area.

##### II. The N.W. Division (of which the N.W. Artesian Basin is part).

- i. The Northern or Exmouth Gulf Area. O.P.A. 258H.
- ii. The Southern Areas.
  - (a) Wooramel River Area.
  - (b) O.P.A. 191H.
  - (c) O.P.As. 231H, 235H, 236H.

##### III. The S.W. Division (of which the Coastal Artesian Basin is part).

##### IV. The Eucla Division (of which the Eucla Basin is part).

#### I.—KIMBERLEY DIVISION.

Following Blatchford's confirmation of Okes' and Price's reports, geological work was immediately undertaken by Blatchford in the Fitzroy valley area and by Mahoney in the Ord River area. This was the first geological work undertaken in this district having as its special object the consideration of the district's oil possibilities. Blatchford (1927) has summarised the results obtained in 1926 and noted the work of previous geologists in the Kimberley District in G.S.W.A. Bulletin 93.

##### i.—The Desert Artesian Basin.

###### (a).—Fitzroy Valley Area.

Blatchford, T., 1927, G.S.W.A. Bull. 93.

The object of this Bulletin as set out in the introduction is to collect together the work of Blatchford and Talbot in the Fitzroy Basin, and to discuss the oil prospects of that area. Reference is also made to the country between the Fitzroy and Ord Rivers and about the latter. The work in the Fitzroy valley was commenced by Blatchford, Talbot and Rowe in 1922 and completed by Talbot in 1923.

Most of the area was found to consist of rock of Carboniferous age. Two series were recognised—the lower limestone series and the upper sandstone series. The bore at Price's Creek, from which the showings of oil had been obtained, was in an area of lower limestone rocks. The following geological sequence was recognised for the Kimberley Division:

Recent.—Surface deposits covering the plains.  
Brown or black river alluvium. Low-lying sandy ridges, known as *Pindan*.

Pliocene(?)—Partly consolidated ferruginous sandstones, grits, conglomerates.

Tertiary(?)—Leucite bearing lava rocks. These are certainly Post Carboniferous and may be Tertiary by comparison with similar rocks of Sumatra, etc.

Jurassic.—Occur as a strip along the west coast from Swan point to Wallal and contain Artesian water at Broome. The eastern boundary of the geological map is tentative.

#### Carboniferous.

##### Upper Sandstone Series.

- i. Ferruginous sandstone, grits, with occasional conglomerate beds.
- ii. Flaggy sandstone and shales. Occasional narrow limestone beds.
- iii. Grits, sandstones and shales.
- iv. Massive sandstone with glacial beds.
- v. Narrow limestone bed.
- vi. Well bedded sandstone with occasional thin bands of shale.

##### Unconformity.

##### Lower Limestone Series.

Grey to white limestones usually massive but sometimes bedded.

Devonian.—Impure reddish limestones at Mt. Pierre. Also base of Napier Range.

#### Cambrian.—

##### Upper Cambrian:

Chocolate coloured sandstone.  
Fossiliferous limestones.  
Mudstone, various coloured limestone and shales—Fossiliferous.  
Massive unfossiliferous limestone.  
Basalt lava flows.

##### Unconformity.

##### Lower Cambrian:

Quartzites.  
Dark coloured shale.  
Limestone—may be absent.  
Quartzite.  
Limestone—thin.  
Quartzite.

From observations in Ord River Valley. Refer to sections Plate VII., G.S.W.A. Bull. 93.

##### Unconformity.

#### Pre-Cambrian.—

Nullagine beds of the Northern Plateau.  
Quartzite, shales, limestones, etc.

##### Unconformity.

Metamorphics with intrusive granites and basic rocks.

Structures considered to be suitable for the retention of mineral oil were recognised at Mt. Wynne, Grant Range, and Poole Range. Each of these is described in detail.

Other conditions for the existence of mineral oil were thought to be favourable but some doubt was expressed as to the existence of suitable cover rock.

\* Map not published.

As a result of the first portion of the geological work drilling was commenced at Mt. Wynne. The other structures had not been found at that stage. Showings of bitumen and oil were obtained and these will be more fully dealt with in Section 5 of this report.

In the main portion of the report no site is selected for further drilling.

Appendix II. deals with the selection of a drilling site at Poole Range, following a visit of inspection by Dr. Wade, and is best discussed after Dr. Wade's work has been recorded.

Wade, A., 1923-24. *Report to Commonwealth Government.*

During 1923-24 Wade visited various areas in Australia on behalf of the Commonwealth Government. Amongst these was the Kimberley Division in Western Australia. During this work he was accompanied by Blatchford, Talbot (in the Fitzroy Valley), and others. The structures previously referred to—at Mt. Wynne, Grant Range, and at Poole Range—were visited. The Rough Range was also examined. Dr. Wade considered that for the Fitzroy Area, any oil present would have had its origin in a series below the Permo Carboniferous Series, and that most probably this series would be of Cambrian age. He was unable to satisfy himself that there were any strata in the Permo Carboniferous in which oil could have originated. Small showings at Price's Creek in the lower carboniferous limestone are discounted as are also the showings in the bore at Mt. Wynne. He also felt some doubt as to the existence of suitable cover rocks. As a test of the petroleum possibilities of the area, he suggested three wells, two at Price's Creek and another elsewhere, preferably at the Poole Range.

Blatchford, T., *G.S.W.A. Bull.* 93—Appendix II.

Following Wade's recommendation Blatchford was instructed to select a drilling site at the Poole Range. This had been located by Talbot, Geologist to the Freney Kimberley Oil Co., and a map had been prepared by him. Poole Range was found to be a collapsed anticline with its longer axis in a N.N.W.-S.S.E. direction. A noticeable feature of the area was the eight faults all striking parallel to the longer axis of the fold. It was thought that any oil migrating would have come from the S.W., and a site was therefore chosen on the west side of the anticline, west of the most westerly fault.

Clapp, F. G. (1925-26). *Articles published in various journals—(See Bibliography).*

During 1924 Clapp made a reconnaissance trip through various portions of W.A. During this trip he examined portions of the Desert Basin and reported unfavourably on the oil prospects of that area. In his summary he says: "The insignificant nature of the oil indications in the several wells drilled, the apparent total absence of natural gas, uncertainty as to the actual existence of any surface indications, lack of shale cover, intense faulting and possible metamorphism of the marginal parts, prohibitive thickness of sandstone throughout enormous areas and somewhat unsatisfactory source of origin, are collectively considered unfavourable to the commercial occurrence of oil in the Desert Basin."

Forman, F. G., 1929. *G.S.W.A. Ann. Rept.*

Forman briefly summarises the geology of the Desert Basin and discusses the oil possibilities. A more optimistic note is sounded in this report. As a result of information from the bores it was considered that sufficient shaly strata were present to provide adequate cover rock. Forman points out the location of all the known structures around the edge of the Fitzroy basin and the resemblance of this arrangement to that occurring in the producing areas of U.S.A. It is suggested that further structures may be found on the southern and eastern boundaries of the Desert Basin.

Wade, A., 1935. *Interim Report to Freney Kimberley Oil Co. (O.P.As. 146H, 186H.)*

The two O.P.As. held by the Freney Kimberley Oil Co. cover an area of 94,400 square miles of the Kimberley Division. The area is bounded on the north by 16th parallel of south latitude, on the east by the Western Australia-Northern Territory State boundary, on the south by 19° 30' parallel of south latitude, and on the west by the 123rd meridian of east longitude. It is shown on the accompanying map.\* Dr. Wade points out that only portion of this is potential oil country. There is a large V-shaped area mainly of rock of the Nullagine Series (Pre-Cambrian), with smaller areas of metamorphic and intrusive igneous rocks. It is the S.W. portion of the O.P.As. which has been examined by Wade. Wade points out that the report is an interim report and as such is subject to revision as the work proceeds. In all, 10,000 square miles were examined by Wade and his assistants. Various types of work were done from reconnaissance to detailed work. The area examined and the type of work done on each is clearly set out in Section 2 of the report. A summary is given of the geological sequence arrived at and a copy of his table is attached. The sequence ranges from Pre-Cambrian to Recent, but it is to the Permo-Carboniferous that Wade attaches importance from the point of view of oil. He finds that there are considerable thicknesses of argillaceous strata, which is important, as early geological work had shown this to be doubtful. He proposed seven unconformities, three of which occur in the Permo-Carboniferous. As a result of his work, Wade considers that the lower beds of the Permo-Carboniferous Series have been too disturbed—folding has been too intense and faulting too prevalent—to make it probable that they would contain commercial supplies of oil at the present time. The presence of unconformities has also increased the chance of leakage of any oil which may have been formed. It is considered that the Permo-Carboniferous beds above the glacial series are the most likely beds to contain commercial supplies of oil. He recommends that the work be continued during the present year, and that search be made for areas with a low degree of folding in the upper Permo-Carboniferous beds.

(b).—From Southern Portion of Desert Basin.  
Areas 21H, 23H, 25H.

These areas were visited by Leo. J. Jones, who made a reconnaissance survey over a large area. They occur in the Eastern Division of W.A., but may be discussed here since geologically they are continuous with the Fitzroy Valley area. The report on O.P.A. 25H is not available at the time of writing, but this

\* Map not published.



area is shown on a map, together with O.P.A. 21H. Also the map accompanying the report on O.P.A. 23H is not available. He recognised the following geological sequence:—

Pleistocene to Recent.—Soil, sand, travertine, chalcedony, gypsum, ferruginous and saline deposits.

Carboniferous.—Upper Sandstone Series. Lower Limestone Series.

Cambrian.—Nullagine beds. Lower Limestone Series.

Pre-Cambrian.—Metamorphic Series.

Archæan.—Granite and Gneiss.

Referring to the Nullagine, Jones says: "My observations along Christmas Creek, north of your company's block, revealed what appeared to me to be an extension of these (Nullagine—R.A.H.) beds resting conformably on a limestone series, containing *Salterella Hardmani*, an undoubted Cambrian form, and hence my provisional classification as Upper Cambrian for these beds." Jones would seem to be in error here, as the Nullagine beds are now considered to be of Pre-Cambrian age (Geological Map of W.A., 1933). He records that the Carboniferous Sandstone Series "are for the most part nearly horizontal, the normal dip rarely exceeding two degrees. In places, however, local gentle warping or folding has taken place and dips up to 27 degrees are recorded." The above is written with reference to 21H. For 23H, dips rarely exceed 5 degrees. The following fossils were found in a range of hills N.E. of No. 27 Well on the Canning Stock Route:—

*Productus subquadratus*.

do. core.

*Spirifera byroensis*.

*Spirifera* sp. nov.

*Orthothetes* sp.

*Nautilus coelonutilus*.

From the lower Limestone Series, he records the following fossils:—

*Chonetes pratti*.

*Dielasma hastati*.

*Productus* sp.

The abundance of fossils in the lower Limestone Series is noted and this series is considered to be the most likely source of petroleum.

No surface indications of petroleum were found.

Two test holes were recommended:—

- (1) Near to Godfrey's Tank on a "well defined dome."
- (2) About 2 miles west of No. 50 Well, Canning Stock Route, on a "structural terrace."

No drilling has been undertaken in this area.

The geology of the Canning Stock Route, the northern portion of which crosses the area covered by Jones, was first described by H. W. B. Talbot (1910). Talbot recognised the existence of a large area of carboniferous rocks.

#### ii.—Ord River Area.

Following the confirmation of Okes' discovery of bitumen close to the junction of the Ord and Negri Rivers, a geological survey of this area was under-

taken by Mahoney (1922). He was able to recognise the following geological sequence (the younger beds are placed first):—

Mt. Elder Sandstone Series.—Coarse-grained sandstones. May be silicified. False bedding.

Negri Series.—Limestone, mudstone and shales. No trace of metamorphism. Limestone fossiliferous. Series would provide impervious "cover" rocks.

Basalt.

Hard grits and conglomerates.

Mahoney considered that the bitumen found in the basalt at Okes' find had been derived from the limestone of the Negri Series. Blatchford (1921), after his first examination, considered that this bitumen had been derived from the series underlying the basalt. Mahoney was later supported by Wade. Further reference will be made to this later.

Mahoney chose a site for the first trial bore some 16 miles south-easterly from Okes' find, on an anticline having a north-west trend. It was said to have a pitch to the north but there is no indication of closure to the south. This site is shown on the map which accompanies this report.\*

Fossils identified by Chapman (1922) indicated an Upper Cambrian age for the Negri limestone.

Wade's visit of inspection (1923-24) in the Fitzroy Valley area has already been noted. On the completion of this he crossed to the Ord River area, making an examination of the country on the way. Two sections accompany Wade's (1923-24) report, and show the geological succession and structure indicated by his traverses. Wade found that the upper portion of the Ord River flows through an area of Upper Cambrian rock, underlain by basalt. These Upper Cambrian rocks are composed of fossiliferous limestones, green and white shales, flaggy mudstones with a massive cherty limestone immediately above the basalt. The Upper Cambrian strata contain well preserved fossils and have a very fresh and young appearance. Wade says "it was hard to realise that we were dealing with one of the oldest series of fossiliferous strata." The basalt is vesicular and is considered to be a flow, not a sill. Underlying the basalt are a series of quartzites, indurated shales, fine grained siliceous flags, with a basal bed some 400 feet thick of a hard massive quartzite.

Soft red, white and yellow sandstone which may be carboniferous, but which contain no fossils, occur at Glass Hill and Mt. Buchanan and other places on the west side of the river. On the east side of the Ord chocolate coloured grits, flags and well bedded sandstone occur in the Mt. Elder Ra. These are apparently conformable with the Upper Cambrian strata, but Dr. Wade thinks that more detailed mapping may show an unconformity. Above these in the Mt. Elder Ra. grey, green and white cherts occur at Trig. J40. These contain *Planorbis hardmanni*, which is a tertiary fresh-water fossil. These occur about 1,000 feet above sea level.

Wade agrees with Mahoney that the bitumen found in the basalt has come from the limestone above, and considers that any oil originally present would have escaped along the junction of the limestone and the basalt. He considers that there is no chance of oil being present in commercial quantities.

\* Map not published.

Blatchford (1927) makes reference to the Ord River Area. He recognises the existence of an unconformity between the basalt and the Lower Cambrian beds. No further drilling is recommended. He believes that the bitumen found in the basalt has been derived from the underlying beds, and has reached its present position by way of fractures, etc., through the basalt.

The arguments advanced by various writers may be summarised as follows:

*Derivation from overlying limestone.*

For:

- (1) Bitumen is found at junction of limestone and basalt.
- (2) Beds of Upper Cambrian Series are impervious and any oil formed in lower portion of these would tend to escape at the junction with the basalt.
- (3) Upper beds are less altered than lower Cambrian beds. Rich in fossils and suitable for formation of oil.

Against:

- (1) Bitumen is not found in overlying limestone or sandstone.
- (2) No bitumen or oil in Okes-Durack bore which penetrated these to basalt.

*Derivation from underlying series.*

For:

- (1) Both places where the bitumen is found is on a line of weakness. Only occurs where rock is fractured.
- (2) Hot spring at Texas Homestead probably comes from below the basalt, suggesting sufficient permeability for fluids to travel.
- (3) The occurrence suggests that the bitumen has been injected into the basalt under pressure. If travelling along junction of limestone and basalt why is it not injected into the limestone above.
- (4) Basalt is sheared and bitumen injected after shearing.
- (5) Bitumen reported in Northern Territory in rock corresponding to lower group in the Ord.

Against:

- (1) Basalt taken as a whole is very compact and impervious, also very thick.
- (2) Any oil occurring in the lower series would tend to leak at the junction of these with the basalt or through some outcropping edge of the lower beds.
- (3) Lower beds consist of quartzites, indurated shales, etc., which have been considerably metamorphosed. Also tilted and faulted in Osmond and Albert-Edward Ras. No evidence of any bitumen occurring in the ranges due to leakage.
- (4) Beds at least lower Cambrian in age and may be older.

Referring to the Ord River Area Wade (1923-24) says: "We believe that the oil originated in the Upper Cambrian strata and that at some age, long past, oil field conditions may have prevailed in the

Ord Area, but the oil has gone and only the residual bitumen remains in the basalt to show what may have been."

II.—NORTH-WEST DIVISION.

Clapp (1925, 1926) visited portions of the North-West Basin during September and October, 1924, during the course of a reconnaissance trip through portions of W.A. He reported unfavourably on the oil prospects of that area. No traces of oil or natural gas had been recorded in the artesian wells. He further considers that the shales are "entirely inadequate" as cover rocks.

Subsequent work may be considered under two headings:—

- (i) The Exmouth Gulf Area.
- (ii) The Areas in the Southern portion of the Basin.

i.—Exmouth Gulf Area.

Clapp refers (1925, 1926) to the existence of Oligocene beds containing *Lepidocyclina*, *Cycloclypeus* in the Cape Range, close to North-West Cape. He notes that these beds are folded into an anticline. These observations were made during a reconnaissance trip through the North-West Basin during 1924.

Woolnough (1932) in an air reconnaissance flight around Australia took air photographs in the neighbourhood of Exmouth Gulf. His report\* is not available at the time of writing. Photographs of Exmouth Gulf Area are, however, available at the Geological Survey of Western Australia.

The area was visited in 1934 by Condit and Rudd for Oil Search, Ltd., Sydney, and later in the same year by Raggatt. A natural result of Raggatt's more detailed observations in an area which has previously been examined in a very broad manner, is that new geological facts have been brought to light and that a revision of the Geological Map in that area is necessary. Detailed reports have not yet been received.

ii.—The Southern Area.

Various areas have been examined in the southern portion of the North West Basin. Most of the work has been of the reconnaissance type, but one area close to the Wooramel River has been examined in more detail. The following areas will be considered:—

An area close to the Wooramel River.

O.P.A. 191H.  
 " 231H.  
 " 235H.  
 " 236H.

(a) —The Wooramel River Area.

The latest and most detailed report on this area is that by Dee and Rudd (1932). The report is accompanied by plans and sections and the earlier work is reviewed.

Attention was first drawn to the area as a result of a hurried visit by Dr. Woolnough and Col. Nicholson, then chairman of directors of the Freney Kimberley Oil Co., in 1928. Woolnough (1928) recommended the area as one with good prospects and well worthy of geological investigation.

\* Dr. Woolnough's report was subsequently available and examined after writing present report. Refer to Bibliography —Woolnough, 1932.

Following Woolnough's recommendation, Talbot made a rapid survey of an area 36 by 25 miles. He submitted a report and map to the Wooramel Oil Syndicate. Talbot noted that the area consisted of sandstone, shales with many thin limestone bands and occasional beds of conglomerate, all of Carboniferous age. The limestones were abundantly fossiliferous. With two exceptions in the neighbourhood of fault planes, the dips were all very gentle. Talbot recommended drilling on a structure S.S.E. from Callytharra Spring.

Later the area was visited by Woolnough (1929) and Feldtmann (1929) in company with Talbot. More detailed work than Talbot had been able to carry out in the time at his disposal was recommended. The existence of the dome-like structure found by Talbot was recognised.

In 1930 the area was visited by Hobson. Some time was spent expanding Talbot's work and later an area about Talbot's Cairn (reference point built by Talbot) was mapped in more detail. Faults in the neighbourhood of the Cairn were mapped. It was considered that the most suitable location for drilling was east of a fault near Talbot's Cairn.

April, 1931, saw Talbot and Hobson again in the area accompanied by P. S. Hossfeld. Further information was collected about the Cairn Area. Talbot and Hobson recommended drilling on what appeared to be a closed structure east of the Cairn. Hossfeld and later Woolnough considered a more detailed examination necessary of the section exposed in the Wooramel River and of the Byro Plain for structure. They were agreeable to the drilling as above for geological information.

Dee and Rudd recognised the following stratigraphical sequence:—

Recent to Tertiary.—Laterites and recent sands. Travertine.

Jurassic?—Grits and conglomerates 5 feet +.

#### *Unconformity.*

Permo-Carboniferous—

(i) Byro Limestone group 600 feet +

Confined to Byro Plain. Sandy limestone and calcareous sandstone with abundant fossil remains.

(ii) Wooramel Sandstone group, 800 feet +

Vary from fine grained micaceous sandstone to coarse quartz grits. Fossiliferous in upper horizons. Fauna of this group are intermediate between those of the Callytharra limestones and the Byro limestone group.

(iii) Callytharra limestone group, 90 feet +

Limestone is grey to brown and varies between a foraminiferal, crinoidal and shelly type. Includes about 5 feet of limestone conglomerate at base. Abundant organic remains.

(iv) Glacial group, 500 feet +

Glacial grits, tillites and boulder beds.

Acidic and basic igneous erratics occur together with quartzites and metamorphosed limestone beds.

#### *Unconformity.*

Pre-Cambrian.—Igneous and Metamorphic Rocks.

The general structure of the area (Dee and Rudd) was shown to be saucer-like with the lowest point some four miles north of Bogadi Outcamp. Faulting is prevalent. The boundary of the Permo-Carboniferous sediments against the igneous and metamorphic rocks to the east and north-west, is marked by faulting. With the aid of aerial photographs various areas were examined for structure, and if necessary these were mapped on a large scale. The results of this work have been collected together by Dee and Rudd, and are shown on a geological map (scale 1 in. = 1 mile). The work around Bogadi, which revealed a saucer-like structure, is shown on a larger scale map (4 in. = 1 mile). Structures of individual areas are discussed in their reports.

Faults are well marked as a result of depositions from ferruginous solutions which have passed along the fault planes.

No indications of petroleum have been recorded in the area. It is considered by Dee and Rudd that leakage might have occurred in the neighbourhood of some of the many faults.

The Callytharra Limestone Series is thought to be a suitable source rock for petroleum. The Wooramel Sandstone Series would provide suitable reservoir rocks. Other conditions necessary for the existence of oil in commercial quantities are not considered to be satisfied. Dee and Rudd conclude that there is doubt as to the existence of suitable cover rocks—none showed up in the section exposed and the chance of their existing in hidden sections is thought to be remote. Both source and reservoir rocks outcrop over extensive areas. No suitable structures were found. Faulting was disclosed immediately to the east of the structure previously recommended for drilling, and it was considered that there was some doubt about its closure. No indication of petroleum is known in this area. For these reasons Dee and Rudd do not recommend drilling.

During the course of their last survey, the area was visited by Woolnough and Hossfeld. Woolnough (1932) was directing an air survey of portions of Australia and the Wooramel area was among those selected. Visual observations were made and photographs of selected areas were made available to Dee and Rudd.

(b).—An Area South of Carnarvon in the Neighbourhood of Shark Bay—O.P.A. 191H.

This is an L-shaped area extending from just south of Carnarvon to 20 miles south of Hamelin Pool. The lower portion of the L-shaped area extends inland for 100 miles. It was examined by Wade for the Freney Kimberley Oil Co. in 1934. Wade found a large portion of the area covered with drift sands, recent limestones and red sandy plains. Traverses were made in numerous directions over the area and in addition the logs of 70 bores sunk for water were critically examined. In the coastal part of the area, the strata met with in boring are summarised as below:—

Tertiary-Cretaceous.—Yellow, grey and white clays and chalks with some thin bands of limestone near the surface. Occur to depth of 500 feet to 1,000 feet.

Upper Jurassic.—Black or dark coloured shales, sometimes with pyrites, thickness 80 to 250 feet.

Permo Carboniferous.—Grey shales and limestones—800 feet (800 feet thick in Carnarvon bore and apparently absent outside area around Carnarvon). Thin chocolate coloured sandy shales overlying hard pink and grey sandstone and coarse grits—500 feet to 800 feet.

Wade suspects the existence of a buried ridge "faulted down to the eastward toward Peron Peninsula and Dirk Hartog Island by a north-south fault and to the north by an east-west fault which more or less coincides with the lower course of the Gascoyne."

Recent, Tertiary, Cretaceous, Jurassic (?) and Permo Carboniferous strata are passed through in one bore of 3,000 feet. Further changes in conditions of deposition are considered to have been steady and slow.

An unconformity is suspected above the Permo Carboniferous Series, thus giving any oil formed a chance to escape. Conditions are not considered favourable to the formation of oil in the Permo Carboniferous beds.

In the beds above the Permo Carboniferous there is an absence of sandstone beds to act as reservoir rocks. Also any oil which may have been formed would have had a chance to escape eastward after tilting and erosion had occurred.

No evidence of oil has been found in any of the bores which have been put down for water, nor have any surface indications been noted.

Wade makes no drilling recommendation.

(c).—O.P.As. 231H, 235H, and 236H.

In 1932 Blatchford and Forman (1932) visited Boolardy Station to get some first hand information in the field on the occurrence of a stinkstone which had been reported. It was thought it might have some bearing on the oil potentialities of the district. After examination it was concluded that the stinkstone was a superficial formation, having no relation to oil. Most of O.P.A. 236H was found to be granite country. Various samples of stinkstone were collected. Subsequent examination of these by the Government Mineralogist and Analyst revealed no trace of mineral oil.

The eastern edge of O.P.A. 235H lying to the west of 236H was examined and it was considered that 235H warranted further geological work.

To do this work, Forman (1932) set out in September, 1932, and made a traverse over large portions of 235H and 231H which lies immediately to the south. Portions of 223H and 234H were also touched upon. It was found that large portions of the area were covered with sand hills completely obscuring the geology. Good exposures were seen, however, in the southern portion about the Murchison River and in the eastern portion. It was found that a considerable portion of the area was occupied by Permo Carboniferous sediments, overlain by Cretaceous sediments towards the coast, the whole dipping to the west at 1°-2°. No structures were observed suitable for the retention of oil, and it was

recognised that because of the sand further geological work by means of surface observations would be difficult.

O.P.A. 235H was not recommended for immediate further work.

### III.—SOUTH-WEST DIVISION.

From time to time numerous indications of oil have been reported from various places, and a certain amount of drilling has been undertaken as a result. In no instances have any of these indications been accepted and confirmed by officers of the Geological Survey of Western Australia. Numerous reports have been written and these are listed in the bibliography. Of these it is sufficient to note Bulletin 65, dealing with the Warren River District, and Bulletin 26 which contains a report on an area about the Princess Royal Harbour.

The occurrence of bitumen on the south coast has already been noted. It has also been noted that it has never been found away from the coast. All writers agree that it cannot be accepted as an indication of petroleum in the districts inland from the beach where it occurs. Specimens were examined in the laboratory by Dr. Simpson, and his observations are recorded in an appendix to Bulletin 65. In his summary, he says: "The South Coast Asphaltum is a true Petroleum residual. It occurs in small masses of identical type along 1,500 miles of coast line and is confined to the immediate vicinity of the ocean. It is capable of having been floated by sea water, and whilst it may be derived from local sources it is more probably the ocean drift from jettisoned or wrecked cargo, or from supplies brought by whalers for caulking their boats."

Other reported indications have been found upon examination to be natural occurrences in swampy regions. No drilling has been recommended.

Recently Forman (1934) has noted that the topographic features near Walyering Peak suggest the existence of what may be a structure suitable for the retention of oil. He considers that more work would be necessary to prove the existence of the supposed structure, and it would also be necessary to examine Permo Carboniferous and Jurassic beds outcropping to the north for possible source beds. No indications of oil were found in the area examined.

### IV.—EUCLA DIVISION.

The geology of the Nullabor Plains and the Petroleum possibilities have been summarised by Maitland (1918). A considerable portion of the area is covered by a cavernous limestone of Miocene age. Bores have shown that underlying this are mainly shale and sandstone of Cretaceous age. Thin bands of dolomitic limestone and glauconitic mudstone have also been recorded. Numerous bores have bottomed on granite.

Summarising the evidence available, Maitland says:—

- (1) There is a large area of Tertiary or Late Cretaceous rocks, which contain amongst their members sandstones of varying degrees of porosity.
- (2) The beds dip at very low angles to the south at about 5°.



- (3) The cliff sections of the coast show that the beds are virtually horizontal, and have not been subjected to disturbance, nor in any way thrown into folds.
- (4) No oil seepages have been noticed anywhere in the plateau.
- (5) Asphaltum, a residue of petroleum, occurs amid flotsam and jetsam on the coast, but has not been found anywhere inland beyond possible depositions by the sea.
- (6) There are no known extensive deposits of organic origin anywhere associated with beds of the Nullabor Plains which are capable of producing oil.

#### 5.—DRILLING FOR PETROLEUM IN W.A.

We have already noticed that a certain amount of drilling was undertaken in the S.W. Division in the neighbourhood of supposed indications. This drilling need not be discussed further since no success resulted, nor was any ever likely.

Subsequent drilling has been confined to the Kimberley Division in four localities:—Price's Creek, Mt. Wynne, Poole Range in the Fitzroy Valley, and the Okes-Durack Bore in the Ord River Area.

##### *Price's Creek.*

The first showings of oil in the Fitzroy Valley were obtained here. Subsequently, four holes were drilled in this locality ranging in depth from 340 feet to 1,008 feet. Numbers 1 (1,008 feet), 2 (340 feet), and 3 (809 feet), sunk in the vicinity of Price's original bore, all showed traces of oil, while number 4 (444 feet), two miles to the west, showed no indications. Numbers 1, 2, and 3 all penetrated limestones of Lower Carboniferous age throughout their entire depth, while number 4 did not reach these until 444 feet deep. Before this it passed through sandstones and shales. Faulting is suspected between numbers 3 and 4.

##### *Mt. Wynne.*

Following early geological work by Blatchford and Talbot, a drilling site was selected and drilling commenced, using a Calyx drill, about the middle of 1922. The first hole was carried to a depth of 894 feet, when it was decided to change to percussion drilling. It was found that the hole was crooked, and it was abandoned. Asphaltum was recorded at several depths, 109 feet, 118 feet 6 inches—121 feet 6 inches, 225 feet and 274 feet (?). The occurrence at 120 feet is described by Simpson (1922) as follows: "This (11 inch of core—R.A.H.) consisted of a firm white sandstone, thickly bedded and traversed by a number of roughly vertical and inclined joints. Nothing resembling bitumen has impregnated the sandstone, but in most of the joints were dendritic films and coatings (up to nearly  $\frac{1}{2}$  in. in thickness) of black and brown organic matter as well as kaolin and occasional small masses of pyrite." Two types of carbonaceous matter were present:—

- (1) A brilliant black plastic asphaltum—less abundant than (2).
- (2) A brown porous fragile material, widely distributed in the joints.

Both were considered to be true petroleum residues the second probably derived from an earlier asphaltum.

A second hole was carried to a depth of 2,154 feet. The log of this bore is given in Bulletin 93, and a copy is attached to this report. The log shows that globules of oil were noted at various depths between 524 feet and 1,886 feet. Bitumen was also recorded between these depths and also shallower. A water shut off was attempted at 2,084 feet but failed owing to the shale band being thin and underlain by a friable sand containing water. Drilling was stopped in September, 1925, at a depth of 2,154 feet.

##### *Poole Range.*

Following Dr. Wade's visit of inspection in 1924, and work by Blatchford and Talbot at the Poole Range, drilling was commenced. A pilot hole was drilled to a depth of 1,000 feet.

In the main hole 10 inch casing was carried to 1,683 feet (Blatchford 1928), and all top waters were cemented off at this point. Soon after continuing drilling in an 8-inch hole, water entered the hole and rose to within 127 feet of the surface. It is not certain where this came from—whether the cement had failed, or a water sand had been struck below 1,683 feet. Drilling was continued in a wet hole. At 2,085 feet to 2,115 feet and at 2,117 feet to 2,131 feet, shows of oil were obtained. Oil was noticed coating the cable and floating on the water. Drilling was suspended at 2,131 feet and the hole mudded up.

An attempt was made to shut off the water at 2,078 feet and test for the oil which had showed from 2,085 feet to 2,131 feet. After drilling through the cement bridge, water entered the hole and rose to within 242 feet of the surface. Blatchford (1929), considered that this water was coming from the oil sands which had been partially flooded.

Drilling was continued (file 218/21, G.S.W.A.) in a 6-inch hole to 2,605 feet, when a brown shale band was struck. It was decided to attempt to cement off the 5-inch casing at 2,616 feet, still in the brown shale. This was only partially successful, water was reduced to 300-400 gallons per hour.

Drilling was again continued, using 4-inch casing. At 3,138 feet there was a showing of gas with minor quantities of a light oil (Blatchford, G.S.W.A. File 27/30). Cementing was again attempted and was this time successful. The hole remained dry until 3,200 feet was reached, when it was again flooded with water, thought to be coming from another water-bearing stratum.

Drilling was continued to 3,264 feet when the tools were lost owing to the rope breaking and the hole was subsequently abandoned.

It is considered that the best showings of oil were obtained at 2,085 feet to 2,115 feet (Blatchford, G.S.W.A. file 27/30).

Following further consideration of the original mapping of the area, a change in drilling site was proposed. The drawing of structure contours disclosed an apparently suitable structure east of the original drilling site (Blatchford, G.S.W.A., file 27/30).

Drilling was undertaken on a new site to a depth of 1,543 feet and then suspended. The exact location of this site is not known to this Department.

The original hole at Poole Range has been filled in. Attached is a log of this bore.

*Okes-Durack Bore—Ord River Area.*

Following Mahoney's work in 1922, a bore was drilled, located as shown on the accompanying map, to 1,196 feet. From 788 feet onwards this bore passed through basalt. A log is attached.

6.—WORK NOW IN PROGRESS.

Two areas are being geologically examined—portion of the Kimberley Division of O.P.As. 146H and 186H, and the Exmouth Gulf Area, O.P.A. 258H.

The geological work in the Kimberley Area is being done by Dr. Wade for the Freney Kimberley Oil Co. (1932), of Perth. Wade's interim report has been noted. He recommends that the geological work be continued during this season.

During last year, the Exmouth Gulf Area was visited by Condit and Rudd, and later by Raggatt for Oil Search Ltd., of Sydney. Further work is contemplated in the North-West Basin by the same company.

No drilling is in progress at the present time.

7.—SUMMARY.

From the report it will be seen that the Desert Basin and the North-West Basin have received most attention and that portions of both are now being geologically examined. Traces of oil have been recorded at Okes' find in the Ord River, in Price's Creek bore, in the Mt. Wynne bore, in the Poole Range bore. Numerous "indications" have been reported from the south coast and south-west coastal regions, but these have not been confirmed by officers of the Geological Survey of Western Australia.

A considerable proportion of the geological work has been of the reconnaissance type, but some areas have been examined in detail. There still remains plenty of scope for geological work in the sedimentary areas of Western Australia.

Drilling has been confined to the Kimberley regions, and no success has been recorded. Trouble has been experienced with cementing off water. In the Poole Range bore many water sands were pierced.

APPENDIX.

EXTRACT FROM WADE'S INTERIM REPORT, 1935.

Provisionally the Geological Sequence is as follows:—

System.	Fitzroy Valley Area.	Christmas Creek Area.
Recent ... ..	16. Blown sands, flood and river silts. Newer lateritic deposits, etc. 15. Low level terraces with mound forming pebble beds, older sand dunes. 14. High level terraces and pebble beds, older laterites and beds of pisolitic ironstone.	16. } 15. } As in Fitzroy Valley area but with clay breccias containing large angular rock fragments and grit bands of Poole Range Area on horizon of 14. 14. }
Tertiary ... ..	13. Clays with reptilian and marsupial remains of Quambun; with insect and plant remains north of Nooncanbah (?)	13. ?
UNCONFORMITY.		
<i>Leucitite Lavas, Volcanic Breccias, Agglomerates, etc.</i>		
Strata of Doubtful Age. May be Jurassic	12. Loosely consolidated, false bedded yellow and white sandstones, grits and conglomerates (waterworn pebbles, mostly quartzite). Argillaceous and ferruginous bands (contain worm tracks, lamelli-branches of pecten-like form) of Erskine and Edgar Ras. Strata horizontal tending to form plateaux and mesas with hard "Duricrust" cappings—old peneplain.	12. Loosely consolidated bedded and false bedded sandstones and cherty beds over sandy ferruginous shales—Mesa country of Upper Christmas Creek: dissected old peneplain—may represent lower horizon than beds in Fitzroy Valley Area.
UNCONFORMITY.		
Permian ... ..	11. Clays and shales with sandy and calcareous horizons. 10. 2nd Ferruginous Series.—Brown sandy shales and flags with limestone bands—sometimes limonitised, concretionary, ripple marked and false bedded. Richly fossiliferous: worm tracks, cephalopods, <i>Athyris</i> , <i>Dielasmia</i> , <i>Pleurotomaria</i> , <i>Bellerophon</i> , <i>Cardiomorpha</i> , <i>Aviculopecten</i> , <i>Waagenoconcha</i> , <i>Aulostegia</i> , Fossil wood, leaves and fronds— <i>Glossopteris</i> ? 9. Grey to blue clays with bands of gypsum and limestones, <i>Productus semi-reticulatus</i> , <i>P. sub-quadratus</i> , <i>Spirifer</i> , <i>Avicula</i> , <i>Strophynchus luluigui</i> , <i>Polyzoa</i> , etc. 8. 1st Ferruginous Series.—Red-brown to almost black sandy shales, flags, coarse grits, conglomerates, ripple-marked and strongly false bedded, concretionary, dark nodular beds with plant remains near base. Flaggy limestones, sometimes partly or completely limonitised, worm tracks, cephalopods, spirifers, <i>Pleurotomaria</i> , <i>Bellerophon</i> , lamelli-branches—pecten types. Fossil wood— <i>Lepidodendron</i> — <i>Calamites</i> , <i>Cordaitea</i> , leaves, fronds, etc.	11. As in Fitzroy Valley Area—Beds contain gypsum 10. As in Fitzroy Valley Area.  9. Alternations of clays and flaggy limestones similar to those of Fitzroy Valley area series seem to be thickening in this direction—2,000 feet. 8. As in Fitzroy Valley area but with inter-bedded white to red friable sandstones and coarse grits, and marked absence of ferruginous infiltrations locally: concretionary. Worm tracks, fossil wood and plant remains. Coarse grit and conglomerate with worm tracks at base in places often altered to a pock-marked quartzite—400 feet.

## EXTRACT FROM WADE'S INTERIM REPORT, 1935—continued.

System.	Fitzroy Valley Area.	Christmas Creek Area.
UNCONFORMITY.		
Carboniferous ...	<p>7. Glacial Series.—Boulder beds interbedded with sandstones of Grant Range. Limestones with glaciated boulders of Mt. Wynne area, clays, sandy shales, etc., beneath. <i>Spirifera hardmani</i>, crinoid stems, etc.</p> <p>6. Massive false bedded sandstones predominating, fine-grained and clayey on some horizons. Minor developments of sand shales—2,000 feet.</p>	<p>7. Poole Range Area.</p> <p>Glacial series, massive lenticular false bedded sandstones with bands of conglomerate and grit with glaciated pebbles, grey sandy and intensely false bedded shales: grey clays, boulder beds with large striated boulders; huge concretionary limestone masses. Whole series characterised by irregularity of deposition and lenticular character of deposits. Fossil wood in large trunks and fragments in silica or limonite. May reach over 1,000 feet in thickness.</p> <p>6. Massive false bedded sandstones with important seams of argillaceous and sandy shales. Banded, yellow and red cherty beds. Fossil wood common, 1,600 feet.</p> <p>Area between Mountain Home Gap and J. 8.</p> <p>Extensive development of boulder beds containing huge boulders of many types resting directly on the chocolate and green series (5) and the massive Devonian limestones (4).</p>
UNCONFORMITY.		
	5. Absent ?	5. Chocolate-coloured shales with green calcareous bands very regularly bedded. Arenaceous in places: beds of blue shale with calcareous nodules and concretions. No fossils found. Pass down into red flaggy limestones with cephalopods—goniatites, orthoceras, etc., crinoids. May be passage beds from Upper Devonian to Lower Carboniferous, 1,500 feet.
UNCONFORMITY.		
Devonian ...	4. Hard massive limestones impure and sandy in places with cherts—tend to become crystalline. 1,000 feet, Oscar Range, Lennard Range, Mt. Wynne Area.	4. As in Fitzroy Valley Area—Corals, stromatoporoids, <i>Atrypa reticularis</i> , etc. <i>Schizophoria</i> , <i>striatula</i> , <i>Spirifera musakheylensis</i> , Bryozoa, <i>Aulopora</i> , etc. 2,000 feet. Basal beds. Thin bedded red limestones alternating with red earthy beds <i>Atrypa</i> . Gasteropods, etc.
UNCONFORMITY.		
Pre-Cambrian Newer	3. Quartzites and quartzitic shales of Nullagine type. Lennard Bore. Mt. Wynne.	3. Quartzites of Nullagine Type—Pillara Gap.
UNCONFORMITY.		
	2. Not seen. 1. Not seen.	2. Granitic rocks invading 1. 1. Metamorphic rocks—mica schists. Areas around Mountain Home Gap and "Blow-em-up" Rough Range.

## MT. WYNNE BORE.

Depth.		Description of Strata.	Remarks.
ft. in.	ft. in.		
0 0 to	16 0	Red compressed sand ironstone conglomerate	... 10in. casing to 10ft
16 0 "	31 4	Hard white sandstone, white clay	
31 4 "	52 0	Red and white sandstone	
52 0 "	68 6	Grey sandstone with bands of white sandstone	
68 6 "	86 4	Hard white sandstone	
86 4 "	94 10	Hard brown sandstone	
94 10 "	106 6	Hard grey sandstone—grey shale	
106 6 "	112 0	Hard brown sandstone	
112 0 "	117 8	Hard grey sandstone	
117 8 "	121 6	Broken sandstone	... Asphaltum in cracks.
121 6 "	126 6	Grey sandstone	
126 6 "	128 6	Brown sandstone	
128 6 "	132 4	Blue sandstone	
132 4 "	142 0	Grey sandstone	

MT. WYNNE BORE—*continued.*

Depth.		Description of Strata.		Remarks.	
ft. in.	ft. in.				
142 0	to 161 0	Coarse grey sandstone slightly fractured in places			
161 0	„ 178 6	Sandy shale and broken sandstone			
178 6	„ 181 0	Sandy shale			
181 0	„ 202 0	Mudstone-pyrites			
202 0	„ 218 6	Hard grey sandstone			
218 6	„ 223 0	Sandstone and pyrites			
223 0	„ 249 3	Sandstone—sandy shale	... ..	Bitumen at 225ft.	
249 3	„ 298 9	Hard grey sandstone	... ..	Carbonaceous matter from 228ft. to 289ft. 1lin.	
298 9	„ 316 0	Fine-grained fairly soft sandstone			
316 0	„ 341 2	Medium-grained sandstone and pyrites			
341 2	„ 361 0	Fine-grained sandstone with coarse bands			
361 0	„ 371 0	Hard grey sandstone			
371 0	„ 399 9	Very coarse, hard grey sandstone	... ..	Carbonaceous matter at 394ft.	
399 9	„ 406 5	Conglomerate			
406 5	„ 474 0	Clean sandstone			
474 0	„ 483 0	Sandy shale			
483 0	„ 500 0	Hard medium-grained sandstone			
500 0	„ 505 0	Sandstone and pyrites			
505 0	„ 513 0	Fine-grained sandstone			
513 0	„ 524 0	Hard sandstone	... ..	5in. casing to 531ft.	
524 0	„ 528 0	Sandstone and pyrites	... ..	Globules of oil and bitumen from 495ft. to 590ft.	
528 0	„ 531 0	Hard sandstone			
531 0	„ 560 0	Jointed sandstone			
560 0	„ 626 0	Sandstone—jointed sandstone			
626 0	„ 717 0	Hard sandstone			
717 0	„ 727 0	Sandstone slightly softer			
727 0	„ 734 0	Broken sandstone—very hard sandstone	... ..	Globules of oil and bitumen at 735ft.	
734 0	„ 890 0	Hard sandstone	... ..	Globules of oil at 773ft. ; particularly hard band at 867ft.	
890 0	„ 912 0	Medium to fine grained compact sandstone			
912 0	„ 1,113 0	Tough, hard, grey claystone			
1,113 0	„ 1,165 0	Alternate bands of shale and hard grey sandstone			
1,165 0	„ 1,640 0	Very fine-grained hard friable sandstone			
1,640 0	„ 1,676 0	Medium to fine-grained sandstone	... ..	Oil seepage.	
1,676 0	„ 1,695 0	Fine-grained sandstone	... ..	Bottom, Nov., 1924.	
1,695 0	„ 1,716 0	Hard grey fine-grained sandstone with pyrites			
1,716 0	„ 1,767 0	Very sandy shale			
1,767 0	„ 1,856 0	Hard grey fine-grained sandstone			
1,856 0	„ 1,878 0	Medium-grained grey sandstone	... ..	A few globules of oil came up in sludge.	
1,878 0	„ 1,886 0	Medium to coarse-grained sandstone	... ..	Many globules of oil came up in sludge.	
1,886 0	„ 1,932 0	Very fine-grained clayey sandstone	... ..	Friable in places.	
1,932 0	„ 2,084 0	Medium to fine-grained grey sandstone	... ..	Friable and broken in places—bad drilling.	
2,084 0	„ 2,099 0	Sandy shale			
2,099 0	„ 2,113 0	Very broken sandstone with some conglomerate and grit			
2,113 0	„ 2,145 0	Very broken sandstone with bands of conglomerate and grit			
2,145 0	„ 2,147 0	Sticky shale			
2,147 0	„ 2,154 0	Sandy shale			

## OKES—DURACK BORE.

Depth to Base of Bed.		
7 feet	—	Reddish brown mudstone.
34 „	Blue flaggy limestone, with nodular fossils (Girvanella).	
58 „	Blue calcareous shale with thin seams of gypsum and thin bands of hard crystalline limestone and some pyrites.	
	Fossils between 45 and 55 feet.	
66 „	Blue to grey limestone with nodular fossils.	
115 „	Grey brown and blue shale with gypsum and hard streaks.	
255 „	Brown mudstone with patches of blue crystals of gypsum present (looks like a flaggy sandstone in places).	
267 „	Grey shale with patches of blue.	
471 „	Brown to reddish sandy mudstone with bands of grit, veins of crystalline gypsum and small crystals of pyrites.	
495 „	Blue-grey shale.	
634 „	Brown, sandy mudstone, calcareous in places.	
636 „	Grey limestone, water rose to within 9ft. of surface.	
657 „	Brown mudstone.	
663 „	Thin limestone cap covering hard banded chert.	
788 „	Grey limestone, crystalline, hard and massive. Gas noticeable in sludge. Petroliferous odour. Slightly fetid from presence of sulphur ; brecciated chert in lower few feet.	
1,196 „	Light blue to grey basalt.	

OKES—DUKACK BORE—*continued.*

Depth to Base of Bed.		
1,196 feet	The basalt is ashy at the top, also at 851ft. ; 867ft. ; from 1,007ft. to 1,035ft. ; from 1,099ft. to 1,124ft. ; from 1,134ft. to 1,180ft., and is vesicular between 978ft. and 1,007ft. It is well jointed in places, the joint faces being coated with a waxy mineral at 800ft. This has been determined as Nontronite, a hydrous silicate of magnesium and iron.	

## FRENEY-KIMBERLEY OIL COMPANY, LTD.

Log of Bore at Poole Range.		
ft.	ft.	
... 156	Yellow sandy clay.	
... 176	Dark grey shale.	
176-212	Very dark shale.	
212-218	Very broken sandstone.	
218-340	Grey shale	
340-404	Grey shale with thin limestone bands.	
404-408	Very fine-grained calcareous sandstone.	
408-538	Grey shale.	
538-540	Calcareous sandy shale.	
540-560	Grey shale.	
560-587	Tillite.	
587-628	Grey shale.	
628-670	Grey sandy shale.	

FRENEY-KIMBERLEY OIL COMPANY, LTD.—*contd.*

## Log of Bore at Poole Range.

ft.	ft.	
670-696		Hard grey shale.
696-717		Hard grey sandy shale.
717-797		Very fine-grained sandstone.
797-810		Grey shale.
810-834		Hard grey shale.
834-908		Grey sandy shale with hard bands.
908-937		Grey shale.
937-950		Very sandy shale.
950-966		Sandy shale darker in colour.
966-1,013		Grey shale.
1,013-1,023		Very sandy shale.
1,023-1,037		Sandy shale.
1,037-1,290		Clayey sandstone.
1,290-1,295		Grit.
1,295-1,370		Grey shale.
1,370-1,467		Clayey sandstone.
1,467-1,586		Very fine-grained sandstone.
1,586-1,590		Very sandy shale.
1,590-1,593		Sandstone.
1,593-1,604		Very sandy shale.
1,604-1,642		Alternate bands of shale and sandstone.
1,642-1,645		Puggy shale.
1,645-1,650		Sandstone.
1,650-1,660		Very fine-grained sandstone.
1,660-1,672		Alternate bands of shale and sandstone.
1,672-1,683		Puggy shale.
1,683-1,687		Puggy shale.
1,687-1,693		Fine-grained sandstone.
1,693-1,729		Clayey sandstone.
1,729-1,737		Incoherent sandstone.
1,737-1,779		Fine-grained sandstone.
1,779-1,805		Fine-grained sandstone.
1,805 ...		In sandstone.
1,867 ...		In clayey sandstone.
1,948 ...		Still clayey sandstone.
2,023 ...		Sandy shale, 1,950ft. to 1,980ft. shale with bands of limestone to present bottom, country very hard from 1,950ft.
2,115 ...		Fine-grained sandstone from 2,043ft. Thick oily substance coming to surface of water in borehole and coating drilling cable from 2,085ft. to 2,115ft. Rock fine sandstone. Water in borehole fallen 15ft.
2,131 ...		Oily matter still coming up; borehole plugged. Decided cease drilling pending instructions from Board. Sandstone coarser.
2,131-2,180		Fine-grained sandstone.
2,180-2,243		Very fine-grained sandstone.
2,243-2,246		Hard clayey sandstone.
2,246-2,293		Fine-grained sandstone with hard bands.
2,293-2,303		Sandy shale.
2,303-2,395		Fine-grained sandstone, clayey in places.
2,395-2,405		Sandy shale.
2,405-2,421		Fine-grained sandstone.
2,421-2,426		Sandy shale, slightly darker.
2,426-2,439		Fine-grained sandstone.
2,439-2,468		Fine-grained clayey sandstone.
2,468-2,498		Fine-grained sandstone slightly clayey in places
2,498-2,507		Hard clayey sandstone.
2,507-2,522		Coarser sandstone.
2,522-2,605		Fine-grained clayey sandstone.
2,605-2,616		Light brown shale.
2,616-2,626		Light brown shale.
2,626-2,642		Very fine-grained sandstone.
2,642-2,670		Very fine clayey sandstone.
2,670-2,674		Brown calcareous shale.
2,674-2,685		Fine-grained sandstone.
2,685-2,738		Very fine-grained sandstone.
2,738-2,766		Fine-grained sandstone (bottom on 20th June, 1930).
2,766-2,771		Brown shale, slightly calcareous.
2,771-2,780		Fine-grained sandstone.
2,780-2,786		Fine-grained sandstone with bands of shale.
2,786-2,791		Fine-grained clayey sandstone.
2,791-2,796		Brown sandy shale.
2,796-2,802		Fine-grained sandstone.
2,802-2,822		Brown shale, slightly calcareous.
2,822-2,861		Very fine-grained sandstone.
2,861-2,871		Medium grained sandstone with numerous specks of a black mineral (tourmaline?).
2,871-2,920		Medium-grained sandstone—probably water bearing.
2,920-3,048		Sandstone.
3,048-3,119		Fine-grained sandstone.
3,119-3,138		Extremely hard grey shale, but last 18in. softer. Bore cemented off at 3,138ft. 4in. casing.

FRENEY-KIMBERLEY OIL COMPANY, LTD.—*contd.*

## Log of Bore at Poole Range.

ft.	ft.	
3,138-3,156		Extremely hard grey shale.
3,156-3,200		Hard brown shale.
3,200-3,215		Sandstone.
3,215-3,220		Puggy brown shale.
3,220-3,246		Fine-grained clayey sandstone.
3,246-3,264		Logs not available.

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## SUMMARY OF THE RESULTS OF THE GEOLOGICAL SURVEY AT BURGESS' FIND.

(South of Burracoppin, Avon District.)

By R. A. HOBSON, B.Sc. (Hons.).

The portion of Mining Reserve 20542 examined consists of an area of gabbro, diorite, diorite gneiss and metamorphosed sediments, intruded by pegmatite dykes, aplite dykes and quartz veins, and surrounded on three sides by granite. It would appear reasonable to conclude that the pegmatite dykes and quartz veins are offshoots from the main granite mass. As outcrops in the area are few and the mine workings are not extensive, no evidence could be obtained to indicate the relationship of the gabbro, diorite and metamorphosed sediments. The gabbro and diorite may be differentiation products from the one magma. The diorite gneiss is considered to be a primary gneiss.

The diorite group is characterised by an abundance of brown hornblende. Hypersthene and augite occur as additional ferromagnesian minerals.

A noticeable feature of the basic rocks is their freshness. When examined in thin section the constituent minerals appear for the most part quite unaltered. The feldspars are clear and glassy.

The rocks of the area have not been subjected to high pressure, although the temperature must have been fairly high. The metamorphosed sediments although gneissic in hand specimen show no cataclastic features in thin section.

Extensive faulting was not observed, and all appeared to be pre-gold.

Shear zones are not extensive and on G.M.L. 13PP. provided the channel along which the gold was subsequently introduced. Remnants of the shear zone provided an "indicator" which had been followed from the surface. The main shear zone in 13PP. is almost vertical. Two shear zones dipping at 35 degrees to the east were observed, one on G.M.L. 13PP. (winze from 105ft. level) and the other on P.A. 179PP. Neither exceeded 2 feet in maximum thickness.

The gold occurs in quartz veins and may extend into the country. The maximum thickness of any gold-bearing quartz vein observed would be less than 2 feet, although a maximum thickness of 3 feet 6 inches is said to have been reached on G.M.L. 5PP. The veins are irregular in shape, rapid variations in thickness are characteristic. Values pitch to the north.

On G.M.L. 5PP. the average width of the stoping appeared less than 4 feet, while on G.M.L. 13PP. it would not exceed 5 feet.

Because of the occurrence of secondary gold, values will decrease below the level of permanent water. Water has not yet been reached in any of the mines. The difficulty of mining will increase with depth, as in the lower levels of G.M.Ls. 5PP. and 13PP. hard unweathered rock has just been reached.

#### NOTES ON SOME MINING GROUPS IN THE YILGARN GOLDFIELD.

By R. A. HOBSON, B.Sc. (Hons.).

The following groups are briefly discussed hereunder:—

##### The Jaccoletti Group:

Comet G.M.L. 3455.  
Gentle Annie G.M.L. 3472.  
Lenodo G.M.L. 3431.  
Jaccoletti South G.M.L. 3542.  
— G.M.L. 3632.  
Four Three's G.M.L. 3541.  
Prospecting Areas.

##### The Glendower Group:

Evelyn Molly G.M.L. 3512.

##### Lenneburg's Group:

P.A. 3211—Old Onchunga lease.

##### The Burbidge Group:

Great Victoria United G.Ms., N.L.—G.M.L. 3480 and others.  
Prince George G.M. (late Broncho G.M.)—G.M.Ls. 3468, 3567, and others.  
Mammoth Ore Mines G.M.L. 3565 and others.  
Grand National G.M.L. 3707.

#### JACCOLETTI GROUP.

Although the name Jaccoletti is no longer in use on official maps, etc., for the group now to be described, it is proposed to revive it as being convenient. The Jaccoletti group includes all those G.M.Ls. and P.As. immediately to the W. of the present townsite of Marvel Loch, and the name serves to distinguish this group from the group of mines immediately to the E. of Marvel Loch townsite. It includes the old Jaccoletti mine (now renamed the Lenodo), one of the older gold mines of this State, and the old Mountain Queen G.M., which in the past was among the larger producers of the southern portion of the Yilgarn Goldfield. There is a considerable variety of rock types in this area, and exposures are, perhaps, better than in other areas examined, but are still not continuous along the strike of the rocks for any appreciable distance.

In general the S.W. portion of the area contains more acid than basic sediments, while the N.E. portion contains more basic than acid sediments. The basic sediments of the N.E. portion may be traced north-easterly into those of the Marvel Loch group. Included in this area of basic sediments but outside the area now being discussed are two lava flows. The major part of the basic sediments are fine grained, but medium and coarse grained varieties are to be found. Included among these are two rather characteristic types. The "Magpie Rock" found in the

Jaccoletti G.M., and immediately to the south, is a dark coloured rock with defined gneissosity, and probably containing appreciable quantities of biotite. It differs from the more usual basic sediments, but has been recognised elsewhere in the goldfield. The other characteristic type is a light yellowish green rock composed of interlocking needles probably of a light coloured amphibole. Unfortunately it cannot be traced along its strike, and is often only exposed in shallow shafts or costeans. The basic sediments are sometimes garnetiferous.

The acid sediments are quartzites, which often form bold outcrops, light and dark grey shales, grey micaceous schists, fuchsitic mica schists, micaceous conglomerates, and "running sands." They are often abundantly garnetiferous. Outcrops are good, but not continuous along the strike. The acid sediments may also be well seen in the underground workings.

Pegmatite dykes are abundant and are often very garnetiferous.

Gold occurs either in quartz veins or in lodes. The former usually occur in basic sediments, but many of the smaller quartz veins occur at the junction of the basic sediments and the acid sediments. The old Mountain Queen G.M., the largest producer in the past, worked a lode occurring in acid sediments at no very great distance from a junction with basic sediments. The general strike of all ore bodies is N.W.-S.E., while their dip may be either to the N.E. or to the S.W. at high angles. The ore bodies arrange themselves *en echelon* along four general lines: The Comet-Eclipse line, the Gentle Annie-Geelong line, the Jaccoletti Mountain Queen line, and the Four Three's line.

The strike of the country is N.W.-S.E. and the dip variable. The general dip of the country is to the N.E., but much local folding has occurred in, at least, parts of the central portions of the area. Two series of drag folds were observed, those having a relatively flat pitch (5°-30°) to the north or south and those having a steep pitch (70 degrees) to the south.

*Comet G.M.L. 3455.*—The present lease includes both the old Comet workings and the old Eclipse workings. Very little work has been done on either of these since Bulletin 63\* was published. Of the old Comet workings very little can be seen at the present time. The lowest level at 224 feet is now not accessible, due to water. It is possible, however, to get into the top of the old stope from this level. A considerable portion of the remainder of the workings has been mullocked, and it is not proposed to describe them. At the time of my inspection no face was accessible.

The old Eclipse West workings are now inaccessible.

Plans and sections of both of these workings were published in Bulletin 63.

The old Eclipse East workings are partially accessible, and were examined by my colleague Mr. R. S. Matheson. In preparing these notes full use has been made of his notes, plans and sections. Only the upper level was examined. The ore body is a lenticular quartz vein, reported to have had a maximum width of 4 feet, and occurring in basic sediments. It strikes N.W.-S.E. and dips to the N.E. at a high angle. The greatest stope length observed was 80

\* G.S.W.A. Bull. 63: The Geology and Mineral Resources of the Yilgarn Goldfield, Part II., The Gold Belt South of Southern Cross, by T. Blatchford.

feet. The vein has been displaced three times by three parallel faults, each dipping to the N.E. at 25 degrees, but each time the displacement has been small.

Access to the workings is gained by means of a vertical shaft north-west from the old main shaft. This shaft has a vertical depth of 97 feet but is not accessible below 73 feet. At this depth there is a drive which may be followed until the old main shaft is reached. This is the only portion of the workings which could be examined.

All three workings contain pegmatite dykes. These appear to be less abundant in the Eclipse East workings than in the other two. All three are characterized by flat faults which have cut off the reef. In the old Comet G.M. the fault channels are occupied by pegmatite dykes of appreciable thickness, indicating that these permatite dykes are younger than the quartz reef.

*Gentle Annie G.M.L. 3472.*—This lease was examined by Mr. R. S. Matheson and the following notes are compiled from his plans and notes.

A series of shafts have been sunk from time to time on this lease, but only two are accessible at present, and active work is confined to one of these. The shaft now being worked has reached a depth of 108 feet. From this level a winze has been sunk to 168 feet and a drive put out in a northerly direction. There is also a level at 61 feet, the north end of which is mullocked.

The ore body is a quartz vein varying rapidly in thickness from a maximum of 3 feet 6 inches to a few inches. It occurs in basic sediments a few inches away from the junction with acid sediments. The dip is generally to the north-east, but south of the shaft now in use the dip has become vertical. Post quartz faulting has occurred.

*Lenodo G.M.L. 3431 (Old Jaccoletti Lease).*—Recently a ten-head battery has been erected on this lease.

The old workings are not now accessible below 120 feet. At this level there is a drive extending southeasterly for 260 feet, portion of which is accessible, through an old stope, from the level above. For about 90 feet from the shaft the ore body has been stoped to the 78ft. level. The whole of the 78ft. level is accessible and the ore body has been more or less completely stoped to the surface. A shaft has been sunk from the surface to cut the north end of the 78ft. level and has been continued below this to 178 feet. The ore body has been driven on for a few feet at this level, but this work was not being continued at the time of my visit.

About four chains east of the old main workings a shaft has been sunk to 63 feet, and driving on a narrow quartz vein had just been commenced at the time of my visit. A certain amount of material had previously been taken from the 40ft. level of these eastern workings, all said to have come from small erratic quartz veins. Minor faulting was observed in these workings.

The ore body in the main workings is a lenticular quartz vein, striking north-west and south-east and dipping to the north-east at 85 degrees. It is quite free from faulting. The country is "magpie" rock, previously described in the section of these notes dealing with the general geology of the Jaccoletti group. The ore body appears to have been intruded

along the planes of gneissosity. No additional shearing is apparent in the country immediately in contact with the ore body.

The average grade of the ore from the Jaccoletti G.M.s. and early companies producing from the same group of leases, for the period 1900-1916, together with a small production from the Lenodo in 1933 is 9 dwts. It is to be noted that ore was obtained from many small workings on leases in the vicinity of the main Jaccoletti workings, but that the major portion of the ore must have come from those workings.

*Jaccoletti South G.M.L. 3542.*—Nine shafts have been sunk at various times on the ground now occupied by this lease. At the present time only two of these are accessible.

Close to the north boundary a shaft has been sunk to 110 feet and there are drives extending northerly for 50 feet and southerly for 75 feet at this level. In the south drive a winze has been sunk for 35 feet. Above the south drive the ore body has been completely stoped to the surface, where it was originally worked by means of an open cut.

Where seen in the south face of the south drive, 110ft. level, the ore body is a lenticular quartz vein having a maximum width of six inches, occurring in silicified acid sediments. Its dip is vertical. The average width of the stoping above the 110ft. level would be about four to five feet, indicating that the vein had previously been wider.

In the winze a quartz vein having a maximum width of 5 feet has been exposed. Values are erratic and the country is exceedingly hard.

The acid sediments in which the ore body occurs in the form of a narrow wedge are enclosed on the north, east, and west sides by "magpie rock."

The other accessible shaft is at the south end of the workings, and has reached a depth of 84 feet. There is also a level at 59 feet. The ore body is a quartz vein which varies rapidly in thickness and occurs at the junction of acid and basic sediments. It has a N.W.-S.E. strike and dips to the S.W. at moderate angles. Much minor faulting parallel to the ore body was observed.

*G.M.L. 3632.*—At the time of my visit this lease was not being worked and the lessees were apparently absent from the district. In the past numerous shafts have been sunk on the area now included in this lease, but only two are now accessible. The deepest of these goes to 74 feet with levels at this depth and also at 53 feet. At 53 feet a quartz vein, dipping westerly at 25 degrees, has been worked to some extent.

The western portion of the lease is mainly composed of acid sediments and the dumps show garnet schists, mica schists and conglomerates. These latter are not abundant. The shafts on the west portion of the lease have all been sunk in very fine grained basic sediments, and are evidently all very old.

*Four Three's G.M.L. 3541.*—This is the most southerly lease of this group. Three shafts exist in the north-west corner of this lease, the deepest of which has reached 110 feet. From this shaft there are levels at 110 feet, 82 feet and 35 feet. These more recent workings have connected with some older workings to the north. Immediately to the south

there is a shaft 68 feet deep, with levels at 68 feet and 40 feet. The whole of the workings referred to above are included in an area 150 feet by 50 feet.

The workings occur at or close to a junction of acid and basic sediments, striking N.W.-S.E. and with a vertical dip. Extensive minor faulting has occurred at the junction of the two types of rock, and it is along these faults that the gold solutions appear to have travelled. Exceedingly good values, 8 to 9 ounces, are said to have been obtained from very small ferruginous quartz veins and masses. Values also occur in the basic sediments but are generally low and there has been no attempt to work these extensively.

*P.As.*—Six *P.As.* were in existence in this area at the time at which the work was done. Values are low and with one exception all have been previously worked as *P.As.* or *G.M.Ls.*

The old Mountain Queen lease is now being worked as two *P.As.* The old main shaft and workings to the north of this are included in one *P.A.*, while the southern portion of the old workings are included in the other. On the northern *P.A.* a small three-head battery has been erected. Except for the southern portion of No. 1 level the old workings of the Mountain Queen *G.M.* were not examined.

#### THE GLENDOWER GROUP.

Two main lines of lode are found in this area—the eastern line, on which the Evelyn Molly, *G.M.L.* 3512, is situated, and the western line, which has at its south end the old Glendower mine, now being worked as a *P.A.* The Evelyn Molly is the only *G.M.L.* in the group, and *P.As.* are not abundant. They are to be found north and south of the Evelyn Molly, and to the north of the old Glendower mine. Values are contained in quartzites, and are generally low. Hand sorting of the ore is often resorted to.

The area is composed of fairly wide alternating bands of basic and acid sediments. The wider basic bands probably contain numerous fairly thin bands of acid sediments, which may be lenticular, and similarly, the wider acid bands contain thin lenticular bands of basic sediments. One relatively thin band 12 feet in thickness of acid sediments—mainly quartzites, but with associated shaly bands—is the lode, which is being worked in the Evelyn Molly, and *P.As.* to the north and south. In places this forms a relatively conspicuous outcrop, and can, with the aid of the underground workings, be traced across the area examined.

The strike of the country is N.W.-S.E., and the dip generally to the west at steep angles. In places, however, it may be vertical. Two series of folds have been recognised, those having an axis pitching to the south at a fairly high angle, and those having a horizontal or nearly horizontal axis. These folds take the form of fairly gentle bends in the beds. They are also to be found in the lodes.

*Evelyn Molly G.M.L.* 3512.—It has already been noted that this is the only *G.M.L.* in this group. Six shafts exist on this lease. One of these was only partially completed at the time of my visit, while at least two of the others were quite inaccessible. The main haulage shaft has been previously sunk to 110 feet but at the time of my visit was inaccessible below 56 feet. At 56 feet the lode has been driven

on north and south. Beyond about 70 feet from the shaft the north drive was completely blocked by broken ore, which was being removed at the time of my visit. A considerable amount of stoping has been done from this level.

The lode can be seen to consist mainly of banded limonitic quartzites, but also to contain shaly bands, to be 12 feet thick, and to be bounded on either side by basic sediments, with faults at the junctions. Exactly similar conditions are seen in a *P.A.* to the south of the Evelyn Molly.

Values are low and not confined to any one portion of the lode.

#### LENNEBURG'S GROUP.

There are no existing *G.M.Ls.* in this group and only four *P.As.* Values are generally low and no *P.A.* is being very actively developed.

Values are contained in quartzite bands, up to 20 feet in thickness occurring in a wide band of basic sediments. The strike is N.W.-S.E. and the dip westerly at fairly high angles. Outcrops are exceedingly poor. Except where seen to occur in underground workings, which are few in number, it is not possible to trace the quartzite bands along their strike. To the north-east and south-west the basic sediments are bounded by acid sediments. It is probable that the wide band of basic sediments contains many narrow bands of acid sediments, the presence of which is indicated by the occurrence of chips of quartzite in soil covered areas, having all the other characteristics of an area overlying basic sediments.

*P.A.* 3211.—Old Onchunga lease *G.M.L.* 956. On this *P.A.* there are at least two well defined quartzite bands extending over its length. Both have a general strike N.W.-S.E. and dip to the S.W. The eastern band is banded limonitic quartzite, while the western one is a white banded quartzite containing no obvious iron. There are no extensive workings, and only in one instance has either lode been driven on for more than a few feet. These workings had been commenced when the field work for Bulletin 63 was being done, and were examined by Mr. Blatchford. Values are generally low.

There is also another band of acid sediments to the west of the western quartzite band referred to above. Four or possibly five shafts have been sunk on this band but no driving has been done.

One or two shallow shafts have been sunk on the other *P.As.* of this group with no results of interest.

#### THE BURBIDGE GROUP.

All leases in the vicinity of the townsite of Burbidge are included in this group, and among these are the Great Victoria group of leases. In the past these have been among the larger producers of the southern portion of the Yilgarn Goldfield, having produced during the period 1906-1927 34,810.41 ounces of gold from 208,121.26 tons of ore treated. A very considerable portion of the area is covered with laterite, soil or alluvium, and supports a vegetation only of scrub and scattered mallee. Rock outcrops are found only on the high ground in the vicinity of the workings.

Both acid and basic sediments are found; the former predominating in the surface exposures and the underground workings. Generally values are confined to acid sediments. Two main types of these are found—a siliceous variety consisting of quartzites and “running sands,” and a metamorphosed argillaceous variety now existing as a grey micaceous shale or sometimes as a *knotenschiefer*. The former of these two types contains the values, which, in a broad way, are controlled by structural features, and which, in any individual mine, may be very irregular. It is significant that the Great Victoria G.M., the only mine which has been worked to any extent, is structurally very different from the other mines of this group. In two groups of leases the values occur in “running sands” at no very great distance from a junction with basic sediments, but not actually at the junction, as is often the case in the southern portion of the Yilgarn Goldfield.

Where they outcrop the lodes form relatively conspicuous features and are very ferruginous. Throughout the mine workings also the “running sands” are often ferruginous. The iron may be distributed more or less evenly throughout the rock or may be concentrated into masses of irregular shape. Most of the iron seen in the workings is secondary, having originated from banded ferruginous quartzites, or from sulphides, which are said to have been found in the deeper and now inaccessible portions of the Great Victoria G.M. Values are often much higher in the ironstone nodules than in the surrounding sandstone, thus indicating the probability of considerable secondary solution and deposition of gold.

The gradual conversion of the “running sand” (originally a quartzite or sandstone) to a jasper is well shown, and almost every stage can be observed. The first stage is the formation of an earthy light yellow-brown coloured mass, without a conchoidal fracture. With further change this becomes glassy, and a conchoidal fracture develops. In a few places a milky white jasper with red patches and streaks has formed.

The dip of the beds is generally to the east at high angles but may be vertical. Westerly dips were observed in the S.E. portion of the area. The general strike is north and south.

Two main general lines of lode occur, one on the east side—the Great Victoria line, and one on the west side—the Prince George (late Broncho) line. The grey *knotenschiefer*, first observed in the Great Victoria workings, can be traced south from there, through the Mammoth Ore Mine’s workings and thence to the Grand National lease. The outcrop is not continuous—soil and laterite areas intervene—but it is reasonable to assume that the same bed occurs in all three places. The Prince George G.M. lode loses itself to the south in a soil-covered flat and to the north in an area of laterite.

The Great Victoria workings occur in a moderately large drag fold pitching northerly at 70°-80°, with the beds dipping generally to the east at about the same angle. The structure indicated is the east limb of a northerly pitching antiform or the west limb of a similarly pitching syncline. Drag folding of a size comparable to that of the Great Victoria was not observed elsewhere in the area.

So far reference has been made only to folds having a steeply pitching axis. There are also present folds having a horizontal or nearly horizontal axis trending in a general N.-S. direction.

*Great Victoria United G.M.s., N.L., G.M.L. 3480* and others.—This company controls a group of leases about the old Great Victoria workings. At the present time a plant is being erected, primarily to treat laterite and surface ore, but subsequently to treat ore which may be broken from depth.

The Great Victoria has previously been worked to a depth of 283 feet. At this depth a crosscut extends north-easterly for 410 feet, and is said to have a winze sunk for some 40 feet. Unfortunately, as water has risen in the old main shaft to 260 feet, this level is not accessible at the present time. Access to the workings may now be had either through the Hamilton shaft or by means of an inclined shaft to the bottom of the open cut, and thence to the 102ft. level. From there the old main shaft continues to the 246ft. level and below. The top portion of the old main shaft has been completely removed in the open cut. The 102ft. level is heavily timbered and appears to be worked out. At 164 feet there are two parallel drives, extending in a N.W.-S.E. direction with their associated crosscuts. No stoping has been done at this level. Below this there is a crosscut extending north-east at 246 feet, and water at 260 feet.

The Great Victoria lode formation consists of a sandy ferruginous formation, occurring between a belt of basic sediments on the south side, and a band of *knotenschiefer* or grey shale on the north side. It has already been noted that this is folded into a moderately large drag fold with a steep northerly pitch. The width of the lode formation varies with its position in the fold. About the Hamilton shaft it has widened considerably, due to buckling within itself and the values have dropped accordingly. Below the north-west end of the open cut, and at the 60ft. level, south-east end of the open cut, the dip is to the north-east, while at greater depths at the south-east end the formation dips to the south-west, or is vertical. Drag folds observed in the workings indicate the presence of folds having a horizontal or nearly horizontal axis.

Values are erratic and scattered throughout the lode formation in those portions of the workings now accessible. Because of the steep pitch of the drag folds it would seem probable that the shoots will be found to pitch to the north.

Minor quantities of vein quartz are observed in the workings.

*Prince George G.M. (late Broncho G.M.), G.M.Ls. 3468, 3567* and others.—Previous work has been confined to the north and south ends of the present workings, but only the old workings at the south end are accessible. A lode formation is being tested by means of some eight shafts, extending in a north-south direction, with crosscuts east and west from each shaft. At the south end there are levels at 125 feet and 198 feet and associated crosscuts. Nos. 1, 2 and 3 shafts at the south end are connected by drives.

Acid, basic and intermediate sediments have been recognised. The basic sediments occur on the east side of the lode formation, and generally contain no



values. The lode formation resembles that of the Great Victoria, but is less ferruginous. "Running sand" is abundant.

Average values are low, and from information disclosed in the present crosscuts appears to be generally about 4 dwts. They extend over varying widths up to 120 feet.

The dip of the beds is generally eastward, but is variable. At the south end of the line of workings gentle folding in two directions is apparent. Axes trend parallel to the lode and have either a steep or flat pitch.

*Mammoth Ore Mines, G.M.L. 3565 and others.*—On G.M.L. 3565 one shaft has been sunk to 97 feet with crosscuts east and west at 53 feet and 97 feet and is entirely in acid sediments. The crosscuts at 97 feet have disclosed values in three places—for 26 feet in the west crosscut and said to average less than 2 dwts., for 15 feet about the shaft and said to average 2 to 3 dwts., for 14 feet at the east end of the east crosscut and said to average 4 dwts. Values in the 53ft. level crosscut are said to average 2 dwts. for about three feet at the west end, and about 2 dwts. over the whole of the east crosscut. General average values would therefore appear to be just over 2 dwts. At the time of my inspection another shaft was being commenced about five chains north from the one described above.

The continuation of the Great Victoria lode formation outcrops on the crest of the hill, which occupies a considerable portion of G.M.L. 3565, but here contains no values. The formation in which the values occur in this G.M.L. lies about half-chain east from the Great Victoria formation, and is separated from it by a band of grey shales. It consists of quartzites, "running sands" and white micaceous shales, with abundant ferruginous patches.

*Grand National G.M.L. 3707.*—Six shafts have recently been sunk on this lease, all in very ferruginous formation, which appears to be the continuation of the Great Victoria lode. At the time of my visit only two of these were accessible. The probable continuation of the grey shales seen on the Great Victoria leases is found on the east side of the hill on which the shafts have been sunk, while immediately west of an old shaft at the north end of the lease basic sediments are exposed in a shallow costean. The north-south continuation of these basic sediments cannot be traced. Their width would not exceed a few chains. It would appear probable that these may be the same horizon of basic sediments as seen at the Great Victoria, but because of areas of soil and laterite this fact cannot be proved.

To the west of G.M.L. 3707 there is an area of laterite, which contains some values, and which has recently been tested by a series of pits. The results of this work are not known to the writer.

#### NOTES ON SOME MINING GROUPS IN THE YILGARN GOLDFIELD.

By R. S. MATHESON, B.Sc.

##### EDWARD'S FIND.

This is the most recent discovery of any note in the southern portion of the Yilgarn Goldfield, and has yielded some excellent crushings of high-grade

gold from a white quartz; the quartz occurs as discontinuous lenses of more or less short length and depth, occurring in drag folds in basic sediments with a gneissic banding.

The quartz reefs vary from a few inches to 6 feet in thickness and follow the general north-westerly trend of the enclosing basic sediments.

The reefs, so far discovered, show a strong tendency to variation in thickness both along the strike and down the dip, and the gold content of the quartz varies considerably. The usual conception of there being a "gold line" does not apply to Edward's Find.

*"Cricket," G.M.L. 13PP.*—Two quartz reefs which strike north-westerly and dip steeply to the west with the enclosing basic sediment country, have been mined on this lease. A thin band of acid sediments interbedded with the basic sediments, lies to the west of the main workings and is exposed in the 50ft. level west crosscut in the shaft just beyond the south boundary of the lease.

The main workings are near the south boundary of the lease. Here "the reef strikes 330 degrees and dips to the west at 80 degrees, being practically vertical for the upper 50 feet. It has been worked in three levels from two shafts sunk to 78 feet and 155 feet, respectively, vertical depth below the brace, situated to the east of the reef and one chain apart."\*

Stoping with respect to the centre of the northern shaft is as follows:—

At the 78ft. level, the reef has been stoped 33 feet north-westerly and 138 feet south-easterly, there being a blank in the south-easterly stoping between 42 feet and 66 feet. The stoping has been carried upwards to the 54ft. level and downwards to the surface of a large granitic dyke, the occurrence of which is mentioned in a separate report by Mr. H. A. Ellis.\*\*

At the 54ft. level, stoping 27 feet north-westerly, 92 feet south-easterly and overhead for 20 feet vertical, has been carried out.

On the 34ft. level the ore body has been mined to 10 feet from the surface, the stoping running 15 feet north-westerly and 7 feet south-easterly from the shaft of reference.

Stoping has been done from one other shaft on the lease, and here a small rich shoot which pitches steeply north-west and reported to average 3 ounces of bullion per ton over the plates, has been mined.

In the 34ft. level south-east drive, stoping has been carried out from 12 feet to 25 feet from the shaft and upwards to the cement. The quartz is continuous along this level and there is two feet of quartz in the face of the S.E. drive, and three feet on the face of the N.W. drive, but only the portion which has already been stoped was payable.

On the 62ft. level stoping has been done south-east of the shaft, between 4 feet and 19 feet. Overhead stoping to the 34ft. level and underhand stoping for 19 feet vertical depth has been done. The ore body is cut off below by a fault whose strike is N. 70 deg. W. and dip 15 deg. N. No evidence can be obtained giving the relative movement

\*Report on James, Nelson & Goodins G.M.L. 13PP., Edward's Find, by H. A. Ellis.

\*\* See p. 48.

on this fault, but judging from similarly disposed faults in this vicinity, there is every likelihood of a continuation of the ore body being found to the west.

*Sunshine, G.M.L. 12PP.*—Numerous quartz reefs with varying strikes have been exposed in the workings on this lease. The quartz is lenticular both horizontally and vertically.

In the Whip shaft, near the south boundary, the reef dips 80 degrees south-westerly and has a N.W. trend. The ore body has been stoped out to the 75ft. level, the maximum stope length being 90 feet and maximum stope width 4 feet. Stoping has been discontinued where the quartz has thinned to a stringer or where the values have become too poor. At 113 feet vertical depth in the shaft is a flat pegmatite dyke 10 feet wide which is said to dip south-easterly. The ore body has been faulted here and pegmatite has come in along the fault. No considerable displacement accompanies the faulting. There is a short east crosscut at 180 feet vertical depth in which is exposed a quartz reef, 2 feet wide, containing sulphides.

No work has been done on this reef yet, although it is said to average 10 dwts. gold per ton. At the northern extremity of the driving on this reef, a pegmatite has just been encountered which will hamper any future work in that direction.

From the level at vertical depth 62 feet, between the two shafts near the north boundary of this lease, stoping has been carried to within 12 feet of the surface. The stope length is 55 feet and maximum stope width is 4 feet.

*Edwards' Reward, G.M.L. 11PP.*—In the north shaft a quartz reef, maximum width 3 feet, has been stoped from the 51ft. level to the surface, over a length of 107 feet. There has been faulting along the floor of the 51ft. level drive, and the footwall has been displaced 8 feet east with respect to the hanging wall. The dip of the fault is reported to be approximately 50 degrees N.

About 25 feet of driving has been done at the 107ft. level in this shaft, and a quartz reef, average width 1 foot, is exposed. Values here are reported to be 4 dwts. gold per ton.

In the shaft immediately south of the above, quartz has been stoped south-east from the shaft over a length of 78 feet. The stoping extends from the 55ft. level to the 28ft. level and the maximum width of quartz was 3 feet. At the time of examination there was 2 feet 6 inches of quartz in the faces of the 55ft. level drive.

At the 103ft. level there is a 10ft. drive east of the shaft, and work is in progress here at present. There is a 4ft. quartz reef showing in the roof of this drive, which is cut off underfoot by a 9in. pegmatite dyke. The pegmatite has come in along a fault striking N. 30 deg. W. and dipping 55 deg. N.E. The drag of the strata on the faultplane shows that the footwall has moved east with respect to the hanging wall. If on sinking below the pegmatite the reef is not found, it should be looked for to the east.

*Lady Mary, G.M.L. 24PP.*—A quartz reef of very lenticular habit has been worked between the two shafts near the west boundary. The basic sediment country near the ore body has been very much disturbed.

Overhead stoping extends on the 68 foot level for a length of 20 feet south-east from the whip shaft, the maximum width being 4 feet. There is a thin quartz stringer along the roof of the 87ft. level drive off the northern of these two shafts.

*P.A. (East of G.M.L. 11PP).*—Lode material with quartz stringers is being worked in the main shaft at present at the 170ft. level and the owners report 6 dwts gold per ton over a width of 12 feet, the exposed length being about 55 feet.

The ore body is also exposed on the 75ft. level and here it is said to be 10 feet 6 inches wide. No stoping has yet been commenced. The basic sediment country here varies in strike from N. 10 deg. E. to N. 30 deg. W.

A 5-head battery has recently been erected on the Sunshine lease, and this will reduce the treatment costs, thereby increasing the ore reserves at this find.

#### MARVEL LOCH GROUP.

(East of Marvel Loch Townsite.)

This group comprises the property of the Marvel Loch Gold Development N.L., that held by the late Marvel Loch Co., G.M.Ls. 3588, 3642, 3662, 3682, 3684, and several prospecting areas.

These holdings are in an area of interbedded basic sediments, acid sediments, and basic lavas which strike north-westerly and dip steeply. The series has been intensely folded and intruded by pegmatite dykes which, in most cases, have been intruded along flatly dipping faults.

The ore bodies, with one exception, are in shears in the basic rocks and the shearing is parallel to the strike of the country. Lode material, lode material with quartz stringers, and quartz with a little lode constitute the ore bodies.

The values throughout are not very high and in some places a rise in values is noticeable with the increase of quartz in the lode material. The country is well oxidised to about 150 feet vertical depth, where the fresher and harder rock begins to appear. Secondary enrichment has taken place near the surface, and as the values here are not very high, it is advisable not to be too optimistic about the chances below water-level (250-300 feet).

Outcrops on this group are scarce, the best exposures, which may be seen west of G.M.L. 3684 and east of G.M.L. 3585, being basic sediments and lavas.

*Marvel Loch Gold Development Co., N.L.*—The company holds seven leases embracing an area of about 85 acres:—

- "Lubra," G.M.L. 3485 (late "Starfinch").
- "Brandizzi," G.M.L. 3430 (late "Undaunted").
- "Artesian," G.M.L. 3586 (late "Firelight").
- "Firelight," G.M.L. 3587 (late "Firelight").
- "Exhibition," G.M.L. 3423 (late "Exhibition" and "St. George").
- "Hill," G.M.L. 3585.
- "Bridge," G.M.L. 3521.

No work has been done on the "Hill" and "Bridge" leases. At the time of examination the company was developing the other leases and erecting the plant.

There are no rock outcrops, the formation being covered by 10 to 15 feet of red clayey soil.

Both acid and basic sediments can be seen in the underground workings. A thin band of acid sediments is encountered throughout the property in the extreme west crosscuts. Other acid sediment bands have been met with in some of the east crosscuts in the "Exhibition" lease. The remainder of the workings are in basic sediment country which is white, sometimes ironstained, kaolinitic material in the oxidised zone. The weathered rock often contains lenticular blebs of biotite which have a parallel arrangement, especially in the lode channels. Flatly dipping and vertical pegmatite dykes have been met with in the workings on the southern leases and these are a potential difficulty to mining. Some of these dykes should be met with at depth in the northern workings if they persist.

The ore bodies are mainly lode material with quartz at the south end, and, with one exception, are in basic sediment country. The exception, which is in acid sediments, is the lode on the 100ft. level from B7 shaft. On this level, it is said to be payable over a length of 90 feet and is 9 feet wide, averaging 12 dwts. gold per ton.

There appears to be three lines of lode in the basic sediments; two of these run parallel and only a short distance apart for a considerable distance and constitute the main lode. The reported length of ore is 1,200 feet over a known width of 4 feet.

The other ore body, known as the Eastern lode, is said to be payable over a length of 75 feet and a width of 60 feet.

The ore bodies have so far only been proved to 200 feet, vertical depth.

The reported estimate of the ore reserves for this property is as follows:—

Positive ore—4,620 tons assaying 12 dwts. per ton.

Ore in sight and at grass—117,540 tons, assaying 5.2 dwts. per ton.

Payable or between 100ft. and 150ft. levels and a short length between 150ft. and 200ft. levels—90,000 tons, assaying 5.2 dwts. per ton.

Total: 212,160 tons averaging 5.3 dwts. per ton.

It must not be assumed that this is the total tonnage available.

The generally accepted view is that this property is on the same line as the late Marvel Loch, but we doubt this statement; firstly, because of the marked difference in the rock types; and, secondly, on our tentative interpretation of the geological structure.

It is thought that there is probably a sharp fold in the strata near the southern boundary of the "Exhibition" lease, so that the lines of the lodes which have been recently exploited would lie somewhere east of the late Marvel Loch. However, definite evidence for this is lacking, and only further development work will clear up the point.

*Marvel Loch, G.M.L. 3413.*—On this lease are the main workings of the late Marvel Loch Co., which were inaccessible at the time of my visit. This prop-

erty is reported on in Bulletin 63,\* since which the mine was in the hands of tributers for a short period, finally closing down in 1916. The ore bodies were in coarse-grained basic sediment country. At present the lessees are doing a little work near the north boundary.

*Marvel Loch North, G.M.L. 3685.*—The late Marvel Loch Co. did most of the work on this lease. The recent workings are near the north boundary, where a considerable amount of crosscutting has been done (on the 50ft. and 105ft. levels) between the three shafts. It was hoped that a continuation of the ore bodies, being developed in the Marvel Loch Gold Development Company's property, would be encountered, but investigation shows that the work was fruitless.

*Alexander, G.M.L. 3642 (late Magpie).*—There is renewed activity on this lease resulting from the enhanced price of gold. The owners are continuing the mining of the same ore body, which is ironstained lode material containing abundant magnetite. The ore body has already been stoped to the 55ft. level and is reported to be payable over an average width of 5 feet. An estimate of the expected stope length was not obtained.

A pegmatite dyke has just been exposed in the end of the east crosscut at the 55ft. level.

Prospecting work is in progress on the remainder of the holdings in this group, but there has been no outstanding success. Further information on these will be to hand at a later date.

#### XANTIPPE GROUP.

There were no existing leases or prospecting areas here at the time of my visit, and from the extent of the old workings, it appears that prospects were not very promising. None of the workings was accessible.

This group is situated in an area of interbedded basic and acid sediments which have a north-westerly strike and a steep dip. The country grades off into acid sediments eastward and into basic sediments westward.

The main workings are in acid sediments and are reported to be prospecting efforts on low grade lodes.

#### DONOVAN'S FIND.

This find is situated about 3 miles south-easterly from Marvel Loch, in an area of interbedded basic and acid sediments which strike north-westerly and dip steeply.

The majority of the ore bodies are granitic quartz reefs with lenticular habit, in drag folds in basic sediment country, but there are instances of quartz reefs which strike across the country, and these are in tension cracks. Also, lode material is being mined in a few places. Property-holders find treatment for their ore at Howlett's battery which is erected on the original find.

There is a paucity of rock outcrops, most of the area being covered by a thick overburden.

Flatly dipping pegmatite dykes which have been intruded along faults are a common feature of this group.

\*G.S.W.A. Bull. 63, pp. 151-156.

Included in this group are the following leases:—

- "Bohemia" G.M.L. 3393.
- "Bohemia South" G.M.L. 3488 (no workings).
- "Bohemia East" G.M.L. 3395 (no workings).
- "Bohemia North" G.M.L. 3396 (no work being done).
- "Francis Furness" G.M.L. 3724.
- "Salvation" G.M.L. 3382.
- "Salvation North" G.M.L. 3410 (no work being done).
- "New Democrat" G.M.L. 3491.
- "Outsider" G.M.L. 3492.
- "Outsider No. 2" G.M.L. 3639 (no work being done).
- "Mussolini" G.M.L. 3434.
- "Propatria" G.M.L. 3690.

*Bohemia, G.M.L. 3393.*—A quartz reef, average width 4 feet, and striking with the country, has been stoped on five levels from the surface to 215 feet vertical depth. The maximum stope length is 250 feet, and the stoping pitches south-east. At depth the quartz contains galena and other sulphides.

There are flatly dipping pegmatite dykes in the upper levels of this mine which have come in along faults which have caused displacements of the ore body. The largest dyke occurs between the 50ft. and 96ft. levels. It strikes N. 40 deg. E., dips 30 degrees N.W., and is 33 feet wide in the main shaft.

An option has recently been taken over this property and the main shaft is being deepened with the object of proving the existence of the ore body at a lower level. To the end of 1933, 5,649 tons of ore were treated for 5,218.65 fine ounces of gold, and specimens totalled 19.66 fine ounces.

*Francis Furness, G.M.L. 3724.*—The ore bodies on this lease are in a band of basic sediments bounded by acid sediments. No. 2 and No. 3 shafts have been reconditioned and give access to portion of the old workings. Here stoping (average width three feet) has been carried out intermittently, the major portion between shafts Nos. 2 and 3, over a maximum length of 280 feet. Two granitic quartz reefs with lenticular habit, both horizontally and vertically, and striking with the country were mined. They run parallel throughout the workings and are only a short distance apart. They are reported to come very close together in places but never meet. Where the reefs are close they have been stoped out together, and elsewhere there are parallel stopes.

The shoots are said to pitch south-east. No. 1 shaft is sunk on a recently discovered body of quartz on the south end of this line of workings. The quartz, which strikes with the country and dips steeply east, has a maximum width of 3 feet and has been mined from 26 feet vertical depth to 120 feet vertical depth below the surface over a maximum length of 80 feet.

As mentioned before, the quartz reefs are in drag folds in the country and this fact is accentuated here.

Where the dip is steep there is an appreciable width of quartz and the values are good, but where the dip flattens the quartz pinches and the values are poor.

Mr. Howlett reports that he crushed a parcel of ore from this reef at the beginning of November, 1935, 180 tons yielding 304 ounces of bullion over the plates.

At the time of my visit there was 2 feet 6 inches of quartz in the bottom of the main shaft, said to assay 1 ounce per ton. But I understand a few days later the quartz pinched to a stringer and the values decreased. However, this is a common occurrence in the ore bodies on this lease and I consider the stringer worth following.

Also lateral prospecting may be done to advantage at the south end because parallel reefs are likely to occur.

*Salvation, G.M.L. 3382.*—Here the ore body is a granitic quartz reef which strikes N. 60 deg. W. with the enclosing basic sediment country. The reef has an average width of 3 feet 6 inches, and has been worked out from the surface to water level (250 feet vertical depth) over a maximum length of 150 feet.

The ore body dips 70 deg. N.E. from the surface to the 100ft. level where a fault striking N. 60 deg. W. and dipping 35 deg. N.E. is encountered. Below, the reef is displaced 10 feet north-easterly and the dip has changed to 70 deg. S.W.

On the 140ft. level a thin, barren quartz vein cuts through the gold-bearing quartz; proving two ages of quartz. Sulphides are in the quartz and the adjacent country rock at the 220ft. level.

The official production figures to the end of 1926 show that 1,407 tons of ore were treated for a return of 29.8 dwts. of gold per ton.

This lease, together with the Francis Furness and Bohemia, is under option at present to the Yellow-dine Mining and Finance Company.

*Propatria, G.M.L. 3690.*—Lode material with quartz veins has been stoped here over an average width of three feet from the surface to 135 feet vertical depth. On the 36ft. level the stope length is 125 feet and below, the stop length is 48 feet, but three feet of lode reported to assay 8 dwts. of gold per ton is showing in the faces of the south-east drives at the 93ft. and 123ft. levels. The ore body underlies 53 degrees south-westerly but flattens to 30 degrees between the 93ft. and 123ft. levels.

A large pegmatite dyke, strike N. 10 deg. W. and dip 45 deg. W., crosses the main shaft between the 36ft. and 65ft. levels, and offshoots from it are intersected in the workings. This massive dyke causes a break in the lode and has been intruded along a post-gold fault which has been accompanied by some displacement. The faulting was of reverse type and the footwall has been displaced about 20 feet north-easterly with respect to the hanging wall.

In the south-east drives throughout the workings a thin, barren quartz vein, striking N. 70 deg. E. and dip vertical, which is post-gold, is intersected.

To the end of 1926, 696 tons of ore was taken from this mine for a return of 1.27 fine ounces of gold per ton.

*Mussolini, G.M.L. 3434.*—A granitic quartz reef of lenticular habit and cutting across the basic sediment country on a north-east strike and dipping 70 deg. S.E. is being mined here.

The reef has an average width of two feet and has been worked from the surface to the 220ft. level. The stoping pitches north-east and stope length near the

surface is said to be 100 feet. At depth only 20 feet of stoping has been done, but there is still three feet of quartz in the faces of the north-east drives at the 171ft. and 220ft. levels, which is reported to be payable.

The values here have never been high, and information obtained from Mr. Howlett concerning the last crushing revealed that a parcel of 46 tons was treated in November, 1935, averaging  $4\frac{1}{2}$  dwts. of bullion per ton over the plates.

*New Democrat, G.M.L. 3491.*—There were no accessible workings on this lease, the following information being supplied by the owners.

A quartz reef, with the same strike as the basic sediment country, has been mined to the 230ft. level from close to the surface. The ore body pitches north-west and on the bottom level stoping has been done over a length of 25 feet, the quartz pinching from two feet wide to stringers at the ends of the stope. The average value of the ore is 7 dwts. of gold per ton.

In the workings nearest the east boundary of this lease, a quartz reef, striking almost at right angles to the country, has been stoped intermittently between the surface and 150 feet, over a length of about 100 feet. The reef dips 75 degrees north-easterly.

A small amount of work has been done on a short lens of quartz, average width nine inches, which occurs near the western boundary.

*Outsider, G.M.L. 3492.*—The main shaft is vertical for 80 feet where a quartz reef, average width two feet, striking N. 30 deg. E. and dipping 65 deg. S.E. is encountered. The shaft underlies from here to the 126ft. level and the quartz has been stoped on both sides of the shaft, the total stope

length being approximately 50 feet. The ore from the stoping is reported to have averaged 15 dwts. of gold per ton. At 131 feet, vertical depth, a 2ft. pegmatite dyke striking N. 30 deg. E. and dipping 45 deg. N.W. cuts across the shaft. The ore body is cut off sharply by the dyke and had not been located below at the time of inspection.

Indications concerning the displacement resulting from the faulting are meagre but point to normal faulting. This being the case, the extension of the ore body should be picked up by crosscutting north-west from the bottom of the main shaft.

No information was available concerning the stoping above 80 feet.

There is 20 feet of ferruginous laterite overlying the basic sediment country on this lease.

*Late Mountain King Lease.*—There is a prospecting area occupying the ground held by the late Mountain King.

A lens of crushed, ironstained quartz, three feet long and three feet maximum width, has recently been worked. It underlies at 55 deg. S.E. and has been taken out below the 72ft. level for 36 feet linear depth where it breaks up. The ore taken from here is reported to have averaged 18 dwts. of gold per ton.

Exploratory work at the 119ft. level exposed a similar looking body, but values are practically negligible. The owners believe their ore body has been displaced by faulting and that this is a separate body. The basic sediment country is certainly very much disturbed, and if the ore body has been displaced, the prospects of picking up the continuation are not very promising owing to its small extent.



## INDEX.

	Page.		Page.
Abbotts Gold Mining Centre .. .. .	12, 13	Magpie (now Alexander G.M.L. 3642) ..	41
Alexander G.M.L. 3642 .. .. .	41	"Magpie" Rock .. .. .	35
Analyses of Waters, Coolgardie Goldfield ..	8	Mahoney, D. J. .. .. .	25
Artesian G.M.L. 3586 .. .. .	40	Mammoth Gold Mines G.M.L. 3565 ..	39
Blatchford, T. .. .. .	23, 24, 26, 28	Marvel Loch G.M.L. 3413 .. .. .	41
Bohemia G.M.L. 3393 .. .. .	42	Marvel Loch North G.M.L. 3685 ..	41
Bowley, B. M. .. .. .	3	Marvel Loch Gold Development, N.L. ..	40, 41
Brandizzi G.M.L. 3430 .. .. .	40	Matheson, R. S. .. .. .	3, 39
Bridge G.M.L. 3521 .. .. .	40	Mining Reserve 20542 .. .. .	34
Burbidge Group .. .. .	37, 38, 39	Moora, Stone deposits .. .. .	12
Burgess' Find .. .. .	34	Mountain Queen G.M. .. .. .	35, 37
Cave Rocks, Water Supply .. .. .	8, 9	Mt. Elder Sandstone Series .. .. .	25
Callytharra Limestone Series .. .. .	27	Mt Wynne Bore .. .. .	24, 29, 31, 32
Christmas Creek .. .. .	25, 30, 31	Mullewa Gold Find .. .. .	5
Clapp, F. G. .. .. .	24, 26	Mussolini G.M.L. 3434 .. .. .	42, 43
Comet G.M.L. 3455 .. .. .	35, 36	Negri Series .. .. .	25
Cricket G.M.L. 13 PP. .. .. .	39	New Democrat G.M.L. 3491 .. .. .	43
Desert Basin, Petroleum Exploration ..	23, 24	New Murchison King Mine .. .. .	13
Donnybrook .. .. .	4, 5	North-West Basin, Petroleum Exploration ..	26
Donovan's Find .. .. .	41-43	Nullagine Beds .. .. .	25
Eclipse East Lease .. .. .	35, 36	Okes-Durack Bore .. .. .	32
Edward's Find .. .. .	39, 40	Oke's Find .. .. .	30
Edward's Find, Water Supply .. .. .	10	Onehunga (late G.M.L. 956) .. .. .	37
Edward's Reward G.M.L. 11PP .. .. .	40	O.P.A. 21H .. .. .	24, 25
Egan's P.A. 3547 .. .. .	4	O.P.A. 23H .. .. .	24, 25
Ellis, H. A. .. .. .	5, 6, 10, 12-16, 18, 19	O.P.A. 25H .. .. .	24
Eucla Division, Petroleum Exploration ..	28	O.P.A. 146H .. .. .	24
Evelyn Molly G.M.L. 3512 .. .. .	37	O.P.A. 186H .. .. .	24
Exhibition G.M.L. 3423 .. .. .	40	O.P.A. 191H .. .. .	27, 28
Exmouth Gulf Area, Petroleum Exploration ..	23, 26, 30	O.P.A. 231H .. .. .	28
Feldtmann, F. R. .. .. .	3	O.P.A. 235H .. .. .	28
Fitzroy Valley Area, Petroleum Explora- tion .. .. .	23, 24, 29-31	O.P.A. 236H .. .. .	28
Firelight G.M.L. 3587 .. .. .	40	Ord River Area .. .. .	25, 26, 30
"Floaters," Murchison Goldfield .. .. .	17	Outsider G.M.L. 3492 .. .. .	43
Forman, F. G. .. .. .	2-4, 24, 28	P.A. 179PP .. .. .	34
Four Three's G.M.L. 3541 .. .. .	36, 37	P.A. 1855N .. .. .	15, 16
Francis Furness G.M.L. 3724 .. .. .	42	P.A. 3211 .. .. .	37
Gentle Annie G.M.L. 3472 .. .. .	36	P.A. 3546 (Whindfield's) .. .. .	3
Geology, Abbotts Centre .. .. .	12, 13	P.A. 3547 (Egans) .. .. .	4
Geology, Yilgarn Goldfield .. .. .	19-22	P.A. 3982 .. .. .	9
Glendower Group .. .. .	37	P.A. East of G.M.L. 11PP .. .. .	40
G.M.L. 5PP .. .. .	34, 35	Permo-Carboniferous Series .. .. .	24
G.M.L. 11PP .. .. .	10	Petroleum Exploration .. .. .	22, 34
G.M.L. 12PP .. .. .	10	Price's Creek .. .. .	24, 29, 30
G.M.L. 13PP .. .. .	34, 35	Prince George G.M.Ls. 3468, 3507 ..	38, 39
G.M.L. 3588 .. .. .	40	Propatria G.M.L. 3690 .. .. .	42
G.M.L. 3632 .. .. .	36	Poole Range .. .. .	24, 29
G.M.L. 3642 .. .. .	40	Poole Range Bore .. .. .	32, 33
G.M.L. 3662 .. .. .	40	Salvation G.M.L. 3382 .. .. .	42
G.M.L. 3682 .. .. .	40	Sandstone, Moora .. .. .	12
G.M.L. 3684 .. .. .	40	Spargo's Find G.M. Syndicate .. .. .	6
"Gnaweeda" Station, Water Supply ..	14, 15	Spargoville, Water Supply .. .. .	6
Gneissie granite .. .. .	5, 6	Stone Deposits, Moora .. .. .	12
Goodin, James & Nelson's Lease 13PP ..	18, 19	Sunshine G.M.L. 12PP .. .. .	40
Grand National G.M.L. 3707 .. .. .	39	South Yilgarn Goldfield, Geology ..	20-22
Great Victoria G.M. .. .. .	38	South-West Division, Petroleum Exploration ..	28
Great Victoria United G.Ms., N.L., G.M.L. 3480+ .. .. .	38	Tuckanarra Battery, Water Supply ..	13, 14
Hill G.M.L. 3585 .. .. .	40	Upper Cambrian .. .. .	25, 26
Hobson, R. A. .. .. .	2, 22, 34, 35	Vranizan G.M. .. .. .	13
Hornblende schist, Mullewa .. .. .	6	Wade, A. .. .. .	24, 30
Jaccolletti Group .. .. .	35-37	Water Supply, Edward's Find .. .. .	10
Jaccolletti South G.M.L. 3542 .. .. .	36	Water Supply, Spargoville, Logan's Find and Cave Rocks .. .. .	6-9
Jones, Leo J. .. .. .	24, 25	Water Supply, Tuckanarra Battery ..	13-14
Kimberley Division, Petroleum Exploration ..	23-26	Woolnough, W. G. .. .. .	26
Lady Mary G.M.L. 24PP .. .. .	40	Wooramel River Area .. .. .	26, 27
Lenneburgs Group .. .. .	37	Whindfield's P.A. 3546 .. .. .	3
Lenodo G.M.L. 3431 (old Jaccolletti) ..	36	"White Horse," Murchison Goldfield ..	16, 17
Logan's Find, Water Supply .. .. .	8	Water Analyses, Coolgardie Goldfield ..	8
Lower Limestone Series .. .. .	25	Xantippe Group .. .. .	41
Lubra G.M.L. 3485 .. .. .	40	Yilgarn Series .. .. .	21
		Yellowdine Gold Find .. .. .	3