1928.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

OF THE

GEOLOGICAL SURVEY

FOR THE

YEAR 1927.

With Eleven Plates and Eleven Figures.

PERTH:

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Annual Progress Report of the Geological Survey for the Year ending 31st December, 1927.

The field activities of the Geological Survey for the year ending 31st December, 1927, have been confined to a detailed geological survey of the southern portion of the Kalgoorlie Field (the Golden Mile); a special report on the South Kalgurli Mine; and numerous inspections of mines, mineral deposits and water supplies, made more from an economic rather than a purely geological aspect.

THE STAFF.

One alteration was made in the staff by the retirement of Mr. A. G. D. Esson, M.A., in December, 1926, and the temporary appointment of Mr. K. J. Finucane, B.Sc., as Assistant Field Geologist, in February, 1927.

FIELD WORK.

T. Blatchford, B.A., Acting Government Geologist.

In addition to the usual office routine, which included the editing of Bulletins Nos. 84, 85, 86, 87, 90, and 93, as well as the Atlas of Maps for Bulletin 83 (already published), much of my time was occupied in the field in making inspections and writing reports on various mines, mineral deposits and water supplies. Such inspections, however, incurred much travelling, and consequently considerable time. As some are merely progress reports, compiled purely for departmental purposes, they have been withheld from publication.

F. R. Feldtmann, Field Geologist.

After his return from long service leave, Mr. Feldtmann resumed duties on the 10th of January. On the completion of maps for the Annual Progress Report for 1926, revising the maps for Bulletin 87, and preparing certain maps necessary for the Kalgoorlie survey, he left for Kalgoorlie on the 31st January. Towards the end of April he was recalled to Perth to prepare further maps for the Kalgoorlie survey, to revise maps for Bulletin 83, and to attend to the office routine during my absence on annual leave. He returned to Kalgoorlie at the latter end of June, remaining there until the 21st of December, when he was recalled to Perth for the Christmas vacation. The results of his work are included in the accompanying reports.

K. J. Finucane, B.Sc., Assistant Field Geologist.

Mr. Finucane, since his appointment in February, has been wholly occupied on the Kalgoorlie survey as Mr. Feldtmann's assistant.

Both these officers are now engaged on the Kalgoorlie survey, assisting Dr. Stillwell to complete his report on that area.

PETROLOGY.

C. O. G. Larcombe, D.Sc., Acting Petrologist.

The petrological work, as during the previous year, has been carried on by Dr. Larcombe mainly at the School of Mines, Kalgoorlie, and for only a small portion of the year in Perth. The work included the determination of bore cores; Kalgoorlie rocks collected by Mr. Feldtmann; and samples of rocks received from the general public.

PUBLICATIONS.

During the year the following publications have been issued, and are now available for the public, viz.:—

Bulletin 84.—The Field Geology and Broader Mining Features of the Leonora-Duketon District, including parts of the North-Coolgardie, Mount Margaret and East Murchison Goldfields, and a Report on the Anaconda Copper Mine and neighbourhood, Mount Margaret Goldfield: by E. de C. Clarke, Field Geologist.

Bulletin 85.—A Geological Reconnaissance of part of the Ashburton Drainage Basin, with Notes on the Country Southwards to Meekatharra: by H. W. B. Talbot, Field Geologist.

Bulletin 86.—The Geology and Mineral Resources of the Yalgoo Goldfield, Part II.; the Mining Centres of Rothesay and Goodingnow (Payne's Find): by E. de C. Clarke, Field Geologist.

Bulletin 87.—A Geological Reconnaissance in the Central and Eastern Divisions between 122° 30′ and 123° 30′ E. Long. and 25° 30′ and 28° 15′ S. Lat.: by H. W. B. Talbot, Field Geologist.

Bulletin 90.—The Geology of a portion of the East Coolgardie and North-East Coolgardie Goldfields, including the Mining Centres of Monger and St. Ives: by E. de C. Clarke, Field Geologist.

Bulletin 93.—The Geology of portions of the Kimberley Division, with Special Reference to the Fitzroy Basin and the Possibility of the Occurrence of Mineral Oil: by T. Blatchford, Assistant State Mining Engineer.

Atlas of Maps to accompany Bulletin 83 (previously published), entitled "The Geology and Mineral Resources of the North-West, Central and Eastern Divisions, between Long. 119° and 122° E., and Lat. 22° and 28° S.": by H. W. B. Talbot, Field Geologist.

Annual Progress Report for the year 1926.

T. Blatchford

Acting Government Geologist.

1.—MANGANESE DEPOSITS OF THE TEANO RANGE AND MOUNT FRASER, PEAK HILL GOLDFIELD.

(T. Blatchford, B.A., Acting Government Geologist.)

Location.—Mineral Claims 7P and 8P, applied for by W. H. Berry, join one another, and are situated at the southern end of the Teano Range. They probably lie in the north-eastern corner of 3083/96 (Lands Plan 79/300). I was unable to fix the locality exactly, due to magnetic variation and the indefinite location on the map of the hills suitable for sighting.

General Description.—The two claims have been pegged to include the manganese deposits on a low ridge which runs east and west. The manganese occurs in sediments, probably of the Nullagine Series, and in this respect they resemble those found on the eastern flank of the Braeside Mineral Belt. The strike of the sediments is slightly north of west with a dip at a fairly high angle to the north. Several varieties of sediments were noted, the main beds consisting of shales, sandstones, fine-grained quartz conglomerates, coarse to fine-grained grits, and a rather conspicuous bed of limestone. As far as could be ascertained the manganese occurs in the finer-grained shale beds. The position of the limestone is relatively different here from that at Braeside, where it underlies the manganese. In these deposits it overlies the manganiferous beds. As a whole the strata has not been subjected to violent earth movements, the tilting being caused by gradual folding. Buckling in the strata was entirely absent.

Manganese.—When approaching the claims, at first sight there appears to be a very large amount of manganese ore scattered over the surface of the slopes of the ridge and around the base, particularly on the southern side. On close inspection, however, the amount proves to be more apparent than real, for many of the black nodules are merely ironstone crusted with manganese oxide, and therefore worthless. Large blocks of fairly pure ironstone (mostly limonitic) are also to be found in considerable quantity.

Where in solid formation it is apparent that the manganese only occurs *in situ* in comparatively narrow lens-shaped outcrops of no great length, though the individual outcrops extend over a considerable distance.

The occurrence has every appearance of being a series of at least three parallel manganiferous zones, in each of which occur a succession of short lenses of ore. As a rule the ore in these lenses is far from being marketable manganese, limonite and other impurities being of common occurrence.

Manganese Ore.—Practically all grades of manganese ore can be found in the deposits, some of the pieces broken being equal to any to be found in the Horseshoe deposit, and could be well classed as high-grade chemical ore.

Quantity of Ore.—I make no pretence to estimate the quantity of ore in these deposits, except to state that in my opinion thousands of tons of marketable ore could be picked up on the surface or broken from the outcrops. Without spending a considerable time in thoroughly sampling it, it would be impossible to form an accurate estimate. Manganese ore is proverbial for its erratic nature in any deposit. The origin of the mineral would suggest such.

On this recent trip I have taken what seemed to be magnificent ore on the surface, only to find that inside the broken boulder the iron contents were such as to render the whole piece worthless. I have seen practically all the important deposits in this State, and this erratic nature of the manganese contents can be noticed in them all, and without proper mining development, in my opinion, it is not safe to estimate quantities except very approximately.

Value of the Deposit.—Notwithstanding the adverse criticism I have made of these deposits, they would be of value as manganese producers if the location was not so unfavourable, for they are unfortunately, by themselves, not large enough to warrant the construction of a railway line, which is no doubt the cheapest mode of transport. They would be worthy of consideration, however, if at any time a railway built for other purposes passed close by them, or a series of similar deposits was discovered in the neighbourhood, particularly so if the price of manganese was to increase above the present rate of 1s. 8d. to 1s. 9d. per unit. Pending these conditions the deposits have no present value.

While inspecting Berry's manganese deposits it was brought under my notice that Messrs. Bain and party had pegged another similar deposit some 15 miles east of the former.

On inspection, these deposits turned out to be similar to Berry's in all geological respects, and what I have already written about Berry's applies almost equally to Bain's. The manganese is formed on the southern slopes of a low range, and lenses of ore can be traced by their outcrops over a length of from 2½ to 3 miles. There are at least three series of these outcrops. None of the lenses is of any great size, but there is quite a considerable quantity of high grade ore scattered over the slopes of the hills and in the outcrops. The deposit is distinctly of the fissure lode type. Compared with the ore in sight on Mineral Leases 7P and 8P there is, I should consider, an equal or greater tonnage of commercial ore available here, but the absence of cheap transport and insufficient quantity of ore cause this deposit to be worthless at present.

Small quantities of manganese were also inspected 10 miles south of Milligan Station and near the Fraser Range.

2.—WATER SUPPLY AT HOLLERTON, YILGARN GOLDFIELD.

(T. Blatchford, B.A., Acting Government Geologist.)

General Remarks on the occurrence of Underground Water.—Underground water supplies occur under the following conditions:—

(a) In weathered zones, particularly if low-lying and where the weathering has reached a considerable depth.
(b) Any foliated or fractured unweathered rock mass.
(c) Porous sedimentary strata.
(d) Porous superficial deposits occuring in low-lying country into which there is surface drainage.

Geology of the Hollerton Area.—From the aspect of an underground water supply, the geology of the Hollerton area is as follows:—

A narrow belt of greenstone striking west by north and east by south forms the higher ground, though the elevation is not great. This greenstone ridge is bounded on the north and south by massive granite. Though slightly foliated in places the greenstone as a whole is massive. There are, however, fractured or foliated zones which have been invaded by subsequent granite intrusives, and the reefs and lodes are intimately associated with these intrusions.

The granite is for the most part massive, though a gneissic structure was observed in certain areas.

Water Supply: (a) *Weathered Zones.*—As far as can be seen in the mine workings the weathered zone does not appear to reach any great depth. In the Great Beacon there is clear evidence that the unweathered rock occurs at the 84-feet level, and sulphides are found in the 100-feet crosscut. The mine is quite free of water, not even showing evidence of moisture.

The Glenelg Queen, which has reached a depth of 120 feet vertical, is still in partially weathered rock. This mine lies at a higher point than the Great Beacon, and will probably not reach the sulphide or water level for some time yet.

Number 1 Bore, lying between the Great Beacon and the townsite, bottomed on greenstone at a depth of 140 feet, and was dry. This bore was on low-lying ground, and reached a considerably greater depth than the workings on the two mines mentioned above.

There does not appear to be much chance, therefore, of finding a water supply in the weathered zone of the greenstones.

With regard to the granite, the unweathered zones are invariably covered with a mantle of surface detritus, and will be referred to later on.

(b) *Foliated or fractured unweathered Rock Masses.*—With the exception of the Great Beacon mine, the sulphide zone has not been reached in any of the mine workings. In this instance there is no evidence in favour of water being found, as is so often the case when the sulphide zone has been reached. The main drive at the bottom level has followed a pronounced shear plane quite suitable for holding water, but is quite dry.

The main shaft at the Glenelg Queen is in fractured country, but the sulphide zone has not been reached. There is a chance here, when the ore channel is cut in this shaft, that water will be found, but at the present rate it will be a considerable time before the shaft reaches the lode.

All the other workings on the field are shallow and dry.

(c) *Sedimentary strata* are absent.

(d) *Porous superficial Deposits.*—Superficial deposits have collected to some extent, and now occupy the two valleys lying between the main greenstone ridge and the granite outcrops. These valleys have a fall towards the west and form the drainage channels of the rain waters.

The boring operations of the Public Works Department have partially tested these two valleys, the details of the bores being as follow:—

No. 1 Bore.—This bore lies between the Great Beacon and the townsite, and was sunk to a depth of 140 feet. It bottomed on greenstone, and was dry.

No. 2 Bore.—Situated about one mile north from Mount Lookout. The bore struck water at about 120 feet, which rose to 114 feet, but the supply was negligible. The bore passed through granitic material, and bottomed in weathered granite.

Nos. 4 and 5 Bores.—These were sunk further down the southern valley: one opposite the 50-mile post, the other adjacent to the 51-mile post. The first reached hard material at a depth of 37 feet and was abandoned. The second was in progress, and had reached a depth of 47 feet in red clays.

No. 3 Bore.—This is in the northern valley, and lies about one mile east of the 47-mile peg. It reached a depth of 147 feet, bottomed on granitic material, and was dry.

Summary.—The probability of finding a shallow underground water supply appears to be a remote one. Further boring in the two valleys referred to, further down their fall, *i.e.*, west of the Rabbit-proof Fence, might meet with success, but it would entail considerable expense in a long pipe line and pumping plant. The sinking of the main shaft on the Glenelg Queen might solve the problem for the one mine. To bore other ore channels, such as Davidson's or Smith's, might equally result in water being discovered, but the expense of sinking shafts in the event of success would be costly and take considerable time.

There was local talk of the Scheme water being extended down the Fence to serve the new settlers. Whether this is correct I am not certain. If so, it would be the best way out of the difficulty. Failing this, if it is the policy to continue searching for surface water, I recommend that the valleys be further prospected down their fall, and that they be systematically tested right across with a series of holes.

3.—WATER SUPPLY AT BALLA AND DARTMOOR, GERALDTON DISTRICT.

(T. Blatchford, B.A., Acting Government Geologist.)

In accordance with instructions, I visited the Balla-Dartmoor areas, and my report on the possibility of obtaining underground water supplies by boring is as follows:—

Before discussing the water question of the Balla-Dartmoor areas, the existing conditions of the underground water supply of the artesian basins lying to the north and south will be briefly referred to in-so far as they affect the question at issue. Such a course is rendered necessary in view of the fact that practically no surface evidence is procurable in either centre which has a direct bearing on the underground water supply.

General Geology of the Two Areas.—The Balla-Dartmoor centres lie in an extensive area occupied by sediments of Carboniferous age (Geological Map of Western Australia). These strata outcrop as far north as the Lyndon River, and extend south to the Irwin River. They probably continue much farther south, but do not outcrop. Their greatest surface development is in the basins of the Gascoyne and Wooramel Rivers.

More recent beds of Jurassic age overlie the west edge of the Carboniferous strata north of Hamelin Pool, and almost completely cover them south of that point. A narrow coastal belt of Tertiary and Post-Tertiary strata overlies the Jurassic. The strata of all these ages are marine sediments.

Immediately east of Northampton there is a pronounced necking of both the Jurassic and Carboniferous beds. This is caused by the granite massif, which outcrops as far as the Geraldine mine on the north, and extends south to the Greenough River. This necking is important as regards fresh water artesian supply, and will be referred to later on.

The dip of the strata in the Gascoyne area is to the west. In the Murchison area no dips were recorded.

In the vicinity of Eradu the dip west of the Greenough is to the west; that east of the river is to the east. This is probably due to faulting.

Artesian Supplies in the Areas previously referred to.—Extensive artesian supplies of fresh and stock water have been found in the Gascoyne and Wooramel basins (Artesian Bores of Western Australia, Appendix N, Interstate Conference Report, 1921).

Apparently no deep boring has been done in the Murchison basin, though it seems highly probable that similar geological conditions exist as far south. In the vicinity of Eradu several bores have been sunk, mostly on the east side of the river. The record of these bores as regards water is that they were either dry holes or struck salt water. Immediately west of the river, at Eradu Siding, the recent bores prove the existence of a probable sub-artesian supply of stock water (total solids 227 and 95).

Further to the south a bore at Geraldton yielded a supply of salt water. The same occurred in the deep bore at Dongara, while at Yardarino a large supply of good stock water (artesian) was struck. As far as I can ascertain the deep bore at Mingenew, which lies farther to the east, was a dry hole. This hole apparently did not bottom.

When considering the possibilities of artesian water being fresh or salt one of the main points is whether the underground water is circulating or more or less stagnant. If there is opportunity for the water to circulate, the salt contained in the strata is eventually all leached out, the reverse being the case in basins or areas without an outlet.

As already stated the strata in the northern areas dip seaward, and have therefore an outlet; hence the artesian water is more or less free from soluble salts. The same applies to the waters west of the Greenough River at Eradu. The probable reason for the Geraldton and Dongara bores being salt is their proximity to the ocean. The Yardarino bore is situated in a strata in which the water is circulating seaward, while the waters further to the east are in a water-locked area, and are consequently salt.

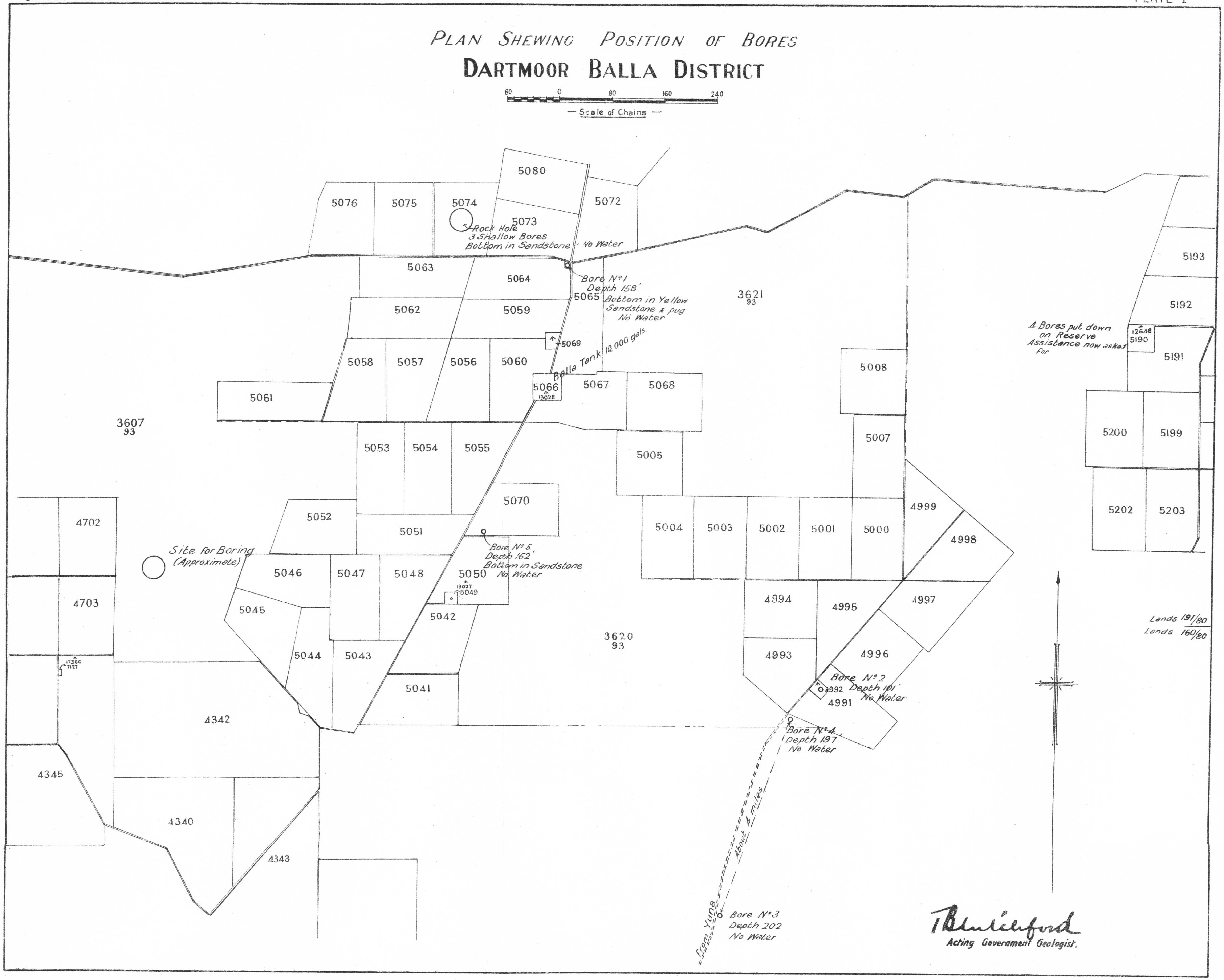
The Balla-Dartmoor Areas.

Geology.—The Balla-Dartmoor areas proper consist of fairly heavily timbered belts of first-class agricultural land surrounded by undulating sand plains. From a geological point of view the country is most uninteresting, for outcrops of the underlying rocks and evidence of structure are almost totally absent. At the Balla Tank (5066/13028) an excavation has been blasted out in a finegrained sandstone of sedimentary origin. Patches of what are locally known as limestone occur frequently in the high-class land. These limestones have been proved to owe their origin to the presence of dark-coloured calcareous marls, which are typical sediments. At the 95-mile well, on the Rabbit-proof Fence, pebbles of granite porphyry, etc., are abundantly scattered over the surface. Some of these pebbles are distinctly smoothed by glacial action, and probably correspond to the glacial beds of the Irwin River. All the hand bores passed through sedimentary deposits, and in no instance was an igneous or a metamorphic rock reported. The evidence for the occurrence of sediments has been stressed on account of a map which was published in 1908, which would lead any reader to form the conclusion that the area was occupied by granites, but which is evidently not the case.

Water—Artesian and Sub-Artesian Supplies.—From the available data there are fairly strong reasons for suggesting that artesian or sub-artesian water would be struck by deep boring. The evidence as to whether the water would be fresh or salt is not so positive. If the prevailing dip of the strata in the northern proved artesian area be maintained as far south as Balla and Dartmoor; or if the westerly dip of the strata west of the Greenough River, in the vicinity of Eradu, comes as far north, there would be every reason for assuming that the water would be fresh, or at worst good stock water. If deep boring is decided upon the bore, in my opinion, should be placed as far north as possible to get away from the narrow neck of strata opposite Northampton, in which circulation is probably not so free, and consequently the underground waters more likely to be salt. There are no data on which to calculate the probable depth of water-bearing strata, but on general principles the depth where water will be struck will vary directly with the distance on the dip from the intake. Assuming the dip to be westerly, the depth of the bore in this case would vary inversely with the distance eastward, and should therefore be located as far to the east as not to unduly increase the cost of boring.

Shallow Waters.—Generally speaking there is no definite evidence on the surface to guide sinking or boring for surface waters. In the Balla area a certain amount of success has been met with, and stock and domestic waters have been located in wells and bores along what appears to a water-bearing zone, which strikes diagonally across the road from Balla to Bininu. The continuation of this zone to the southeast has apparently been tested by Bores Nos. 3 and 4 without success. I can make no better suggestion than that further boring be done along this line, and consider the position marked on the plan (Plate I.) to be quite a good spot to test. At Balla Tank there is apparently a good hard catchment which would fill a much larger reservoir than the present one. One bore sunk on Tank Reserve 5071, three miles north of Balla Tank on the Rabbit-proof Fence, failed to strike water down to 158 feet. Unless this hole has fallen in it would be advisable to sink it further, at least until the clay or "pug" has been passed through. If this hole is successful the shallow holes to the west might be continued. Failing to find water in either of these localities, it seems useless to continue a shallow boring policy.

Dartmoor.—At Dartmoor No. 1 Area one hole has been bored to a depth of 101 feet on W/R 13152, and No. 4 Bore to a depth of 197 feet. Successful boring seems to be hopeless in this locality.


PLAN SHEWING POSITION OF BORES
DARTMOOR BALLA DISTRICT
80 0 80 160 240
Scale of Chains
Rock Hole
3 Shallow Bores
Bottom in Sandstone - No Water
Bore No 1
Depth 158'
Bottom in Yellow
Sandstone & pug
No Water
Balla Tank 10,000 gals
4 Bores put down
on Reserve
Assistance now asked
for
Site for Boring
(Approximate)
Bore No 5
Depth 162'
Bottom in Sandstone
No Water
Bore No 2
Depth 181'
No Water
Bore No 4
Depth 197
No Water
Bore No 3
Depth 202
No Water
From Yuna
About 4 miles
Lands 191/80
Lands 160/80
3607
93
3621
93
3620
93
5080
5076
5075
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5073
5072
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4343
T. Blatchford
Acting Government Geologist.

In Dartmoor No. 2 Area two localities in which boring might be successful are: (a) Continue the hole on Reserve 12648, and (b) stand off to the west and test the country south of Reserve 17940 at the 95-mile. In the first case the hole bottomed on a boulder bed, which should be a good reservoir for water overlying a clay or other impervious bed. In addition the present bore site is in low-lying ground. The second position (anywhere in the vicinity of the south-western peg of 3823/93), though some distance from the farming blocks, offers a reasonable chance of success on account of the coarse nature of the surface sands and the fact that water has been found at a shallow depth at the well at the 95-mile.

In conclusion, if shallow boring is to be resorted to for water supply in either of these centres, my recommendation, other than that already expressed, is first to try and locate water where most wanted and then endeavour to follow up the water-bearing horizon by systematic boring. In any case attempts to find water in these areas by shallow bores will be more or less controlled by a considerable element of chance, for it will be to a large extent mere stabbing in the dark.

4.—MINING PROSPECTS OF GRANT'S PATCH, NEAR HALL'S CREEK; KIMBERLEY DIVISION.

(T. Blatchford, B.A., Acting Government Geologist.)

Grant's Patch.—Grant's Patch is situated some 300 chains east by south of the 175-mile peg on the Hall's Creek-Turkey Creek telegraph line and 50 miles northnortheast of Hall's Creek. The name was taken from one of the original prospectors, who discovered gold in the later eighties.

Geology.—Briefly the main geological features are more or less foliated fine-grained greenstones invaded by later pegmatite dykes, classified in the State Geological Map under the general name of metamorphics. The country from a mining point of view resembles much of our Eastern goldfields. Striking through the greenstones in a general north by west direction (340°) are several parallel lines of quartz reefs. These reefs as a rule run parallel to one another, and with but few exceptions do they show a greater thickness than a few inches. The dip of the reefs is either vertical or slightly to the east. Traces and occasionally irregular patches of lead sulphide (galena) are of frequent occurrence in the quartz veins. There is little doubt that the silver contents occur in this galena.

Mine Working.—As would naturally be expected most of the old mine workings have either partly or completely fallen in. They are fairly numerous, and give the appearance that the original prospectors must have located payable values to have persisted in their prospecting. It is also obvious that much of the quartz that was raised has been taken away, possibly to the Hall's Creek battery, which was then in existence. Unfortunately I can find no record of any crushings.

Mr. George has done a little development on his lease, and from the vein of quartz, about 12 inches thick, which he had exposed to a depth of about 12 feet, I took three samples (1-3). These contain 1½ to 4½ ounces of silver, but only traces of gold. A little galena was showing in this reef, which probably accounts for the silver contents.

Some half a mile northeast from George's workings a shaft had been sunk to a shallow depth in a conspicuous quartz outcrop occurring in a parallel vein. A sample broken across two feet of solid quartz in the shaft, or rather trench, yielded 1 dwt. 15 grs. of gold and a trace of silver (No. 4). At a distance of half a mile, still to the northeast, is another parallel line of quartz reef on which quite a considerable amount of prospecting has been done, though the workings have since collapsed. A sample from stone scattered on the surface, and which contained a fair amount of galena, yielded a trace of gold and 2 ozs. 19 dwts. 11 grs. of silver (Sample No. 5). Two more samples were taken from the surface of outcrops lying slightly to the west of George's mine, and yielded respectively a trace of gold and I oz. 19 dwts. 5 grs. of silver and 2 dwts. 21 grs. of gold and 13 ozs. 3 dwts. 21 grs. of silver (Samples 6 and 7). A sample taken from a narrow quartz leader at the well yielded a trace of gold and 5 dwts. 14 grs. of silver. The well is supposed to yield a good supply of water.

General Remarks.—The results of the eight samples are in my opinion very discouraging, particularly as the previous samples were much higher and the fact that the veins are small. The numerous workings which were made when prospectors were at fever heat in their search for gold might naturally suggest that there might be payable reefs abandoned, but the samples taken do not indicate such conditions, and I am afraid that the chance of success in this area is very remote. The silver contents, though considerable, are in my opinion worthless without appreciable gold values.

5.—POSSIBILITIES OF MINERAL OIL OCCURRENCES IN THE ESPERANCE DISTRICT; EUCLA DIVISION.

(T. Blatchford, B.A., Acting Government Geologist.)

In Mr. Hancock's company I inspected the localities in the vicinity of Esperance, in which he assumes there are indications of mineral oil.

Geology.—Though covered over in many places by shallow deposits, granite is the prevailing rock in the vicinity of Esperance, and may be found extending far inland towards Norseman and out to sea to a distance of 30 to 40 miles, where it outcrops into numerous islands. A long line of outcrops may be found along the seashore, and frequent outcrops occur at a distance of not more than six miles in from the coast. Running parallel with the sea shore, and at a mean distance inland of some two to three miles, is a long line of salt lakes or lagoons, the most noted of which is the Pink Lake, from which considerable quantities of marketable salt have been obtained. Mr. Hancock contends that this lagoon area is a deep depression which has been filled with sediments which are oil-bearing.

There is no doubt that the granite area as far north as Norseman, and probably considerably further north, was underlying the ocean in Miocene times.

Scattered remnants of sediments such as found at Norseman and near St. Ives carry fossil remains of that age. The Plantagenet beds further west, which occupy a considerable area in the vicinity of Albany and extend as far east as the Hamersley River, were also laid down in a Miocene sea. None of these beds has proved to be of any appreciable thickness.

Since Miocene times the country has gradually risen, and probably continues to do so, as evidenced by the raised sea beaches found along the coast which contain shells of the same species as exist at the present day.

Some 40 miles south of Esperance the ocean soundings suddenly increase from 40-50 fathoms to 120-600 fathoms, showing a very sudden fall, and indicating the probability of a pronounced fault scarp. The uplifting area probably extends as far south as this.

With regard to the depression in which the lagoons occur, this can be easily explained by the fact that sand dunes and recent lime-bearing sandstones are naturally forming along the seaboard, and the sea and other waters have been cut off from the ocean and become impounded. This is no phenomenon but a common occurrence on many seaboards, governed to a large extent by prevailing winds, inland drainage and sometimes ocean currents. There is no evidence that the deposits underlying the lagoons have any great depth, and they will probably prove if bored to be merely shallow typical coastal calcareous sandstone beds, with probably thin irregular beds of mudstone.

Indications of Oil.

Page's Farm.—At Mr. Page's farm, some 10 miles north of Esperance, there is a fine example of iridescence, due to the oxidation of soluble ferrous salts brought to the surface in spring waters. The water apparently comes from a saturated layer lying near the surface, for the top of a low-lying ridge is quite spongy over a considerable area. Attempts have been made to drain this ridge, but so far have not been successful. There is probably quite a quantity of the soluble iron salts in the water, for in the drains the heavy precipitation of iron oxide is very evident. The iridescence is very marked, but is in no way similar to that produced by a film of mineral oil.

McCarthy's and Cole's Farms.—These two farms adjoin and are situated near Myrrup, further to the east. Geologically they lie partly in granite and partly in recent sediments, as witnessed by modern sea shells which may be picked up in the wheat fields. The oil phenomena consisted of some fresh water and mud springs, which so often occur under similar conditions, and are in no way associated with mineral oil occurrence. On McCarthy's block are some rather remarkable cracks in the sediments (contraction cracks) which extend for a considerable distance, probably 150 yards, and contain fresh water. There is no sign of hade, but simply the earth has cracked, due probably to a rearrangement of underground drainage. There was no sign of mineral oil in the water in the cracks.

In conclusion, I am thoroughly convinced that there is no geological evidence nor oil indications in favour of finding mineral oil in the vicinity of Esperance.

6.—POSSIBILITIES OF OIL IN THE PEEL ESTATE, FREMANTLE DISTRICT.

(T. Blatchford, B.A., Acting Government Geologist.)

I visited the Peel Estate with Mr. A. E. Green, and examined his bore on Block 333.

This bore is situated in low-lying country, in which are numerous patches of swampy ground. The bore is practically in a swamp, though the ground where the bore is situated was dry at the time of my visit. The sample taken was from the borings at a depth of 80 feet. Mr. Green assured me that at times there was a strong smell of oils in the borings from this hole, and that he had extracted traces of mineral oil from the borings.

The sample (264) on analysis yielded a small percentage of waxy residue, which Dr. Simpson considers is probably of a vegetable nature and does not resemble petroleum or its residuums.

Where Mr. Green is boring is in country which was at one time low-lying, but has since been filled in probably only to a comparatively very shallow depth in very recent geological times. There is no evidence of suitable structure or genuine oil seepage, or in fact any indication favourable to the occurrence of mineral oil. I regard boring for oil in this locality as mere stabbing in the dark.

A sample (262) was taken at a spot near a swamp about 1½ miles south of Block 333 of sandy loam, which was supposed to have a peculiar smell and an extractable quantity of mineral oil. Here again a yellowish-white waxy product was extracted, but Dr. Simpson comments that "such extracts have been found to be common in soils in this State, and are probably of recent vegetable origin, not indicating the presence of any petroleum or its residuums."

In "Kerosene Lane," on Mr. E. F. Wall's block, there is a patch of ground the top three to four inches of which are darker than the underlying sand. Samples were taken of the top layer and the underlying sand. The top sample (263) "yielded an oil extract of 1.09 per cent. oily extract. Of this .863 per cent. was a brown hydrocarbon oil resembling a refined medium-grade lubricating mineral oil. Direct distillation of the soil yielded a similar oil without any lighter fractions."

The second sample (265), taken from immediately underneath the first, yielded only the white waxy residue, which is according to Dr. Simpson "probably of vegetable origin, and does not resemble petroleum or its residuums."

The origin of the oil in the top layer could be either that (1) it was accidentally spilt from a motor car, etc., or leaked from oil drums; (2) that there is an oil seepage nearby, and that oil has spread from this seepage over the surface. Owing to the configuration and nature of the spot where the samples were taken, which is on the east side of a long sand dune of recent geological age, I fail to see how the oil could come from a genuine oil seepage. On the other hand there is certainly no indication of oil having been stored on the spot, nor is there any apparent reason which would lead to the conclusion that the oil came from a leaky motor vehicle. The statement was made to me that there were more of these "oily patches," and as the occurrence is interesting, I would like to make another inspection and clear up any doubt.

[Since the above report was written fresh samples have been taken and these, with one exception, gave negative results for mineral oil. The conclusion arrived at is that the first results were due to mineral oil having been spilt at the surface either from a motor tractor or oil drums.]

7.—BORING FOR COAL AT ERADU, GERALDTON DISTRICT.

(T. Blatchford, B.A., Acting Government Geologist.)

The following is my report on the cores obtained from the No. 1 Calyx Bore at Eradu, situated one mile west of Eradu railway station on the Railway reserve, with notes on the geological features observed in the locality.

Cores.—Much of the core apparently broke up during boring operations, and reached the surface in the form of mud or sand. The attached log has been compiled from the actual cores, typical pieces of which have been registered for future reference. Analyses of the coal seams are attached.

Geology.—In the immediate vicinity of Eradu the country can be conveniently divided into two classes: (1) Narrow alluvial river flats; (2) low-lying hills, for the most part covered with lateritic ironstone and sand and overgrown with dense scrub. At the crest of some of the hills typical "breakaways" occur. As may be expected, exposures of the underlying strata are rare, and only occur in the river banks and "breakaways." I was only able to find two exposures in which the dips and strikes could be measured with any degree of accuracy. At a point about 20 chains north of the railway bridge beds of argillaceous sandstones and narrow beds of conglomerates are exposed on the western bank of the river. These beds dip at an angle of two to three degrees to the west.

In this vicinity a considerable amount of boring has been done—one calyx and four hand bores. A 6ft. seam of coal was struck in the calyx bore at a depth of 118 feet. Mr. Campbell, who investigated this discovery, came to the conclusion that the coal seam and beds had a strike of approximately north and south and a dip of 5° 33′ to the east (94°).* If both observations are correct, it is apparent that there must be a fault in the river bed, the beds on the west side dipping west and those on the east side of the river dipping east, in which case there can be no connection between the 6ft. coal seam of the river bore and the seams found in the No. 1 calyx bore just completed.

Furthermore, there is a difference of elevation between the surface of the calyx bores of some 120 feet (aneroid readings only). The 6ft. seam was struck at 118 feet below the river bed, *i.e.*, 238 feet below the surface of No. 1 calyx bore, or 68 feet below the coal seams in that bore. If the strata in the river bore dipped west at an angle of three degrees, it should have been intersected at the No. 1 calyx bore at a depth of 514 =

118 feet depth of coal seam in river bore;

120 feet difference in elevation of surface at two bores;

276 feet due to dip.

For the coal seam in the river bore to have been missed in the No. 1 calyx bore, a dip to the west of six to seven degrees would be necessary, and this seems highly improbable.

Finally the easterly dip described by Mr. Campbell is further confirmed by a dip observed at Eradu Pool, some two miles south of the railway line. On the eastern bank of the pool the dip is undoubtedly easterly (eastsoutheast) at a low angle.

On the evidence it appears reasonably safe to assume that the coal seams in the two calyx bores are not the same seam.

Assuming they are not, if further prospecting by boring is to be done to test the two coal seams, the sites must be chosen accordingly.

As the water line is already laid for a considerable distance (for a site to prove the seams in the No. 1 calyx bore), I suggest as a second site a spot 30 chains north of No. 1 calyx bore. This hole need only go down far enough to re-sample the seams, and at the same time it should settle the important question of the strike of the beds. A bore 250 to 300 feet will probably suffice.

To prospect the 6ft. seam found in the old calyx hole, which in my opinion is by far the most important, I have chosen two new sites which with the old calyx bore will form a more or less equilateral triangle. If the seam is struck in the two holes suggested, we will have all the information we require about this seam. There is in my opinion quite a reasonable chance of workable coal being located in this locality.

If Mr. Campbell's dip is accurate, I would expect the southern hole (No. 4) to strike the coal horizon at approximately the same depth as in the river bore, *i.e.*, 140-150 feet, for it will be on the strike, and allowance has been made for the bore site being on the higher river bank.

No. 3 Bore would be required to go down at least 300 feet before there would be any chance of reaching the coal, and preferably another, say, 500 feet of boring should be done in this hole to prospect the lower strata for other seams of coal.

There may be some little difficulty about the site chosen for No. 4 Bore, as the ground was under crop last year. If there is any strong objection, the site could be moved a little further to the west on to the road as indicated. Water supply for both Nos. 3 and 4 Bores can be obtained without trouble from the same supply as is being used at present for No. 2 calyx bore, the connection being made at the main at the railway siding. There will be ample pipes available to connect with either bore site.

The positions of the suggested bore sites are shown on the accompanying lithograph (Plate II.).

The programme mapped out above will entail at least 800 feet of boring, and if the No. 3 hole is carried down as recommended, a total of 1,300 feet of boring will be required.

* G.S.W.A., Bull. 38, p. 33.

LOG OF BORE CORES RAISED FROM No. 1 CALYX BORE AT ERADU, ONE MILE WEST FROM ERADU SIDING, ON RAILWAY RESERVE.

No. of sample.	Depth of core.				Description.
	ft.	in.	ft.	in.	
1	30	0	64	0	White gritty sandstone.
2	64	0	75	0	Finer grained yellow sandstone.
3	75	0	98	0	Similar to No. 1 sample.
4	130	0	140	0	Fine-grained argillaceous sandstone.
5	140	0	157	0	Coarse-grained red sandstone.
6	159	0	170	0	Micaceous shale.
7	164	0	166	0	A band of darker shale.
	170	0	180	3	Coal.
	181	6	183	0	Coal.
8	183	0	188	4	Grey shale.
	188	4	190	3	Coal.
9	190	3	199	0	Grey shale.
10	199	0	204	0	Coarse sandstone.
	207	0	240	0	Conglomerate.
11	240	0	244	0	Shale. Contains organic matter—possibly plant remains.
12	244	0	344	0	Soft sandstone. Practically no core.
13	344	0	345	0	Shale.
14	408	0	464	0	Friable sandstone.
	464	0	470	0	Soft friable shale.
15	470	0	544	0	Friable sandstone with minor bands of shale similar to 464–470.
16	544	0	550	0	Shale.
	550	0	580	0	Similar to 16.
	580	0	587	0	do.
	587	0	637	0	No core. Sandstone.
17	637	0	640	0	Dark shale.
18	640	0	663	9	Sandstone with shale bands (sample of shale).
	663	9	668	0	Dark shale similar to shale bands in 18.
	668	0	686	0	Soft friable sandstone with minor bands of shale.
	686	0	695	0	Shale similar to 18.
	695	0	803	9	Sandstones with minor bands of shale.
20	803	9	804	1	Band of pyrite.
19	804	1	832	0	Fine grey shale to bottom of hole

Analysis.

No.	3096/26	3097/26	3098/26
Depth	ft. in. ft in. 170 0–180 3	ft. in. ft. in. 181 6–183 0	ft. in. ft. in. 188 4–190 3
Proximate analysis—	per cent.	per cent.	per cent.
Moisture ...	13·66	10·67	7·78
Volatile matter	36·41	31·32	26·65
Fixed carbon...	24·74	30·69	29·00
Ash	25·19	27·32	36·57
	100·00	100·00	100·00
Calorific Value— B.T.U. ...	...	5493	...
Colour of Ash ...	Light brown	Dirty white	Brownish white

8.—GEOLOGICAL OBSERVATIONS MADE WHILST TRAVELLING IN WEST KIMBERLEY UP THE VALLEYS LYING BETWEEN THE PENTECOST AND KING RIVERS, THEN EASTWARD ACROSS THE DENHAM AND ORD RIVERS AS FAR AS ARGYLE STATION ON THE BEHN RIVER.

(Including a Report on the reported discovery of Argentiferous Galena on Speewah Station.)

(T. Blatchford, B.A., Acting Government Geologist.)

Introductory.—In view of the fact that high grade samples of silverlead ore were received from the manager of Speewah Station, on the Denham River, and that these samples were reported to have come from a lode of considerable dimensions occurring in country hitherto unknown to be mineral-bearing, the writer was commissioned to visit the locality and report on the possibilities of the discovery. Availing himself of the opportunity of personally seeing at least some portions of the Kimberleys, Mr. Clarke, Lecturer in Geology at the University, accompanied the party.

We left Fremantle by the State boat "Koolinda" on 28th July, 1927, arriving at Wyndham on the 10th August. Here we were met by Mr. M. P. Durack, who not only provided us with an excellent plant of riding horses and packs, but also acted as our guide for the journey as far as Argyle Station. At this point we left the horses and journeyed by motor transport back to Derby. The expedition with which the journey was made, particularly the section between Wyndham and Argyle, was mainly due to Mr. Durack's organisation and bushmanship, for much of the country we passed through was rough and trackless, in which a stranger might easily meet with considerable difficulty in finding suitable crossings.

One of our main difficulties was plotting our course with any degree of accuracy. In addition to the irregular course we were forced to follow, we found extremely few land marks fixed by survey, and on the other hand we came across many features which were not on the maps we carried. However, the track followed, as plotted on the accompanying plan (Plate III.), should be sufficiently accurate to show approximately the position of the main points of interest referred to in the following pages.

Fortunately the season had been a good one, and little trouble was experienced in finding water and feed for the horses and mules at convenient stages for camping.

Physiographic Features.—No authentic descriptions from actual personal observations has been published regarding the physiography of the Kimberley Division. Jutson (Bull. 61, Geol. Survey of W.A.) refers to the Kimberley area in general as an elevated tableland, probably an uplifted peneplain, connected by a narrow fringe to an outer low-lying peneplain, which extends far to the south and east. He describes the inland tableland as an area occupied by a labyrinth of hills and ridges with intervening low-lying plains well watered by numerous streams.

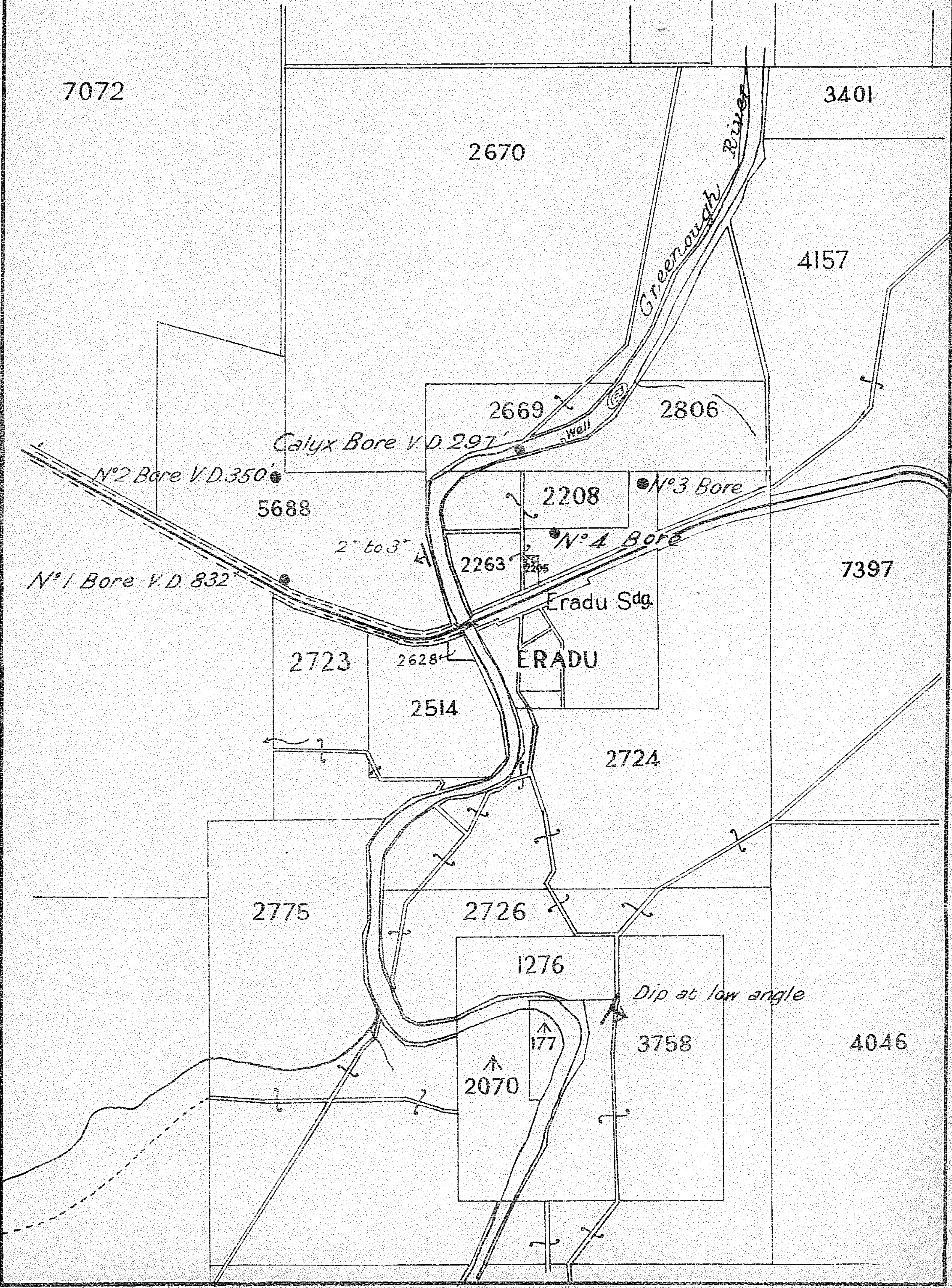
The surface features of the section we traversed correspond very closely to Jutson's description, and may be summarised as a succession of narrow flat-topped ranges, usually of considerable length, with occasional disconnected irregular ridges and isolated hills. The main ranges are separated by narrow valleys, seldom exceeding from three to four miles in width.

We found strong evidence that the sedimentary beds had been uplifted to at least 1,500 feet above sea level, and during the period of uplift they had been folded, the major axes of the folds having a prevailing north and south strike. Denuding agencies subsequently planed the crests of the folds down to the base of the sediments, forming valleys which are now separated by the remnants of the flanks of the

Plan Shewing Bore Sites at Eradu

40 0 40
Scale of Chains

T. Blatchford
Acting Government Geologist.



folds, which occurred usually as long narrow ranges. These ranges and ridges can therefore be regarded as the remnants of the old plateau, and stand out in bold relief to the valleys lying between them.

Owing mainly to their uniform geological structure, which consists of extensive beds of hard compact sandstones or quartzites overlying softer shales, tuffs, etc., the sides of the ranges are usually precipitous near the top, with a long talus extending from the bottom of the cliffs to the base (Fig. 2). This cliff structure is very characteristic, and is evidently due to the weathering of the underlying shales or tuffs being more rapid than that of the harder overlying standstones and quartzites. Undermined, the top beds break off in large masses rather than fret away gradually. No doubt vertical jointing adds largely to the process.

The valleys lying between the hills are as a rule covered with volcanic soils which apparently produce excellent pastures, particularly for cattle and horses. In most of the valleys the natural water supply is good, for in addition to the main streams, permanent springs are fairly plentiful.

After crossing the Ord the hills and valleys cease, and are replaced by extensive black soil plains which extend far away to the eastward. These plains, though extremely fertile in ordinary seasons, lack permanent water supplies, and on this account do not carry the number of stock they should. There is much to be achieved in establishing artificial supplies by boring, sinking wells, or surface catchments. Timber, chiefly eucalypti, is fairly plentiful in the valleys and particularly near the water-courses, and though not of first-class quality is ample for general station purposes.

Geology.

General Remarks.—Practically no detailed geological descriptions of the inland plateau of Kimberley are to be found in the published records of past observers, though there are certain occasional references to the main structural features. This may be accounted for by the fact that previous observers such as E. T. Hardman, 1885[1]; H. P. Woodward, 1891[2]; Dr. Logan Jack, 1906[3]; Herbert Basedow, 1916-1917[4]; and Dr. Arthur Wade, 1925,[5] were all engaged on special missions which held them to investigating more or less definite sections of the fringe of the plateau rather than any portion of its interior.

Gibb Maitland in 1901 certainly traversed the section lying to the west of the Chamberlain River, but his report refers more to the structural than the detailed aspect.[6]

The following are short and usually disconnected descriptions of points of interest which were examined when travelling from Wyndham down the valley lying between the Pentecost and King Rivers and across to the Ord. They were made on a single traverse, and must be considered merely as casual observations along the road rather than having any pretence to a thorough geological description. When possible specimens of the various rock types were collected and petrological descriptions of some of these rocks will be added. Photographs of striking features were taken where opportunity offered, and some of these will also be attached to illustrate the salient features.

From the observations we made it became obvious, however, that many of the geological problems of this interesting section of the State will require much careful study before they can be satisfactorily solved, and in addition much mapping will also be necessary.

[1] Report on the Geology of the Kimberley District. Parliamentary Paper, No. 34 of 1885.
[2] Report on the Goldfields of the Kimberley District. Parliamentary Paper, No. 18 of 1891.
[3] The Prospects of obtaining Artesian Water in the Kimberley District. W.A. Geol. Survey. Bull. 25, 1906.
[4] Narrative of an expedition of Exploration in North-Western Australia: Trans. Roy. Geog. Soc. Aust., S. Aus. Branch, Vol. XVIII., 1916-17.
[5] Petroleum Prospects in Kimberley: Parl. Aust., 1924, No. 142.
[6] W.A. Geol. Survey, Ann. Prog. Rept., 1901.

Wyndham.—The most conspicuous geological feature in the vicinity of the township of Wyndham is an irregular semi-detached series of hills, the highest point of which is West Mount Bastian (Fig. 1), which rises to an elevation of 1,079 feet above the surrounding country. These hills are composed of a top bed of sandstones, underlain by extensive shale beds. The prevailing dip of the beds is to the south-east at an angle of about seven degrees. Boring in the townsite has proved that the shale beds extend a further 1,197 feet below the surface, and lie on a second sandstone horizon proved to a depth of at least 1,320, when boring operations were suspended. A search was made for organic remains in the shales, but was unsuccessful.

The possibility of obtaining artesian water in the series has been dealt with in detail by Dr. R. Logan Jack in his report on the possibilities of artesian water in Kimberley, published in 1906.[1]

At the "Three-Mile," *i.e.*, three miles from Wyndham on the Hall's Creek Road, an interesting outcrop of basalt was noted. There was insufficient evidence to form a definite opinion as to whether this occurrence was a basaltic flow or intrusion. The rock is a dense basaltic type, showing occasional small facets of cleavable felspar.

..Under the microscope it is a mass of felspar microlites lying in all azimuths, with numerous grains and small prisms of augite. Distinct idiomorphic phenocrysts of plagioclase and augite may in places be noted. Irregular grains of magnetite are common.[2]

In many respects the rock resembles the basalts of the Antrim Plateau and the basalts of the Argyle Area.

Leaving Wyndham and the "Three-Mile" we travelled for 22 miles in a general south-easterly to southerly direction to the Wyndham Meatworks Pumping Station, on the King River, which lies almost opposite North Mount Cockburn. On the left hand we passed broken ridges consisting of sandstones, but as these were similar to the beds at Wyndham they were not examined.

North Mount Cockburn and Cockburn Range.—North Mount Cockburn is almost a replica of the Bastian with a greater development of the overlying sandstones, which have a thickness of about 200 feet. These beds show signs of ripple marking and current bedding (Fig. 3). They are underlain with shales, partly calcareous near their base, and con-

[1] The Prospects of obtaining Artesian Water in Kimberley: By Logan Jack. W.A. Geol. Survey, Bull. 25, Perth 1906.
[2] Petrological Description by Dr. C. O. G. Larcombe.

taining concretions of black calcite, which had been mistaken for bitumen. The series is undulating, but in the main dips westerly at low angles. To the east of the pumping station the dip of the beds is to the east. After leaving the pumping station the course turned slightly to the southwest and followed up Cockburn Creek, in a gorge occupied by it, for a distance of some eight miles, when the first "jump up" was crossed. A "jump up" is the local name for a cross ridge or saddle in a valley or gorge. This particular example consists of much broken and disturbed sandstone or quartzite, and probably represents a sheared zone which, owing to secondary mineralisation or silicification, offers more resistance to denudation than the main formation. "Jump ups" are not uncommon in the ravines and valleys of the Kimberley plateaux, and are particularly detrimental to wheel traffic, often rendering impassable for vehicles what might otherwise be quite a good roadway.

At three places in the bed of Cockburn Creek more steeply dipping rocks occur. First, near the mouth of the ravine a quartz vein, four feet wide, outcrops in micaceous shales, striking at 165 degrees and dipping west at 70 degrees. Two miles further up the ravine alternating beds of quartzites and shales strike at 210 degrees, and dip west at 30 degrees; and at a pool eight miles farther on, indurated thin bedded shales and quartzites have a strike of 20 degrees, and dip east at 70 degrees.

After descending the "jump up" on the south side, the track followed Gap Creek to the juction of a small tributary of the Pentecost River. Turning sharply to the left we followed up this creek until we reached Fish Pool, distant about 20 miles from the pumping station. The hills lying to the west of the pool dip to the west, and are either sandstones or quartzites.

Travelling from Fish Pool in a general southerly direction we passed over quartzites and shales. About two miles past Fish Pool these beds dip to the north at an angle of 30 degrees, these steep dips persisting for some distance about this spot. In the bed of a small watercourse a breccia of vesicular volcanic rock was seen well exposed and cemented in a few spots by quartzite. The volcanic rock appears to be contemporaneous with the quartzite beds.

In addition, the series has been invaded by basic igneous rocks. One occurrence was observed some seven miles south of Fish Pool where red-banded shales, which are very friable, are overlain by a dense fine-grained basic igneous rock. As these red shales could be seen extending for a considerable distance to the northwest, it is more than probable that the sill also has a wide extent. Under the microscope it is—

"Made up of small lath-shaped plagioclase and angular augite with some black oxide of iron. The slide shows a considerable staining by red oxide of iron. The rock is a somewhat ferruginous basalt."[1]

A second and much more extensive invasion of igneous rock occurs about 9 to 10 miles south of Fish Pool. Here a mass of coarsely crystalline massive gabbro extends in a westsouthwesterly direction for at least five miles, when it turned to the east away from our course; but it could be seen extending at least four to five miles further on. Where we examined it the mass was at least one mile wide, and wherever seen the sediments dip away from it at angles of at least 25 degrees. The mass is probably a laccolith, as in no instance was it observed cutting through the overlying sediments. The gabbro itself is, however, invaded by a finer-grained basic rock, in places up to two chains in width.

"Under the microscope the gabbro is found to be a holocrystalline aggregate of comparatively fresh plagioclase near labadorite and beautiful plates of very pale brownish cleaved and well twinned augite arranged ophitically with regard to the felspar. A little of the augite is diallagic. Patches of black oxide of iron are present, but are not abundant. This rock is an ophitic gabbro."*

The intrusive dyke under the microscope shows—

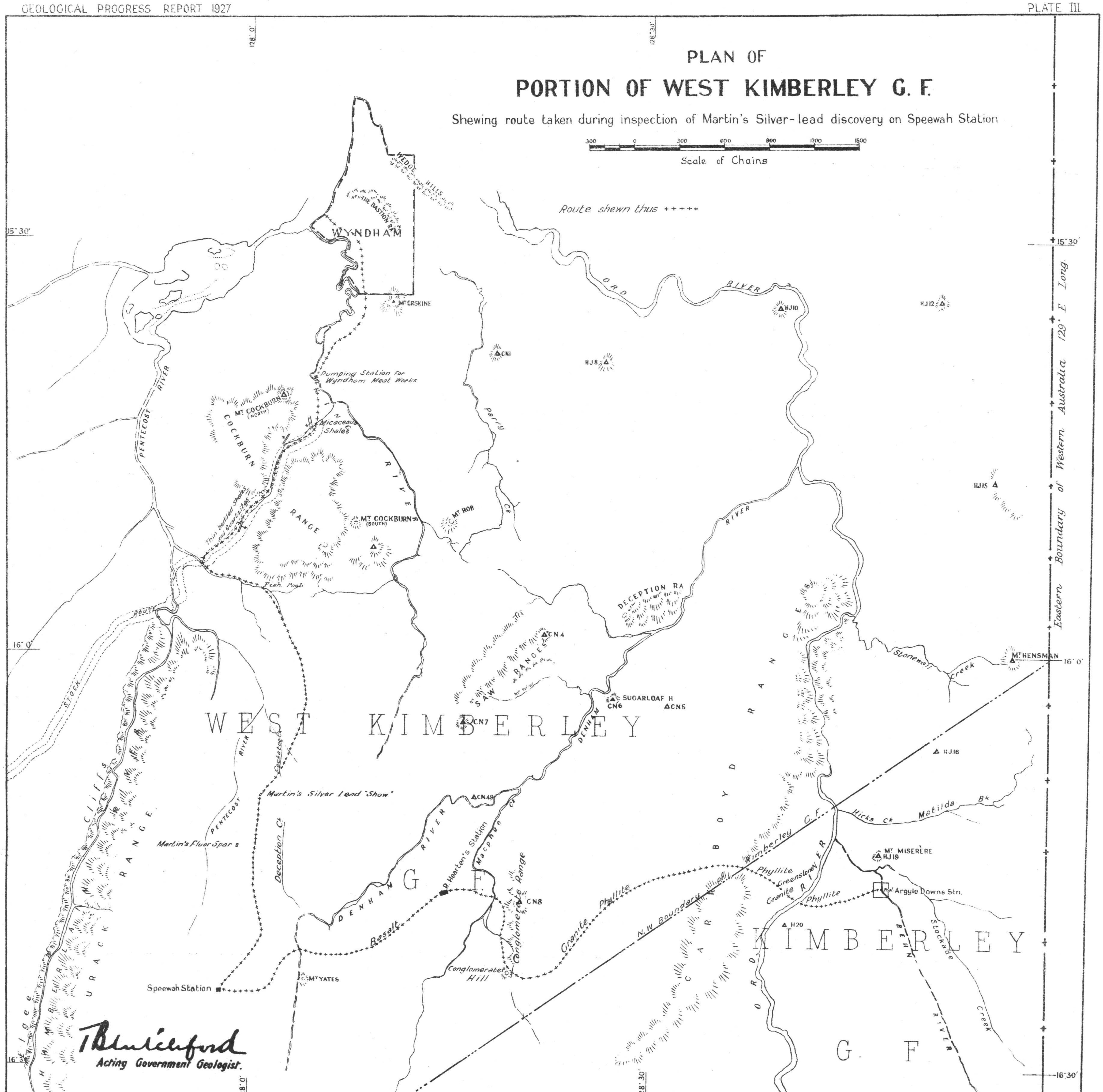
"Lath-shaped plagioclase intimately intergrown with grains and prisms of augite and contains grains and patches of black oxide of iron. A few bright green patches of chlorite were noted. The rock is a dolerite."*

The last three or four miles of the journey before reaching Martin's silver-lead mine were down a valley (Fig. 4), bordered on the eastern side by cliffs 300 to 500 feet in height. These cliffs consist of an uppermost layer at least 50 feet thick of a whitish quartzite, which in places shows signs of current bedding. Interbedded with this bed near its base is a 4-foot seam of tuff. Beneath this tuff bed and perfectly conformable to it are 40 feet of coarse tuff. Beneath this again is a series which probably forms the remainder of the cliff but is largely obscured by talus of fine-grained tuffaceous rock which breaks up into small and large fragments. In one of these was noted a small half-inch seam of quartz lying parallel to the bedding planes. A few more or less vertical faults, probably with a maximum throw of 40 feet, traverse the series.

Martin's Silver-Lead Show.—Martin's silver-lead show occurs on the extreme eastern slope of a low ridge, similar in form to a river terrace, which is separated from the cliffs by an alluvial flat about one mile wide. The lead deposit, which consists mainly of quartz mixed with a minor quantity of lode material, strikes north and south along this slope and dips at a very low angle to the east, the dip corresponding almost to the slope of the ridge. There is practically no overburden to the lode. The footwall is a coarse-grained granitic rock which can be followed in a low range of broken hills extending for several miles to the southwest. This footwall rock is probably a second laccolith from which the roof of sediments has been completely denuded with the exception of a thin scale of baked sandstone and shale or tuff, fragments of which are fairly plentiful on the surface of the ridge. The laccolith shows a vertical range in character from coarse, through finer-grained, up to fine-grained. A sample of the rock, taken from the footwall of the rock, showed the following characteristics when examined under the microscope.*

[1] Petrological description by Dr. C. O. G. Larcombe.

* Petrological descriptions by Dr. C. O. G. Larcombe.


PLAN OF
PORTION OF WEST KIMBERLEY G. F.
Shewing route taken during inspection of Martin's Silver-lead discovery on Speewah Station
Scale of Chains
Route shewn thus +++++
WYNDHAM
ORD RIVER
PENTECOST RIVER
COCKBURN RANGE
Mt. COCKBURN (NORTH)
Mt. COCKBURN (SOUTH)
Pumping Station for Wyndham Meat Works
Micaceous Shales
Mt. ERSKINE
Mt. ROB
Perry Ck
DECEPTION RA
SAW RANGES
SUGARLOAF H
WEST KIMBERLEY
DENHAM RIVER
Martin's Silver Lead "Show"
Martin's Fluor Spar
Deception Ck
Speewah Station
Mt. YATES
R. Hearten's Station
Conglomerate Range
Conglomerate Hill
Basalt
Granite
Phyllite
Greenstone
N.W. Boundary of Kimberley G.F.
BOYD RANGES
CARR BOYD RANGES
Stonewall Creek
Mt. HENSMAN
Hicks Ck
Matilda Bk
Mt. MISERERE
Argyle Downs Stn.
BEHN RIVER
Stockade Creek
KIMBERLEY G. F.
Eastern Boundary of Western Australia 129° E Long.
T. Blatchford
Acting Government Geologist.

"A crystalline mass of clouded felspar, some of which is certainly plagioclase graphically intergrown with the quartz in many places. Apatite rods are common in the quartz. All the ferromagnesian mineral has gone. It is now represented by bright green chlorite. A feature of this rock is the large plates of partially leucoxenised ilmenite. The rock is a basic chloritised granophyric type of granite."

A second sample broken on one of the hills to the southwest showed sufficient pyroxene to warrant the rock being classified as a granophyric pyroxene granite. There is no evidence of foliation in this rock mass, neither were any later intrusions of basic dykes noted.

The lead deposit was first exploited by cutting several shallow costeans, which were not sunk deep enough to reach the footwall, and as these workings showed considerable widths of lode material, as they naturally would, it was not unreasonable for the prospector to form an optimistic opinion of his discovery. However, when the costeans were deepened and the footwall was exposed there seemed little doubt that the deposit was merely the remnant of a flattish mineral segregation lying on the top of the laccolith. The greatest thickness in any of the costeans is three feet six inches. Galena, cerussite, malachite and azurite occur in scattered patches in the quartz, and native silver associated with the copper minerals was also noted in some quantities.

Four samples, broken from the lode where exposed in the costeans, yielded the following results:—

No. of sample.	Description.	Lead.	Silver.	Copper.	Gold.
		per cent.	ozs. dwt. grs.	per cent.	dwt. grs.
1	Centre costean, bottom section over 2ft. ...	3·87	23 4 6	3·03	0 5
2	Centre costean, top section over 1ft. 6in. ...	0·09	3 4 19	0·72	0 21
3	North costean over 2ft.	4·61	5 3 9	Trace	1 15
4	South costean over 1ft. 6in.	2·53	18 3 15	1·94	1 15

From Martin's camp we journeyed up the valley in a general southerly direction for about nine miles, and then turned a short distance off our course to the east to inspect some deposits of fluorite. The country rock passed over for this distance was mostly a coarse-grained greenstone, probably a continuation of the laccolith forming the footwall of the silver-lead lode. The only other rock noted was a very fine-grained dyke, about nine inches thick, striking east and west. The fluorite occurs in parallel veins with a north and south strike and a vertical dip. They apparently occur in a brecciated zone of a finer-grained basic rock.

"Under the microscope it consists of beautiful plagioclase showing carlsbad, albite and pericline twinning, the latter being very noticeable. Some of the felspars are cracked and contain dusty patches of alteration. The augite is pale brown, partially schillerised, and strongly twinned. It occurs in large irregular-shaped patches with a strong prismatic tendency, and in places has undergone slight chloritisation. There are some patches of black oxide of iron. A little quartz is present, some of it in the form of micropegmatite. This rock is a micropegmatitic quartz gabbro."*

Striking parallel with the vein is a narrow very fine-grained basic dyke evidently intrusive and probably intimately connected with the brecciation. The widths of the fluorite veins vary from 10 to 24 inches and the colour from semi-transparent and glassy to opaque white and light blue. Patches of galena frequently occur in some of the veins. Otherwise much of the fluorite is free from contamination, and would be of commercial value if more accessible.

Three more fluorite veins occur about seven miles southsouthwest of the first deposits and 2½ miles northwest of Speewah homestead. These veins likewise strike along north and south lines in a brecciated zone, similarly to the first deposits.

Though persistent in length, the veins are narrow and contain appreciable quantities of galena as an impurity. On the other hand some of the fluorspar is of high-grade quality and free from galena. Owing to the distance from the market the deposit is of no commercial value at present.

From Martin's silver-lead mine the country traversed was similar in topographical features to the previous stage. The rocks were for the most part coarse-grained greenstones.

Travelling from Speewah Homestead to Hearten's Homestead.—The first part of the route after leaving Speewah homestead was over basic igneous rocks, but near the south end of the laccolith a very good section was passed showing thin bedded tuffs. These tuffs are held up by long vertical lines of silicification (with crustification) and resemble those lying on top of the laccolith at Martin's silver-lead show. They dip south at the south end and east at the southeast end of the laccolith. After passing over these, a distance of about four miles, the route lay over quartzites which have a generally westerly dip and continue past the Denham River to within five miles of Hearten's homestead, where basic igneous flows of the same character as the breccias seen near Fish Pool come in and occupy the valley almost as far as the Conglomerate Range. Lying about three miles south of the Denham River crossing, Mount Yates (Fig. 10) makes a conspicuous landmark. The mount is really a text-book example of a volcanic "plug," rising through the quartzite 400 feet above the level of the river. The rock is fine-grained and of reddish colour, but unfortunately was too far weathered for accurate petrological determination.

"A fine-grained soft greenstone with a brownish streak. It is traversed by veinlets of glassy quartz. Under the microscope it is a mass of black and red oxide of iron with some greenish alteration material. Quartz veinlets are distinct. This is a ferruginous chloritic greenstone. It is almost surely of igneous origin, but it is so rotten that there is no positive evidence."*

The eastern side of the "plug" has been denuded by the river. On the western side the quartzite can be seen lying up against the wall of the neck where their gentle dip is unmistakably reversed. They have quite a different appearance from the ordinary quartzites although no distinct contact alteration minerals were noted.

* Petrology by Dr. C. O. G. Larcombe.

The next rock, the marginal rock of the plug proper, with inclusions of quartzite, is intensely silicified. Quartz veins, some vuggy with well-developed pyramids of quartz, form a regular network. Nearer the centre of the plug, which is at least 300 yards in diameter, the rock is less seamed with quartz veins and resembles the fine-grained igneous rocks previously referred to.

Between Hearten's homestead and Conglomerate Range the country rock is basalt, which near Hearten's weathers into a black friable soil quite different from the red soil of the more crystalline igneous rocks.

Conglomerate or Ragged Range (Figs. 5 and 7) owes its striking outline to the fact that its western side is composed of alternating bands of conglomerate and red sandstone. The sandstone is usually quite soft and pulverulent except where locally slightly more cemented patches occur and break away in great slabs. The conglomerate itself is composed essentially of pebbles, ranging from the size of marbles up to boulders a foot in diameter, perfectly rounded and apparently all quartzite. In this respect they resemble the Nullagine conglomerates. Two bands of conglomerate, 50 feet thick, are seen on the west side of the range, but proceeding eastward the conglomerate rapidly thickens till, in Conglomerate Bluff (Fig. 6), it attains a thickness of about 600 feet. Scattered through the conglomerate there are small lenses of sandstone. Further to the east of Conglomerate Bluff the conglomerate apparently thins out again and is replaced by sandstones very similar in appearance to the Upper Carboniferous sandstone series of the Fitzroy area. To decide whether these conglomerates should be classified as Nullagine beds or whether they are replicas of the conglomerates found embedded in the Carboniferous series will require much further study. Though far more massive in structure they certainly resemble very closely some of the conglomerate beds found in the vicinity of Mount Wynne and other localities in the Fitzroy area.

Shortly after passing Conglomerate Hill, medium-grained to coarsely-porphyritic granite is crossed. This granite is intrusive into the phyllites which are highly dipping, now east, now west, and strike east of north. These phyllites extend as far east as Prospect Creek (Fig. 8), which we followed down through the Carr-Boyd Range practically to the Ord River. The base of these ranges, in my opinion, consists of phyllites representing the metamorphic series as described by E. T. Hardman and others occurring in various localities on the outer fringe of the plateau, notably Hall's Creek, where the overlying sediments have been denuded down to their base.

After crossing the phyllites and on the eastern flanks of the Carr-Boyd Range, we find a strip of granite about half a mile wide. This granite appears to be sheared along its western edge, but this is a fluxion structure, for further in it becomes massive. In certain sections it is coarsely porphyritic, in others medium, even-grained with xenoliths of phyllites, proving that it has intruded the latter. On the eastern edge of the granite is a zone of a few hundred feet of intensely brecciated fine-grained flinty rock which may be a sediment or may be a highly altered greenstone.

After passing over this zone the same rock is found in a more massive condition, then an area of perhaps three-quarters of a mile of intensely sheared greenstone. The shearing planes in this greenstone strike in a general northeasterly direction and, like the phyllites, dip now east, now west. They are traversed by a few quartz reefs which have a generally parallel strike with the shear planes, but a discordant, generally steeper dip. East of the greenstone belt there are three miles of granite country, when the Ord River is reached. After crossing the river a few hills of silky phyllite were noted and a curiously coloured sedimentary rock outcropping in a low ridge about three miles southwest of Argyle homestead. The general strike of this outcrop is north and south, with an almost vertical dip.

No fossil remains could be found in the immediate vicinity of the ridge, but limestone beds containing abundant remains of *Salterella* outcrop a short distance to the east. It is probable that the beds in question are the tilted edges along a fault of a bed underlying the limestones. The colouring of one band of rock is either red or grey, or both, distributed sometimes in a most regular banding, at others as a grey background on which are red oval spots partially or completely detached (Fig. 11). At times both the banding and the spacing of the red spots are almost perfect, though such is not always the case.

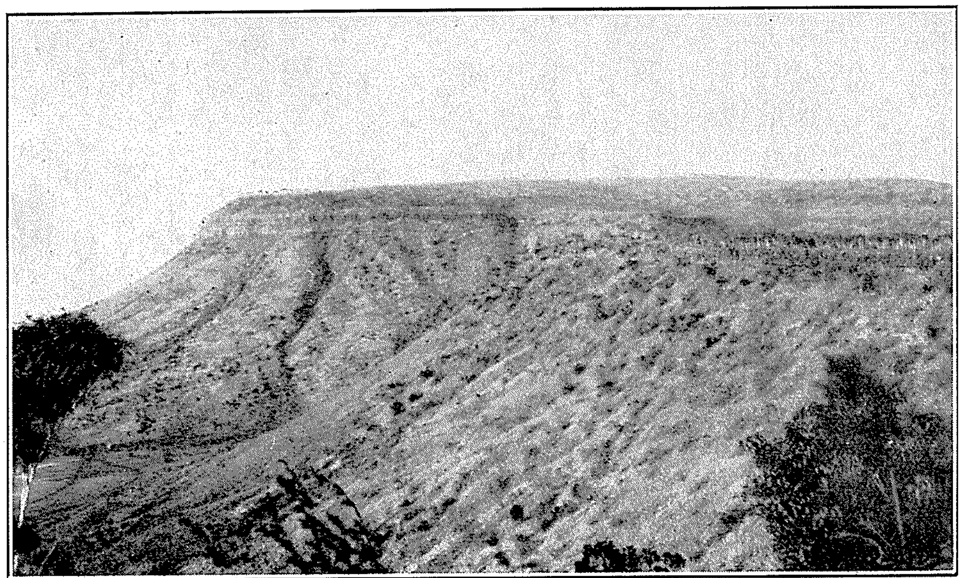
Under the microscope the rock shows an almost uniform composition of fine angular quartz grains cemented with aluminous material, the red colouring being due to a small percentage of iron oxide. In some specimens the rock is almost wholly grey with just a few remaining portions of the red spots; in others the rock is almost entirely red with the grey bands just appearing. What the true reason is for the extraordinary regular colouring is obscure, but I agree with Clarke that it is probably due to the leaching out of the iron oxide; but why in such regularity is not evident.

Similar rock has been picked up by the writer in the vicinity of Braeside Station on the Oakover River, but it has not been found occurring *in situ* in that locality.

Black soil plains (Fig. 9), probably underlain by the basalt flows which are exposed at the surface further to the east, extend to Argyle Station and spread out far away to the north and east.

Conclusions.—From a mineral point of view the country traversed does not give the impression of being favourable for the occurrence of either gold, mineral, or base metal deposits. The sandstones, shales, and interbedded tuffs, although of Pre-Cambrian age, show no signs of mineralisation. Small veins of fluorspar containing galena were certainly found in the underlying basic rocks in the Speewah valley, but only where a slight shearing of the rocks had taken place due to a local intrusion. On the whole the basic rocks are massive and are therefore not likely to be metalliferous.

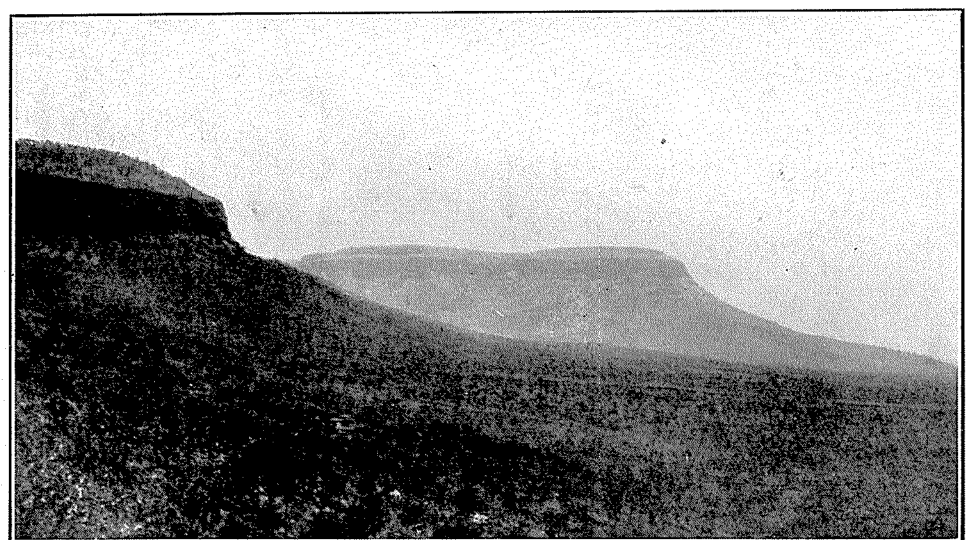
Fig. 1.



F. 345.

The Bastian, near Wyndham.

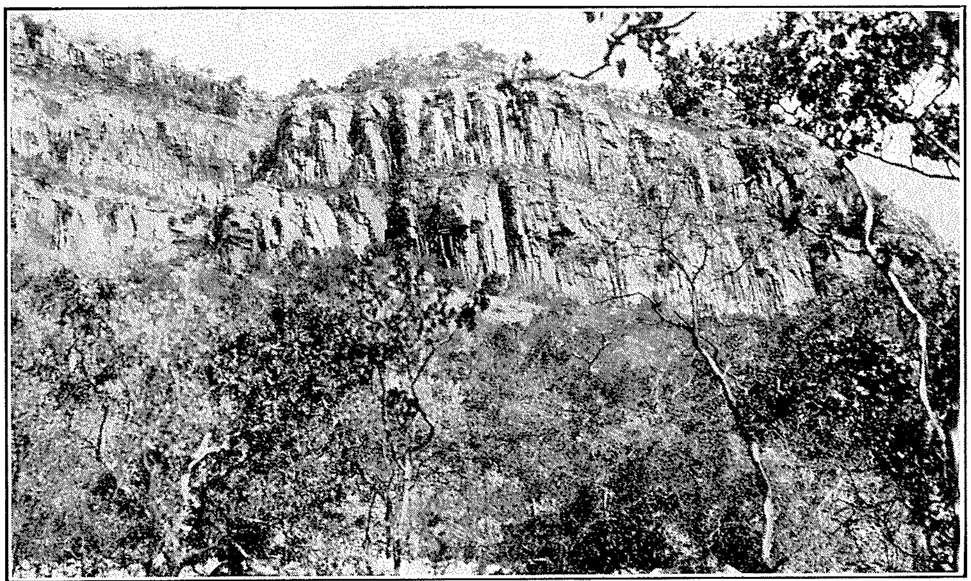
Fig. 2.



F. 357.

Western side of Cockburn Valley, with Mount Cockburn in the far distance.

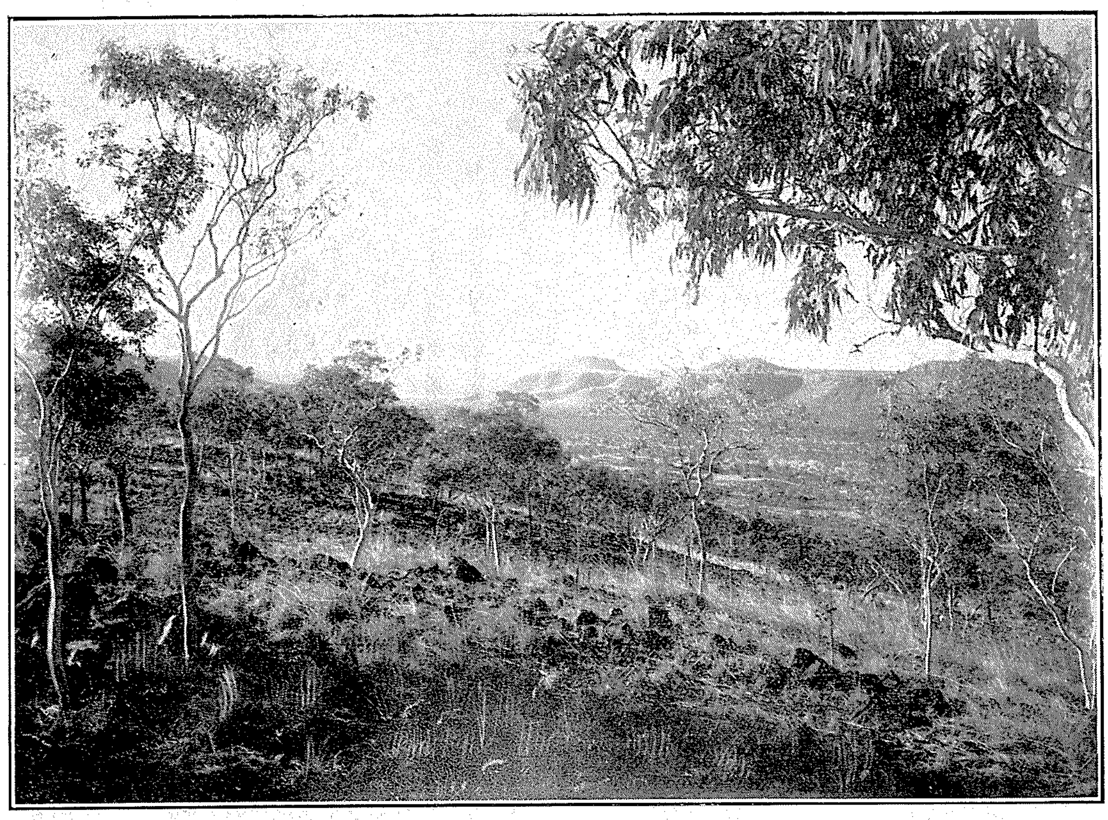
Fig. 3.



F. 363.

Quartzite Cliff, eastern side of Mount Cockburn.

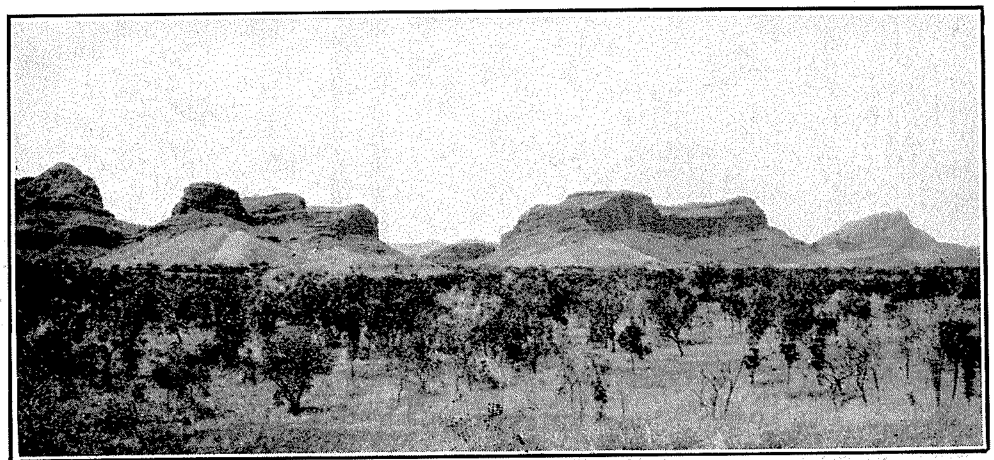
Fig. 4.



Neg. 1856.

Looking northeast up Speewah Valley, from near Martin's Silver-lead show.

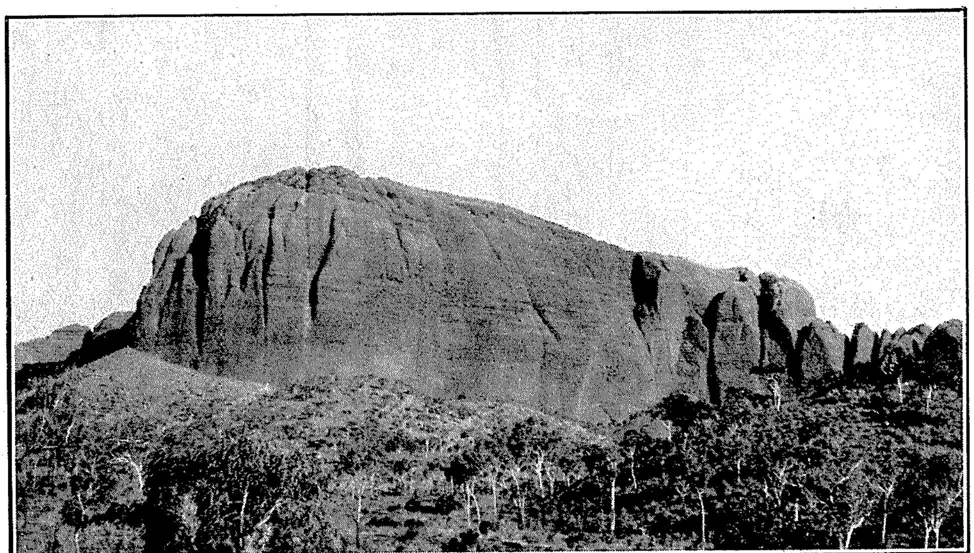
Fig. 5.



F. 344.

Eastern flank of Conglomerate Range.

Fig. 6.



F. 339.

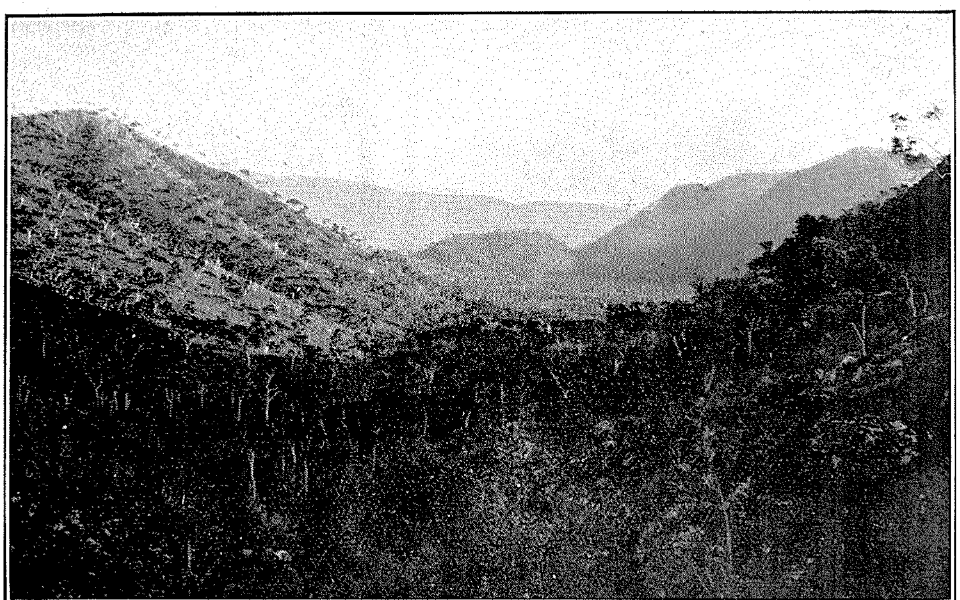
Conglomerate Hill: portion of Conglomerate Range.

Fig. 7.

F. 342.

Showing pebbles in conglomerate beds at base of Conglomerate Range.

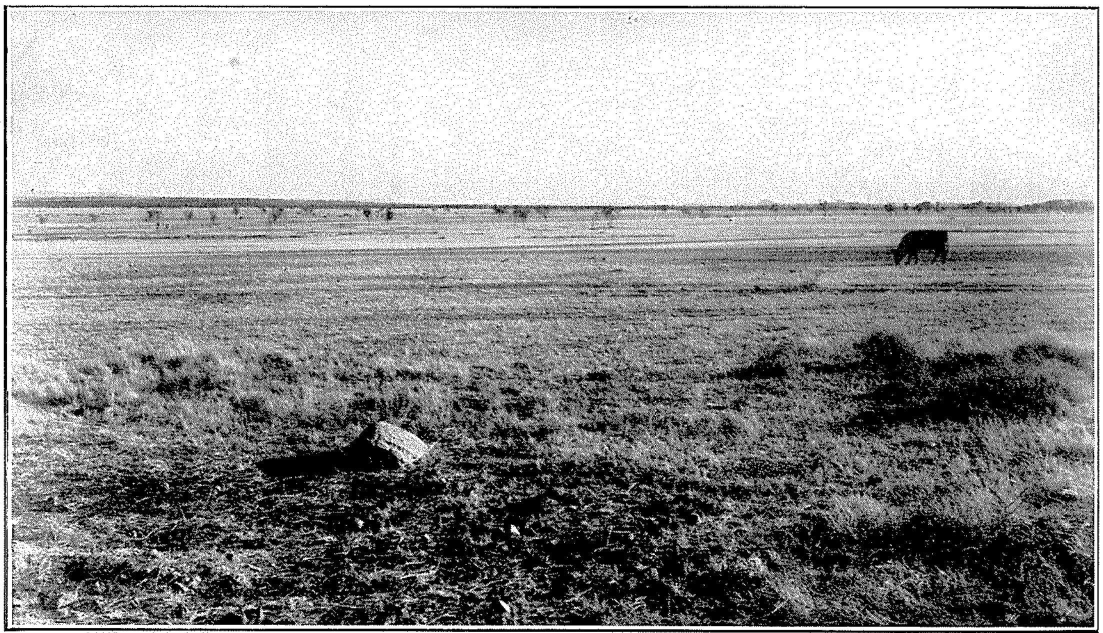
Fig. 8.



F. 341.

Looking northwest from top of "Jump up" in Prospect Gorge.

Fig. 9.



Neg. 1855.

Black soil plains of Ord River, Mount Elder in far distance.

Fig. 10.

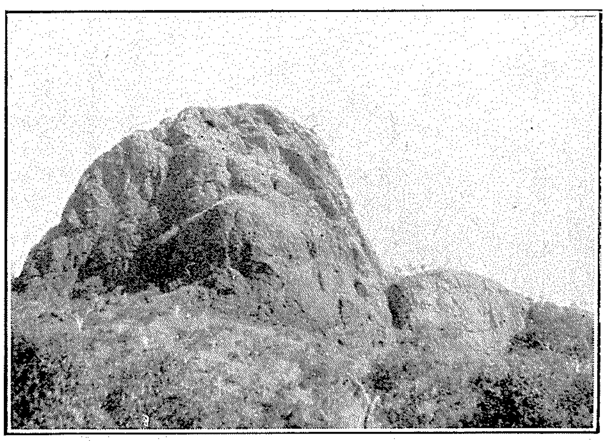
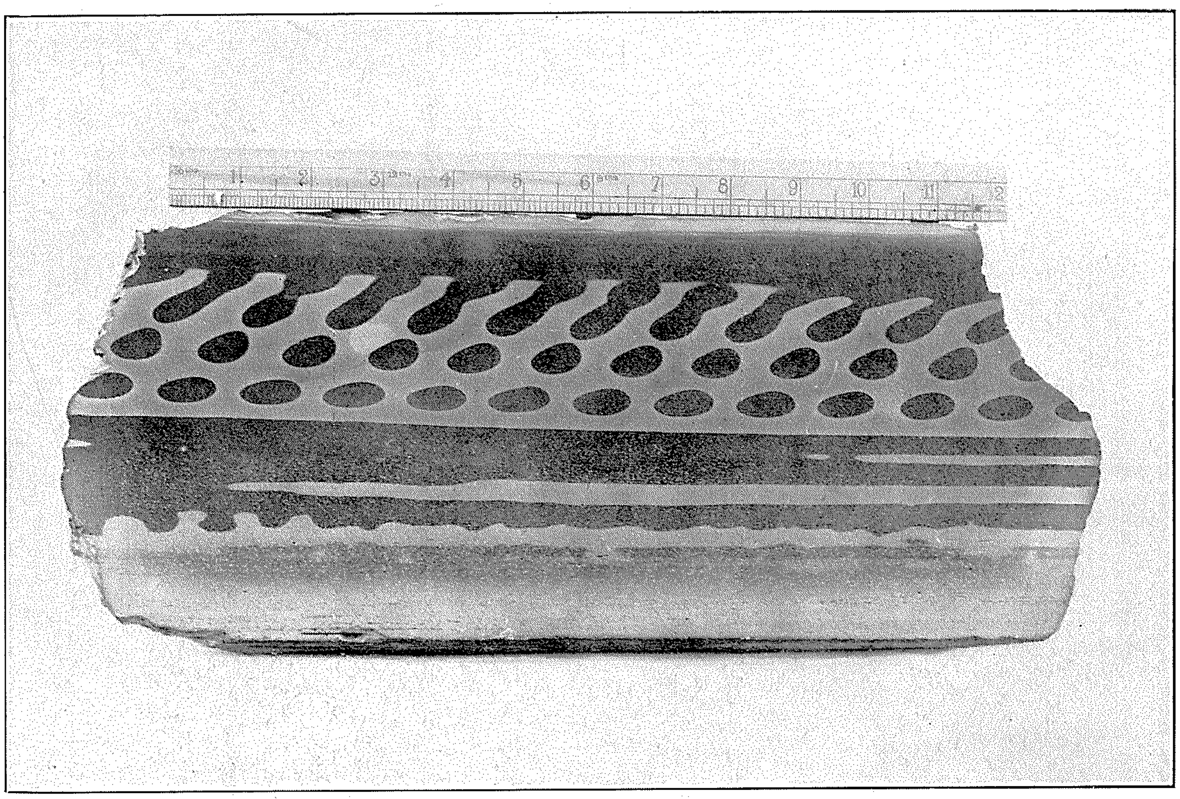


Photo.: E. de C. Clarke.

Mount Yates, Volcanic plug.

Fig. 11.



Neg. 1857.

"Zebra" rock, from three miles southwest of Argyle Station.

As explained in the previous pages of this report, the silver-lead deposit at Speewah was more than probably a local enrichment at the contact with the basic rocks and the sediments.

In Prospect Gorge the basic rocks are more favourable than elsewhere, as they are intensely sheared and foliated, but the scope for prospecting would be more or less limited to where these rocks were exposed in the gorges. They were seldom seen at the surface elsewhere.

The country down the Pentecost and as far east as the Ord River, particularly the numerous valleys, appears eminently suitable for raising and fattening stock, especially horses and cattle, and with an improved water supply should carry far more than at present. The lack of water supply is still more pronounced on the black soil plains east of the Ord, and the same applies not only to the Ord River basin, but also to the great portion of the Fitzroy valley, and I am confident that in many places artesian or sub-artesian water could be found by comparatively shallow boring in many portions of these areas.

9.—BORING FOR MINERAL LODES AT MEEKATHARRA, MURCHISON GOLDFIELD.

(T. BLATCHFORD, B.A., Acting Government Geologist.)

In accordance with Ministerial instructions I visited Meekatharra and chose three boring sites which I consider to be the most suitable for exploiting at depth one of the most important ore channels.

In the month of June, 1925, a deputation from the Meekatharra Roads Board waited on the Hon. the Minister for Mines and suggested the following boring programme:—

1. To bore the north and south ends of Paddy's Flat.
2. Assist a deep bore in the Fenian Mine on the £ for £ basis.

I interviewed Mr. Roberts, the general manager of the Ingliston Consols Extended and Fenian Mines, who was one of the deputation, and he assured me his company do not wish to bore in the Fenian Mine. The boring suggested in the north end of Paddy's Flat was really intended to test the Ingliston Consols Extended lode at a depth of 1,500 feet. Since the request was made the main shaft on this mine has been sunk and a lode opened out at the 1,100-feet level. Mr. Roberts is of opinion that deep boring in the north end is not necessary now as the continuation of the lode at depth has been proved.

The original programme has thus been reduced to boring on the south end of Paddy's Flat.

As my instructions did not limit me to choosing sites on Paddy's Flat only, inquiries were made locally as to whether there were more suitable sites. I found, with two exceptions, that all the old large gold-producing mines had ceased operations and are now flooded and, more or less, abandoned, and that mining at Meekatharra was at a very low ebb, the Ingliston Consols and Fenian being the only two of the important mines of the early days which showed any real activity.

Fortunately a very complete survey of the district and mines of Meekatharra had been made by Mr. E. de C. Clarke in 1916, and with a few exceptions little development had since taken place, so that his report stands good for the present. I have discussed the present idea of boring with him and he agrees with the members of the Roads Board that the south end of Paddy's Flat would be the most likely locality to yield satisfactory results, particularly on the Ingliston Consols-Fenian-Marmont line of lode and particularly in that section lying between the Marmont and Gwalia Extended.

The geology and description of the "Consols" group is set out in detail in Clarke's Bulletin 68 (pages 155-159) and are briefly as follows:—

"**Geology.**—The rocks consist of two groups derived either from dolerites or peridotites and two intrusives of quartz porphyry and basaltic dolerite. High-grade mines have been found in both groups, but only in the vicinity of the quartz porphyry, with which they apparently have a close connection. The richest of the mines are found in the first group, and comprise the Fenian, Ingliston Extended, and Marmont. With regard to their position in respect to the quartz porphyry, we find the lodes lie either to the east or west of the dykes and in one particular case, the Ingliston Consols group, the dyke is found crossing from the hanging to the footwall of the lode. The broken nature of the lode in this mine may probably account for greater circulation of gold-bearing solutions and corresponding higher gold contents in this section."

South of the Marmont only limited prospecting has been carred out. On the Gwalia Extended the lode was located and worked to a depth of 200 feet, some 9,600 ozs. being recovered from 4,300 tons of ore crushed. Most of the gold, I am informed, was in the rich gold leaders which cut through the lode material in all directions. The same lode has apparently been located in the Micky Doolan and Marmont Extended leases and, though there is some doubt as to whether it is a continuation of the Fenian Consols line, it will probably be found to be a continuation.

Generally speaking the richer portions of the lodes in the Consols area appear to occur in "shoots" which dip to the north. A notable instance of this may be seen in the Fenian mine, where practically all the payable ore has pitched into the Ingliston Consols below the 1,100-feet level.

Having this in mind I have endeavoured to place the bore holes a little to the north of where gold has been found near the surface. With regard to the depth at which the lodes would best be cut in the bores, it is recognised that in the upper levels of the adjoining mines the regular ore body was not found until a depth of from 150 to 200 feet vertical was reached.

I suggest, therefore, and have acted accordingly, that the bores be placed and declined so as to strike the ore body at about 350 feet, allowing for the dip of the lode to the east to be normal, viz., 30 feet in each 100 feet vertical.

The three sites chosen are on Crown lands and I would suggest that these areas be reserved until such time as the boring is completed.

10.—INTERIM REPORT ON THE GEOLOGY AND ORE DEPOSITS OF KALGOORLIE.

(F. R. FELDTMANN, Field Geologist.)

INTRODUCTION.

The detailed underground survey of the Golden Mile was commenced at the beginning of February. Early in the same month I was joined by Mr. Finucane, Assistant Geologist, who assisted in carrying out the survey during the remainder of the year.

Owing to the disadvantages and difficulties of preparation of a surface map of the area it was decided to adopt a plan on a horizontal plane 1,100 feet above sea level, this plane taking in all the mines. The preparation of such a plan has one disadvantage, namely, that where the plane adopted does not correspond with the levels of the mine workings, the various geological features have to be projected.

The programme adopted also included the preparation of a series of cross sections, and also of longitudinal sections of the principal lodes, the latter showing, where possible, the distribution of the rich shoots and payable and unpayable ore.

The determination of the positions of rock boundaries, lodes and other geological features involves the examination not only of accessible mine workings, but also of such additional data as are available in bore cores and mine plans and records. During the year, in addition to the survey of underground workings, 2,720 feet of bore cores were examined. The preparation of helios of mine plans and sections and the examination of assay records also occupied a portion of Mr. Finucane's time.

The number of original rocks and the intense alteration that they have undergone over wide areas, and the complexity of the structural features, have necessitated a great deal of careful preliminary investigation into the relationships of the rocks, the degrees and types of alteration and their bearing on ore deposition, and the number and relative ages of structural features such as faulting and shearing and their effects on the lodes. Much careful examination was necessary to enable one to distinguish between the altered forms of even such originally widely different rocks as the quartz dolerite and albite porphyrite.

During the year the survey was mainly confined to the western portion of the belt, particularly the Ivanhoe and Golden Horsehoe Mines, but the general survey was interrupted by a detailed examination of the lower levels of the South Kalgurli mine, consequent on a request from the manager. This mine forms the subject of a separate report.

In addition to the examination of the upper levels of the Ivanhoe and Golden Horseshoe mines it was considered advisable to examine the lowest accessible levels of the Ivanhoe mine, and, in view of the uncertainty regarding the Golden Horseshoe, to take advantage of such times as it was possible to descend that mine to examine those accessible levels that it was thought would afford most information.

Thanks are due to the managers and staffs of the mines visited for the courtesy shown in facilitating the work in every way, and particularly for the valuable information supplied.

GENERAL GEOLOGY.

The rocks of the Kalgoorlie auriferous area, in particular those of the North End, were described in detail in Geological Survey Bulletin 69, and it is unnecessary to give more than a brief description except as regards those features that occur only, or to a far greater extent, in the Golden Mile. As, however, no entirely satisfactory brief description has been published of the geology and geological history of the auriferous area, a brief account of the sequence of events is included in this report.

The rocks of the auriferous area are separable, in order of age, into three main divisions—the Older Greenstones, the Younger Greenstones, and the Albite Porphyrite Dykes. A broad belt of hornblende porphyrite, from which the albite porphyrite dykes are probably apophyses, occupies a large part of the valley west of the towns of Kalgoorlie and Boulder, but as, so far as known, this rock does not occur within the mining area, it is not described here. For the same reason the sediments forming a wide belt some distance east of the mining area are not described in this report.

The Older Greenstones are as a rule much finer in grain than the Younger Greenstones, though medium-grained facies occur, and were most probably originally basaltic dolerites extruded as lava flows. Possibly beds of volcanic ashes alternated with the flows in places, but this has not been definitely established.

The Younger Greenstones intruded the older series as large dykes, of which the most important, economically, occupies the greater part of the main ridge east of Kalgoorlie and Boulder, along which the main portion of the mining area is situated. The northern and southern limits of this dyke have not been determined. At the North End its maximum width is rather more than a mile, but its average width in that portion of the field is a little under three-quarters of a mile. South of Mount Gleddon it narrows considerably, but widens out again north of the Golden Mile. On the Golden Mile its maximum width is likewise rather more than a mile.

Like the older series, the Younger Greenstones vary in texture, but are usually of medium coarse grain. They have a much wider range in composition than the older series, ranging from sub-basic to ultrabasic. The original rocks consisted of quartz dolerites and quartz gabbros, dolerites, hornblende dolerites, pyroxenites, and peridotites. The greatest variation is at the North End, where representatives of all these facies, with the exception of the hornblende dolerites, occur. Peridotite derivatives occupy a fairly wide area west of Hannans Lake. On the Golden Mile the original rocks were more constant in composition, and consisted almost wholly of quartz dolerite. There was, however, some variation in the relative proportions of the felspars and pyroxenes of the original rocks.

Prior to the introduction of the gold-bearing solutions and possibly prior to the intrusion of the rocks by the albite porphyrites, both Older and Younger Greenstones were uralitised by pressure, *i.e.*, the pyroxenes of the original rocks were altered to hornblende, the dolerites being converted into epidiorites and amphibolites and the proxenites into hornblendites. A varying degree of schistosity was possibly also developed at this period, the planes of schistosity dipping at a slightly flatter angle than those formed by subsequent shearing.

The albite porphyrites intruded both Older and Younger Greenstones as dykes, prior to gold deposition. These rocks were composed mainly of albite felspar with a little quartz. Phenocrystal and non-phenocrystal varieties occur. In a few dykes, mainly at the North End, phenocrysts of hornblende occur in addition to felspar, linking these rocks with the hornblende-quartz porphyrite of the valley west of Kalgoorlie and Boulder. The dykes have a wide range in size. Among the most important are one, a mile and a half in length and nearly 600 feet in maximum width, which runs through the middle of the Younger Greenstone dyke in the northern portion of the North End, ending a little north of Williamstown; one running through the Hainault, South Kalgurli, and Associated mines; and a third, running through the Great Boulder, and passing into the Ivanhoe mine at depth. This last dyke has a maximum width of about 300 feet. It probably runs south to join a large mass of porphyrite south of the Golden Mile. The strike of these dykes ranges from northwest to northnorthwest, and the dip is usually southwest at steep angles. The general effect of these dykes on the lodes is to cause impoverishment where the lodes are within the dykes, though rich patches have occurred at the junctions of the dykes and the greenstones.

Subsequently to the intrusion of the albite porphyrites pressure from a southwesterly direction resulted in the formation of a series of overthrust faults. striking approximately northwest and dipping southwest at flat but varying angles. These faults appear to be few in number and to be confined to the eastern margin of the main quartz dolerite dyke. They affected the margin of the dyke at its junction with the older rocks now represented by calc schists, and also the adjacent albite porphyrite dykes.

The faulting of the eastern margin of the main quartz dolerite dyke was followed by intense and widespread shearing, due to pressure from a south-southeasterly direction, which probably extended over a long period with intervals of relaxation. The pressure resulted in the formation of a number of main shear zones, mostly striking northnorthwest, but in places northwest, and dipping southwesterly at steep but varying angles. The movement appears to have been nearly horizontal, the rock on the hanging-wall side of the shear zones being thrust in a northwesterly direction relatively to that on the footwall side. In places there was a slight upward component of the movement.

Although the shearing mainly preceded the introduction of the mineralising solutions, it overlapped mineralisation and the pressure found relief along different lines at different times, the shear zones and planes formed at one period not necessarily coinciding with those of another, though lying in the same general zones of weakness.

At one period not long preceding that of ore deposition a series of steeply dipping fissures at right angles to the main shear zones was formed, mainly in the western half of the Younger Greenstone dyke at the North End. At another period, less deep-seated pressure from the north alternated with that from the south and resulted in the formation, at the North End, of a series of shallow-dipping overthrust faults striking nearly due east. The fissures of both series were subsequently filled with auriferous vein quartz.

Widespread vein-alteration of the rocks by mineralising solutions succeeded the shearing, although, as stated, the two apparently overlapped. The mineralising solutions most probably arose from the magma from which the porphyrites were previously derived. The most widespread effect was carbonation over extensive areas, but the degree of alteration varied, becoming progressively less as the distance from the lines of weakness along which the solutions travelled increased.

The carbonation affected the greater part of the Younger Greenstone dyke in the vicinity of the Golden Mile, a comparatively narrow strip on the western side remaining unaltered, as well as a few small areas near the middle of the dyke. One such area of unaltered amphibolite, about 160 feet in width, is exposed in the main west crosscut at the 1,800ft. level of the South Kalgurli mine, between the Lake View East and Lake View lodes. The central portion of the dyke, between the Golden Mile and the North End was altered though not over as great a width or to as great a degree as the Golden Mile. The Older Greenstones east of the main quartz dolerite dyke were also highly altered, the alteration being widest and most complete east and immediately north of the Golden Mile.

The widespread alteration, by carbonating solutions, of the epidorites and amphibolites of both series gave rise to chlorite-carbonate rocks (greenstones) somewhat similar in appearance to the original rocks, but usually with the composing minerals less distinguishable in the hand specimen. At the North End, the ultrabasic hornblendites and serpentines were altered to talc-chlorite-ankerite and talc-mesitite rocks. Where the alteration was most intense, bleached white, reddish, or gray rocks were formed, composed mainly of carbonates, with some quartz and varying quantities of sericite, and, in the Younger Greenstones, usually containing leucoxene derived from the original ilmenite, but with either magnetite or pyrite formed at the expense of the original ferro-magnesians.

The determination and delineation of the limits of the vein-altered rocks, particularly those of the Younger Greenstones, is of the highest importance, as it may be laid down as a general rule that the payable lodes are confined to the vein-altered rocks and do not occur in the epidiorites and amphibolites. On the Golden Mile, the western limit of the quartz dolerite greenstone is a short distance west of the western boundaries of the main Ivanhoe and Golden Horseshoe leases at the surface, and has a slight westerly dip.

Among the Older Greenstones the most highly altered forms are the rocks to which MacLaren has applied the term "calc-schist," although in places the structure is sheeted and jointed rather than schistose. These rocks are characterised by their very fine grain and even texture, palish-gray colour, and fairly smooth fracture, and, where less sheared, by a blocky structure, due to jointing. In some of the rocks included for convenience under the general field term of calc-schist, chlorite is present in small quantities, linking the rocks with the fine-grained greenstones.

The bleached rocks resulting from the intense alteration of the quartz dolerite epidiorites and amphibolites are more varied in appearance. As with the calc-shists, some of the rocks contain small quantities of chlorite and may be termed semi-bleached greenstones. Two varieties of semi-bleached greenstone were noted, one an almost white rock with pale green flecks of chlorite, visible to the naked eye the other a pale grayish, more or less massive, slightly pyritic rock in which white lath-shaped forms representing former felspars are visible to the naked eye. Rock of the second type occurs at the 1,700ft. level of the South Kalgurli mine, near the junction of crosscut 94 feet south and south drive 20ft. west.

Another variety of bleached quartz dolerite greenstone is the gray bleached type. These are somewhat bluish gray, fine-grained, usually sheeted or slightly schistose rocks, composed of sericite, carbonates and some quartz, and containing grains of magnetite, in places distinctly noticeable to the naked eye, giving the rock the appearance of a knotted schist.

The typically bleached rocks are almost white or pale reddish in colour, and contain varying quantities of pyrite or magnetite crystals, or both, and in places arsenopyrite, visible to the naked eye. The grain is usually fairly coarse, though fine-grained facies occur, and a schistose structure is present in many places. A fairly wide area of the magnetite-bearing variety was observed in the main west crosscut at the 1,300ft. level of the Golden Horseshoe mine, but the pyritic variety is more common. The coarser varieties of these rocks have, except for the pyrite usually present, some resemblance in the hand specimen to granite for which they were mistaken by some of the earlier observers. The coarser-grained reddish variety is commonly known as "corned beef rock" among the miners.

The distribution of the bleached rocks is irregular. Small areas of these rocks occur along some of the minor lode channels, but the larger areas appear to be mainly confined to the vicinity of the main lode channels. Even here their distribution is very irregular and as a general rule bleaching appears to be most noticeable in the vicinity of the albite porphyrite dykes. In some instances the apparent great width of the bleached zones exposed in the crosscuts is misleading. In the main west crosscuts at the 1,300ft. level of the Golden Horseshoe and the 2,720ft. level of the Ivanhoe, cross vein systems of quartz were noticed associated with the bleached or partly bleached rock, and the apparent width of the bleached zones is really more nearly their length, their width being probably only a few feet on either side of the cross veins. In the western portion of the North End, bleaching is almost entirely confined to a few inches on either side of cross quartz veins.

The carbonation and sericitisation are not confined to the greenstones. The albite porphyrite dykes have also been carbonated and sericitised in places at their junctions with the greenstones and in the vicinity of the lodes. The resulting rock is difficult to distinguish, in some places indistinguishable, from the bleached or aphanitic greenstones. In some of the dykes, however, the presence of small angular green flakes of chloritic and, in places, probably fuchsitic material serves to distinguish them from the altered greenstones. The origin of the green flakes is somewhat doubtful. Three alternatives exist, namely, either that they are xenoliths, representing fragments of greenstone caught up in the dykes during their intrusion; secondly, that they represent fragments of greenstone torn into the dykes by shearing; and thirdly, that they represent former phenocrysts of hornblende in the dykes themselves. Against the first and second alternatives are the facts that they occur in so many of the dykes, both at the North End and the Golden Mile; that they are found in some of the larger dykes at some distance from the greenstones; that their range in size is not great; and that their maximum length is probably less than an inch and the average considerably less than half an inch. Against the third alternative is the fact that no hornblende has as yet been detected in the less altered dykes of the Golden Mile, although it occurs as phenocrysts in some dykes at the North End. The balance of evidence appears to favour the third alternative.*

There is reason for supposing that carbonation extended over a period of time considerably greater than the relatively short period of ore deposition. The absence of bleaching from some of the highly sheared portions of the lodes, and its presence in places where no defined lodes exist indicates that the channels available for the passage of the bleaching solutions did not coincide with those available for the gold-bearing solutions. In places where both bleaching and lode veins occur together, the lode veins appear to be distinctly younger. It is probable, therefore, that much of the bleaching took place prior to gold-deposition. On the other hand some of the cross quartz veins with which bleaching is also associated appear to be slightly younger than the lodes, suggesting that bleaching took place both before and after gold deposition.

A table showing the original rocks of the Kalgoorlie district and their altered forms is given below. The sediments, the relative chronological position of which is doubtful, are omitted from this table.

* Evidence obtained since the above was written indicates that the green flakes are of two distinct types. Some of the flakes recently observed are much larger than those hitherto discovered and undoubtedly represent former fragments of greenstone. On the other hand, the comparatively even distribution and size, and in some cases the shape, of most of the small flakes indicate their origin from former hornblende phenocrysts.—F.R.F.

TABLE SHOWING THE ORIGINAL ROCKS OF THE KALGOORLIE DISTRICT AND THEIR ALTERED FORMS.

Original rocks.		*Altered forms of rocks.*		
Lavas (Older Greenstones)	Basaltic dolerites	Fine-grained epidiorites and amphibolites	Fine-grained greenstones	Calc-schists
Older intrusives—sub-basic to ultra-basic (Younger Greenstones)	Quartz dolerites and quartz gabbros	Coarse-grained epidiorites and amphibolites, including some actinolite-zoisite amphibolites	Quartz dolerite greenstones	Bleached greenstones.
	Dolerites	Actinolite-zoisite amphibolites	Dolerite greenstones	Bleached dolerite greenstones and possibly some fuchsite-carbonate-quartz rocks
	Hornblende dolerites	Lustre-mottled amphibolites		
	Pyroxenites	Hornblendites	Talc-chlorite-ankerite rocks	Some fuchsite-carbonate-quartz rocks
	Peridotites	Serpentines	Talc-mesitite rocks	Some fuchsite-carbonate quartz rocks and carbonated serpentine of Hannan's Lake
Younger intrusives—intermediate to acid	Hornblende-quartz porphyrites			
	Albite porphyrites or quartz keratophyres		Carbonated sericitised albite porphyrites	

A geological feature common not only at Kalgoorlie but at other centres of the goldfields should be mentioned here, namely, the jaspers and graphitic schists. These rocks occur as bands up to 50 feet in width and, though usually comparatively short in the Kalgoorlie area, may extend for several miles in length. They occur both in the Older and Younger Greenstones and in the albite porphyrites. They consist at the surface of highly siliceous rock with a laminated ribbon-like structure and may be pale yellowish-gray in colour or consist of alternating bands of gray or yellow and dark-brown colour, the latter due to the presence of iron ore. The iron staining is usually most marked near the surface. Some of these rocks become less siliceous a few feet below the surface, appearing as sheeted zones of clayey material.

Below the oxidised zone the more typical of these rocks occur as laminated siliceous bands of dark gray or black colour, due to the presence of graphite, or, in the albite porphyrites, as bands of black graphitic schist. Iron sulphides are commonly present, usually as grains of pyrite, but in places as nodules, of elliptical shape and about the size of small marbles, of marcasite coated by pyrite. Small granular masses of pyrrhotite also occur in the graphitic schists in the albite porphyrites. Bands of graphitic schist up to 50 feet in width occur in the Golden Mile but some are only from a mere film to a few inches in width though of considerable length as compared with their width.

A sedimentary origin has been assigned to these rocks by some of the earlier observers, but from their common occurrence at Kalgoorlie and other centres in igneous rocks of various types at a very considerable distance from any known sediments, and their common association at Kalgoorlie with albite porphyrite dykes, there is little doubt that they represent highly sheared and sheeted zones in which graphite and, in places, cryptocrystalline quartz were subsequently deposited. The manner in which the graphite was deposited is still in doubt. It undoubtedly arose from an igneous magma, most probably that from which the porphyrites were derived, and probably in the form of a hydrocarbon, but whether in solution or as a gaseous emanation has not yet been determined, nor whether it and the associated silica were deposited at the same time.

The age of the graphite relative to bleaching and ore deposition has likewise not been determined, but I am inclined to regard it as older than either. The introduction of gold and tellurium was probably a short and special phase towards the end of the period of vein-alteration, and it is probable that the formation of tellurides was restricted to a particular portion of the period of ore deposition, as although much of the gold is associated with pyrite some of the richest telluride ore occurs in portions of the lode where relatively little pyrite is present. Moreover, the fact that although in places the rich ore consists of highly siliceous lode matter, in others it is apparently no more siliceous than the enclosing rock, and also that in some of the most siliceous lode matter the gold content is exceeding low, suggests that the gold and much of the silica were deposited independently, although small quartz veins were undoubtedly formed during the deposition of gold and tellurides.

Ore deposition was followed by a recurrence of pressure during which further faulting took place at two periods, the first in which pressure from an east-northeasterly direction predominated, resulting in the formation of one main and possibly several minor faults dipping in that direction at about 45 degrees. The main fault is exposed at the 1,200-feet level of the Ivanhoe mine.

During the second period pressure from a south-westerly direction predominated and found relief in the formation of a much greater number of faults dipping southwest at angles ranging mostly between 30° and 50°. These faults appear to be confined to the western portion of the belt, namely, to the Ivanhoe, Horseshoe, and Great Boulder mines, where they have affected the lodes to a considerable extent.

Mention should also be made of a series of faults, striking eastnortheast, which affect the Golden Zone lode at the North End. These appear to be of purely local occurrence and to be due to a thrust movement arising at a shallow depth, as the faults appear to die out at a depth of 500 feet, although the horizontal displacement at the surface may be as much as 120 feet. Beyond the fact that they are later than gold deposition, the relative age of these faults is unknown.

Probably one of the last earth movements of importance was that which resulted in the formation of a number of shear zones and planes striking roughly parallel to the lodes but with a steeper, almost vertical dip, some of the planes having a slight but distinct easterly dip. This shearing caused a reopening of the lodes in places and is of some importance as affecting the stoping of the ore bodies. The post-gold shear zones of the Hannans Reward-Mt. Charlotte leases at the North End probably belong to this series.

The probable sequence of events in the geological history of the Kalgoorlie area is shown in the following table:—

TABLE SHOWING PROBABLE SEQUENCE OF EVENTS IN THE GEOLOGICAL HISTORY OF KALGOORLIE.

Introduction of rocks and mineralising solution.	*Earth movements.*
Extrusion of basic lavas (Older Greenstones)	
Intrusion of lavas by Younger Greenstone dykes	Pressure converting most of greenstones into epidiorites and imposing a schistose structure in places
Intrusion of greenstones by large dyke of hornblende porphyrite and smaller dykes of albite porphyrite	
	Relatively shallow pressure from southwest, causing overthrust faulting in places along margin of main Younger Greenstone dyke
	Deep-seated pressure from southsoutheast with shearing over fairly wide areas and formation of shear zones
Introduction of hydrocarbons with formation of graphitic schists along main shear zones	
Introduction of carbonating solutions containing sulphur and potash, extending over lengthy period and resulting in formation of calc-schists, greenstones and bleached greenstones followed by solutions containing gold, accompanied by sulphur and potash and later by tellurium	Recurrence of pressure with further shearing and formation of steep cross fissures at North End, followed by overthrust faulting from north affecting North End
	Less deep seated pressure accompanied by overthrust faulting, predominating at first from eastnortheast, followed by more intense pressure from southwest with formation of Boulder-Ivanhoe-Horseshoe series of faults
	Recurrence of deep-seated pressure probably mainly from south with formation of later shear zones and reopening of fissures along lodes

THE FAULTS.

The pre-gold faults.—Economically, the most important of the pre-gold faults affecting the eastern margin of the quartz dolerite dyke at its junction with the calc-schists, and the adjacent albite porphyrite dykes is the large fault which formed the hanging wall of the Brownhill-Oroya shoot. This shoot has not yet been examined in detail.

Another fault of this series has affected the calc-schist boundary and the albite porphrite dyke immediately west of the boundary, at the 1,800-feet level of the South Kalgurli mine, and is responsible for the flat dip of the East lode between the 1,800-feet and 1,920-feet levels. This fault consists of several planes forming a fault zone, instead of a single well-defined plane. Its dip varies considerably, but probably averages a little more than 40 degrees. It may be identical with the fault below which the calc-schist boundary dips sharply westward between the 1,944ft. and 2,095ft. levels of the Associated mine. Another less defined fault or series of fault planes, some distance west of the last, appears to have been responsible for bringing the east and west branches of the Australia lode together near the 1,700-feet level of the South Kalgurli mine, with the consequent formation of the rich shoot above that level. The Lake View East lode has been deflected along a similar fault still farther west, at the 1,800-feet level of the same mine. The dip of these faults is very variable and probably ranges from about 25 to 55 degrees.

The pre-gold faults have been responsible for the formation of ore shoots in different ways. In the first case, as shown by MacLaren, by overthrust faulting a relatively impermeable roof was opposed to the upward passage of the ore-bearing solutions, causing congestion and consequent deposition of gold and tellurides in mass. Of this the Brownhill-Oroya shoot is the most notable example.

The shoot formed at the junction of the two branches of the Australia lode above the 1,800-feet level of the South Kalgurli mine is an example of the second case. Here the solutions which travelled up the western branch of the lode shear were deflected along the fault planes to join those of the eastern branch, and gold and tellurides were deposited in mass in the sheared and shattered rock above the fault.

The adverse effect of the pre-gold faults from a mining point of view, *i.e.,* as viewed from the surface downwards, is that by overthrust faulting the economically less favourable calc-schist extends more sharply westward below the faults and the area of probable productive rock in a mine is thereby lessened at the lower levels.

The post-gold faults.—As stated, there are at least two series of these faults, of which the older is of much less importance, being represented, so far as is known, by only one important fault, namely, the easterly-dipping fault exposed at the 1,200-feet level of the Ivanhoe mine, and possibly by several minor faults. The second series is represented by a number of faults in the Ivanhoe, Golden Horseshoe, and Great Boulder mines. These faults usually strike between northwest and northnorthwest and dip southwest at flat angles, but both strike and dip are variable, neither being constant in the one fault. The extreme range in dip is probably from 20 to 55 degrees, the average being probably about 40 degrees. Although in the very early days of the field these faults were probably not thoroughly understood, at a comparatively early date excellent work was done in the attempt to map these faults both in plan and section. Many of the faults, however, have only been exposed in a few places, and some of those places where the faults had been met were inaccessible when their mapping was attempted and great difficulty was experienced in correlating them in plan and section.

Approximately fifteen of these faults are shown on the Main Shaft section of the Ivanhoe mine and more than twenty on that of the Golden Horseshoe.

The detailed examination of the 106-feet and 189-feet levels of the Ivanhoe mine has shown that the faults are by no means as simple as was at first supposed and indicates that some, at least, occur as systems consisting in places of two or more main faults, which may in turn consist in places of several planes joined by diagonal planes.

Owing to their complexity and the fact that the strike and dip are not constant great difficulty was experienced in tracing the faults from place to place. Moreover a fault which in one crosscut is well defined and consists of a single plane marked by several inches of crush clay (flucan), in the next may consist of a number of planes a few feet apart, which, owing to the general shearing the rocks have undergone, are not easily detected except where exposed by driving or stoping. The displacement of the lodes along the different faults varies considerably. Along most it appears to be small, but on the No. 1 slide (fault) in the Golden Horseshoe the displacement of the No. 3 lode along the fault plane, according to Mr. V. H. R. Murray, underground manager to the company, is nearly 90 feet. In the Ivanhoe mine the New lode has been thrust nearly 40 feet along the plane of No. 1 slide in Section 8, and in a rise from the face of the south drive on the New lode in Section 4 the displacement of the lode along the fault plane is 32½ feet. This last is a beautiful example of a clean-cut fault, particularly as the lode is narrow and well defined and is vertical where cut by the fault. The distance mentioned was measured along the plane between the vertical portions of the west wall of the lode above and below the fault, but the lode below the fault has been dragged along the plane for a distance of 9 feet 8 inches.

Where a strong fault consists of a single well-defined plane the displacement is usually clearly defined, but where it consists of a number of planes with movement along each the faulting may not be so clear, especially where the lode has been dragged along the planes, and the lode may only appear to be somewhat broken and to have an unusually flat dip.

The main faults occurring at the 106-feet and 189-feet levels of the Ivanhoe mine—as named on that mine—from west to east are: "A" slide, a branch of No. 1 slide (in the northern portion of the mine), No. 1 slide, No. 2 slide, and No. 3 slide. In addition, a small fault, not shown on the mine plans, throws the West lode three or four feet at the 106-feet level, at a point about 250 feet southwest of "A" slide.

The "A" slide-No. 1 slide groups of faults appear to be branches of one system, the so-called "Branch of No. 1 slide" lying between the two and apparently splitting, going south, in Section 5 at the 106-feet level and Section 6 at the 189-feet level, into two branches running towards "A" slide and No. 1 slide respectively. The more westerly branch is apparently joined by a branch of "A" slide running southeast towards No. 1 slide and continues to the south as a group of planes, roughly parallel to and from about 30 to 50 feet west of the main plane of No. 1 slide, but eventually joining it about coordinate 1,400 feet south. The main plane of No. 1 slide continues south in the Golden Horseshoe mine under the same name, passing a few feet west of the Main and No. 2 shafts at the 100-feet level, but an easterly branch of No. 1 slide, apparently diverging from the main fault in Section 12 of the Ivanhoe mine, continues south in the Horseshoe as No. 2 slide, which lies approximately 60 feet east of the main shaft and 110 feet east of No. 2 shaft at the 100-feet level.

The western branch of "A" slide has not been detected in the Horseshoe mine but may be represented at the 200-feet level by a diagonal plane noticed near the face of the main west crosscut. From the strike and shallow dip of this plane, however, it more likely represents the westernmost fault of the Ivanhoe mine and it is more probable that the western branch of "A" slide joins No. 1 slide north of the crosscut.

Both "A" slide and No. 1 slide are well defined in the main east crosscut at the 106-feet level of the Ivanhoe mine, where they are situated respectively about 80 feet and 240 feet east of the drive from the plat, No. 1 slide being immediately west of Wigg shaft. In this crosscut each consists of a main well-defined plane marked by more than a foot of crushed material, but though No. 1 slide is well defined in the

New lode drive east of Drysdale shaft, neither fault is so well defined south of the main east crosscut, and unfortunately portions of the workings at the 106-feet level that might have thrown further light on the positions and behaviour of these faults at several points were inaccessible.

"A" slide apparently displaces the Middle lode between 30 and 40 feet below the 106-feet level in Section 8.

No. 2 slide and No. 3 slide are probably branches of another system. At the 106-feet level of the Ivanhoe mine No. 2 slide can be definitely located only in the east crosscut off Drysdale shaft, about 80 feet west of the East lode, and for a short distance in the drive on that lode from about 110 feet south of the crosscut. A fault observed in east crosscut 1,400 feet south, on the Great Boulder boundary, is probably the southern continuation of this fault.

At the 189-feet level No. 2 slide has been cut in the east crosscut from Drysdale shaft at about 185 feet from the shaft, and also in the drive on the East lode from about 90 to 140 feet north of the main east crosscut. What appears to be its southerly continuation is situated about 15 feet west of the drive on the Boulder lode in the east crosscut in Section 14. This fault continues south in the Golden Horseshoe as No. 3 slide, which lies a short distance west of No. 4 lode in the northern portion of the mine at the 100-feet level.

The positions of the Ivanhoe No. 3 slide shown on the plans of the 106-feet and 189-feet levels do not agree. The position given on the northern portion of the plan of the 189-feet level is approximately correct, but at the 106-feet level the fault is probably entirely in the Great Boulder mine. In the main east crosscut at the 189-feet level it appears to lie a few feet east of No. 2 slide, which, however, could not be definitely identified, and it may join No. 2 slide to the south, but more probably diverges again to enter the Great Boulder mine. It is probably identical with the Horseshoe No. 4 slide, which is situated a few feet west of No. 4 lode north of the main east crosscut at the 200-feet level.

THE JASPERS AND GRAPHITIC SCHISTS.

As already indicated, the deep-seated pressure which extended over a long period found relief at different points in the various zones of weakness at different times, the shear lines forming the most accessible paths for mineralising solutions at one period not necessarily coinciding with those of another period. The formation of the graphitic schists, bleached zones, and lodes took place along such lines as offered the easiest paths at the particular period.

The best defined and longest line of jasper in the Kalgoorlie area occurs in the Younger Greenstones at the North End. The southern end of this line is a short distance south of the Bulong Road, whence it runs northnorthwest, gradually converging towards the eastern margin of the Younger Greenstone dyke, which it joins near the Broad Arrow Road immediately north of the old Sir John G.M.L. 4468E. It continues northward well beyond the limits of the area mapped. At depth this band is highly siliceous and though graphitic is less so than some to the south.

Between the Bulong Road and Williamstown are several lenses of Jasper, passing into graphitic bands at depth, but these are relatively short and are very erratic in strike, ranging from northnorthwest to northeast.

The jaspers and graphitic schists of the Golden Mile are mostly comparatively short, but have a great range in width. With the exception of those occurring along some of the older fault planes, their association with albite porphyrite dykes, in particular the Great Boulder dyke, is more marked than at the North End. The most important zone of jaspers and graphitic schists in the Golden Mile is associated with the Great Boulder dyke, most of the lenses occurring within the dyke. Individual lenses range in width from a mere film to at least 50 feet, a lens apparently 50 feet wide having been cut in a borehole put in east from the main north drive at the 2,720-feet level of the Ivanhoe mine into the Great Boulder. The maximum length of the larger lenses has not been determined, but many of the thinner lenses are several hundred feet in length. The lenses of graphitic schists occurring within the albite poryphrite dyke are not confined to the margins of the dyke but are distributed throughout the dyke. In a bore depressed at an angle of 69 degrees, from the south drive on the Ivanhoe East lode in Section 14 of that mine, 13 different lenses of graphitic schist were cut within and on the margins of the dyke, ranging from a few inches to about nine feet (calculated width) in width.

The effect of the graphitic schists on gold deposition where they are associated with the lodes has not definitely been determined. They have been stated to cause impoverishment, but this may have been due to other causes. At the North End rich patches have occurred at their junctions with cross quartz veins, and a small rich shoot on the North Collier mine was associated with a graphitic seam.

THE POST-GOLD SHEAR ZONES.

The shear zones formed subsequently to ore deposition are usually noticeable as a number of planes a short distance apart, nearly vertical but as a rule with a slight easterly dip. Their average strike probably approaches very nearly that of the lodes, but in places they cross the lodes at a very acute angle, as in the south drive on the East lode at the 106-feet level of the Ivanhoe mine, in Section 13. At winze 1,185 feet south, in this drive, the east wall of the stope above the level is on one of these planes, which may have been mistaken for the wall of the lode. Being usually more marked than the planes of the lode shears and cutting them at acute angles, both vertically and horizontally, these planes are apt to interfere with stoping operations.

A feature ascribable to this latter shearing is the narrow fissures or shear planes that in many places mark the middle of the lode channels. Usually after occupying a position near the middle of the lode for some distance they run to one or other of the walls, but in some cases they follow the middle of the lode for a considerable distance and have been found useful as a guide in driving where the lode is otherwise ill-defined.

THE LODES.

Distribution.—The lodes of the Golden Mile may be separated into two main groups, an eastern and a western. Of these the eastern group is distributed over a wider area. In the upper levels of the mines the two groups are separated by the Great Boulder albite porphyrite dyke.

The eastern group includes the lodes of the Kalgurli, South Kalgurli, Associated, Great Boulder Perseverance, and Lake View Consols mines; the western those of the Great Boulder, Ivanhoe, Golden Horseshoe, Chaffers and Hannans Star mines.

With the exception of the lower levels of the South Kalgurli mine, the detailed survey has so far been confined to the western group of mines.

In the South Kalgurli mine the principal lodes from east to west are the Australia lode, the Lake View lode, and the Perseverance lode. Of less importance are a lode about 85 feet east of the Australia lode at the 1,800-feet level; a lode in the Kalgurli mine about 180 feet east of the last and entirely in calc-schist at the lower levels; the Lake View East lode between the Australia and Lake View lodes; and the El Oro lode between the Lake View and Perseverance lodes.

Mention should also be made of several cross lodes striking roughly between west and westnorthwest. These include the Cross lode of the South Kalgurli mine and Tetley's lode and Tetley's No. 2 Cross lode of the Associated mine.

The principal lodes of the western group are the Boulder lode, including the Horseshoe No. 4 lode, and the Ivanhoe East lode (Horseshoe No. 3 lode). Of less importance are the Ivanhoe New lode, Ivanhoe Middle lode (Horseshoe No. 2 lode), Patterson lode, and the Ivanhoe West lode (Horseshoe No. 1 lode). These less important lodes are all situated west of the two principal lodes.

So far as examined, the lodes of the eastern group, certainly the eastern members of that group, appear to be more irregular and lenticular in habit than the two main lodes of the western group, and to have a lower gold content, though very rich shoots have occurred in them.

It is noticeable that whereas, as a general rule, the more important and longest lines of lode strike approximately northnorthwest, the less important lodes strike more nearly northwest or even, in the case of the cross lodes, westnorthwest, and converge towards and usually join the main lodes, going south. Exceptions to this are the Horseshoe No. 2 and No. 3 lodes, the former striking approximately northnorthwest, the latter bending in a southeasterly direction towards the No. 4 lode in the northern portion of the mine.

The eastern members of both groups of lodes are adversely affected at depth, but through different causes.

In the eastern area, the calc-schist, in which the lodes become less defined and generally much poorer, dips at a flatter angle than the lodes, the dip being further flattened where the margin is affected by the pre-gold flat faults, and the probable productive area of the mines is gradually lessened. Owing to the slightly more northwesterly strike of the calc-schist the southern portions of the mines are affected at a greater depth than the northern. Although at the surface the calc-schist boundary is less than half way across the Oroya North block and just outside the Australia East lease, the Kalgurli mine is entirely in calc-schist at the 1,800-feet level, and the Australia North lease of the Associated mine is similarly affected a little above the 2,095-feet level. The calc-schist enters the South Kalgurli mine, opposite the Main shaft, about the 1,700-feet level and enters the Main shaft at a depth of about 1,950 feet. The area of favourable rock in this mine is further lessened by the presence of a large albite porphyrite dyke on the hanging-wall of the calc-schist. As, however, no flat faults were detected east of the calc-schist boundary in the crosscut connecting with the Kalgurli mine at the 1,800-feet level, the calc-schist and albite porphyrite dyke may not affect the Australia lode in the South Kalgurli mine for a considerable depth below the present workings.

In the western group the adverse influence is the great albite porphyrite dyke of the Boulder mine. Possibly in part owing to the greater resistance of these rocks to shearing rendering the lode shears in them narrower and less defined, in part owing to the lack of iron-bearing minerals to act as precipitants, the lodes in the albite porphyrite dykes are generally unpayable.

The Boulder dyke is of very considerable though variable width. In Section 8 of the Ivanhoe mine it is 250 feet wide in some places, in others probably as much as 300 feet. It narrows, however, to the south and in Section 14 is only about 140 feet wide at a depth of 3,400 feet.

Although dipping at a steep angle, probably averaging about 75 degrees, though in places as high as 85 degrees, the Boulder dyke is flatter than the practically vertical Boulder lode and nearly vertical Ivanhoe East lode, which enter it at depth. As with the calc-schist in the eastern group of mines, the albite porphyrite dyke has a more northwesterly strike than the main lodes of the western group, and in consequence the northern portions of the lodes enter the dyke before the southern. In Section 8 of the Ivanhoe mine the dyke enters the mine at a depth of approximately 2,200 feet and meets the East lode at about 2,300 feet. This, however, is probably the tongue mentioned below. At the 3,620-feet level the dyke is apparently about 90 feet east of the Main shaft, but this level was under water when the mine was examined. Judging by its position in the bores put in from the 3,620-feet level the dyke meets the projected line of the Main shaft at 3,880 feet. The dip appears to be flattening at depth, although this may be only local.

The dyke has previously been regarded as simple in form but the detailed examination of the lower levels of the Ivanhoe mine shows that the dyke in the southern portion of the mine does not occupy the full width assigned to it on the mine plans, and that part of the supposed main body is a short tongue about 300 feet in length which runs south from the western side of the dyke and is separated from the main body by a wedge of bleached greenstone. The tongue appears to leave the main dyke about 670 feet south of the north boundary of the lease, at the 2,720-feet level, the line of junction pitching south. The East lode passes through the gap between the tongue and the main dyke at the 2,720, 2,870 and 3,020-feet levels, though the great part of the lode is in the porphyrite for about 200 feet south of the junction. From a point about 120 feet south of the main east crosscut at the 2,720-feet level, the East lode is entirely in quartz dolerite greenstone, bleached or partly bleached for some distance south of the junction.

Instead of continuing on its normal dip and passing through the albite porphyrite dyke at depth as had been hoped, the Ivanhoe East lode in the Main shaft section, as shown by the bores from the bottom levels, is still mainly within the hanging-wall half of the dyke at the greatest depth penetrated—approximately 4,080 feet—and is unpayable, though an occasional fairly high assay was recorded. It appears, moreover, to have split going down.

The probability is that the lode does eventually pass through the dyke, though at a much greater depth than its dip above the dyke indicated.

Owing to the inaccessibility of the lower levels I was unable to examine the few places in the north-east corner of the main lease where the dyke has been exposed in the Golden Horseshoe. It certainly does not cross the projected line of the Main shaft until at a much greater depth than in the Ivanhoe mine.

Mineral Composition and Structure.—The lodes vary widely in appearance, structure, and mineral composition, and the one lode may vary considerably from place to place. A lode may consist of highly siliceous and highly pyritic rock of a palish grey colour; of highly siliceous rock with but little pyrite; of highly sericitic and usually pyritic silvery-grey schist; of rock of the grey bleached type; of, in some parts of the subsidiary lodes, bleached greenstone of the white or reddish type; or of sheared and slightly schistose greenstone differing in no way from that of the more sheared portions of the country rock, but in places carrying veinlets of carbonate. Another variety of highly altered greenstone associated with the lodes is that to which Larcombe has applied the term "aphanite." The typical aphanite is a fine-grained, even-textured, usually more or less schistose rock of a grey colour mottled with paler yellowish areas. It consists mainly of carbonates and sericite with some quartz. Microscopically, its most characteristic feature is its lack of structure. In places it forms the rock enclosing the lodes, in places, where the lodes are poor, actually occupies the lode channel. It is much commoner in the western group than in the eastern.

As a rule the main lodes of both groups are composed of more highly altered rock than the less important lodes such as the Lake View East and El Oro lodes in the eastern group and the Ivanhoe Middle and West lodes in the western group.

Where the lodes are highly siliceous, indicating more complete alteration and replacement of the original rocks, the silica appears to have travelled along the previously existing shear planes from which it spread outwards until all the rock within the zone of most intense shearing was silicified, the silicification more or less obliterating the original shear planes. In places, as at the face of the south drive on the East lode at the 3,020-feet level of the Ivanhoe mine, the lode consists of a band of highly siliceous rock, of which a portion, seldom more than a few inches in width, may have a brecciated structure, enclosed by a varying width of less siliceous, highly schistose sericitic, carbonated, and more or less pyritic rock, with, in places, a few veinlets of quartz. Usually, where the lodes are wide and highly altered, short veins of quartz, either at right angles or diagonal to the strike of the lode, traverse the lode from wall to wall and are useful as indicating the width of the lode channel. The wider and more altered portions of the lodes are also marked in places by flat heads or "floors," which may be very numerous and only a few inches apart.

Although a payable gold content occurs in places where the lodes consist of highly altered siliceous rock, this is by no means an invariable rule and in many places the highly siliceous portions of the lodes are unpayable. As already mentioned, it would appear that silification and gold deposition were to a large extent independent of each other and a high degree of silification occurs in places where the lodes are in the generally unproductive albite porphyrite.

The richer ore appears to be usually associated with the highly schistose sericitic and pyritic type of lode. In places the greenish-coloured vanadium mica roscoelite is associated with rich ore.

In places in the eastern group, for example, the rich shoot in the Australia lode at the 1,600-feet level of the South Kalgurli mine, the rich ore appears to consist largely of rock of the grey bleached type containing a relatively small proportion of pyrite, but with irregular lenses and patches of tellurides and lesser quantities of free gold and occasional small veins of quartz and carbonate carrying thread-like veinlets of telluride and small irregular pieces of free gold.

Usually but little gold is present where the lode consists of little altered greenstone.

As is known to most miners, the pyrites associated with payable ore is finely granular and of a warm colour. Lode matter carrying coarse grains or crystals of pyrite is seldom, if ever, payable, nor does the whiter variety appear to be associated with a payable gold content.

Ore shoots.—The part played by the pre-gold faults in the formation of the Brownhill-Oroya shoot and the probability of a similar fault or faults being responsible for the rich shoot above the 1,700-feet level in the South Kalgurlie mine have already been mentioned. Although only a small proportion of the shoots of the Golden Mile have been investigated in detail, it would appear from the available evidence that structural features have been the governing factors in the formation of the shoots. In addition to the examples already mentioned shoots have occurred at the junctions of cross lodes and main lodes; of subsidiary lodes and main lodes; and of two branches of the one lode. The formation of ore shoots at such junctions is most probably due to the concentration of greater quantites of the auriferous solutions in those places where a relatively wide area of highly sheared and shattered rock afforded an easy passage, and, in a few cases, a further concentration where relatively unsheared rock prevented the further passage of the solutions. The shear zones available for the passage of the gold-bearing solutions were doubtless irregular in their width and in the degree of shearing the rocks had undergone, and the occurrence of wider areas of sheared and shattered rock probably accounts for the formation of shoots of payable and even rich ore at those places where no junction exists.

11.—THE SOUTH KALGURLI GOLD MINE, BOULDER, EAST COOLGARDIE GOLDFIELD.

(F. R. Feldtmann, Field Geologist.)

INTRODUCTION.

Following a request from the manager of the South Kalgurlie Gold Mine, I was instructed to make an examination of this mine. The objects of the examination were:—

(a) To determine the downward continuation, if any, of the rich shoot worked above the 1,700-feet level.

(b) To determine so far as possible the positions of the rock boundaries, in particular those of the calc-schist and adjoining albite porphyrite dyke.

(c) To review generally the possibilities of the mine at depth with reference to the possible occurrence of other payable shoots.

As my examination only concerned the lower levels of the mine, the detailed survey was restricted to the 1,800-feet and 1,920-feet levels and parts of the 1,600-feet and 1,700-feet levels. Parts of the intervening stopes and several other levels were, however, briefly visited. As it was impossible to survey the stopes in detail, the lodes as shown in the accompanying sections are necessarily somewhat diagrammatic between the levels.

In connection with the examination, Nos. 18 and 19 levels of the Associated Gold Mine were also visited.

LOCATION.

The main lease of the South Kalgurli Consolidated Limited is G.M.L. 1208E, comprising 13 acres and situated east of the Kalgoorlie-Boulder Block road, immediately north of "The Block." It is bounded on the northwest by the Hainault mine, on the northeast by the Kalgurli, on the east by the Associated, on the southeast by the Great Boulder Perseverance, and on the southwest by the Enterprise, formerly the Great Boulder No. 1.

The mine is worked from two vertical shafts—the Main shaft, 1,970 feet in depth, and Morty shaft, nearly 1,100 feet in depth. The collar of Morty shaft is 31 feet below that of the Main shaft.

The mine coordinates are measured from the centre of the Main shaft, the assumed north being on a bearing of N.38°41′W.

GEOLOGY.

The rocks occurring in G.M.L. 1208E include Older Greenstones—most probably derivatives of basaltic dolerite—Younger Greenstones or derivatives of quartz dolerite, and albite porphyrite in the form of dykes intruding the greenstones.

The Older Greenstones.—The Older Greenstones consist of the highly carbonated fine-grained grey rock to which MacLaren has applied the term "calc-schist," and of a slightly darker less altered chloritic rock, intermediate between typical calc-schist and the chloritic rock, to which the term "fine-grained greenstone" was applied in Geological Survey Bulletin No. 69. The chloritic facies occurs in the main east crosscut at the 1,800-feet level where it forms the western margin of the Older Greenstones, immediately east of an albite porphyrite dyke. It passes insensibly into the more normal type. Both rocks may be roughly included in the term "calc-schist."

The calc-schist probably enters the lease from the Kalgurli mine at or a few feet below the 1,700-feet level. It appears to strike approximately parallel to the northeast boundary of the lease, but no definite data on this point are available. It is greatly to be regretted that no records, similar to those now kept, were kept of the changes of rock in a number of bores put out, in the earlier days of the mine, northeast from north drives 38 feet east, 16 feet west, and 123 feet west, at the 1,800-feet level, as these would have afforded valuable information on this point. In the main east crosscut at the 1,800-feet level the calc-schist boundary is 66 feet from the centre of the Main shaft. Here it dips southwest at about 50 degrees, owing to the presence of a fault, but must steepen a short distance below the level. Owing to an unfortunate set of circumstances I was unable to examine the shaft for more than a few feet below the 1,920-feet level, but according to Mr. Mundle, surveyor to the company, the calc-schist enters the shaft about 30 feet below that level. This would give a dip of about 68 degrees, which is probably about its normal dip where unaffected by faults.

The Younger Greenstones.—The Younger Greenstones include quartz dolerite amphibolite, quartz dolerite greenstone, bleached greenstone, and aphanite, as well as the lodes representing extreme forms of vein-alteration. Quartz dolerite amphibolite—the least altered quartz dolerite derivative found in the Kalgoorlie mining area—is uncommon on the Golden Mile, but an area about 160 feet in width was observed in the main west crosscut at the 1,800-feet level, between the Lake View East lode and the albite porphyrite dyke which forms the footwall of the Lake View lode. It represents an area that has escaped the effects of the wide-spread chloritisation and carbonation that accompanied or preceded gold-deposition and by which the quartz dolerite greenstone was formed.

Quartz dolerite greenstone forms the bulk of the country rock of the mine. It is either dark greenish in colour or speckled dark green and white and may be either massive or schistose.

The bleached rocks mark a further degree of alteration in which the chlorite and leucoxene of the greenstones have been wholly or partly replaced by either magnetite or pyrite. In places the replacement is only partial, giving a whitish rock with faint green specks. This may be termed "semi-bleached greenstone," of which typical examples occur in the main west crosscut at the 1,800-feet level.

The typical bleached greenstones are white, pale-grey, or pale reddish or brownish rocks with specks of pyrite or magnetite. In this mine the pyritic variety predominates.

Close examination is sometimes needed to distinguish these rocks in the field from the albite porphyrite, particularly when the latter is sheared and carbonated and sericitised.

Another variety of bleached quartz dolerite greenstone found on this mine, usually in close association with the ore bodies, is the grey bleached type, and probably much of the rock that has on the mine been termed "aphanite" belongs to this group. These are grey rocks, usually sheeted or slightly schistose and showing small black specks of magnetite in the hand specimen. They contain gold in places. Typical specimens were seen in the underhand stope below the main south drive at the 1,600-feet level, between coordinates 250 and 280 feet south.

The rocks termed "aphanite" by Larcombe represent more crushed and highly altered areas, usually in the immediate vicinity of the lodes. They are usually of a palish-grey colour, mottled with paler yellowish areas and are of even, fine-grained texture in the hand specimen. Microscopically their most important feature is their absence of structure. This type is not common on this mine, the only place where it was observed being the more southwesterly portion of crosscut 230 feet south at the 1,920-feet level.

The Albite Porphyrite Dykes.—These dykes are well known and need little description. Typically they consist of pale, almost white, rock, but some are pale yellowish or even strongly pinkish in colour. The unaltered rocks consist of a groundmass composed mainly of felspar with a little quartz, in which are small felspar phenocrysts, usually visible to the naked eye, but in many places these rocks are highly sheared and schistose and contain sericite and carbonate, together with some pyrite, in place of the original felspars. They are then difficult to distinguish from the bleached greenstones. The common occurrence in these dykes, however, of small angular flakes of a pale green mineral often serves to distinguish them from the bleached greenstones.

At least three of these dykes occur at the lower levels of the mine, one lying between the Perseverance and El Oro lodes at the 1,500-feet level; one, about 20 feet wide, forming a fairly constant footwall to the Lake View lode; and one, previously mentioned, from about 60 to 85 feet east of the East branch of the Australia lode, at the 1,800-feet level, and adjoining the hanging-wall of the calc-schist. This dyke is 21 feet wide in the main east crosscut at the 1,800-feet level, but probably reaches a width of 50 feet farther north. At the 1,920-feet level it is probably 80 feet in width near the Main shaft, but its eastern boundary has not been cut at this level.

THE FAULTS.

The faults occurring on the Kalgoorlie Field belong to at least two different series, namely, those formed prior to ore deposition and those formed subsequently to ore deposition. The faults of both series dip west or southwest at angles ranging from about 35 to 55 degrees, but usually between 40 and 45 degrees. One or two examples of a third, easterly-dipping, series are known. A number of the faults younger than the lodes occur on the western side of the "Belt," but none, so far as I know, have been definitely noted on the eastern side. On the other hand several faults have affected the calc-schist boundary prior to ore deposition and I have little doubt that a narrow zone of flat planes seen in the main east crosscut at the 1,800-feet level, immediately west of the calc-schist boundary, and also in north drive 38 feet east, at the same level, represents a fault of this series. The narrow width of the albite porphyrite dyke at this level and the flat dip of the calc-schist boundary are most probably due to overthrust faulting along these planes, as is also the position of the lode followed in north and south drives 38 feet east at the 1,800-feet level. This fault passes through the albite porphyrite dyke between the 1,800-feet and 1,920-feet levels, and at the 1,920-feet level is from about 13 to 21 feet west of the dyke and from about 77 feet to 85 feet west of the Main shaft. The effect of these faults is to bring the calc-schist boundary more sharply to the west below the fault.

Other flat planes, doubtless belonging to the pre-gold period of faulting, were seen in the main west crosscut at the 1,800-feet level, and, as shown in the main cross section, the Lake View East lode has followed a fault of this series at this level. Moreover, the greater distance apart of the two branches of the Australia lode in the southern portion of the mine at the 1,800-feet level, or, more correctly, the junction of the two branches above that level, appears to be due to the West branch having followed one or more planes of this series between the 1,800-feet and 1,700-feet levels. One of these planes can be seen in the stope on the West branch at the 1,700-feet level a short distance south of crosscut 94 feet south. Several flat planes seen in the main west crosscut at the 1,800-feet level, between coordinates 210 and 220 feet west, may be the downward continuation of this fault, which, farther north, may join the fault affecting the Lake View East lode.

THE LODES.

In general the lodes of this side of the "Belt" appear to be more irregular and lenticular in habit than those of the western side and are more difficult to follow over any distance. In places the lodes are highly siliceous, indicating more complete alteration and replacement of the original minerals. In other places the lode-rock is more or less bleached and sericitic and highly sheared. In yet others the rock, though usually highly sheared, appears to be less altered and is little different in the hand specimen from a somewhat crushed greenstone, though the microscope may reveal a considerable degree of alteration. It was noticed that as a rule in this mine the highly siliceous portions of the lodes seldom carry gold in payable quantities, also that some of the richest portions of the shoots, carrying stringers and patches of tellurides and, to a less extent, free gold, did not otherwise appear in the hand specimen to be greatly altered, and contained but a small amount of pyrite.

The most important lodes of the South Kalgurli mine, from east to west, are: the Australia lode, the Lake View East lode, the Lake View lode, the El Oro lode, and the Perseverance lode. In addition there are the Cross lode near coordinate 200 feet north, and a lode about 80 or 90 feet east of the Australia lode at the 1,800-feet level. For convenience this last lode is referred to in this report as the East lode, and must not be confused with the Australia lode which has sometimes been styled the East lode on the mine plans.

Various smaller or less defined lodes or lenses of lode matter occur which it is difficult to correlate from level to level. Several of these occur between the Australia and Lake View East lodes at the 1,800-feet and 1,920-feet levels.

The Perseverance Lode.—This lode has not been stoped below the 1,200-feet level. It probably passes out of the mine above the 1,500-feet level as it does not appear to have been cut in the long west crosscut at that level.

The El Oro Lode.—This lode likewise has not been stoped below the 1,200-feet level, except for a very short distance at the 1,500-feet level, where it has been driven on for nearly 500 feet. Here its gold content was exceedingly low. Judging by the amount of stoping, this lode is much lower in average value than the Perseverance lode and only a relatively small proportion has proved payable.

Above the 1,000-feet level the El Oro lode has a fairly marked westerly dip, but below that level it straightens up slightly.

The main west crosscut at the 1,800-feet level does not quite reach this lode, which, however, should be only a few feet west of the face.

The Lake View and Lake View East Lodes.—A considerable amount of stoping has been done on the Lake View and Lake View East lodes at the upper levels of the mine, but below the 1,000-feet level work has mainly been confined to the more easterly of the two lodes. But little stoping has, however, been done below the 1,350-feet level.

At the 1,700-feet level the Lake View East lode has been driven on for about 170 feet north of crosscut 94 feet south, and south of that crosscut it has been followed to the Perseverance boundary. It has been stoped for a short distance above the level, but the gold content was low.

At the 1,800-feet level, the Lake View lode was cut about 500 feet west of the Main shaft and was driven on south for a few feet, but the gold content was low. The lode has also been cut in borehole 249 feet south, put in west from the south drive on the Lake View East lode at this level. In this borehole the gold content was somewhat higher, two assays of 8½ dwts. being recorded.

The Lake View East lode has been driven on for a considerable distance north and south of the main west crosscut at the 1,800-feet level. At this level, and for a short distance above and below, it has followed a flat fault. In the north drive it consists only of a single flat seam. This drive leaves the lode about 120 feet north of the crosscut and bends to the northeast (or nearly true north), cutting near the face a strong body of highly siliceous lode material assaying up to 7 dwts.—probably the junction of two lodes cut in the main west crosscut at 160 feet and 240 feet west of the shaft. Further work on these lodes might reveal a payable ore body, though probably of small dimensions. No lodes corresponding to these two were seen at the 1,700-feet level.

The south drive on the Lake View East lode at the 1,800-feet level does not follow the lode very closely. It is mainly on the footwall portion. Near the Perseverance boundary the lode consists of a number of stringers of varying width but mostly of low grade. Assays of 10 dwts. were, however, recorded between 65 and 80 feet south of the main west crosscut.

In the main west crosscut at the 1,920-feet level, the lode consists of three comparatively narrow seams, between coordinates 346 feet west and 370 feet west.

The Australia Lode.—The Australia lode is, at the lower levels, the most important lode in the mine. It consists of two main branches—the East branch and the West branch—joining both to the north and south. Of these, the East branch, which has proved the more productive, is regarded as the main branch. It appears to correspond to the No. 3 lens of the Associated mine. Near the southern boundary of the South Kalgurli the lode appears at some of the levels to branch again, going south.

At the 1,600 and 1,700-feet levels the two main branches are in the shape of a bow, the West branch forming the body of the bow and the East branch, though usually the wider, the string. At the 1,800-feet level both branches curve outwards. The maximum width apart of the two branches at the lower levels of the mine ranges from about 45 feet at the 1,600-feet level to about 100 feet at the 1,800-feet level. The East branch is the more regular in strike and width. The West branch varies considerably in width and in the southern portion of the 1,600-feet level consists merely of a few shear planes in little altered country. At the 1,700-feet level it is much stronger, but consists of a number of lenses and stringers rather than one continuous body.

The northern junction of the two branches is apparently only a few feet north of the main west crosscut at the 1,600-feet level. A very small rich patch is stated to have occurred in the West branch a short distance above the level, immediately south of the main west crosscut. At the 1,700-feet level the junction is much farther, probably 130 feet, north. At the 1,800-feet level the junction is about 200 feet north of the main west crosscut. At the 1,920-feet level the position of the junction has not been determined, but may not be so far north as at the 1,800-feet level.

At the 1,700-feet level the West branch is the better defined north of the shaft and has been stoped up to about 20 feet above the floor of the level for some distance.

In general, neither branch has proved very productive north of the shaft, and at the 1,800-feet level both appear to be represented by mere seams from about 80 feet north of the main crosscut.

The southern junction of the East and West branches of the Australia lode is by far the more important, as along it one of the richest shoots of the mine has been formed. It varies considerably in pitch at the levels examined. At the 1,600-feet level it is 240 feet south of the Main shaft, along the strike of the East branch (235 feet by the mine co-ordinates). Here the West branch is represented merely by a shear plane along which subsequent movement has taken place.

At the 1.700-feet level the junction is nearly 270 feet south of the shaft. The West branch is fairly wide at and near this point.

At the 1,800-feet level the two branches are much farther apart in the southern portion of the mine, the West branch having a much flatter dip between the 1,700-feet and 1,800-feet levels. This appears to be due to the presence of one or more old fault planes with a flat westerly dip along which the ore-bearing solutions have been deflected, and at this level, if, as seems without doubt, the lode cut in the west boreholes at 194 feet south and 331 feet south is the West branch of the Australia lode, the junction must be a considerable distance south of the southern boundary of the lease and there is no hope of finding a downward continuation of the rich shoot in the mine at this level.

At the 1,920-feet level little is yet known as to the relative positions of the two branches. It is possible that they are not so far apart as at the 1,800-feet level, but there appears to be no chance of their junctioning in the southern portion of the mine.

Another shoot of good ore occurred along the East branch from between about 20 and 60 feet south of the shaft, along the strike of the lode, to about 110 feet south of the shaft. It extended from a depth of about 1,400 feet to about 30 feet above the 1,700-feet level, where the lode became very narrow. Below the 1,700-feet level a much shorter body of good ore extended down to about 1,740 feet immediately north of winze 97 feet south. A leading stope has been taken off, to a height of 20 feet above the 1,800-feet level from about 100 feet to 140 feet south of the main west crosscut, in the hopes of getting the downward continuation of this body, but the gold content was disappointing.

The East Lode.—This lode has not been worked above the 1,800-feet level. At this level it has been followed for about 350 feet north and 260 feet south of the main east crosscut, where it is about 35 to 40 feet east of the east side of the shaft and on the hanging-wall of the albite porphyrite dyke. It branches immediately north of the crosscut, the East branch running more towards the eastern side of the dyke, the West branch, which has been followed in the more northerly workings, clinging fairly closely to the hanging-wall of the dyke, but straighter and mainly a few feet inside the dyke. In the drives north of the main crosscut the lode has largely followed the flat fault previously mentioned as affecting the albite porphyrite dyke and the western boundary of the calc-schist. The gold content of the lode north of the main crosscut was very low.

South of the main east crosscut the lode is lenticular in habit and difficult to follow. Assays up to 8dwts. were obtained from west crosscut 92 feet south, where the lode is fairly wide. At the southern end of south drive 38 feet east the lode is only represented by a shear zone in little altered greenstone. South of the main east crosscut the lode diverges from the dyke and the fault, which have not been cut south of the crosscut, and its dip is more normal.

Above the 1,800-feet level what appears to be the same lode was cut in borehole 12 feet north, at the 1,600-feet level, from about 113 feet to 118 feet east of the shaft. Here, according to the mine records, it is represented by a band of bleached greenstone assaying up to 4dwts. The albite porphyrite dyke was not cut in this bore, but is probably not far east.

Below the 1,800-feet level this lode was cut in the Main shaft at about 1,850 feet, on the hanging-wall of the dyke.

Without doubt the drives off the main west crosscut at the 1,920-feet level, at 67 feet west, are on this lode, which at this level hugs the hanging-wall of the dyke very closely. Near crosscut 198 feet south, however, the lode splits, the eastern branch entering the dyke, which bends more westerly south of this point, the western and narrower branch following the hanging-wall of the dyke. Throughout the drives at this level the gold content of the lode was very low, but one assay of 7dwts. was obtained from the eastern branch of the lode in east crosscut 198 feet south, and this branch was being followed south when I last visited this level.

CONCLUSIONS AND RECOMMENDATIONS.

The Calc-Schist.—The rock cut in the main east crosscut at the 1,800-feet level, at 66 feet from the Main shaft and immediately east of the albite porphyrite dyke, is undoubtedly the calc-schist, which, with few exceptions, has proved to be unfavourable to the occurrence of payable ore bodies. The crosscut as well as the incline winze from the Kalgurli boundary to the Kalgurli 1,850-feet level were closely examined, and proved to be entirely in calc-schist east of the point mentioned.

As stated, the calc-schist probably enters the mine a little below the 1,700-feet level. Owing to an overthrust fault, or series of faults, its dip is flat to a little below the 1,800-feet level, but must straighten up near the level as, according to the mine officials, it does not enter the Main shaft till about 30 feet below the 1,920-feet level.

The strike of the calc-schist boundary could not be determined with certainty. North of the main east crosscut at the 1,800-feet level it most probably adjoins the eastern boundary of the albite porphyrite dyke and is probably roughly parallel to the western boundary of the dyke, as shown on the plan of the 1,800-feet level. South of the main east crosscut, judging by its position in the Associated mine, it probably bends in a more easterly direction, diverging slightly from the dyke, and is probably not far from the easternmost corner of the lease.

As the albite porphyrite dyke hugs the western margin of the calc-schist so closely, and their effect on the lodes is generally the same, namely, impoverishment, they may be regarded together. Normally their strike and dip in this mine approach those of the lodes fairly closely, the dip being if anything a trifle flatter. Therefore, unless other faults occur below the 1,920-feet level they are not likely to affect the lodes for a considerable depth below the present workings. No traces of other faults were noticed east of the calc-schist boundary at the 1,800-feet level, but unless seen at their junction with a change of rock these faults, owing to the general shearing the rocks have undergone, are usually very difficult to detect.

The Australia Lode.—The main factor in the formation of the rich shoot in the Australia lode above the 1,700-feet level was a structural one, namely, the junction of the East and West branches. Other additional factors have been suggested, namely, the junction of the Associated No. 4 lens with the East branch at or close to the East and West branch junction, and also the presence of a "calcite floor" which influenced the distribution of the gold above and below it.

The Associated No. 4 lens, situated west of No. 3 lens which, as stated, apparently corresponds to the Australia Lode East branch, occurs in the same general channel of shearing, similarly to the West branch, of which, indeed, in spite of its difference in strike, it may broadly be regarded as the southerly continuation. It has not been regarded as of any great importance on the Associated mine. Its probable occurrence in the South Kalgurli mine and junction with the East branch is merely to be regarded as part of the same factor as the West branch junction.

Regarding the occurrence of "calcite floors" and their possible influence on gold distribution, these are thin veins of quartz and carbonate, nearly flat, but usually with a slight westerly or northwesterly dip, and must not be confused with the flat "floors" commonly occurring within the lodes. Their age relative to that of the lodes has not yet been definitely determined, but they are undoubtedly younger than the albite porphyrite dykes which they fault in places. If younger than the lodes they cannot have affected gold distribution, though they may have faulted the lodes slightly. If older, it is possible that they influenced the distribution of gold in their vicinity to a slight extent. One of these "floors" is stated to occur at the No. 16 (1,695 feet) level of the Associated mine, but does not seem to have had any marked immediate effect on the gold content of the lode.

A similar "floor" was seen at the No. 18 level (1,944 feet) of the same mine, where it was observed to fault an albite porphyrite dyke, apparently the same dyke as that occurring at the 1,800-feet and 1,920-feet levels of the South Kalgurli.

A "floor" of this type was observed in the South Kalgurlie mine in the stope between the 1,600-feet and 1,700-feet levels, below winze 328 feet south and about 28 feet below the 1,600-feet level. As good ore extended practically to the 1,700-feet level, the presence of this "floor" does no seem to have had any marked immediate effect on the gold distribution. It was noted, however, that the stope below the "floor" and north of the winze extended for some feet west of that above the "floor."

On the evidence at present available I am inclined to regard these "floors" as younger than the lodes and to have had no effect on gold distribution other than that of slight faulting of the lodes themselves. Further evidence is, however, necessary to determine this point.

The outstanding facts, therefore, are that the rich shoot of the Australia lode occurs at the southern junction of the East and West branches, and that with the diverging of these branches below the 1,700-feet level this shoot ceases to exist so far as the South Kalgurli mine is concerned, though it is possible that other bodies of payable ore may exist along either of the two branches. The junction of the two branches at and above the 1,700-feet level and their divergence below that level is, I have little doubt, due to the solutions which formed the West branch, having been deflected along a previously-existing fault line most probably consisting of several planes.

Regarding the position of the East branch at the 1,920-feet level, there is little doubt that the lode driven on at that level is the downward extension of that followed in drives 38 feet east at the 1,800-feet level, and termed the "East lode" in this report, and although it is possible that the East branch has junctioned with this lode a short distance above the 1,920-feet level, it is more likely that the lode matter cut in the main west crosscut from about 80 to 87 feet and from 103 to 118 feet, west of the shaft, represents the East branch of the Australia lode and also the seams at about 58 feet and 73 feet southwest of the south drive, in crosscut 230 feet south, the West branch being represented at this level by two branches at about 134 feet and 150 feet west of the shaft. As the East branch of the Australia lode appears to have normally a slightly steeper dip than the East lode, the two may eventually junction, though not for some considerable distance below the present workings. The two branches of the Australia lode might be further tested at the 1,920-feet level, preferably by two boreholes from the south drive. These could be put in from west crosscuts 113 feet south and 198 feet south on bearings of S.37°W. and S.30°W. respectively. Each might have to be put in for a distance of 120 feet or 130 feet before the West branch channel was completely penetrated.

The East Lode.—This lode, as stated, has not been worked above the 1,800-feet level, but what is apparently the same lode has been cut in east borehole 12 feet north at the 1,600-feet level. In this bore it is entirely in the quartz dolerite derivatives. Although the gold content of this lode has not so far proved to be payable—the highest assay recorded being 8¼dwts.—it might be tested by boring at the 1,700-feet level. A convenient place might be east crosscut 165 feet south off south drive 47 feet east. The lode should be about 60 feet east of the face of this crosscut. A bore put in east from the south drive off the plat at the 1,700-feet level, a few feet south of the ore bin, should cut this lode at about 90 feet.

Other Lodes.—The Lake View lode has been generally regarded as of low grade on this mine, and but little work has been done on it at the lower levels. The assays of 8dwts. recorded from west borehole 248 feet south, at the 1,800-feet level, suggest the possibility of the occurrence of a payable shoot, but the lode is so far west at the lower levels that, except by driving from the main west crosscut at the 1,800-feet level, much dead work would have to be done before the lode is cut. To reach this lode by continuing west crosscut 94 feet south at the 1,700-feet level would probably mean about 160 or more feet of crosscutting, with the probability of the lode proving unpayable when reached.

The Lake View East lode has, in general, given better returns though this lode also has mostly been of too low grade to be payable. Assays, however, from two places in the south drive on this lode at the 1,800-feet level, namely, between 65 and 80 feet and between 195 and 225 feet south of the main west crosscut, suggested the advisability of further testing the lode at these points by taking off a leading stope, and this work was being taken in hand when I last visited the mine. Although low assays were recorded from the hanging-wall portion of the lode in borehole 249 feet south, this portion might also be further tested.

Lodes or lenses of lode material were previously mentioned as occurring between the Australia Lode West branch and the Lake View East Lode at the 1,800-feet and 1,920-feet levels. Two of these were cut in the main west crosscut at the 1,800-feet level at about 160 feet and 240 feet west of the Main shaft. What is probably the junction of these two lodes was cut near the face of north drive 298 feet west, at the same level, between coordinates 185 feet and 207 feet north, and assays up to 7dwts. were recorded, suggesting the advisability of further testing these lodes, A convenient method would have been to continue west crosscut 150 feet north, off north drive 123 feet west, to cut these lodes and then drive north to cut north drive 298 feet west near the face. West crosscut 150 feet north is, however, now mullocked up.

In conclusion, there appears to be little hope of finding another shoot comparable to that worked on the Australia lode above the 1,700-feet level and the main hope of the mine, apart from the ore bodies developed above the workings examined, appears to lie in the discovery of ore bodies of lower but still payable grade along the main lines of lode.

PETROLOGICAL WORK.

(C. O. G. Larcombe, D.Sc.)

Two hundred and twenty-six (226) sections have been examined and described, made up as follows:—

Geological survey of Kalgoorlie ..	83
State boring operations	68
Wiluna	14
Various departments, etc.	61
	226

In addition to the above, about 150 sections have been made for Dr. Stillwell by my assistant. These were not examined by me but handed to Dr. Stillwell direct.

The most important matters dealt with during the year have been—

1. Petrological examinations of cores from the bores at Coolgardie.
2. Petrological examinations of cores from the bores at Sandstone.
3. Petrological examinations of cores from the bores at Ajana.
4. Examination of specimens collected by the field staff working on the geological survey of Kalgoorlie.
5. Petrology of Wiluna ores.
6. Petrological determinations for the department and for the general public.

1.—BORING AT COOLGARDIE.

Report on No. 1 Bore, Coolgardie.—This bore was put down in a westerly direction at an angle of 60 degrees (see Plates X. and XI.). It reached a depth of 623 feet along its direction of inclination. The vertical depth was 540 feet and the horizonal distance 311 feet. The bore passed through eight dykes and the assay value of the core taken from these dykes is indicated in the following table:—

No. of Dyke.	Depth in Feet.	Distance through.	Rock.	Assay Results.
	ft. in. ft. in.	ft. in.		
1	38 7—45 6	6 11	Dense brown felsite ...	Gold nil.
2	66 6—72 9	6 3	Do. do.	do.
3	180 0—183 0	3 0	Dense pale grey felsite ...	do.
4	391 0—411 0	20 0	Dense grey felsite	do.
5	415 6—422 0	6 6	Do. do.	do.
6	549 0—564 0	15 0	White aplite impregnated with pyrrhotite and traversed by small glassy veinlets of quartz containing pyrrhotite	549ft.—552ft. : Gold, 12dwt. 4grs. per ton. 552ft.—555ft. : Gold, 6dwt. 23grs. p r ton. 555ft.—558ft. : Gold, 4dwt. 3grs. per ton. 558ft.—561ft. : Gold, 2dwt. 17grs. per ton. 561ft.—564ft. : Gold, 3dwt. 4grs. per ton. Average (5 assays) : Gold, 5dwt. 20grs. per ton.
7	570 0—577 0	7 0	Dark gray felsite with a little pyrrhotitic aplite	570ft.—573ft. : Gold, 0dwt. 21grs. per ton. 573ft.—575ft. : Gold, 0dwt. 10grs. per ton. 575ft.—577ft. : Gold, 2dwt. 9grs. per ton.
8	597 6—623 0	25 6	White aplite impregnated with pyrrhotite and traversed by small glassy veinlets of quartz containing pyrrhotite. A little felsite from 613ft. 6in. to 617ft.	597ft. 6in.—600ft. 2in. : Gold, 2dwt. 14grs. per ton. 600ft. 2in.—603ft. : Gold, 5dwt. 19grs. per ton. 603ft.—606ft. : Gold, 6dwt. 3grs. per ton. 606ft.—609ft. : Gold, 4dwt. 22grs. per ton. 609ft.—612ft. : Gold. 6dwt. 16grs. per ton. 612ft.—613ft. 6in. : Gold, 1dwt. 15grs. per ton. 613ft. 6in.—617ft. : Gold, 0dwt. 8grs. per ton. 617ft.—619ft. : Gold, 2dwt. 18grs. per ton. 619ft.—621ft. : Gold, 2dwt. 18grs. per ton. 621ft.—623ft. : Gold, 6dwt. 11grs. per ton. Average (10 assays) : Gold, 4dwt. 0gr. per ton.
		90 2		

The above table indicates two significant features: (1) that two auriferous dykes were cut, viz., No. 6 between 549 and 564 feet, and No. 8 between 597ft. 6in. and 623ft.; (2) that the felsite rock is valueless, the values being confined to the pyrrhotitic aplite.

The average of five assays of core from No. 6 dyke was 5dwt. 20 grains of gold per ton over 15 feet. The average of 10 assays from the No. 8 dyke was 4dwt. of gold per ton over 25ft. 6in.

Nature and origin of the Lodestuff.—The rock (lodestuff) containing the values is a species of fine-grained granite known as aplite. It is a white rock of medium grain made up mainly of felspar and quartz, throughout which numerous irregular-shaped patches and grains of pyrrhotite—magnetic pyrites (Fe_nS_{n+1})—are scattered. In addition, this rock contains small glassy veinlets of quartz with pyrrhotite, and where these veinlets occur the values are generally highest.

Under the microscope the lodestuff (auriferous or gold-bearing pyrrhotitic aplite) is seen to consist of a medium-grained aggregate of quartz and felspar with irregular shaped ragged patches and grains of pyrrhotite scattered throughout the mass. Plates of slightly clouded orthoclase and finely striated plagioclase (near albite), showing both carlsbad and albite twinning are common. The quartz is shapeless, cracked, and sometimes in mosaic form. Irregular shaped patches of calcite may be seen. There is a noticeable amount of actinolitic hornblende in shreds, patches and nests. Flakes of bright brown biotite are intimately associated with the hornblende, and both these minerals appear to be of primary origin. Apatite rods occur. Glassy quartz veinlets traverse the aplite, and pyrrhotite forms a constituent of these veinlets.

Origin of the Aplite and its economic Significance.—The aplite is an acid rock of igneous origin. It occurs in the form of dykes. The mineralogical constitution of these dykes, viz., quartz, orthoclase, plagioclase, actinolite, biotite, apatite, calcite, pyrrhotite and occasionally gold, suggests that they are special differentiation products from some acidic (granitic) magma. The interesting feature is that the pyrrhotite—with which the gold is evidently associated—may be regarded as an accessory constituent of the aplite, *i.e.*, a part of the original magma.

The glassy quartz veinlets no doubt are contained in minute contraction fissures formed in the rock during its gradual cooling, and filled by the residual acid siliceous solutions containing pyrrhotite, and in places possibly gold.

Petrology:

(a) *The Greenstones.*—These, as shown by microscopic examination of the core rock, have been tremendously changed and altered, both physically and mineralogically, as the result of dynamic forces and chemical change. The phases of alteration are numerous, but for practical purposes the greenstones may be divided into (1) the reconstructed amphibolites, and (2) the hornblende-biotite-quartz schists.

(1) *The reconstructed amphibolite* is the common country, and this rock, together with its modifications, was the main formation from the surface to 518 feet. It is a dense green rock made up of a more or less confused aggregate of hornblende prisms and plates, often broken down into actinolitic fibres. In the less altered rock the plates lie in all azimuths. The hornblende plates may be seen undergoing distinct carbonation and chloritisation. Calcite is not infrequently segregated between the plates. Grains and mosaics of quartz, with specks of black oxide of iron and a little iron pyrites, make up the rest of the rock. At 497 feet the amphibolite is more schisted, chloritised and carbonated, while talc makes its appearance.

(2) *Hornblende-biotite-quartz schist.*—This rock occupies a powerful zone of schisting from 518 to 597 feet 6 inches. This zone contains the two large auriferous dykes, Nos. 6 and 8. In hand specimen the rock is beautifully banded, the alternating bands being made up of mosaics of quartz and calcite, hornblende and biotite, the latter bands being subordinate.

(b) *The Acidic Rocks.*—These are represented by dykes, some of which are auriferous and represent the so-called lodes. The dykes are of three types, viz.:—

1. Felsite;
2. Aplite containing pyrrhotite; and
3. Biotite aplite.

1. *Felsite.*—Of the eight dykes recorded five were felsite. It is a dense brownish to grey felsitic rock, consisting mainly of a cryptocrystalline aggregate of quartz and felspar, very often with numerous pale greenish actinolite needles scattered throughout it. The felsite is of no significance, because so far as this examination has gone the felsites do not contain any gold and must be neglected.

2. *Aplite containing pyrrhotite.*—This rock is of great importance because it is gold-bearing. Aplite is simply a fine-grained form of granite without dark constituents visible to the naked eye. The pyrrhotite, which possibly contains the gold—or in any case is associated with it—is a sulphide of iron that is attracted by the magnet. Pyrrhotite is brown, while iron pyrites is brass-yellow. The pyrrhotite-bearing aplite has already been described when discussing the nature and origin of the lodestuff. It is a medium-grained white to grey rock made up mainly of quartz and two kinds of felspar—orthoclase and plagioclase. Ragged grains and patches of pyrrhotite are scattered throughout this rock, in which it plays the part of an accessory constituent; that is to say, the pyrrhotite formed a part of the original magma from which the aplite crystallised. Glassy quartz veinlets, sometimes containing pyrrhotite, traverse the tplite, and wherever they occur values are likely to be good.

3. *The Biotite Aplite.*—A curious rock forms the hanging-wall of the No. 6 and No. 8 auriferous dykes. for a foot in the No. 6 dyke and 8ft. 6in. in the No. 8 dyke. At 548 feet it is an intensely altered rock with the appearance of a biotite granulite, consisting of a mass of scales and plates of brown biotite set in a fine-grained mosaic of quartz and possibly felspar with some calcite. At 596 feet the rock is somewhat

coarser in grain and is made up of calcite, biotite and hornblende in a quartz-felspar mosaic. At first it was thought that this rock may have been a metamorphic zone on the edge of the aplite dykes, but it has finally been interpreted as a differentiation product from the aplite and of increased basicity because: (a) it is not in both walls of the dyke; (b) it has the ground mass appearance in 548; (c) at 622 feet is decided dyke with biotite; (d) the ferromagnesian in the aplite is the same; and (e) its physical appearance suggests dyke rock.

Plate XI. is a cross section through the No. 1 bore, showing the position of the rock formations and auriferous dykes passed through.

REPORT OF No. 2 BORE, COOLGARDIE.

This bore was commenced 250 feet due north from No. 1 bore. The direction of boring was due west and the angle of depression 60 degrees. It was commenced on 24th March and completed on 15th November, 1927. It reached a depth of 1,052.25 feet, *i.e.,* a vertical depth of 911.27 feet and a horizonal distance of 526 feet.

The object of this bore was to test at depth the auriferous acid dykes that had been worked to about 300 feet in vertical depth in Tindal's mine. The bore passed through 22 dykes and the assay value of the core taken from these dykes is indicated in the following table:—

No. of Dyke.	Depth in feet.	Distance through.	Rock.	Assay results.
	ft. in. ft. in.	ft. in.		
1	173 0—177 0	4 0	Felsite	Gold, Nil.
2	467 9—482 0	14 3	Very fine grained to felsitic rock with specks of sulphide	do.
3	522 0—533 0	11 0	Pale aplite—medium to fine-grained and felsitic on foot wall. Impregnated with pyrrhotite and containing glassy quartz veinlets	522ft.—525ft. : Gold, trace. 525ft.—528ft. : Gold, nil. 528ft.—531ft. : Gold, 3grs. per ton. 531ft.—533ft. : Gold, nil.
4	537 6—547 9	10 3	White aplite strongly impregnated with coarse pyrrhotite and a little fine-grained pyrites. Sulphidic veinlets present.	537ft. 6in.—539ft. : Gold, 6oz. 9dwt. 13grs. per ton. 539ft.—541ft. : Gold, 0oz. 6dwt. 8grs. per ton. 541ft.—543ft. : Gold, 0oz. 0dwt. 5grs. per ton. 543ft.—545ft. : Gold, 0oz. 0dwt. 3grs. per ton. 545ft.—547ft. 9in. : Gold, 1oz. 16dwt. 1gr. per ton.
5	563 6—565 3	1 9	Dark felsite	Gold, nil.
6	570 0—571 0	1 0	Strongly felsitic dark dyke with specks of pyrrhotite and glassy quartz veins	Gold, nil.
7	575 0—576 9	1 9	Dark felsitic aplite with a little pyrrhotite	Gold, nil.
8	580 4—587 0	6 8	Pale aplite impregnated with pyrrhotite—some in coarse patches	580ft. 4in.—581ft. 10in. : Gold, 1dwt. 5 grs. per ton. 581ft. 10in.—583ft. : Gold, 5grs. per ton. 583ft.—584ft. : Gold, 3grs. per ton. 584ft.—585ft. : Gold, 3dwt. 4grs. per ton. 585ft.—586ft. : Gold, 10grs, per ton. 586ft.—587ft. : Gold, 10grs. per ton.
9	589 0—609 6	20 6	589ft.—595ft. : Dark aplite with numerous specks of sulphide 595ft.—600ft. : Centre of dyke. Pale fine-grained aplite with a considerable amount of fine-grained pyrrhotite and at 597ft. a distinct glassy quartz vein with pyrrhotite 606ft.—609ft. 6in. : Dark felsitic dyke with specks of sulphide	589ft.—591ft. : Gold, 3grs. per ton. 591ft.—593ft. : Gold, trace. 593ft.—596ft. 9in. : Gold, nil. 596ft. 9in.—597ft. 6in. : Gold, 7dwt. 20grs. per ton. 597ft. 6in.—606ft. 6in. : Gold, nil. 606ft. 6in.—608ft. 6in. : Gold, 5grs. per ton. 608ft. 6in.—609ft. 6in. : Gold, 1dwt. 15grs. per ton.
10	611 6—615 0	3 6	Dark felsite without any sulphide	Gold, nil.
11	657 0—658 0	1 0	Gray felsite	Gold, nil
12	664 0—670 0	6 0	Gray somewhat felsitic aplite with a little pyrrhotite	Gold, nil.
13	690 0—693 0	3 0	Dark felsite	Gold, nil.
14	694 0—695 0	1 0	Gray felsite	Gold, nil.
15	713 0—748 0	35 0	Mostly a fine-grained to felsitic dark gray aplite with specks of pyrrhotite. Rock dark from 739ft. to 748ft. and containing garnets. No sulphide from 740ft.—748ft.	713ft.—730ft. : Gold, nil. 730ft.—733ft. : Gold, 14grs. per ton. 733ft.—736ft. : Gold, 5grs. per ton. 736ft.—748ft. : Gold, nil.
16	751 3—758 0	6 9	Dark fine-grained garnetiferous dyke with no sulphides	751ft. 3in.—754ft. : Gold, nil. 754ft.—756ft. : Gold, traces. 756ft.—758ft. : Gold, 14grs. per ton.
17	760 0—764 0	4 0	Fine-grained gray aplite with no sulphides	Gold, nil.
18	766 0—771 0	5 0	Pale fine-grained aplite with a little pyrrhotite	Gold, nil.
19	793 0—799 0	6 0	Gray felsite with no sulphides	Gold, nil.
20	806 8—808 0	1 4	Dark felsite	Gold, nil.
21	810 0—818 6	8 6	Dark gray felsitic aplite with a little disseminated pyrrhotite	810ft.—813ft. : Gold, nil. 813ft.—816ft. : Gold, trace. 816ft.—818ft. 6in. : Gold, nil.

Report of No. 2 Bore, Coolgardie—*continued.*

No. of Dyke.	Depth in feet.	Distance through.	Rock.	Assay results.
	ft. in. ft. in.	ft. in.		
22	824 0—886 0	62 0	From 824ft. to 856ft. nice looking aplite with disseminated pyrrhotite and occasional glassy quartz veins 856ft. to 886ft. dark mottled granodiorite	824ft.—830ft. : Gold, a trace. 830ft.—841ft. : Gold, nil. 841ft.—843ft. : Gold, 5dwt. 21grs. per ton. 843ft.—845ft. : Gold, 10grs. per ton. 845ft.—851ft. : Gold, nil. 851ft.—853ft. : Gold, a trace. 853ft.—855ft. : Gold, nil. 855ft.—858ft. : Gold, a trace. 858ft.—881ft. : Gold, nil. 881ft.—884ft. : Gold, a trace. 884ft.—886ft. : Gold, nil.

Nature and Origin of the Lodestuff.

Similar remarks apply to the lodestuff in both bores. The general description of the lodestuff given under No. 1 bore applies to No. 2 bore.

Out of the 22 dykes met with in the No. 2 bore only two, viz., Nos. 4 and 8 dykes, showed evidence of payable values. No. 9 dyke is only separated from No. 8 by two feet of actinolitic schist, so Nos. 8 and 9 may perhaps be best regarded as one dyke.

The No. 4 dyke is possibly the equivalent of No. 6 dyke in No. 1 bore, and Nos. 8 and 9 are possibly the equivalent of No. 8 in No. 1 bore.

The No. 4 Dyke.—This extended from 537ft. 6in. to 547ft. 9in., *i.e.,* 10ft. 3in. along the direction of the bore. Its vertical depth was from 466 to 475 feet and its horizontal distance from the starting point of the bore in a westerly direction would be 268 to 273.5 feet.

The values in this dyke, as shown in the above table, ranged from 3 grains to 6oz. 9dwts. 13 grs. per ton. An assay from 545 to 547ft. 9in. gave 1oz. 15dwts. 1gr. of gold to the ton. The gold is probably contained in the sulphide, but I am strongly inclined to believe that free gold was also present. Mr. B. H. Moore, M.E., showed that concentration of the sulphide greatly increased the value and he showed that free gold was present. Simple panning gave 2.1 grains of concentrate from 50 grammes of ore.

In hand specimens the ore from the No. 4 dyke is a white granitic-looking rock impregnated with sulphides of iron and containing small glassy quartz veinlets and veinlets of sulphide. It is a coarse-grained aplite approaching a fine-grained granite. The chief sulphide is pyrrhotite, but there is certainly some ordinary iron pyrites in this ore.

Under the microscope it consists of a mediumly coarse holocrystalline aggregate of quartz and felspar, the latter predominating and containing a lot of plagioclase. Calcite interstitially arranged is not uncommon and there are numerous rods of colourless apatite. Nests and fragments of greenish chloritised hornblende are scattered throughout the slide. Shapeless patches and grains of pyrrhotite impregnated the rock and a little crystallised iron pyrites may be seen. Quartz veinlets traverse the aplite.

The No. 8 dyke, from 580ft. 4in. to 587ft., all contained values, but the grade was very low, the highest assay being 3dwts. 4gr. of gold per ton. The rock from this dyke was, however, a pale pyrrhotitic aplite. Section 4961, from 582 feet, was a very felspathic variety rich in plagioclase and containing shapeless and ragged pieces of pyrrhotite disseminated throughout it. Some calcite was intergrown with the felspar, and scattered plates of chloritised hornblende were noted.

The No. 9 dyke, from 589ft. to 609ft. 6in., gave still poorer results than No. 8—as shown in the table. A small piece between 596ft. 9in. and 597ft. 6in., near the middle of the dyke, consisted of pale pyrrhotitic aplite with glassy quartz veinlets containing pyrrhotite, and assayed 7dwts. 20gr. of gold per ton. This result is no doubt due to special differentiation at this point. The next highest assay was 1dwt. 15gr. of gold per ton from 608ft. 6in. to 609ft. 6in. The remaining nine assays were negligible. The No. 9 dyke was a good example of textural and mineralogical changes, as follows:—

589ft.-596ft. 9in.: Dark felsitic non-sulphidic type.

596ft. 9in.-601ft. 6in.: Pale aplite with pyrrhotite.

601ft. 6in.-606ft. 6in.: Dark felsitic non-sulphidic form again.

606ft. 6in.-609ft. 6in.: Pale aplite with pyrrhotite.

If the Nos. 8 and 9 dykes in the No. 2 bore correspond to the No. 8 dyke in the No. 1 bore, it is clear that 250 feet south from the Nos. 8 and 9 dykes there is a considerable improvement in uniformity and grade of values—as shown by assay results of No. 8 dyke in No. 1 bore. It is quite evident that the felsitic types are valueless and the economic development of these dykes depends upon the relative proportions of pale or white aplite rich in pyrrhotite or quartz veinlets to dense dark non-sulphidic or felsitic types.

Petrology.

The rock formations are naturally similar to those met with in the No. 1 bore. But the increased depth of the No. 2 bore to 1,052ft. 3in. has revealed important features, viz., (1) a considerable increase in the width of the schisted zone into which the dykes had intruded; (2) the presence of another dyke (No. 22) to the westward of the two auriferous dykes; (3) the passing of the aplite by imperceptible gradations into a rock rich in the ferromagnesian minerals—hornblende and biotite, viz., granodiorite; (4) the fact that the schist zone is riddled with acid dykes, 22 having been encountered in 1,052 feet of boring.

The rock formations are as follow:—

1. *Greenstones*: Hornblende schists and reconstructed amphibolite, etc.

2. *Acid Rocks*: Felsite, aplite and granodiorite.

1. *The Greenstones.*—The whole zone into which the dykes have been intruded consists mainly of a reconstructed amphibolite and its modifications, viz., hornblende and actinolite schists with, in places where greater chemical and mineralogical changes have taken place, hornblende-biotite-quartz schists. A pretty uniform and consistent hornblende-actinolite schist and a confused aggregate of hornblende, actinolite and tremolite occurs from 615 to 750 feet. The rich No. 4 dyke is in actinolite schist.

2. *The Acidic Rocks.*—These are represented by dykes, some of which are auriferous and form the lodes. The dykes include—

(a) the felsites;
(b) the pyrrhotite-bearing aplites; and
(c) the granodiorite.

(a) *The felsites.*—These are valueless and call for little comment. Ten distinct felsite dykes were cut, but the felsite occurs also on the edge of the aplite dykes or even in them, the latter occasionally containing specks of pyrrhotite. They are cryptocrystalline aggregates of quartz and felspar, often with disseminated actinolitic rods, which account for their dark colour.

(b) *The pyrrhotite-bearing aplites,* which form the lodestuff, have been described under Bore 1. An important feature revealed by Bore 2 is that the pyrrhotitic aplites do not all contain gold.

(c) *The granodiorite* forms about half of No. 22 dyke on its footwall side. It is clearly a more basic differentiation product from the aplite dykes. It contains quite a lot of bright green hornblende and brown biotite.

Summary of Conclusions.

The results of the petrogrophic examination of core from the No. 1 and No. 2 bores have revealed facts of considerable interest regarding the geological occurrence, nature and origin of the ore deposits. Amongst the interesting conclusions that have been arrived at from these facts may be mentioned the following:—

1. The geological occurrence is in the form of a series of dykes intruding a powerfully altered and more or less schisted zone of reconstructed amphibolite.

2. The number of dykes met with was considerable, viz., 8 in No. 1 bore and 22 in No. 2 bore.

3. The dykes are made up of three kinds of rock, viz.: (a) felsite; (b) a dark dioritic type—granodiorite; and (c) a pale to white aplitic type impregnated with pyrrhotite.

4. The gold "values" are confined to the aplitic type, the felsitic and dioritic types being absolutely devoid of values.

5. Out of all the dykes encountered only four, two in each bore, gave evidence of promise so far as their gold contents were concerned. The dykes referred to are No. 6 and No. 8 in Bore 1, and 4 and 8 in Bore 2. For practical purposes No. 9 dyke in Bore 2 may be considered with No. 8, from which it is separated by only two feet of actinolite schist at the place where the bore passed through it.

6. The Nos. 6 and 8 dykes in Bore 1 are large low-grade formations made up of pale pyrrhotitic aplite with glassy quartz veinlets at intervals. These two dykes contain very consistent values over 40 feet where cut by the bore.

7. The No. 4 dyke in Bore 2 was 10ft. 3in. through where cut by the bore. Assays showed values ranging from 3 grains to over 6oz. of gold per ton. The Nos. 8 and 9 dykes were, on the whole, very low grade, but assays increased to 7dwts. 20gr. of gold per ton where patches of pyrrhotitic aplite occurred. The large proportion of felsite and non-sulphidic aplite were responsible for the poorness of dyke 9.

8. The following table would seem to indicate that No. 6 dyke, Bore 1, and No. 4 dyke, Bore 2, are one and the same; while No. 8 dyke, Bore 1, and Nos. 8 and 9 dykes considered together in Bore 2 are the same. The horizontal distances are quite in accordance with what is known of the line of strike on these dykes:—

——	Depth along inclination of bore.	Distance through.	Vertical depth.	Horizontal distance.
	ft. in. ft. in.	ft. in.	ft. in. ft. in.	ft. in. ft. in.
Bore 1—Dyke 6	549 0—564 0	15 0	476 0—488 0	248 6—282 0
Bore 2—Dyke 4	537 6—547 9	10 3	466 0—475 0	268 0—273 6
Bore 1—Dyke 8	597 6—623 0	25 6	518 0—539 6	298 0—311 5
Bore 2—Dykes 8 and 9 (as one) ...	580 4—609 6	29 2	502 0—528 0	290 0—304 7

9. The most important rock is the pyrrhotitic aplite, which forms the lodestuff and carried the gold.

10. The most important mineral is pyrrhotite, because it either carried the gold or is intimately associated with it. Pyrrhotite is an interesting form of magnetic sulphide of iron.

2.—BORING AT SANDSTONE.

1. In June, 1926, six sites were chosen at Sandstone, and boring was commenced on 13th October of that year. Three of these bores (Nos. 1, 2 and 3) were put down vertically to test at depth the Black Range reef, which has been followed in the workings of the Black Range mine. The other three bores

(Nos. 4, 5 and 6) are to be put down to test at depth the Sandstone reef, which has been followed in the workings of the Oroya Black Range mine. Five of these bores have now been completed, and the sixth bore is about to be commenced.

2. *Boring at the Black Range Mine.*—Boring at this mine was commenced on 13th October, 1926. Since this date three vertical bores have been completed, as follows:—

No. 1 Bore, depth 852 feet.
No. 2 Bore, depth 762ft. 2in.
No. 3 Bore, depth 774 feet.

In each of these three bores a powerful ore channel was met with, but the values disclosed were quite unpayable. The depths of these channels are as follow:—

No. 1 Bore: lode channel 611ft. 6in. to 640ft., *i.e.,* 28ft. 6in.
No. 2 Bore: lode channel 589ft. 6in. to 616ft. 6in., *i.e.,* 27ft.
No. 3 Bore: lode channel 567ft. to 585ft., *i.e.,* 18ft.

The highest values were from the No. 3 bore, where the quartz from 573ft. 11in. to 576ft. 2in. assayed 5dwts. 11gr. of gold per ton. The next highest assay was from 576ft. 2in. to 577ft. 3in. in the same bore, where the quartz assayed 3dwts. 1gr. of gold per ton.

It should be remarked that the channels revealed in these three bores were very powerfully schisted, and bore evidence of the action and crushing by tremendous earth forces. The enclosing quartz dolerite had been broken down to calcite-chlorite-leucoxene schist. The schist, however, contained practically no gold, the only gold of any note being recorded from the No. 3 bore, as already indicated.

Details of No. 1 Bore:

General.—This bore was put down vertically and reached a depth of 852 feet. Between 611ft. 6in. and 640ft. it passed through a well-defined channel, where powerful schisting had taken place and the country rock—quartz dolerite—had been broken down and mineralogically reconstructed into a calcite-leucoxene-chlorite schist. This channel is evidently the downward extension of the Black Range reef. The whole of the core from this schist channel was assayed, but the results were negative. Nine assays were made in three-feet sections. Of these, eight samples contained no gold at all, and one sample between 627 and 630 feet assayed three grains of gold to the ton.

There was only 3ft. 6in. of core from the surface to 60ft. This was divided into four samples and each was assayed separately, but no gold was found in them.

Geology.—The order of succession of rocks passed through was as follows:—

Depth. ft. in. ft. in.	Nature of Rock.
0 0—100 0	Rotten soft yellow and brownish ferruginous rock (zone of oxidation).
100 0—611 6	Fresh quartz dolerite with marked leucoxene.
611 6—640 0	Lode channel made of calcite-chlorite-leucoxene schist.
640 0—852 0	Fresh quartz dolerite with marked leucoxene.

Petrology.—The quartz dolerite is quite fresh. It is dense, somewhat mottled, and medium to fine in grain, showing white felspar and dark augite, with prominent white leucoxene on wetted surfaces. Occasionally glassy grains of quartz may be seen.

In section it is holocrystalline, and consists of pale brownish augite, altered felspar, quartz, leucoxene, and apatite. The felspar is ophitic, and micropegmatite is strongly developed.

Right up against the sheared channel at 640 feet the quartz dolerite is still massive, but it has been broken down into a quartz-calcite-chlorite rock. The quartz is all that is left of the original minerals, the felspar and augite being represented by calcite and chlorite.

Calcite-chlorite-leucoxene schist: This rock occurs between 611ft. 6in. and 640 feet, where the quartz dolerite has been so thoroughly schisted and affected by pressure and chemical changes as to produce a calcite-chlorite-leucoxene schist. The foliation planes are powerful; in fact the leucoxene has been drawn out into long streaks with their longer axes in one direction. Traces of the original quartz of the dolerite may be seen in the schist.

Details of No. 2 Bore.—The object of this bore was the same as No. 1, viz., to test at depth the Black Range reef. It reached a vertical depth of 774 feet. Like the No. 1 bore, it was throughout in quartz dolerite and its modifications. At 589ft. 6in. the lode channel was entered and continued to 616ft. 6in. The whole of the lodestuff was assayed, mostly in three-feet sections, and with disappointing results, as shown in the following table:—

From	589ft. 6in. to 600ft.	... No gold.
	600ft. to 603ft. ...	... Gold, 5 grs. per ton.
	603ft. to 612ft. 1in.	... No gold.
	612ft. 1in. to 615ft. 6in.	... Gold, 14grs. per ton.
	615ft. 6in. to 616ft. 6in.	... No gold.

The following is a brief description of the rock formations passed through:—

Depth. ft. in. ft. in.	Nature of Rock.
0 0— 97 0	Rotten rock from zone of oxidation.
97 0—589 6	Mottled quartz dolerite with leucoxene.
589 6—616 6	Lode channel consisting of schisted and highly altered quartz dolerite with quartz from 604ft. to 606ft. 6in.
616 6—774 0	Quartz dolerite.

Details of No. 3 Bore.—This bore, in conjunction with No. 2 and No. 3 bores, was put down vertically to test at depth the downward extension of the Black Range reef. It was stopped at 774 feet.

Values.—In the course of this bore four highly altered and crushed zones were met with. Their depth and values are as follow:—

Shear Zone.	Depth. ft. in. ft. in.		Assay result.
No. 1 ...	207 10—211 6	...	Gold, nil.
2 ...	497 9—501 3	...	Gold, nil.
3 ...	537 0—537 10	...	Gold, nil.
4 ...	567 0—585 0	...	
	567 0—569 0	...	Gold, nil.
	569 0—570 7	...	Gold, 10grs. per ton.
	570 7—573 11	...	Gold, nil.
	573 11—576 2	...	Gold, 5dwt. 11grs. per ton
	576 2—577 3	...	Gold, 3dwt. 1gr. per ton.
	577 3—585 0	...	Gold, nil.

The No. 4 shear zone is evidently the main channel. It consists of slightly pyritic carbonated and broken up quartz dolerite, but not so noticeably schisted as the rock from the main channels in the Nos. 1 and 2 bores.

The gold seems to have been confined to the siliceous (quartz) portion of the channel from 573ft. 11in. to 577ft. 3in., but here the values were less than 6dwt. of gold to the ton.

The zone of oxidation ended at 86 feet. Apart from the four schisted and altered channels referred to above, the whole of this bore was in mottled quartz dolerite similar to that met with in the Nos. 1 and 2 bores. At depth there is a tendency for the quartz dolerite to pass over in to epidiorite, *e.g.*, S. 4867 and S. 4868, from 600ft. and 633ft. 2in., respectively.

3. *Boring at Oroya Black Range Mine.*—Three vertical bores—Nos. 4, 5 and 6—are to be put down at this mine to test at depth the Sandstone reef. The Nos. 4 and 5 bores have been completed, and the No. 6 bore was commenced towards the end of December, 1927.

The No. 4 bore was stopped at 700ft. 4in. and the No. 5 bore at 753ft. 2in. Although in both bores well-defined shear zones were met with the gold content was negligible, as will be noted under the detailed description of each bore.

Details of No. 4 Bore.—The object of this bore was to test the downward extension of the Sandstone reef which had been worked in the Oroya Black Range mine. It was carried down vertically to a depth of 700ft. 4in.

Two rock formations were passed through, viz.: (1) a dense aphanitic pale greenish rock which formed the general country rock, and (2) a dense black dolerite dyke.

The country rock is a dense pale greenish fibrous zoisite amphibolite. R. 1/4423, S. 4911 from 700ft. 4in. consists largely of fibrous hornblende distributed amongst relict and possibly albitised felspathic material with some clear zoisite. Small shapeless individuals of quartz are scattered throughout this mass, together with grains of what appear to be remnants of leucoxene. This rock evidently forms a key to the origin of the fibrous amphibolites which were possibly basic rocks of basaltic to doleritic texture containing quartz. The country rock of the Nos. 4 and 5 bores is so considerably different lithologically from that met with in the Nos. 1, 2, and 3 bores, that it may be of a different age—possibly belonging to the older greenstones.

The details are as follow:—

Depth. ft. in. ft. in.	Nature of rock formation.
0 0—115 0	Creamy-coloured oxidised rock.
115 0—295 0	Dense fibrous amphibolite.
295 0—296 0	White quartz.
296 0—308 0	Dense fibrous amphibolite.
At 308ft.	An inch shear zone.
308 0—350 0	Dense fibrous amphibolite.
350 0—352 0	Channel 1, brecciated amphibolite.
352 0—359 0	Dense fibrous amphibolite.
359 0—361 0	Channel 2, brecciated amphibolite.
361 0—484 6	Dense fibrous amphibolite.
484 6—496 5	Fresh ophitic dolerite.
496 5—505 5	Dense fibrous amphibolite.
505 5—508 5	Channel 3, quartz with some iron pyrites and mispickel.
508 5—573 0	Dense fibrous amphibolite.
573 0—580 0	Channel 4, mainly quartz.
580 0—700 4	Dense fibrous amphibolite.

Sheared, brecciated and other channels.—This bore proved that considerable disturbance had taken place at different depths. Schisting and brecciation were distinct and open spaces filled with quartz were noted. All the rock from these disturbed zones was assayed. The following are brief descriptions of the structural and other changes met with:—

Channel 1, 350ft.-352ft.: Crushed rock with a cement of zoisite, epidote, and calcite, all recrystallised.

Channel 2, 395ft.-361ft.: Breccia of country rock, epidotised and cemented by carbonates.

Channel 3, 505ft. 5in.-508ft. 5in.: Quartz with some iron pyrites and mispickel in lath-shaped crystals. Only 1 foot of core obtained over these 3 feet.

Channel 4, 573ft-577ft.: Mainly white quartz. Only 1ft. 7in. of core received.

Channel 5, 577ft.-580ft.: Mainly quartz, somewhat cellular and iron-stained. Only 16 inches of core received.

From these remarks it would appear as if the main reef extended between depths of 573 and 580 feet.

Assays.—Any rock material showing distinct structural or mineralogical changes, or any evidence whatever of the presence of values, was assayed. The details are as follow:—

	Depth. ft. in. ft. in.	Result.
Channel 1 ...	350 0—352 0 ...	Gold, nil.
2 ...	359 0—361 0 ...	Gold, nil.
3 ...	505 5—508 5 ...	Gold, 21grs. per ton.
4 ...	573 0—577 0 ...	Gold, nil.
5 ...	577 0—580 0 ...	Gold, nil.

These assays show that the gold is in the quartz and not in the breccia.

Details of No. 5 Bore.—The object in putting this bore down was the same as for No. 4 bore, viz., to test the Sandstone reef at depth. It reached a total depth of 753ft. 2in.

This bore, like No. 4, passed through two similar rock formations, viz.: (1) a dense aphanitic pale green fibrous amphibolite, and (2) a black dolerite dyke.

The details of the rock material met with are as follow:—

Depth. ft. in. ft. in.	Nature of rock formation.
0 0—226 0	Decomposed oxidised greenstones.
226 0—450 0	Massive fibrous zoisite amphibolite.
450 0—455 0	No. 1 shear zone of calcite-chlorite schist.
455 0—508 0	Dense zoisite amphibolite.
508 0—514 0	No. 2 shear zone—similar to No. 1.
514 0—523 0	Dense zoisite amphibolite.
523 0—531 0	Dense black ophitic dolerite.
531 0—603 6	Dense zoisite amphibolite.
603 6—610 0	No. 3 shear zone with quartz.
610 0—753 2	Dense zoisite amphibolite.

Shear Zones.—This bore passed through three distinct shear or crush channels at the following depths:—

No. 1 shear channel, 450 to 455 feet.

No. 2 shear channel, 508 to 514 feet.

No. 3 shear channel, 603ft. 6in. to 610 feet.

The rock in these channels was crushed down in large part into a calcite-chlorite schist associated with some quartz. The auriferous solutions have evidently missed these channels.

Assays.—The assay samples were taken from the shear zones referred to, but the results were negative. The details are as follow:—

	Depth.	Assay results.
No. 1 shear zone ...	450ft to 455ft.	... Two assays: gold a trace.
No. 2 shear zone ...	508ft. to 514ft.	... Two nil; one a trace
No. 3 shear zone ...	603ft. 6in. to 610ft.	No gold.

No. 6 *Bore.*—This bore is also to test the Sandstone reef. At the present time it is down 273 feet, but the material has not yet been examined (5th January, 1928).

3.—BORING AT AJANA.

A deep bore was commenced at Ajana in October, the object being to test at a depth of about 700 feet the lead lodes in the Surprise mine. This bore was started on the western side of the lode at a depressed angle of 55 degrees and a horizontal bearing of 86 degrees.

Boring began in decomposed weathered granite, which continued to 22 feet, when hard granite came in. The granite extended to 415 feet, where a basic rock was encountered. The bore at the present time (25th January, 1928) is down 730 feet, and the material is under examination.

4.—GEOLOGICAL SURVEY OF KALGOORLIE.

Eighty-three rock sections were examined under the microscope, and it is fortunate that, notwithstanding their tremendous alteration, it was possible satisfactorily to determine nearly all of them.

5.—PETROLOGY OF WILUNA ORES.

Petrological investigations were carried out at intervals during the year on material from the Wiluna Company's mine, submitted by the State Mining Engineer and the Government Analyst.

The investigations for the State Mining Engineer were made with the specific object of determining the genesis and mutations of the ore. A lengthy report has already been presented by the writer (Annual Report, Department of Mines, 1925). It will therefore be sufficient to add the following extract from recent reports:—

"A remarkable feature is that there is no great evidence of schisting and shearing. The maceration, alteration, and reconstruction of the original rock are so great and thorough that your (State Mining Engineer's) conception of a shatter zone is very suggestive. The general microscopic evidence is in favour of mashing rather than shearing.

"It would appear that, concomitant with or slightly subsequent to the mashing process in the shattered zone, the rock mass was invaded by siliceous carbonated, alkaline, sulphidic, and auriferous solutions at high temperatures and pressures, with resultant metasomatism and reconstruction of the quartz dolerite greenstone into its present form of lode stuff. The granular sulphide of iron and prismatic forms of mispickel are without doubt of primary origin."

Amongst the material submitted by the State Mining Engineer was a black rock with which the writer was unacquainted at the time his original report was prepared. The rock in question came from a dyke which penetrates the west lode at the 200-feet level, north of the Central shaft. It is dense, black, and aphanitic, with a somewhat blocky tendency. In places it was peppered with minute specks of what proved microscopically to be leucoxene. Many small cleavage facets of felspar were scattered throughout the specimen.

Under the microscope it is seen to be made up of a mass of small and more or less clear plagioclase felspars lying in all azimuths. The ferro-magnesian constituents have disappeared; they have been replaced by patches of carbonates and pale green chlorite, both minerals being distributed interstitially between the felspars.

The slide is peppered with small grains and patches of leucoxenised ilmenite. The rock may be termed a carbonated chloritised dolerite.

6.—PETROLOGICAL DETERMINATIONS FOR THE DEPARTMENT AND FOR THE PUBLIC GENERALLY.

This forms part of the routine work, but there was nothing of very special nature to report from the material examined.

The Government Analyst submitted a number of rocks, amongst which the most interesting were those from the Tabba Tabba Tinfield, where remarkable garnetiferous zoisite-uralite schists were apparently derived from epidiorites along lines of shearing and crushing.

Other samples examined came from the York district, Mullewa, Lake Grace area, Beverley, Glenelg Hills, Geraldton, and other places.

INDEX.

INDEX—continued.

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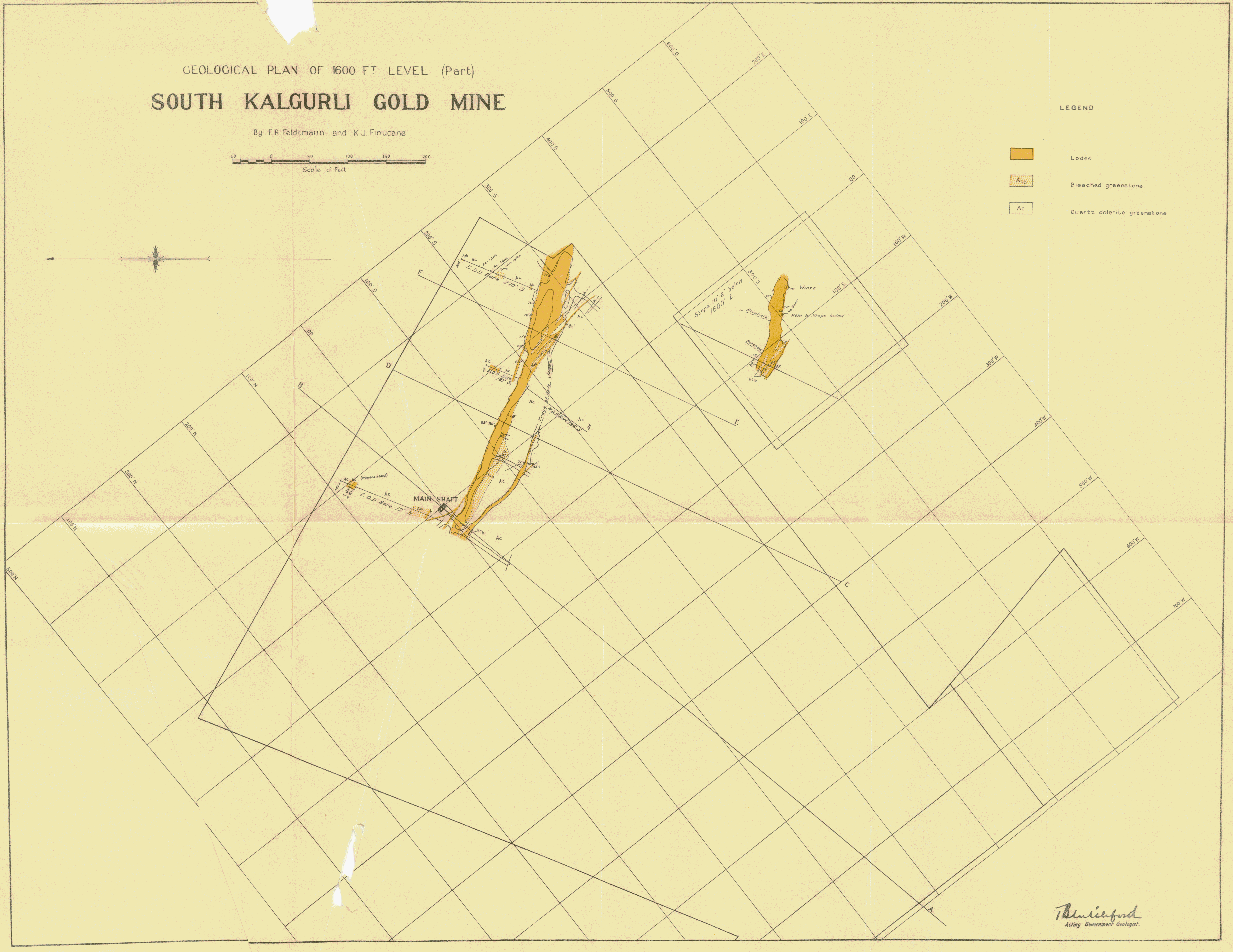
GEOLOGICAL PLAN OF 1600 FT LEVEL (Part)

SOUTH KALGURLI GOLD MINE

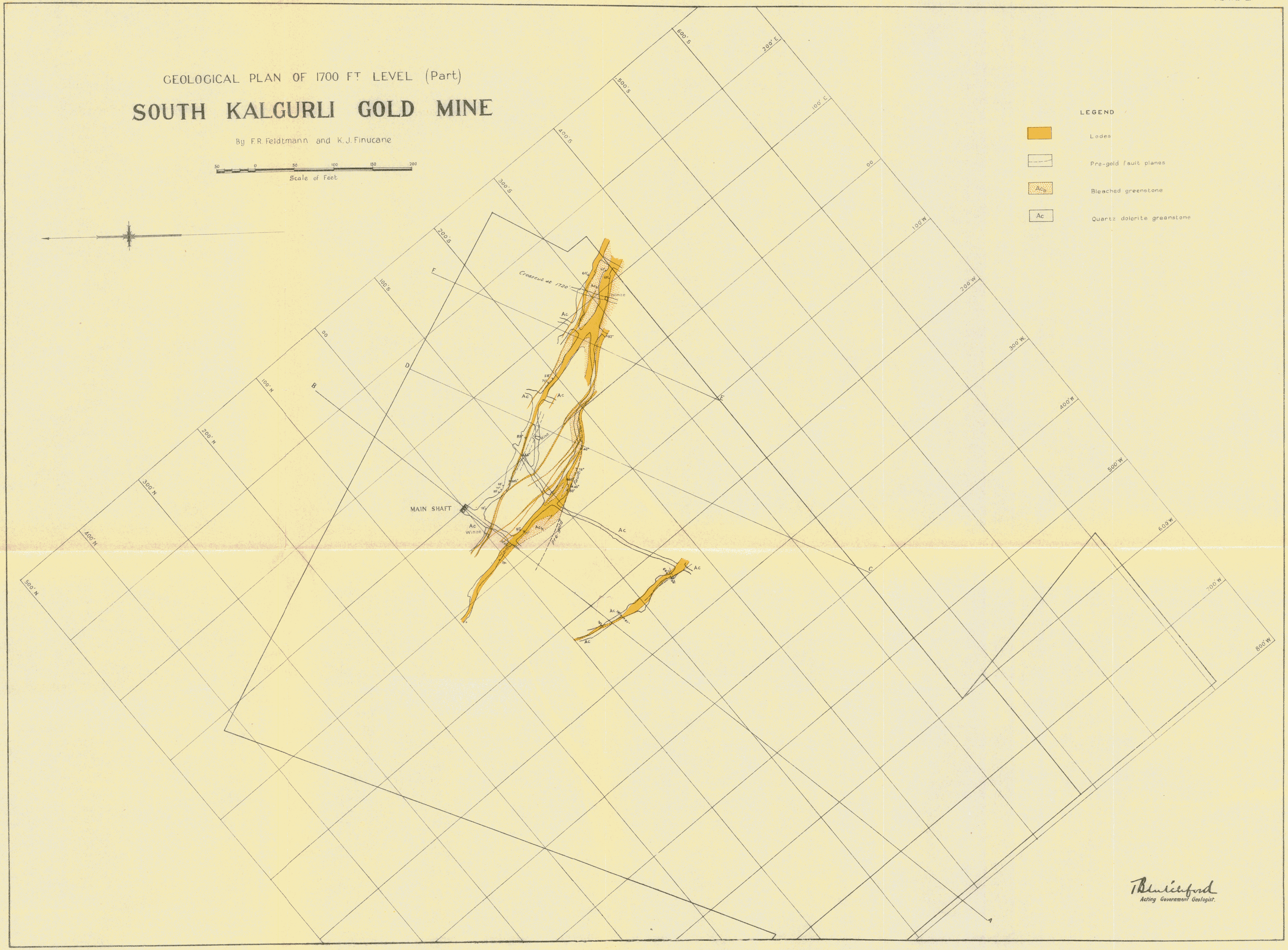
By F.R. Feldtmann and K.J. Finucane



GEOLOGICAL PLAN OF 1700 FT LEVEL (Part)

SOUTH KALGURLI GOLD MINE

By F.R. Feldtmann and K.J. Finucane



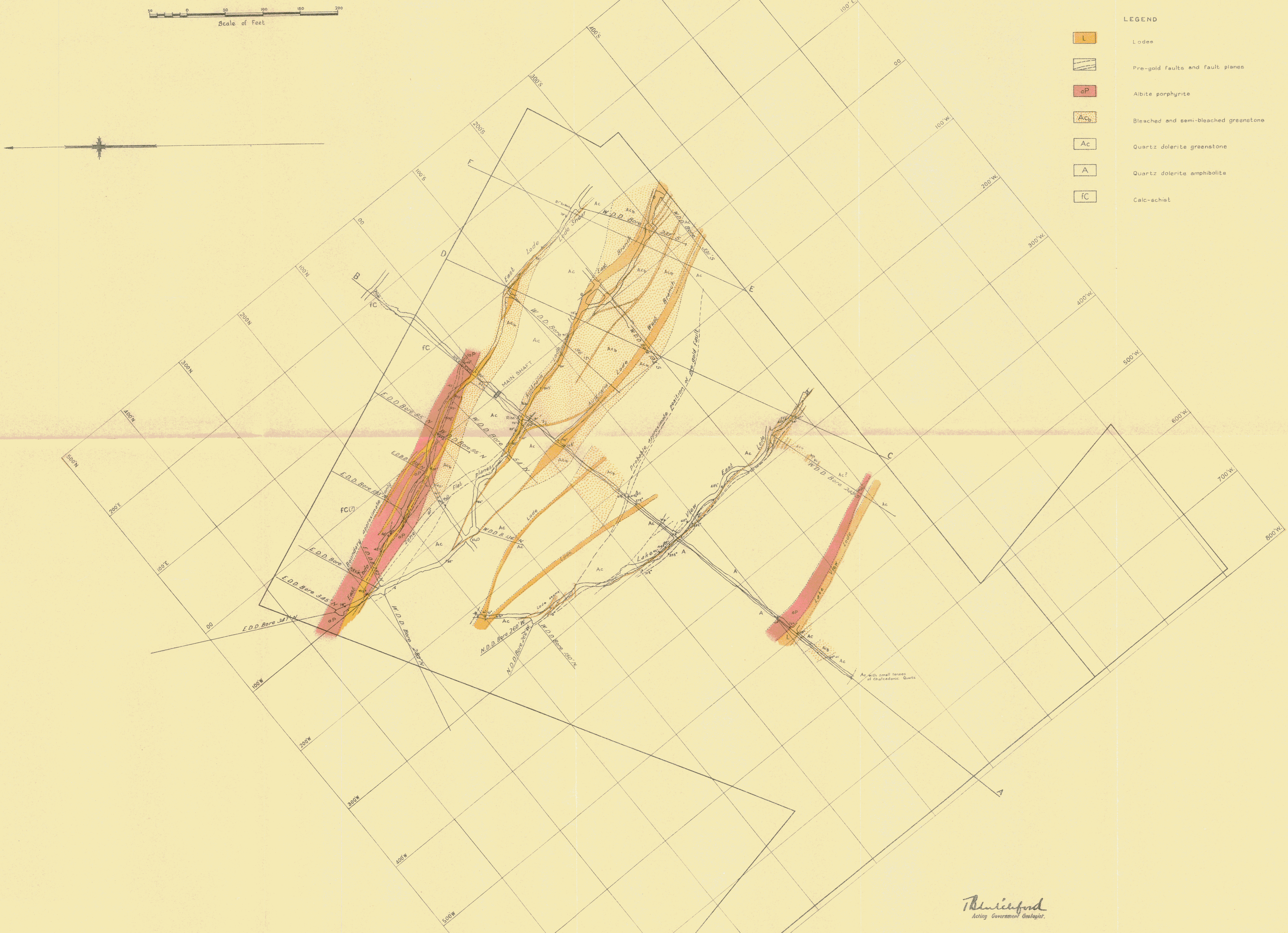
Acting Government Geologist.

GEOLOGICAL PROGRESS REPORT 1927. PLATE VI.

GEOLOGICAL PLAN OF 1800 FT. LEVEL

SOUTH KALGURLI GOLD MINE

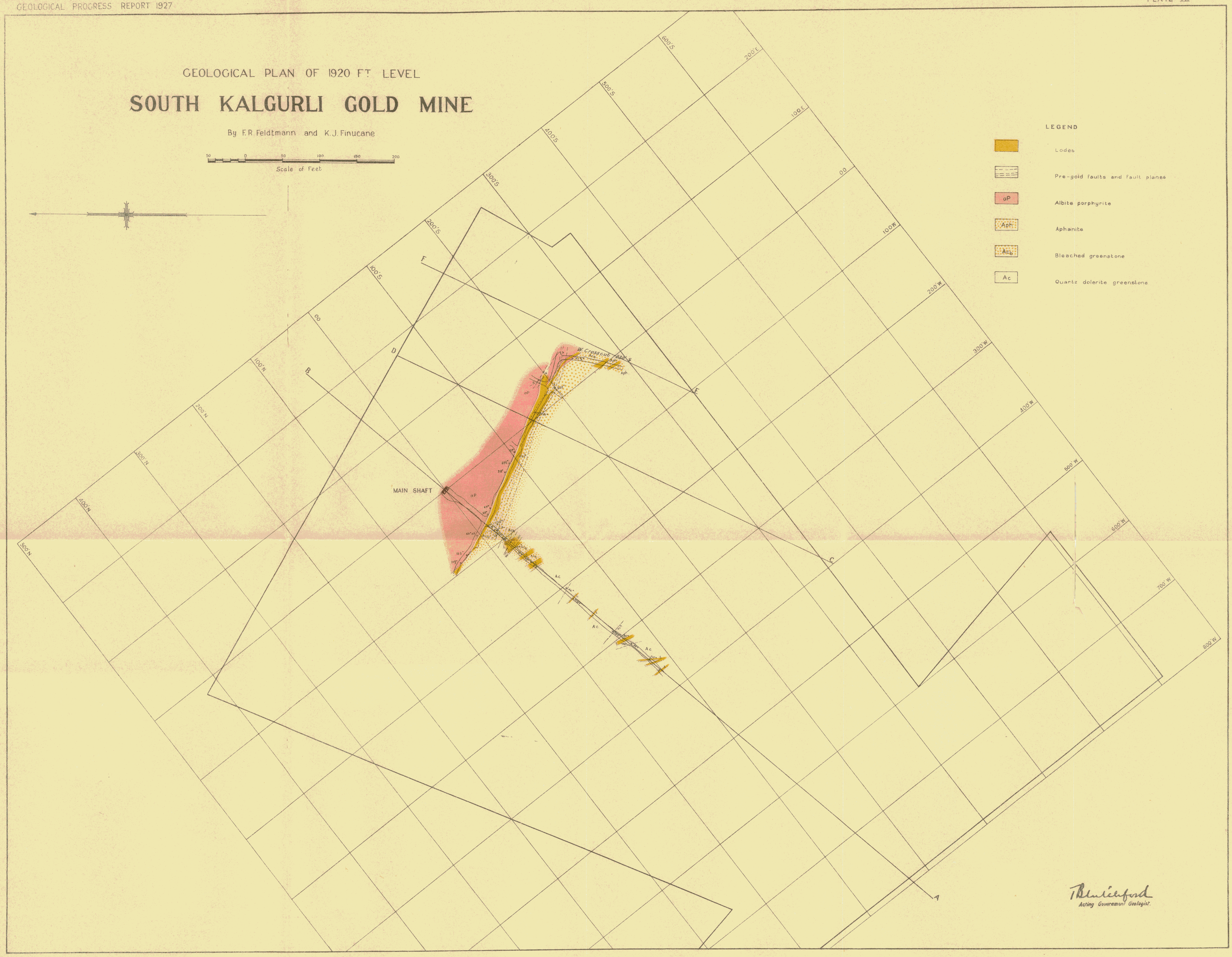
By F. R. Feldtmann and K. J. Finucane



LEGEND

L	Lodes
	Pre-gold faults and fault planes
aP	Albite porphyrite
Ac_b	Bleached and semi-bleached greenstone
Ac	Quartz dolerite greenstone
A	Quartz dolerite amphibolite
fC	Calc-schist

T. Blatchford
Acting Government Geologist.

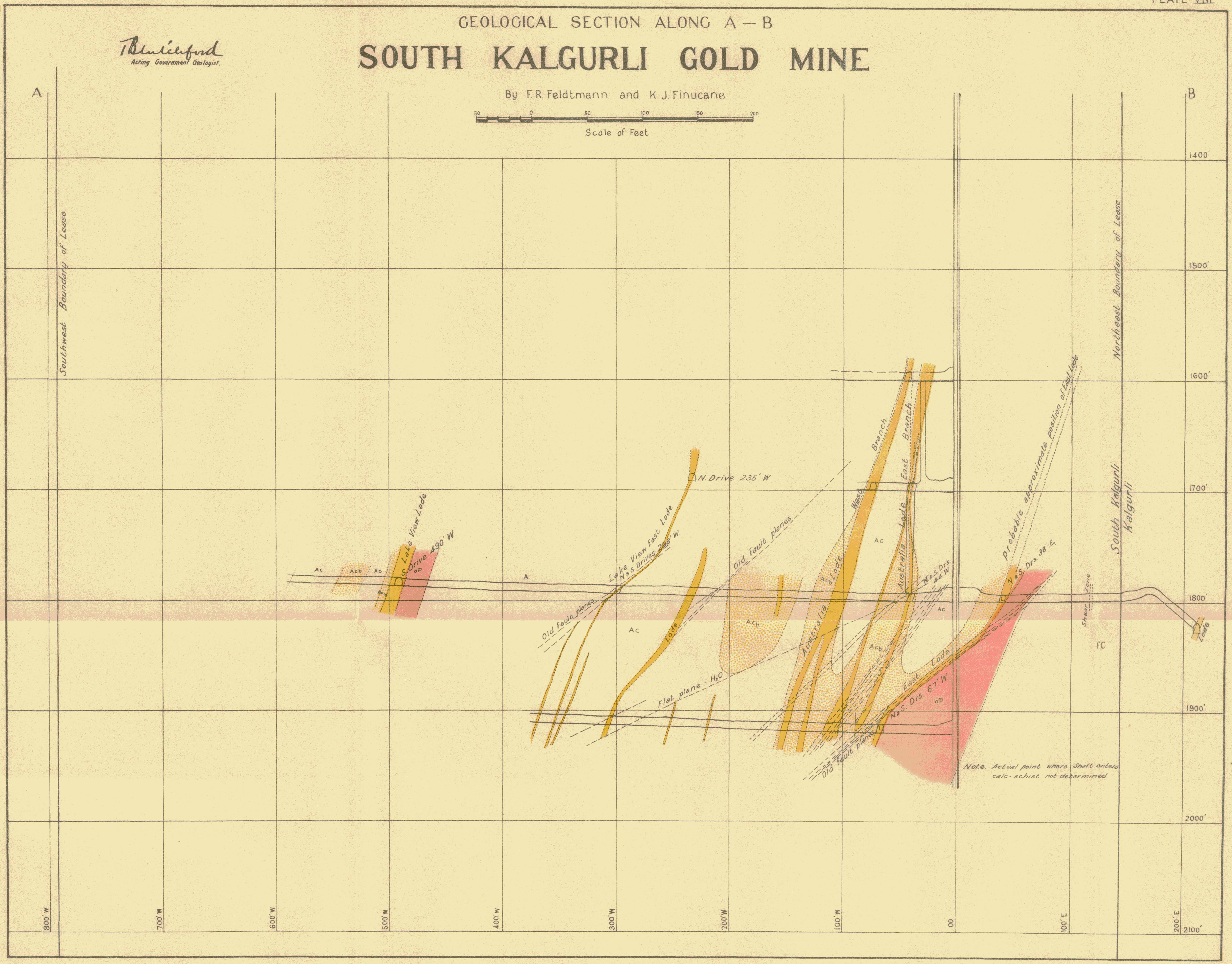

GEOLOGICAL PLAN OF 1920 FT LEVEL
SOUTH KALGURLI GOLD MINE
By F.R. Feldtmann and K.J. Finucane
50 0 50 100 150 200
Scale of Feet
LEGEND
Lodes
Pre-gold faults and fault planes
aP
Albite porphyrite
Aph
Aphanite
Acb
Bleached greenstone
Ac
Quartz dolerite greenstone
MAIN SHAFT
W. Crosscut
600'S
500'S
400'S
300'S
200'S
100'S
00
100'N
200'N
300'N
400'N
500'N
200'E
100'E
100'W
200'W
300'W
400'W
500'W
600'W
700'W
800'W
A
B
C
D
E
F
Acting Government Geologist.

GEOLOGICAL SECTION ALONG A — B

SOUTH KALGURLI GOLD MINE

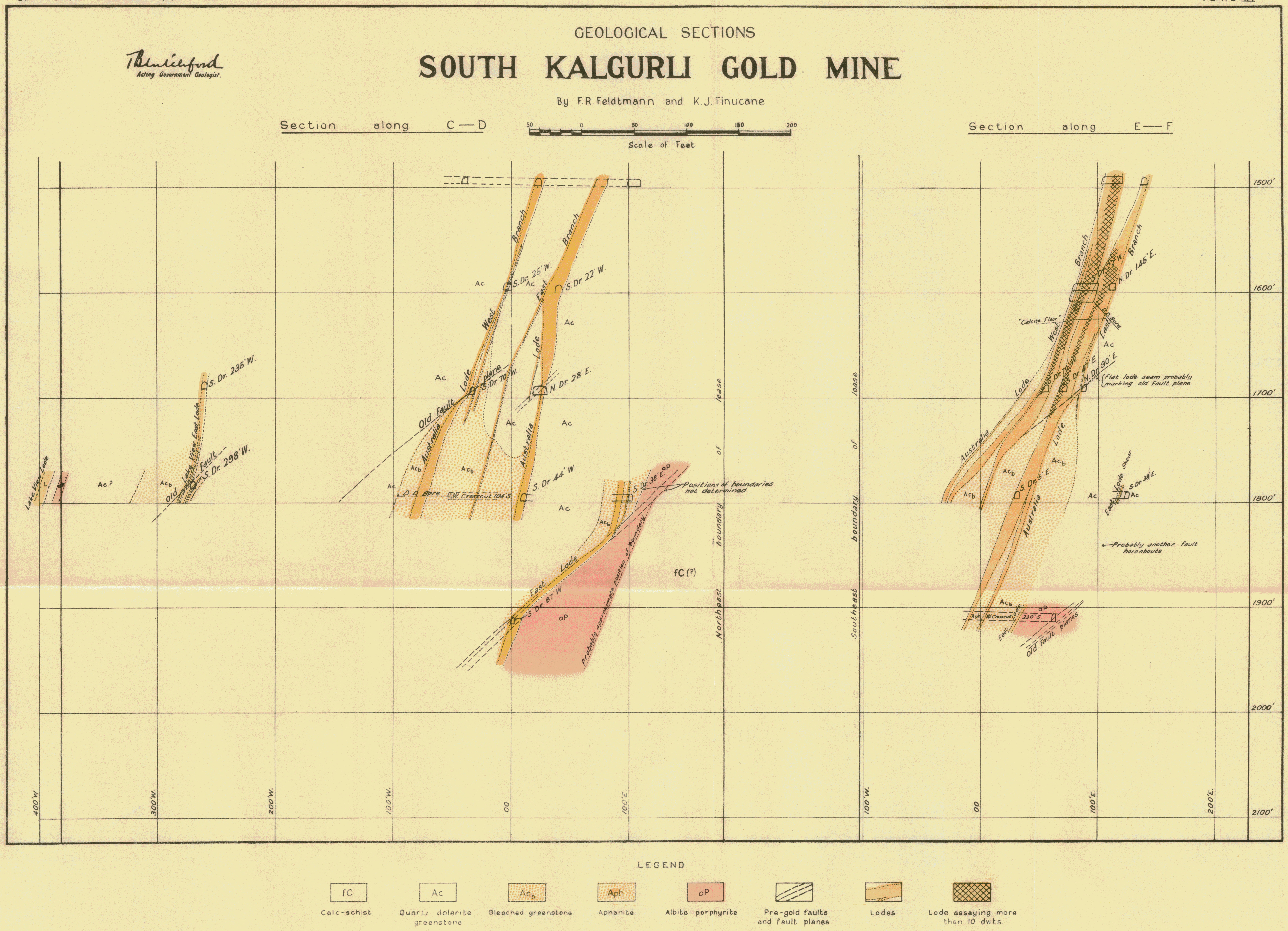
T. Blatchford
Acting Government Geologist.

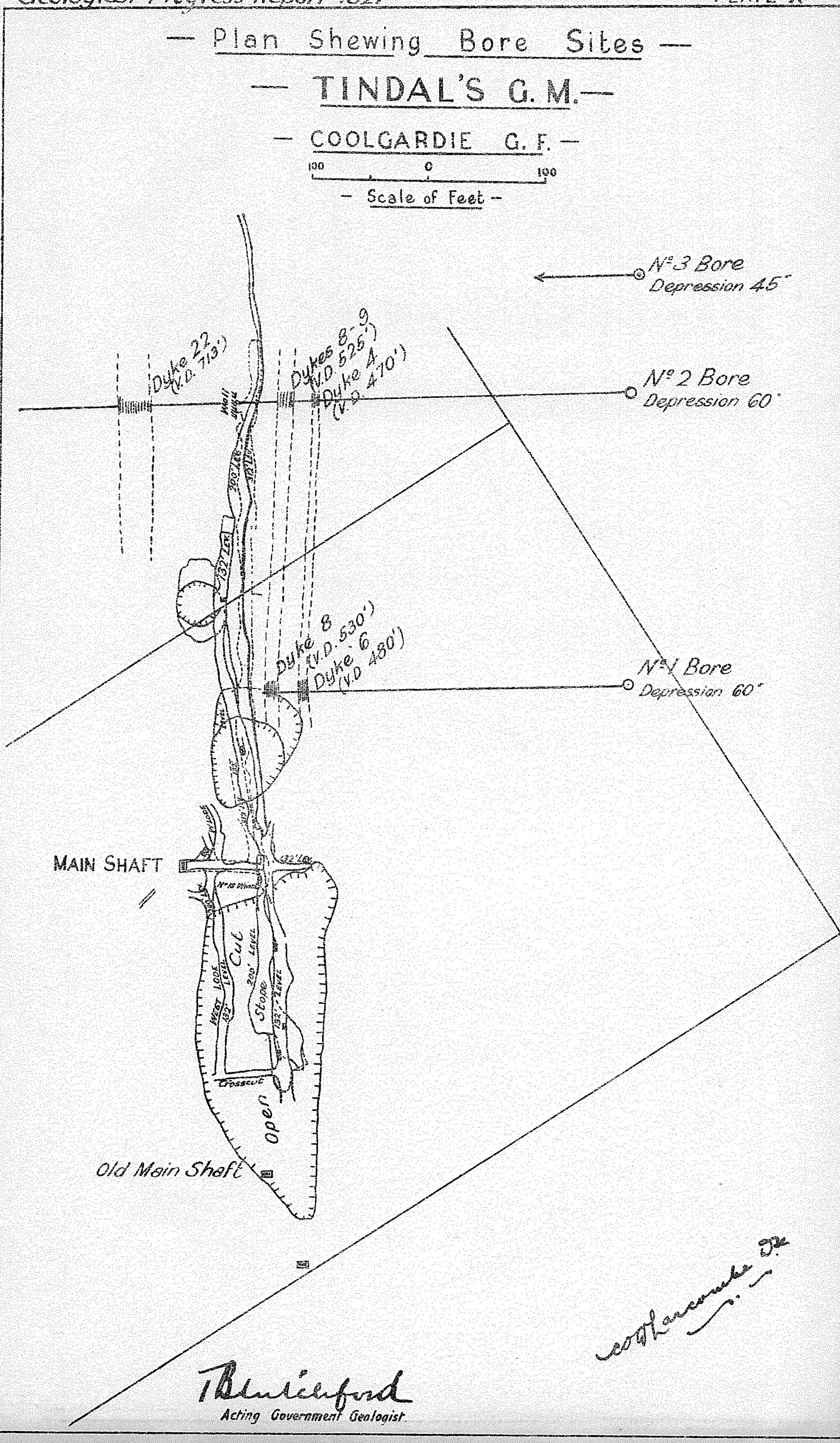
By F. R. Feldtmann and K. J. Finucane



LEGEND

fC	Calc schist
A	Quartz dolerite amphibolite
Ac	Quartz dolerite greenstone
Acb	Bleached greenstone
aP	Albite porphyrite
	Pre-gold faults and fault planes
	Lodes

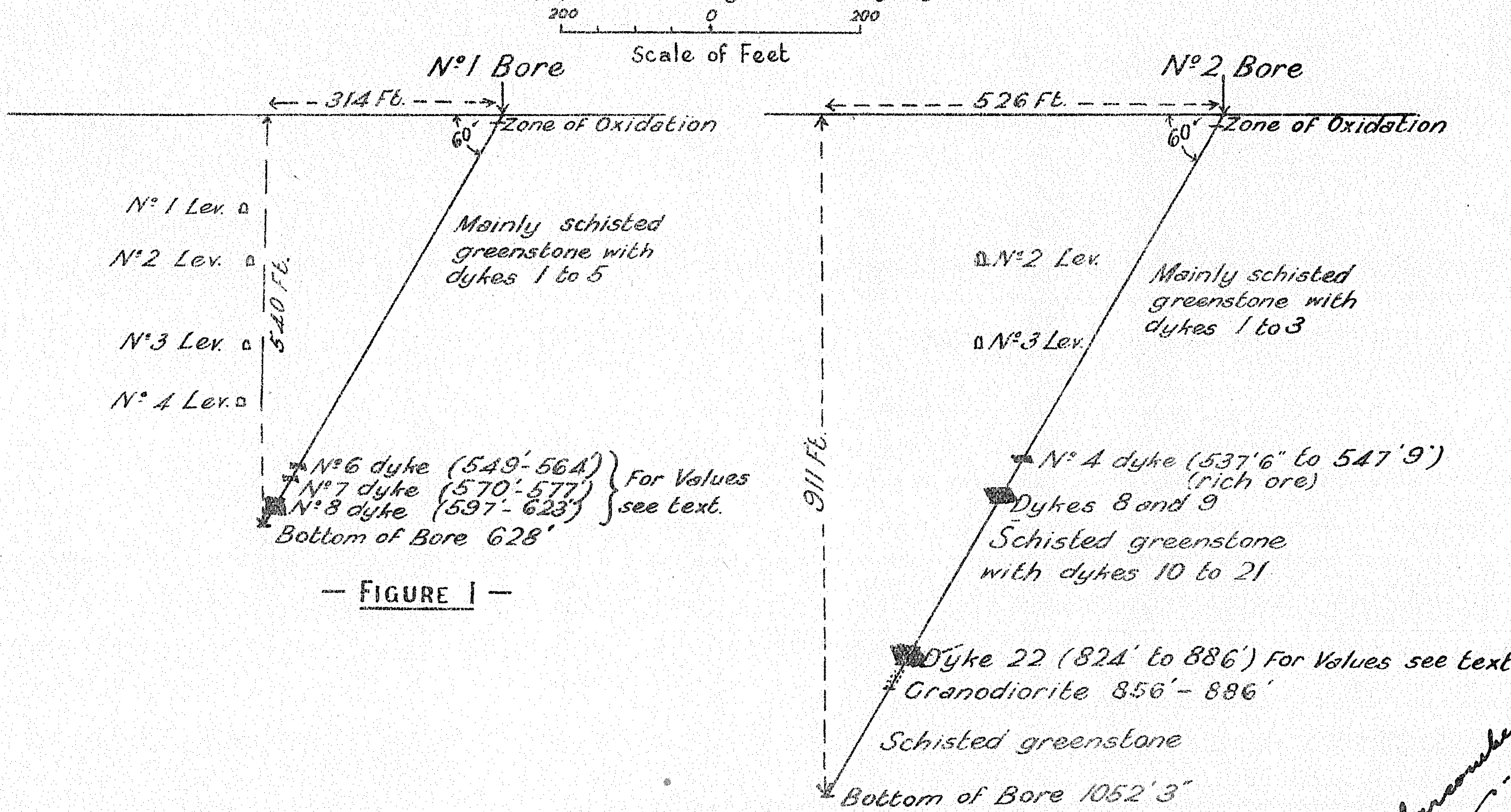

GEOLOGICAL SECTIONS
SOUTH KALGURLI GOLD MINE
By F.R. Feldtmann and K.J. Finucane
Acting Government Geologist.
Section along C — D
Section along E — F
50 0 50 100 150 200
Scale of Feet
1500'
1600'
1700'
1800'
1900'
2000'
2100'
400 W.
300 W.
200 W.
100 W.
00
100 E.
100 W.
00
100 E.
200 E.
Northeast boundary of lease
Southeast boundary of lease
West Branch
East Branch
S. Dr. 25' W.
S. Dr. 22' W.
West Lode
East Lode
Old Fault plane
S. Dr. 70' W.
N. Dr. 28' E.
Australia
S. Dr. 44' W
D.D. Bore
W. Crosscut 194' S
S. Dr. 235' W.
Lake View East Lode
Old Fault
S. Dr. 298' W.
Lake View Lode
Ac?
S. Dr. 38' E.
Positions of boundaries not determined
fC (?)
East Lode
S. Dr. 67' W
Probable approximate position of boundary
N. Dr. 145' E.
"Calcite Floor"
Flat lode seam probably marking old Fault plane
N. Dr. 90' E.
East Lode Shoot
S. Dr. 38' E.
Probably another Fault hereabouts
W. Crosscut 230' S.
Old Fault planes
LEGEND
fC Calc-schist
Ac Quartz dolerite greenstone
Acb Bleached greenstone
Aph Aphanite
aP Albite porphyrite
Pre-gold faults and fault planes
Lodes
Lode assaying more than 10 dwts.


— Plan Shewing Bore Sites —
— TINDAL'S G. M. —
— COOLGARDIE G. F. —
100 0 100
— Scale of Feet —
Nº 3 Bore
Depression 45°
Dyke 22
(V.D. 713')
Dykes 8-9
(V.D. 525')
Dyke 4
(V.D. 470')
Nº 2 Bore
Depression 60°
132' Level
Dyke 8
(V.D. 530')
Dyke 6
(V.D. 480')
Nº 1 Bore
Depression 60°
MAIN SHAFT
132' Lev.
Cut
Stope
200' Level
West Lode Level
Crosscut
Open
Old Main Shaft
Acting Government Geologist.

Geological Section Through Nos 1 and 2 Bores

TINDAL'S GOLD MINE COOLGARDIE

Shewing positions of gold-bearing dykes.



— FIGURE 1 —

— FIGURE 2 —

Acting Government Geologist.