1930.

WESTERN AUSTRALIA.

ANNUAL PROGRESS REPORT

of the

GEOLOGICAL SURVEY

for the

YEAR 1929.

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Annual Report of the Geological Survey for the Year 1929.

I have the honour to submit for the information of the Hon. the Minister for Mines my report on the work of this branch of the Department of Mines for the year 1929.

STAFF.

Early in the year the junior assistant Geologist, Mr. K. J. Finucane, severed his connection with the Department to take a more lucrative position on the Tasmanian Geological Survey. Later in the year his position was filled by Mr. F. G. Forman, another graduate in Science from the University of W.A. Otherwise there has been no change in the personnel of the Staff.

FIELD WORK.

Government Geologist.—In addition to ordinary office routine, I was able to make the following field inspections:—

1. An investigation, with Mr. R. L. Jack, deputy Government Geologist of South Australia, of the surface water problems in connection with the 3,500 Farm Scheme of the southern area.
2. An investigation into the occurrence of foul air in the Coronation or Moondyne Cave at Margaret River.
3. The sampling and estimation of the Manganese Ore in the Southern Series of the Horseshoe Deposits at Peak Hill.
4. An investigation of the occurrence of bitumen on Cheyne Beach.
5. Two conferences at Northampton with Mr. Ferguson, the controller of the Geophysical Survey, of the lead deposits of that district.
6. An inspection of a reported tin discovery near Mt. Dockrell in the East Kimberley Division.
7. An inspection of the oil bore at Poole Range in connection with the cementing off of the water from the oil sands at a vertical depth of 2,085 feet.
8. An inspection of a coal discovery at Nannup on the Busselton-Bridgetown Railway.

In addition to the above field inspections two papers were compiled, one a memorandum on the Gold Resources of W.A. for the International Geological Congress XVth Session, South Africa, 1929; and in conjunction with Professor E. deC. Clarke a description and classification of the Pre-Cambrian Rocks of the State, made at the request of the Interstate Geological Conference held in Adelaide in May, 1928.

As it has been decided to cease boring, at least temporarily, for coal at Eradu, a report has been compiled of the work completed to date, with the object of setting out all the data obtained during the two boring campaigns undertaken to investigate the coal seams of that area.

Accompanying this report are a block isometric plan and two sections prepared by Mr. F. G. Forman, a general surface plan showing the relative position of the various bores, and a plan of the bores showing thickness of coal seams with their reduced levels.

Field Geologists.—For the greater portion of the year the assistant Field Geologists were engaged on the underground survey of the Boulder Belt. In addition and in company with Dr. Woolnough, Mr. Feldtmann visited and reported on the Wooramel Area, in connection with the occurrence of mineral oil in that locality. Owing to an urgent request from the management of the Great Boulder Perseverance Mines, Mr. Finucane made a survey of the East Boundary Lode to locate the position between the 1,300 and 1,750ft. levels, and the Australia East Lode at and below the 1,750ft. level. Mr. F. G. Forman has presented a short paper comparing the structural conditions of the Fitzroy Basin with those of some typical noted oil fields in America, based on his personal observations of the latter.

PETROLOGY.

During the year Dr. Larcombe has petrologically examined cores from the bores sunk on the following mines:—

Big Bell, Braeside Mineral Belt, Mararoa South, Prophecy, Kitchener, Carbine, Little Bell, and Enterprise.

In addition numerous rocks have been sectioned both for Departmental officers and the public.

The full reports, together with petrological descriptions of the bore cores, etc., except in such cases when the investigation has been made for purely departmental reasons, will be found in the following pages.

In conclusion I desire to express my appreciation of the work and loyal support of my staff during the past year.

T. BLATCHFORD, B.A.,
Government Geologist.

25th February, 1930.

INVESTIGATION OF THE SURFACE WATER PROBLEMS IN CONNECTION WITH THE SOUTHERN AREA OF THE 3,500 FARMS SCHEME.

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

In company with Dr. Jack this investigation, which has been carried out over the Northern area in the previous year, was continued to the Southern area.

The data collected on this trip only confirmed the opinion previously formed, viz., that fresh surface waters would only be found when coming from granite or hard catchments and then at no great distance from their crests.

Positive evidence of cyclic salt accumulation was obtained particularly in one instance, where the rain water caught in a depression on the top of a granite outcrop, and which had no overflow even after heavy rains, had accumulated sufficient salt to turn it into a dense brine. This pool of water, known as the Basin, occurs three miles east of the 90-mile post on the No. 1 Rabbit-proof Fence.

There seems to be little or no hope but that the farms throughout this area will be dependent on surface catchment water, except when situated close to granite outcrops and in rare cases where there is a gradual fall from high ground with an impervious bottom.

INSPECTION OF THE MOONDYNE CAVE RELATIVE TO FOUL AIR OCCURRENCE IN THE LOWEST CHAMBER.

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

In company with the three cave guides, Messrs. Dawson, Connelly and Brennan, I inspected the Moondyne (Coronation) Cave to investigate the reported occurrence of foul air in the bottom of the cave.

The air from the entrance of the cave down through the various chambers, following the course which visitors take, was found to be quite fresh, in so far that no inconvenience was felt by any member of the party, neither was the flame of the candle noticeably affected. On the bottom floor, however the conditions of the air were very different and a lighted candle, when lowered to within a few inches of the actual floor of the cave, was quickly extinguished.

I did not realise the presence of impure air until walking round with the guides for a few minutes, when an effect approaching giddiness was experienced and it was then that a candle would burn freely almost anywhere. It was evident that the layer of foul air diffused and when inhaled, caused very slight giddiness, though the dilution was so great that the air would not affect a naked candle. On this account samples were not collected at the time, but Guide Brennan on two subsequent visits filled the retainers, analyses of the gas collected being as on the attached report.

From these analyses it is evident that poisonous gas does occur in the Moondyne Cave and that care must therefore be exercised when showing visitors through the cave. If the precautions which have been practised in the past are continued (the guide descends with a naked candle first and notes the effect), there should be no real danger in allowing visitors to pass through quickly. Careful inspection of the lowest chamber by the guide, however, should be insisted upon and the stay of visitors in the bottom section of the cave should be made as short as possible.

To obviate the presence of the noxious gas more circulation is necessary. This could be effected by laying a 6 to 8 inch pipe from the entrance to the bottom floor or drill a six-inch hole from the surface to the roof of the bottom cave and connect to the floor with a short pipe. As the cave is a very beautiful example of cave formation, it would be regrettable to lay an unsightly pipe throughout the interior, which would not be so effective as a shorter vertical bore. If a light portable boring plant could be obtained it would not cost much to punch a six-inch hole about 150 feet in length, for the country rock would be relatively soft, dry and easy to bore. In this case the exact position of the bore, however, should be fixed by accurate survey so as not to risk destroying a valuable cave formation. If pipes are to be used the length necessary to work round corners, etc., should be obtained from the guides themselves, who know best what they require.

Copy of Assay Certificate 423/29.

Lab. Nos. 1299 and 1300.

Summary of Analysis:

	Sample collected 14th Feb., 1929.	Sample collected 3rd Mar., 1929.
	per cent.	per cent.
Carbon dioxide ..	6.06	2.77
Oxygen	13.64	17.58
Nitrogen (by difference)	80.30	79.65

Owing to the bottles being wet the carbon dioxide originally present in the gas may have been slightly higher than the above figures indicate.

The air collected on the 14th February is distinctly asphyxiating and may cause serious symptoms in man. A recent (1927) authority states:

> When the oxygen of the inspired air is diminished from the normal 21 per cent. to values between 16 and 12 per cent., the first perceptible signs of anoxemia* develop. . . . When the oxygen is diminished to values between 14 and 9 per cent. the higher centres of the brain are affected.

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

REPORT ON THE HORSESHOE MANGANESE DEPOSIT.

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

I have the honour to submit for the information of the Council of Industrial Development the results of my sampling of the southern series of the two Manganese deposits situated at Horseshoe, in the Peak Hill Goldfield. Unfortunately the original intention of sampling both deposits was not adhered to, the men sinking the sample holes being paid off even before all the necessary holes had been completed on the southern series.

Locality and Communication.—The Horsehoe Manganese deposits are situated about 16 miles by road north-west from Peak Hill townsite, 85 miles by rail north of Meekatharra, and 16 miles north-east, in a direct line, from Mount Fraser.

Geology.—Both deposits occur in Pre-Cambrian sediments. These old beds have, in the vicinity of Horseshoe, a strike varying from north 25-45 degrees east, with a very steep dip to the north-west. The beds have been subjected to considerable stresses and chemical alterations, which have produced folding, variations in depth, and probably shearing or crushing along lines, which strike more or less east and west across the general strike.

*Lack of sufficient oxygen in the blood.

The beds consist essentially of argillaceous material so altered at the surface to preclude a definite classification. Other beds are highly siliceous and occur as quartzites. These beds were probably laid down originally as sandstone.

Quartz veins are not uncommon, and lenses of manganese, iron ores, and mixtures of both are quite frequent and may be seen outcropping at irregular intervals for considerable distances. Similar occurrences have been noted at Mount Fraser in the Teano Ranges and in lesser quantities in many of the beds of this series.

Manganese Deposits.—In dealing with the genesis of the manganese deposits Mr. Montgomery writes as follows:—

One cannot be very certain of a theory of the formation of these deposits until they have been cut into by mining work so as to give good sections for examination, but at present the most likely explanation appears to be that the ore-bodies follow the general line of some sort of a fracture of the country across its stratification, along which strong lode-forming action has gone on with alteration of the rock to more or less pure oxide of manganese, and in some places to brown oxide of iron. Towards the west end there were possibly several such lines of fracture and mineralisation. From these lode-like bodies there has later on been a great deal of superficial depositions of manganese ore forming thick sheets of secondary manganese over what was the surface of the ground at the time of their formation. The deposits could therefore be regarded as a general crust of manganese oxide over the areas shown on the map, with an unknown number of veins going down into the ground below the crust, and doubtless carrying manganese oxide to some considerable depth.

The main part of the deposit, however, gives the impression of being a superficial deposit, probably formed similarly to some of the lateritic iron ores. It is very dense, clean, black oxide of manganese, and in places shows a brecciated structure, especially along the edges of the portions of the ore body which show lode characteristics.

The sample holes recently sunk on the southern series, and which were not seen by Mr. Montgomery, throw considerable light on the origin, and in my opinion have proved without much doubt that there has been a higher concentration of the mineral contents of the original sediments in a series of parallel lenses where they cross an east and west crushed or shear zone, and that the outcrops of these lenses subsequently, on weathering, produced talus, which on spreading over the surface became partly recemented by circulating solutions and partly, possibly, by laterisation.

The main evidences in support of the above, which the sample holes have exposed, are the following:—

a. High-grade manganese ore gradually changing to one in which iron predominates. This is typical of managanese lodes.

b. High-grade manganese ore suddenly cutting out and found lying on barren schist—signifying that the ore has rolled over from a rich outcrop to cover barren ground.

c. Boulders of rich and low-grade ore mixed and lying on barren ground—a mixture of the talus from two lenses. On one occasion the boulders (60C) were rounded and worn down to a comparatively uniform size appoximating that of a cricket ball.

d. Layers of waste rock are frequently found in the deposit and fine earthy waste separating boulders of ore is extremely common.

e. Some of the sample holes continued in more or less solid ore for over 20 feet, low-grade ferro-manganese ore still remaining in the bottom of the hole, indicative of a lens or lode. In other holes the ore cut completely out at depths of a few inches with no sign of lode material below.

f. Bands of low-grade ore are occasionally found overlying ore of much higher grade, the latter resting on barren ground—distinct evidence of talus action.

The evidence in favour of an east and west shear zone is the undoubted local enrichment in both deposits, the unusual extent of the deposits, and the general layout of the ore bodies.

Numerous lenses of ore can be found by following along the strike of the country, but there are so few deposits of any extent that the concentration must be due to some local cause. Furthermore, where the underlying rock is exposed, as in the cutting for the ore bins, there is distinct evidence of crushing and folding.

From a commercial point of view the chief factor to be considered is the irregular nature of the manganese values, which naturally infers difficulties in sampling, in higher costs for recovering and in grading the ore, and reduction in tonnage.

Sampling.—On my first visit to the Horseshoe I found that the whole of the southern deposit had been laid out by the company's surveyor into chain squares, and that several sample holes had already been sunk at irregular intervals, also that Mr. Elliot was conducting a sampling campaign for the Broken Hill Proprietary. By mutual consent we arranged that the subsequent shafts should be sunk in some order, and as far as possible at definite intervals. It was also agreed on that all holes should be continued until country rock or low-grade ferro-manganese ore was reached, and in the latter case drill holes should be pushed down further into the bottoms to avoid any possibility of misjudgment.

As Mr. Elliot was doing his field analyses from day to day, his results were most helpful in determining when to cease sinking. Unfortunately some of the holes were not completed and holes are still lacking on part of sections 60, 59, 68, and 73 and the eastern section of the deposit lying to the east of section 102. The surface indications of this narrow portion of the deposit are not at all encouraging, and except for a limited tonnage at the extreme eastern end there does not appear to be much ore of considerable value.

Generally speaking my samples were broken in three-foot sections and from the opposite sides sampled by Mr. Elliot with the object of obtaining a closer average value. A slight difference in depth of the trial holes is due to the slope of the hill on which the excavations have been made. This will account, no doubt, largely for minor discrepancies between individual samples. The average for any particular hole, however, will be found to correspond quite closely enough for all practical purposes. In breaking the samples any obvious waste or low-grade ore was not touched but recorded as closely as possible as waste, either by measurement in the holes themselves or the proportions as dumped at the surface. The foreman helped us much in this respect by instructing the miners during shaft sinking to separate the ore, both in filling the buckets and dumping.

It is obvious, however, that the estimates of waste are approximate but should be within, say, 5 to 8 per cent. of the true value.

Estimation of Ore Reserves.—As far as possible the ore has been graded into groups where the predominating manganese values are over 50 per cent., under 50 per cent. and over 45 per cent., and under 45 per cent. and over 40 per cent. Ore below 40 per cent. has not been estimated for reasons which will be explained later.

The areas embracing these grades of ore were calculated with a planimeter and the analyses reduced to foot values.

One ton was allowed for every 10 cubic feet of unbroken ore. This may appear low, but judging from the way the ore breaks on firing, considerable waste must be incurred. In working out the gross tonnages, allowance has been made for the percentage of waste.

The boundaries of the various groups must be considered as more or less tentative, but in the aggregate the tonnages called for should work out satisfactorily. It must be realised, however, that there is no hard and fast line of demarcation in values in any portion of the deposit or in any of the groups. One group, however, will probably support the other when the ore is broken and graded.

Ore containing less than 40 per cent. manganese has not been estimated for the following reasons. This class of ore is as far as can be seen very variable in depth, waste and quality; and a considerable further number of sample holes would be necessary and many of the present holes would require sinking further before even an approximate estimate of the tonnage of ore of that grade could be made. I do not consider there is any probability of exporting ore of this grade, for it is too high in manganese for a ferro-manganese ore and too low in manganese-contents to be classed as a manganese ore. Furthermore, the lower the grade of manganese apparently the more mixed with waste becomes the ore, which would undoubtedly increase the mining costs.

A reference to the plan attached shows clearly that the higher grade ore extends from section 101 westward through the deposit, the area (2) occurring in sections 82, 87, 93 and 101 containing the highest values.

A smaller area (3) contains equally high values with corresponding values buried below much lower values in area (II.). On the flanks of the cut forming the bins in section 26 a small amount of high-grade ore has been developed, but the tonnage is so limited that it has no bearing on a general scheme of expenditure.

Of the second grade (45 to 50 per cent.) the estimates of areas (5) and (7) are fairly certain, but there is a doubt as regards area (8) on account of the lack of at least two or more sampling shafts; which, unfortunately, though marked on the ground, were not started. The tonnage estimated for this area has been based on the holes in 58A and 81C which for safety sake was then reduced 30 per cent., pending a completion of the necessary sampling.

Of the third grade there is not much necessity for comment. The tonnage is not great in any area and the waste is much greater than in the higher grade ores, making this grade very doubtful as to its commercial value.

With regard to the outside areas containing ore under 40 per cent. manganese sufficient has already been written—such ore may be treated for the present as valueless. I concur with Mr. Montgomery in his estimates of the ore east of section 101, and regard that portion of the deposit as practically worthless, except in the extreme eastern end where there may be some 15,000 tons of fairly high-grade ore. As no holes were put down in this section I prefer not to quote figures either as to values or quantities.

The following is the estimation of ore reserves worked out as the result of the sampling:—

Grade.	Area.	Tons.	Mn.	MnO_2.	Fe.	SiO_2.	Waste.	Averages.					
								Tons.	Mn.	MnO_2.	Fe.	SiO_2.	Waste.
Over 50 %	1	450	51·13	73·37	8·94	0·35	5	81,000	50·7	73·3	6·3	0·98	12·3
	2	67,243	50·90	73·10	6·1	0·97	12	...	...	...	...	...	...
	3	12,248	51·08	74·7	7·54	1·9	14	...	...	...	...	...	...
	4	800	50·77	...	...	...	25	...	...	...	...	...	...
45% to 50%	5	20,644	48·08	71·9	8·4	1·11	10	55,000	46·4	69·8	9·7	1·4	15·2
	6	2,937	47·00	71·5	10·6	1·42	*nil*	...	...	...	...	...	...
	7	31,605	45·00	68·0	10·5	1·6	20	...	...	...	...	...	...
	8*	28,000	45·1	67·0	9·0	1·5	20	28,000	45·1	67·0	9·0	1·5	20·0
40% to 45%	9	15,253	39·3	...	22·01	2·5	30	66,000	42·0	...	14·4	2·4	34·5
	10	20,000	41·6	...	18·9	3·6	50	...	...	...	...	...	...
	11	31,000	43·4	...	7·65	1·5	33	...	...	...	...	...	...

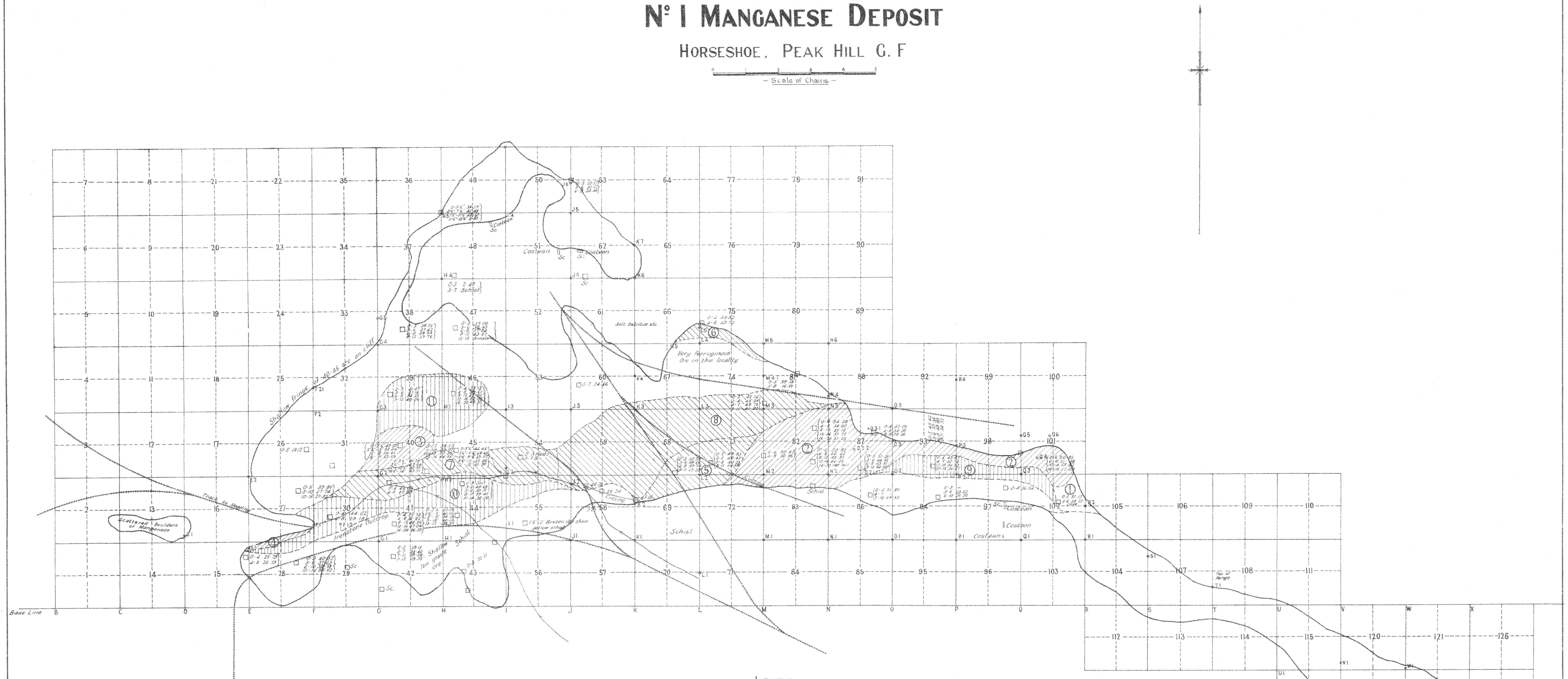
* Owing to the incomplete sampling of this area the tonnages quoted must be regarded only as probable ore.

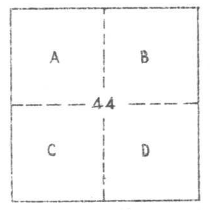
Marketing and Market Prices of Manganese Ore.—There are two distinct classes of marketable manganese ore—Chemical and Metallurgical. Unfortunately there is no very definite standard for either class, variations in specifications occurring from time to time to meet the requirements of supply and demand.

Generally speaking chemical ore is used only in the manufacture of oxygen, chlorine, bromine, and disinfectants; as a decolouriser of glass, in calico printing and dyeing; in colouring glass, pottery and brick; as a drier in paints and paint pigments; as a depolariser in dry batteries, and in the manufacture of drugs and chemicals.

Nº I Manganese Deposit

Horseshoe, Peak Hill G. F





Key for Subdivision of Large Squares

Legend

Over 50% Mn	(diagonal hatching)
45-50% Mn	(reverse diagonal hatching)
40-45% Mn	(vertical hatching)
Under 40% Mn	(blank)

Estimated Tonnages and Values

%	Area	Tons	Mn	MnO_2	Fe	SiO_2	Waste	Average Total Tonnages: Tons	Mn	MnO_2	Fe	SiO_2	Waste
Over 50	1	450	51·13	73·37	8·94	0·35	5	81,000	50·7	73·3	6·3	0·98	12·3
	2	67,243	50·90	73·10	6·10	0·97	12						
	3	12,248	51·08	74·7	7·54	1·9	14						
	4	800	50·77	–	–	–	25						
45-50	5	20,644	48·08	71·9	8·40	1·11	10	55,000	46·4	69·8	9·7	1·4	15·2
	6	2,937	47·00	71·5	10·60	1·42	Nil						
	7	31,605	45·00	68·0	10·50	1·60	20						
	8	28,058	45·10	67·0	9·0	1·50	20	28,058	45·1	67·0	9·0	1·5	20
40-45	9	15,253	39·30		22·01	2·50	30	66,000	42·0		14·4	2·4	34·5
	10	20,000	41·60		18·90	3·60	50						
	11	31,000	43·40		7·65	1·50	33						

The chief qualifications for chemical manganese is an ore containing a high percentage of oxygen and not more than one per cent. of iron. A low percentage of lime is also necessary.

Ore high in lime, low in oxygen, phosphorus and silica is classed as furnace or metallurgical ore, provided the manganese content is capable of producing 80 per cent. ferro-manganese.

The following specifications from various buyers have been kindly supplied to me by the Secretary of the W.A. Manganese Company:—

Keely & Tennant, Jersey City—

First Grade:

MnO_2—87 per cent. or better.

Fe_2O_3—under 1 per cent.

Copper—under 1 per cent.

Second Grade:

MnO_2—75 per cent.

Fe_2O_5—2 per cent.

Copper—0.05 per cent.

Harshun, Fuller & Godwin—

MnO_2—85 per cent.

Iron—under 1 per cent.

This firm is buying Caucasian ore of 87 per cent. MnO_2 and 0.58 per cent. Iron.

Metal & Thermit Corporation—

Manganese—56 per cent.

Iron—1 per cent. (max.).

Silica—1 to 1.4 per cent.

Phosphorus—0.02.

Sulphur—0.02.

Copper and other metals—nil.

Foote Mineral Company—

MnO_2—85.88.

Iron—1.25.

Copper—0.03.

Writing in 1925 Spurr and Wormser * state that specifications for dioxide or chemical ore were formerly 80 to 90 per cent. MnO_2 but much ore has been used running as low as 70 per cent. MnO_2, iron should be under 2 per cent., copper not exceed 0.02 per cent., and cobalt, nickel and arsenic should not be present in appreciable quantities.

Applying these specifications to the highest grade ore at Horseshoe it is evident that though the chief constituent MnO_2 is on the low side it still could be considered as chemical ore of a sort if it were not for the excessive percentage of iron, which is far above the limit set down in any specification. Chemical ore at Horseshoe must therefore be regarded as non-existent unless the Company can obtain a definite quote from some firm who may see fit to use it for a special purpose.

With regard to quotations for Metallurgical ore there appears to be as much variety in the specifications as for Chemical. Spurr and Wormser state that in England and Germany the common basis is 50 per cent. Manganese at so much per unit, with a small bonus or penalty for each unit above or below standard, a maximum of 8.9 per cent. silica and 0.20 or 0.15 per cent. phosphorus. A specification furnished me by the Secretary for the Company for Metallic ore requires—

Manganese—48.50 per cent.

Silica—8.00 per cent. or under.

Iron—7.00 per cent. or under.

Phosphorus—0.16 per cent. or under.

*The Marketing of Metals and Minerals. By Josiah Edward Spurr (Editor Eng. & Min. Journal) and Felix Edgar Wormser (Assist. Editor Eng. and Min. Journal).

In order to ascertain the percentage of phosphorus, four average samples of the higher grade ore were analysed with satisfactory results, all of which were below the above specification. As the iron contents are about correct and the silica much below standard, the two higher grades of Horseshoe ore should be readily marketable at current rates, which at present are ruling at about 1s. 2d. per unit C.I.F. England. I am afraid that the lower grade and ore under 40 per cent. manganese are too rich in iron to be marketable except under some possible special contract. With regard to this statement it may be quoted that the Broken Hill Proprietary are shipping low-grade ferro-manganese ore to America from Iron Knob. This is correct, but the ore is particularly free from impurities and is being put on boats for a very few shillings per ton; so the comparison cannot be regarded as a parallel case.

Cost of Mining and Transport.

Mining.—With few exceptions the deposit has been proved to be irregular and containing variable quantities of waste and low-grade ore which would necessitate sorting and extra transport. The fractured nature of the deposit is also detrimental to cheap mining, as it was found to be impracticable to drill holes of any considerable depth. Light charges would be necessary so as not to break up the ore, otherwise there would be likelihood of considerable loss incurred by the fines mixing with the waste. A considerable amount of spalding would be necessary, which would also increase the cost. The ore as a rule bores quickly, though difficulty in this respect was experienced in some of the holes. Taking all these factors into consideration the average costs of mining the deposit would not be so low as might appear at first, and I should place them at not less than 6s. or 7s. per ton for the ore landed on trucks at the mine and allowing for the removal of the waste.

Transport.—I have no definite opinion as to what the cost of railing from the mine to Meekatharra would amount to per ton, and can only assume a cost proportional to distance and cost per mile quoted by the Government from Meekatharra to Geraldton, which works out roughly at 5s. per ton.

Handling Charges at Geraldton.—The Company's figures for this item were four shillings with a suggestion that if there are sufficient bins the charge can be reduced to 2s. per ton—say 3s.

Freight (Ocean).—Company's figure is 25s.

To these must be added overhead charges, etc., which I am not prepared to estimate.

The costs are probably, therefore, as follows:—

	£	s.	d.
Mining at Horseshoe	0	6	6
Railway freights to Meekatharra ..	0	5	0
Railway freights, Meekatharra to Geraldton	1	0	0
Charges at Geraldton (average) ..	0	3	0
Ocean freight	1	5	0
	2	19	6

The above makes no allowance for charges at Meekatharra, interest, insurance, commission on sales, which will no doubt bring the total to well over £3 per ton.

Conclusions.—The sampling of the southern deposit has proved:—

1. That there is no chemical ore—the iron contents being far too high to comply with any recognised specifications.
2. Of metallurgical ore there is at least 81,000 tons containing 50.7 per cent. manganese with a possible 10-15,000 tons of the same grade at the eastern end of the deposit, which has not been sampled. The iron content of this grade is below specifications.
3. Of the second grade 45-50 per cent. manganese there are 83,000 tons but the iron content is on the high side.
4. Ore of the lower grades contains too much iron to conform to specifications, though no doubt some of this class of ore could be sold at a reduced price as low-grade ore.
5. With the exception of iron contents the ore as a whole is free from penalisable impurities, the amount of silica being particularly low.
6. With the ruling price per unit at 1s. 2d. C.I.F. London and the costs of production and transport as quoted, the best grade would not cover costs, so until the market firms considerably or the company can put up some fresh and positive evidence which may alter the existing conditions, I cannot recommend any capital expenditure for the erection of ore bins, etc., at Geraldton or in any other direction.

Before closing my report I would like to express my sincere thanks for the help and courtesy shown me, both by the representatives and staff of the Manganese Company and to Mr. Elliot of the Broken Hill Proprietary.

REPORT ON THE OCCURRENCE OF BITUMINOUS MATERIAL WHICH MR. HASSELL COLLECTED ON CHEYNE BEACH AND FORWARDED FOR IDENTIFICATION.

T. Blatchford, B.A.

In accordance with your instructions I visited Cheyne Beach in the company of Mr. H. Hassell and collected a second sample of the bituminous material which he had reported.

Locality.—The bitumen occurred in two localities:

(1) On the beach lying west of Warriup Creek.

(2) At a spot some three miles to the east of the first locality and close to the mouth of Cordanup Creek.

The material was only found in small flat pieces from the size of a sixpenny silver piece to mere grains. The pieces were irregularly scattered over quite a considerable length of beach, 400 to 500 yards, and from the water's edge to well up the sides of the sand dunes where it had, no doubt, been deposited by the waves and winds during rough weather.

Mr. Hassell's statements about the occurrence are as follows:—

1. That although he has been a frequenter of the beach for many years, neither he nor any of his employees had noticed the bituminous material under review before the month of November, 1927.

2. That both Mr. R. C. Wilson, A.S.M.E., and Mr. Le Mesurier had a few months previously passed over the beach near the entrance to Warriup Creek and neither had observed the occurrence, though it was in abundance when he first found it a few months afterwards.

3. That in his opinion it is therefore a quite recent occurrence, and in no way connected with the ordinary bituminous jetsam, so commonly reported along the coast.

4. He considers that it was not derived from sources where mineral oil might have been used, such as for windmills, garages, motors, etc.

5. That according to his observations it is only found in the two localities referred to, and that it is in greater abundance during heavy easterly weather.

Geology.—The geological features of the country in the vicinity of Cheyne Beach are comparatively of a simple character. There are two classes and two ages of rocks—Pre-Cambrian granites or gneisses and sedimentary beds of Miocene age. The granites and gneisses commence immediately north of Warriup Creek and Green Range and extend far away to the north. A narrow belt of granite is also exposed along the coast between Lookout Point and Albany.

A considerable development of Miocene Beds lies between the two granite areas and follows up the valley of the Kalgan River as far north-west as Kendenup.

Further afield the Miocene beds have been located at Tambalup, Ongerup, and as far north as Norseman. Extensive areas of Miocene beds are also found in the Fitzgerald River Valley, and they also form a strip of country, some few miles wide, lying immediately to the north of the Barren Ranges. These beds have so far not been accurately surveyed.*

There is no doubt that the Miocene beds were laid down in a comparatively shallow ocean (fossil sponges abound in some of the beds), the floor of which has since risen. The highest point at which the beds have been recorded is in the vicinity of St. Ives, which has an elevation of well over 1,000 feet above sea level.

As the basal beds of the Miocene series are exposed at sea level, there is no doubt that the deposit was originally at least 1,000 feet in thickness, probably much more. Probably the greatest thickness on the land surface will be found in the Fitzgerald Brown Coal series, which is no doubt a sunken field of Miocene strata, similar in occurrence to those at Collie and Wilga. Whether the Miocene beds extend past the coast line to the south and cover the Continental Shelf, which is some 30-35 miles wide, is difficult to decide. Within the above limits it is noteworthy that the soundings are very uniform with a variation only of a few fathoms, which rather points to the absence of extensive denudation and suggests the possibility that the beds were faulted down and failed to rise above sea level.

Further to the south of the 35-mile limit the soundings suddenly rise to 1,500-2,000 fathoms.

Following on the theory that a section of the beds had been faulted and that the bitumen was a seepage, I requested Dr. Simpson to investigate whether there could be any genetic connection between the oil extracts from the Fitzgerald brown coal and the bitumen. He could find none, so this source for the

*The mapping of the south coast ceased on the death of H. P. Woodward in the year 1917.

bitumen is not very hopeful, and the old idea that the flotsams are carried by ocean currents on to the coast will have to stand for the present and for this particular case also.

I still consider, however, that the bitumen was not derived from oil spilt from ships' engines, etc., but has come from a natural seepage.

Attached is a copy of the Government Analyst's report.

Lab. No. 1695.

The Sample, which was said to come from Cheyne Beach, consisted of rounded fragments of black material slightly plastic in consistency. Microscopic examination showed the masses to be porous, and associated with clean quartz sand. The presence of fibrous matter or vegetable cells could not be detected.

The sample when freed from adhering sand floated on water.

Solubility: The sample was completely soluble in carbon bisulphide and turpentine, but only partially soluble in petroleum spirit.

A separation by solvents was as follows:—

	Per cent.
Soluble in petroleum spirit	70.2
Residue soluble in carbon bisulphide ..	22.5
Carbonaceous matter	.3
Mineral matter	6.3
Water	.7
	100.0

The petroleum spirit soluble portion consisted of a dark brown wax with melting point of 72°C.

The carbon bisulphide portion consisted of a black lustreless bitumen with no definite melting point, but softening at 95° approximately.

The mineral matter consisted of sand grains and iron oxide, representing 4.6 per cent. and .80 per cent. respectively of the total, together with traces of calcium, magnesium and sodium.

Ultimate Analysis:

	Per cent
Carbon	77.8
Hydrogen	12.5
Nitrogen	.2
Sulphur	.7
Ash	6.3
Moisture	.7
Oxygen (by difference)	1.8
	100.0

Calculated to the N, S, ash, moisture and O free sample, this represents a hydrocarbon, or more probably a mixture of hydrocarbons, containing C 86.2 per cent.; H 13.8 per cent., approximating to the general formula CnH_2n, which, according to R. Heger, most closely represents the composition of Ozokerite.

The percentage composition of Ozokerite is given as C, 85.7 per cent.; H, 14.3 per cent.

There is no indication that this material has any relationship to the Fitzgerald River brown coal. It appears to be an inspissated petroleum, but whether the removal of the light oils was effected by nature, in which case this material is a crude ozokerite, or by human agency, it is impossible to say.

(Sgd.) EDWARD SIMPSON,
Government Mineralogist and Analyst.

GEOPHYSICAL PROSPECTING AT NORTHAMPTON BY THE ELECTRICAL METHOD.

The Geophysical Research party, under the leadership of Mr. J. C. Ferguson, arrived in Northampton about the middle of the month of June. When they had become established on the Wheal Ellen Mine, I joined the party for a few days to discuss the geological side with Mr. Ferguson and to inspect several other areas in the northern end of the field, which must also prove favourable for investigation. Samples of the waters, etc., were also collected for analysis.

In July arrangements had been made for Dr. Bieler and Professor Rankine to join issue and discuss the problems at Northampton on the ground with Mr. Ferguson.

Unfortunately, Dr Bieler, on his way to Northampton, became seriously ill and after a very short illness passed away in the Geraldton Hospital. In addition to the loss to his friends and fellow officers, by whom he was held in the highest respect, Dr. Bieler's untimely end was a serious loss to the Geophysical Research in Australia and to the scientific world in general.

Professor Rankine continued his journey and joined the party for a few days during the latter days of the month.

At this time the party had completed the survey of the Wheal Ellen Mine and had commenced that of the Baddera. The survey of this and the Mary Spring, South Geraldine, and Block 7 mines has since been completed and a full report of the results from Mr. Broughton Edge, the Director of the Survey in Australia, is expected shortly.

BREN'S AND LIDSTER'S REPORTED TIN LODES, 9 MILES SOUTH-EAST OF MOUNT DOCKEREL.

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

An inspection of this area was made on account of several samples being sent in and which contained either tin or tantalite or both.

Locality: Most of the samples were labelled as coming from the north-eastern end of Cummins Range. As the position of the Cummins Range is not correct on the Lands map, the locality had best be referred to as Mt. Dockerell, which is a definite and fixed landmark. The workings, as shown me by B. Essan, whom I fortunately met in the locality, are situated on the head of the Willy Willy Creek, but a short distance down from the watershed, which separates these waters from those of Wolf Creek. There were no prospectors on the ground, Brens having employment on the Margaret Downs Station and Shaw was working a rich leader some ten miles distant.

Geology.—The rocks in the area and for some miles around consist of the group originally named by E. T. Hardman "Metamorphics." These metamorphics may be best described as a very old formation of sedimentary rocks and lavas, which have been subjected to much stress and chemical alterations. They represent some of, if not, the oldest rocks of the State and comprise mica schists, phylites, etc., crossed and recrossed by more recent intrusive basic dykes and pegmatites.

This belt of metamorphic rocks extends as a fringe around the Kimberley plateau, ending at Yampi Sound, on the western extremity and is the mineral belt of the Kimberleys.

Bren's Find.—I do not think there is any doubt that the prospectors found small quantities of stream tin and tantalite in some of the narrow gullies, joining the upper course of the Willy Willy Creek, but as these courses are invariably narrow, there would be no hope of locating a large deposit of alluvial.

With regard to the reported lodes, there is no doubt that a confusion arose and what was considered tin, was really a much altered tourmaline. This tourmaline occurs plentifully in many of the pegmatites, and it is highly probable that the small amount of stream tin and tantalite have been derived from this source. I broke a sample from one of the pegmatites, which had been exposed by the prospectors, but with negative results as regards both tin and tantalite.

The position may be summed up as a genuine mistake on the prospectors' part, much exaggerated by outside speculation.

BORING FOR MINERAL OIL AT POOLE RANGE.

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

The state of the bore at Poole Range in October, 1928, is set out on page 5, G.S.W.A., A.R. 1928. Oil was struck at a depth of 2,085 feet, but the hole became flooded with water to within 127 feet of the surface. The hole was then filled with clay and temporarily closed pending arrangements being effected to cement off the water.

On my arrival at the bore on 10th September, 1929, the mud had been cleaned out to a depth of 2,078 feet, *i.e.,* seven feet above the level of the oil sands.

A cement bridge 10 feet thick was then put in on top of the mud and a six-inch casing lowered to the top of this cement and cement pumped in around the casing from the surface until the pressure rose to 300 lbs. to the square inch.

The cement was allowed to remain setting for a period of one month. After my arrival the water was gradually lowered in the casing by baling until it was proved to the satisfaction of all present that the casing was water-tight.

A hole was then carefully bored through the cement bridge until the clay was reached and still there was no water. On continuing the boring in the mud, water very suddenly broke in and rose to a height of 242 feet below the surface, or 115 feet below the original level. The water would obviously have come from three sources:—

(a) Top waters due to the cement behind the casing failing.
(b) From the oil sands.
(c) From below the oil sands.

Top Waters.—It appeared highly improbable that the water was top water for it was not likely that the cement behind the casing would fail. The fact that the water did not reach the original level also points strongly to this conclusion.

Oil Sand Water.—There is little doubt from the evidence that the oil sands were flooded and that the water was held in balance by the open top waters, *i.e.,* before cementing, when the pressure was removed the water in the oil sands would, under normal conditions, flow back into the hole, and particularly if there was any gas pressure behind them.

Bottom Water.—Had the flow been from strata below the oil sands it would be natural to suppose that the mud would have been driven up the hole.

The evidence, to my mind, is in favour of the water coming back from the flooded oil sands.

Bailing under normal conditions made no impression on the water in the bore, and as Mr. Fox objected to "swabbing" it was agreed to continue bailing until the gear for a pump could be assembled. Pending these arrangements I left the bore on 15th September, intending to return later after the pump had been installed.

After my departure swabbing was tried and as no impression was made on the level of the water, it was decided to cement the hole up from the bottom, abandon the oil sands at the 2,085 feet level, and carry on with a five-inch hole and look for a lower horizon.

From a State point of view what must now be watched is whether the cement holds or not, for in my opinion, boring in a wet hole, except under special conditions, should not be allowed. From personal conversation with Dr Woolnough I know he was of the same opinion, and I refer you to his written statement reading thus:—

> The risk of flooding of the entire field is too great and oil legislation in every part of the world is most drastic in this connection.

BORING FOR COAL IN THE VICINITY OF NANNUP.

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

Introduction.—For many years past various attempts have been made by different parties to locate by boring payable coal seams in the extreme southwestern corner of our State. Details of this boring may be found either in an extract of the Mining Handbook, by A. Gibb Maitland, Bulletin 65 (G.S. W.A.), by H. P. Woodward, or in an article by R. C. Wilson on oil prospecting in the area under consideration, which appears in the Annual Report of the Mines Department for the year 1921. For the present purpose it will not be necessary to recapitulate all the details set out in these reports, though a summary of the more important results will be necessary.

The present inspection has arisen from the fact that a fresh party have reported finding coal in a bore near Bibilup Siding on the Wonnerup-Nannup Railway Line.

Geology.—The main structural features of the area in question are twofold, and comprise a depressed valley or sunkland bounded by the Darling scarp fault on the east and probably a second fault lying immediately to the east of an exposed granite ridge extending from Cape Naturaliste on the north to Cape Leeuwin on the south (*).

The strata lying in the sunkland consist of shallow surface sandy deposits or laterites which overlie beds of sandstones, grits, shales, coal and lignite seams, and possibly conglomerates. Basalt has also been found in several places and probably represents a sill or buried lava flow. Geologically the age of these deposits is considered by most observers to be Carboniferous or Permo Carboniferous, corresponding to that of the Irwin River, Collie and Wilga Coal Fields. If the main structural feature of the coastal plain be considered, it seems highly probable that the beds are a continuation of the Irwin River series, the Collie and Wilga areas being minor and detached sunklands of the same formation.

*By expressing the idea of a second fault I find I am not in accord with previous writers, who no doubt based their opinion on the assumption that Nos. 5 and 6 Busselton bores bottomed on gneiss or granite. That this is so is not at all conclusive, for in No. 5 bore, gneiss was passed through and red granite struck, which points more to the nature of a conglomerate, also in No. 1 bore, Venn's Estate, gneiss was passed through into sandstone, the gneiss being undoubtedly a boulder. Furthermore, if the boundary line between the western granite and the sediments be continued to the north, it is in fair alignment with the edge of the continental shelf (*vide* Admiralty Chart).

Coal Deposits previously located in the District.

Fly Brook and Warren River (*South-Eastern corner*):

A number of bores were put down at Fly Brook, the deepest of which was 128 feet. This particular bore passed through 17 seams of coal aggregating 20 feet in thickness. The largest seam was 5 feet 4 inches in thickness, but had a 6 inch clay parting; the next largest seam was 2 feet 4 inches with a 3 inch parting. Compared with Collie and New South Wales coals, the following analysis shows the Fly Brook coal to be very like Collieburn Collie coal:—

——	Fly Brook.	Collieburn.	Collie Prop.	N.S.W.
Water	14·51	13·81	12·39	2·22
Volatile Matter ...	37·89	36·16	26·79	29·94
Fixed Carbon ...	44·89	45·19	52·01	58·99
Ash	2·71	4·84	8·81	8· 85

At the Warren River, No. 3 Bore attained a depth of 1,700 feet, the first 500 feet of strata corresponding with the Fly Brook measures, though the coal seams were insignificant.

From 500 to 1,700 feet most of the rock passed through was detrital granitic material, the bore evidently being too close to the scarp fault to disclose the true nature of the lower strata.

Busselton District:

Six bores were sunk in the vicinity of the Vasse River, a few miles south of Busselton, to depths varying from 144 to 653 feet. Although 25 coal seams were passed through, no seams of a payable nature were discovered, the greatest thickness of any seam was 3ft. 6in. No records of any analyses are procurable.

Donnybrook:

Several seams of low grade coal were struck in the old shafts worked originally for gold, but none of the coals were of a quality fit for commercial use. The following are the results of some analyses taken by the staff of the Geological Survey from P.A. 155H.

——	1.	2.	3.	4.
Moisture	26·95	31·34	31·28	35·00
Volatile Hydrocarbons	25·46	28·43	31·57	28·60
Fixed Carbon ...	21·98	24·37	26·12	24·70
Ash	25·61	15·86	11·03	11·70
Calorific value ...	5710	6315	6928	6429

And a sample of a seam 5 feet in thickness taken from a depth of 73 feet in Murphy's Shaft:—

No. 1. Moisture 36.28 parts per 100.
Volatile Hydrocarbons 21.67
Fixed Carbon 22.60.
Ash 13.50.
Calorific vaue 6072.

Jarrahwood.—Coal was discovered here on P.A. 8627 near the crossing of the Wonnerup-Nannup railway line. Several seams of a coaly nature were reported but proved to be of too low a grade to be of any importance.

Coal has also been reported from the Preston River, a few miles from Bunbury, and at Alexandra Bridge, and six miles north of Longbottom Farm, on the Blackwood River. From the second locality I was able to collect a sample of coal which was lying scattered over the sandy bottom of the river, the result of which is attached.

Recent Developments in the vicinity of Bibilup.—In the vicinity of Bibilup a series of five hand bores have been sunk well within the sedimentary area and in one bore a seam of coal of a thickness of 7 feet 6 inches has been reported. Furthermore a sample of this seam which occurs in No. 4 Bore at a depth of 165 feet to 172 feet 6 inches has been very favourably commented on by the Government Mineralogist and Analyst, who states that the sample is "a valuable coal if there is any quantity of it available." The following is the result of the analysis:—

	Per cent.
Moisture	12.87
Volatile hydrocarbons	37.75
Fixed carbon	43.84
Ash	5.54
	100.00

Unfortunately, as is almost the invariable experience with handboring, a very small sample of the coal was recovered, and the syndicate financing the original boring now desires to test the discovery with a calyx drill on £ for £ basis.

A fair summary of the possibilities and probabilities of finding coal at Bibilup appear to be as follows:—

1. The area in which the boring is suggested is undoubtedly a coal bearing zone, probably of the same age as the Irwin River and Collie Fields.
2. Coal of varying qualities has been found throughout this area, but up to date no payable seam has been discovered, though the quality at Fly Brook was equal to that of the Collieburn seam.
3. The sample of coal produced by the syndicate as coming from their bore No. 4 at a depth of 165 feet equals that of a good Collie coal.

4. The syndicate are desirous of prospecting to depths beyond those which they can reach with a hand-boring plant, and are prepared to pay £ for £ of total cost of boring to a depth of 750 feet.

5. It is evident that the syndicate are prepared to support the work already done by putting up substantial money to do further testing both of the seams which their borer has found and also to endeavour to locate deeper seams.

Provided the work of boring is carried out with a Calyx drill and a reliable foreman, and the syndicate pay half the cost, my opinion is that as there is quite a reasonable chance of finding payable seams, boring under these conditions is justifiable and I recommend accordingly.

THE PRE-CAMBRIAN AREAS OF WESTERN AUSTRALIA.

Introductory.—At the Geological Conference held in Adelaide during the month of May, 1928, it was decided that individual members representing the various States be requested to supply a map showing the areas occupied by the Pre-Cambrian rocks in his State.

By mutual consent Professor E. deC. Clarke and the writer undertook to supply a paper and map as applied to the Western Australian section.

As Professor Clarke had previously written a short paper on the same subject he kindly consented to write the fuller report, hereunder, with slight alterations and additions, resulting from mutual collaboration.

We are both indebted to Miss F. Armstrong for the active part she took in the compilation of the map.

T. BLATCHFORD, B.A.,
Government Geologist.

PRE-CAMBRIAN IN WESTERN AUSTRALIA.

The supposedly Pre-Cambrian rocks of Western Australia cover about one-third of the State, and because they yield most of our mineral wealth, have been more closely studied than any other group of rocks. But the areas studied are separated by wide spaces, the geology of which is known only in a general way, and since palæontological help is as yet lacking, correlation of the various types of rocks found in one district with those found in another is very difficult.

Some attempt at such correlation, resulting in the division of the Pre-Cambrian into 5 Series, was made in 1923.* The following statement is partly an abbreviation of this very condensed paper but contains several notable modifications.

The Yilgarn Series.—At various places in the Yilgarn Goldfield (of which Southern Cross is the best known centre), *e.g.*, Westonia, Parker Range, Marvel Loch, are chiastolite and andalusite rocks, quartzites and crushed quartz conglomerates, which Blatchford and Honman consider to be the oldest rocks of the Yilgarn Goldfield,† being invaded by "greenstones." The "greenstones" are in turn invaded by granite. In many other parts of the *State lying south of the latitude of Shark's Bay*, occur metamorphic rocks, which in some cases are certainly, in other doubtfully of sedimentary parentage and with which other metamorphic rocks make igneous contact. Examples of such occurrences are:—

(a) The Phillips River District,‡ where are found greatly folded and contorted rocks, mainly mica schists and the such-like, "pelites," which Blatchford, Montgomery and MacLaren regard as older than the greenstones and which are metalliferous. Apparently, overlying these "pelitic" rocks is a large succession of quartzites, quartz schists, and similar rocks. As the relation of these two facies has not yet been made out, we have distinguished the sandy phase under the name of the Mt. Barren-Stirling Range Series. This series extends east and west through the Barrens, in one of which (West Mt. Barren), very pronounced folding is shown.

(b) Along the front of the Darling Scarp at Aramadale, Cardup and other places§, is a narrow band of slate and quartzite, invaded by both the greenstone and the granite of the Darling "Range."

(c) About 25 miles north and north-east of Perth, surrounded by the granite and greenstone country of the Darling Peneplain, and also near the supposed continuation of the Darling Fault, are occurrences of staurolite cyanite and quartz schists and quartzites,|| covering in all, so far as we know at present, an area of about 200 square miles. Farther north, between Moora and Mingenew, a little-known belt of metamorphics may belong to the same series and is shown thus on the map.

(d) It is quite likely that *north of the latitude of Shark's Bay,* there are many areas whose rocks judging from descriptions written many years ago, may well belong to the Yilgarn Series. However, considering the lack of recent detailed information, we think it best to leave these, as on the latest Geological map of the State, in the Mosquito Creek Series—a series regarding which there is some doubt as will appear below. As an instance may be cited, the country between the Wooramel and Arthur Rivers, and at Bangemall and Station Peak¶, where is a series, said to be sediments metamorphosed to quartz and mica schists, marble, etc., and is invaded by both granite and greenstone.

(e) Phyllites and mica schists invaded by granites and by basic rocks, were noted during a

* Clarke, E. deC.—The Pre-Cambrian System in Western Australia. Jour, Roy. Soc. W.A. IX. Pt. II.

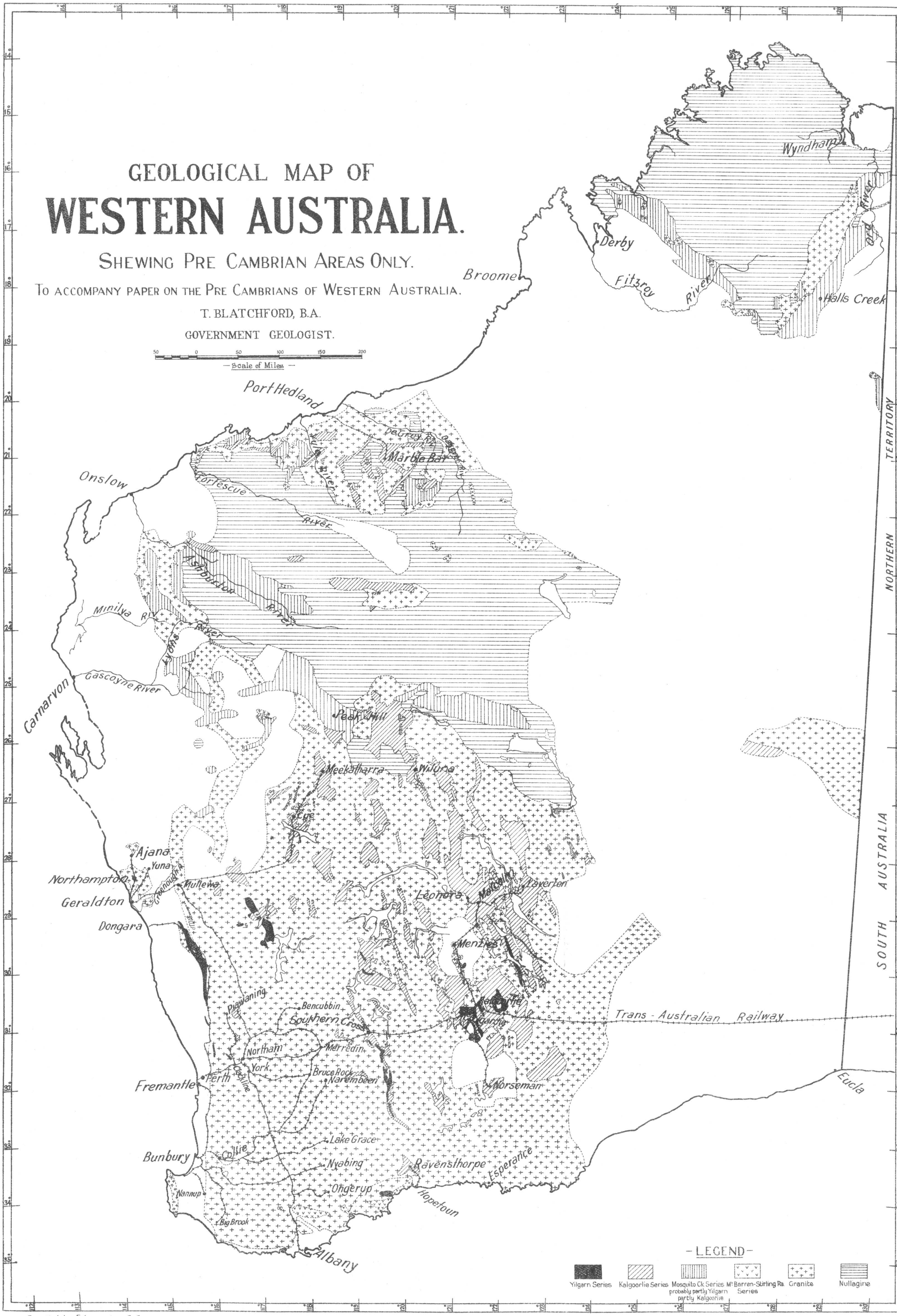
† Blatchford, T., and Honman, C. S.—Geology of the Yilgarn Goldfield. Geol. Surv. of W.A. Bull. No. 71, p. 33, Figs. 1-4 show the characteristics of some of the rocks of this series. Further illustrations will be found in Bull. 63 (Blatchford), pp. 31-43.

‡ Woodward, H. P.—The Phillips River Goldfield. Geol. Surv., W.A., Bull. 35, pp. 11-12. (Woodward regards these rocks as highly metamorphosed igneous).
Montgomery, A., and MacLaren, M.—Philips River Mines. Report on the development of the Phillips River Auriferous Copper Mines, with Geological Report on Mines of the Phillips River Gold & Copper Co., Ltd., Dept. of Mines, W.A. 1914.

§ Honman, C. S.—Geol. Surv. of W.A., Bull. 48, p. 63.

|| The only published notes on these rocks are by Simpson, E. S., Jour. Roy. Soc. W.A. XII. p. 57, and by Clarke, E. deC., Report Hobart Meeting A.A.A.Sc., 1928, p. 52.

¶ Maitland, A. G.—Geol. Surv. W.A., Bull. 33, p. 41, etc.
Woodward, H. P.—Geol. Surv. W.A., Bulletins 41, describes (p. 12) a series of metamorphosed sediments which he says (p. 10) are possibly and even probably the oldest rocks in the district.



GEOLOGICAL MAP OF
WESTERN AUSTRALIA.
SHEWING PRE CAMBRIAN AREAS ONLY.
TO ACCOMPANY PAPER ON THE PRE CAMBRIANS OF WESTERN AUSTRALIA.
T. BLATCHFORD, B.A.
GOVERNMENT GEOLOGIST.
Scale of Miles
LEGEND
Yilgarn Series
Kalgoorlie Series
Mosquito Ck Series probably partly Yilgarn partly Kalgoorlie
Mt Barren-Stirling Ra. Series
Granite
Nullagine
Wyndham
Derby
Fitzroy River
Broome
Halls Creek
Port Hedland
Marble Bar
Onslow
Fortescue River
Ashburton River
Minilya R.
Lyons River
Carnarvon
Gascoyne River
Peak Hill
Meekatharra
Wiluna
Ajana
Yuna
Northampton
Geraldton
Mullewa
Dongara
Leonora
Malcolm
Laverton
Menzies
Trans-Australian Railway
Southern Cross
Bencubbin
Northam
Merredin
York
Perth
Fremantle
Bruce Rock
Narembeen
Norseman
Eucla
Lake Grace
Bunbury
Collie
Nyabing
Ravensthorpe
Esperance
Ongerup
Hopetoun
Nannup
Big Brook
Albany
NORTHERN TERRITORY
SOUTH AUSTRALIA
Compiled by F. Armstrong, B. Sc.

recent reconnaisance in the East Kimberley, between the Denham and Ord Rivers, about Lat. 16° 20′ long. 236° 30′. It was not possible to search for evidence as to the relationship between these rocks and the "greenstones" lying east of them, but there is little doubt that such evidence is available and that the belt has a considerable extension in a north-south direction.

(f) Sillimanite schists, quartzites, etc., occur near Mt. Aloysius (lat. 26°, long. 128° 40′).*

It seems possible that the metamorphic conglomerates of Kanowna† belong to this oldest series of rocks. Many other widely scattered occurrences of highly metamorphic rocks, most of which are pretty certainly sediments and older than both the granite and the greenstone of their neighbourhood, are known,‡ and those which are sufficiently extensive are shown on the accompanying map, as the Yilgarn Series—from the Goldfield in which they are, so far as we know, best developed and in which they have been most closely studied. It is likely that many more patches will be found especially in the areas now shown on the State Geological Map as granite.

It will appear later in these notes that it is uncertain whether all the granites in the State are virtually of one age, and also whether all the greenstones are more or less contemporaneous. Hence, obviously, we cannot assert that all occurrences of metamorphic sediments which are invaded by both the granites and greenstones of their neighbourhood are of the same age. Nevertheless, the use of one series name for all rocks of the same type and relationship, seems an advantage.

Kalgoorlie.—This term used by Honman,§ is convenient because the series is most fully developd at Kalgoorlie. It consists of metamorphosed basic, intermediate and acid lavas dyke rocks and pyroclastics together with some sediments. The most widely developed are the "greenstones" which are metamorphosed dolerites, basalts and gabbros with common, though relatively small, ultrabasic phases. These are the rocks generally termed "diorite" by miners and prospectors.

At Kalgoorlie Feldtmann found that‖ the greenstones are divisible into older and younger. The older consists mainly of metamorphosed basic lavas. Apparently invading them is a later series of metamorphosed basic and ultra basic rocks—the "younger greenstones." Apparently no very constant difference, microscopical or chemical, between the "older" and the "younger" greenstones has yet been discovered, but it seems as if the younger are rather characterised by relics of ophitic texture and by presence of original quartz.

In this connection it may be pointed out that one of the most difficult features of the greenstones is that marked megascopic differences are often little indication of real difference. Nearly all the epidiorites of the Kalgoorlie Series have been affected by dynamic metamorphism, but the amount varies, so that greenstone-schists or even graphitic slates will be found in actual contact with a massive greenstone —which it is, of course, only natural to suppose is a later intrusion. Further observation in the field and microscope-study show, either that the apparent intrusion is only a portion of the greenstone which has escaped the excessive shearing or, more likely, that owing to some small difference in composition or surroundings the obviously sheared rock owes its appearance to more advanced weathering.

The "younger greenstones" are the chief goldbearing rocks of Kagoorlie and rocks precisely similar microscopically and in field occurrences carry the ore bodies in nearly every one of the gold mining centres of the State, at any rate in those south of the latitude of Peak Hill (in the Pilbara District). Maitland calls similar rocks the "Warrawoona Series," but nowhere except at Kalgoorlie has satisfactory evidence been adduced for the existence of two "ages" of greenstones so that we cannot say whether the greenstones elsewhere are equivalent to the older or to the younger greenstones at Kalgoorlie.

Besides the greenstone facies of the Kalgoorlie Series there is developed in the country between Leonora and Kalgoorlie and also south of Kalgoorlie a very considerabe area of metamorphosed rocks whose original character is in most places very difficult to determine. Some of them appear to have been originally sediments, others acid flows and pyroclastics. Evidence of the relationship of these rocks to the greenstones is rather scanty. It may be, and one of us (T.B.) inclines rather definitely to this view that they are best classed with the older Yilgarn Series and are the remnants of the folds of ancient sediments which were invaded by the older series of greenstones. On the accompanying map these sediments near Kalgoorlie are therefore shown as Yilgarn. On the other hand there appears to be in places a little evidence that these sediments are contemporaneous with the greenstones—using contemporaneous in a broad way.¶

* Geol. Surv. of W.A., Bulletin 75, p. 89.
† Blatchford, T., and Jutson, J. T.—Geol. Surv. W.A., Bull. 47, p. 19, etc.
‡ These are enumerated in Jour. Roy. Soc. W.A., Vol. IX., Part II.
§ Geol. Surv. of W.A., Bull. 66, p. 44.
‖ Geol. Surv. of W.A., Bull. 69, p. 13.

¶ The following table summarises the latest information on these areas :—

Region.	Bulletin Number.	Acid Rocks, etc.	Sediments.
North of Kalgoorlie	73	p. 25	pp. 32 and 67
	78	p. 17	p. 49
	79	...	...
	84	p. 31	p. 32
South of Kalgoorlie	66	p. 18	p. 21
	82	p. 19	p. 20
	90	p. 17	p. 17

It is possible, for example, that the "Kurrawang Series" of metamorphosed conglomerates and other finer grained sediments, including chiastolite schists, comes here in the Pre-Cambrian succession. In his first report (Bull. 56, p. 16, etc.) Honman classifies the Kurrawang Series thus, but in a later work (Bull. 66, p. 35) he makes it the youngest formation in the area mainly because "it contains detrital material belonging to the neighbouring porphyries and greenstone schists," but also because at Mt. Jackson, about 100 miles to the WNW "there is a series of conglomerates similar to the Kurrawang Series but resting unconformably on rocks allied to the Kalgoorlie Series." We may note that several visits of inspection to exposures of the Kurrawang conglomerates have not resulted so far as we are concerned in the finding of pebbles of any rocks characteristic of the Kalgoorlie Series.

An apparently very similar series of conglomerates, etc., at Yilgangi has been described by Jutson in Bulletin 73, p. 66.

Again a series of gold-bearing conglomerates at Yandanhoo Hill, in the Yalgoo Goldfield* (about lat. 29° 30′, long. 117° 20′) may come here in the succession.

It is suggested that in the Kalgoorlie Series we have the altered products of a long period of igneous activity in which there were in places relatively insignificant periods of quiescence and sedimentation. This period might, on Chamberlain's conception of the early stages of the Earth's history, be imagined to be ushered in when the first formed acid shell cracked and to some extent foundered in the more basic substratum with consequent squeezing out of some of the basic magma. The basic magma contained much smaller only partly assimilated patches of more acid material formed by melting of portions of the acid shell. These more acid portions have been recognised in the country between Menzies and Duketon. This period of igneous activity was protracted and the lavas, tuffs, etc., of its earlier part would be cut, later in the same period, by dykes originating from the same magma. It seems therefore, that while in some parts of the State greenstones of two or even more ages—since one will invade others, will be found in other parts no such evidence will appear, and, therefore, it is clear that accounts of the Kalgoorlie Series from different parts of the country will not tally.

Mosquito Creek Series.—Among Western Australian geologists it is generally believed that in the North-West Land Division of this State there is developed a series younger than the Kalgoorlie Series, *i.e.* younger than the auriferous greenstone series in whatever part of the State it may occur. This younger series is stated to consist in the main of sediments which are metamorphosed, though not as profoundly as those of the Yilgarn series, and which like the rocks of the Kalgoorlie Series may carry gold-bearing lodes. Maitland in his Summary of the Geology of Western Australia,† p. 17, writes that the North and South Dromedaries Range east of Nullagine township is made of vertical beds of conglomerate containing numerous pebbles of the laminated quartz and jaspilite which form part of the Warrawoona Beds, which, as already mentioned, are the equivalent in this region to the Kalgoorlie Series. Dr. E. S. Simpson, who has examined the rocks of this region, is also of opinion (personal communication) that there occurs in this part of the State a series of metamorphic sediments containing fragments of the Kalgoorlie Series.

However, one of us (T.B.) who has travelled widely in this "North-West" region inclines to the opinion that some of the metamorphic rocks which have been mapped as Mosquito Creek are really part of the much older Yilgarn Series, others may be representatives of the sedimentary facies of the Kalgoorlie Series and others belong to the much later Nullagine Series. It is felt that until more precise information is available regarding the individuality or otherwise of the occurrences marked Mosquito Creek Series on the latest geological map of the State it will be wisest to draw attention to the lack of co-ordinated knowledge of the geology of this portion of the "North-West" by indicating the areas concerned as "Mosquito Creek Series, possibly partly Yilgarn, partly Kalgoorlie."

If the presence of fragments of rocks of the Kalgoorlie Series in such conglomerates as the Karrawang, Yilgangi and Yandanhoo (see above) is established, then these formations would be included in the Mosquito Creek Series—provided of course that the independence of the Mosquito Creek Series is proved.

We would reiterate that if the Mosquito Creek Series is to be recognised as a distinct member of the Pre-Cambrian it must be proved to be (a) younger than the Kalgoorlie Series and yet (b) distinctly metamorphosed.

Main Granite Series.—A large part of the State is, on the latest geological map, shown as "Granite and Gneiss." It has been noted above that acid and acid-intermediate rocks form part of the Kalgoorlie Series. There is usually little difficulty in distinguishing them from the Main Granites which are clearly intrusive into the Kalgoorlie Series. But the coarser grained fragmentals of the Yilgarn Series where most metamorphosed are almost indistinguishable from igneous gneisses, and detailed work on the "granite and gneiss" areas will probably disclose more patches of such metamorphosed sediments. (A good example is Mt. Leonora, described in Bulletin 13 of the Geological Survey of W.A. as a crushed granite but later shown to be most probably a metamorphosed sediment).‡

It must be clearly understood that in the big areas coloured as granite there are small unmapped patches of greenstone. Some are invaded by the granite, *i.e.*, belonging to the Kalgoorlie Series, and thus particularly in the "Wheat Belt" are dykes invading the granite. It is improbable that any of these greenstone areas are large enough to show on the scale of the map submitted.

Apart from these subtractions from the granite and gneiss area which, though interesting, will not be important areally, it is doubtful *whether or not* all the granitic rocks of the State are, even broadly speaking, of the same age. Some geologists have been inclined to regard all the Western Australian granites with gneissic texture or any approach to it as definitely older than those which are massive, but in every area in the Goldfields where the granites have been studied in any detail it has been pretty definitely shown that the gneissic rock grades into the massive. It is suggested that in these instances gneissosity, in whatever degree developed, has been

* Maitland, A. G.—" The Gold Deposits of Western Australia." Extract from the Mining Handbook, p. 36.
† Extract from The Mining Handbook, Geol. Sur., Memoir No. 1, Chapter 1.
‡ Geol. Surv. W.A., Bull. No. 84, p. 24, and literature there cited.

caused in some places, by drag along contact with the invaded rock (generally "greenstone"), in others is a fluxion structure produced by movement in the magma when partially frozen, and in others is due to shearing after the consolidation of the magma.

While, however, the presence or absence of gneissosity is in itself a poor criterion of the relative ages of different granites in the State it is likely that further work will prove the gneissic granites of Northampton, C. Naturaliste, Albany, and many other localities round the borders of the Western Australian "Shield" to be very much older than those of the Goldfields. The goldfields granites invade the Yilgarn, Kalgoorlie and Mosquito Creek Series (if the last is a separate entity), whereas the marginal gneisses are themselves cut by dykes of a greenstone which seems indistinguishable in every way from the goldfields greenstones. It is suggested that these marginal gneisses may be highly metamorphosed sediments of Yilgarn age mixed with remnants of the "first earth-shell."

Nullagine Series.—This Series was first so named by Maitland,* who wrote—

> Next in antiquity to the greenstone schists comes the series of sandstones, grits, conglomerates, thin limestones, and associated volcanic rocks, so well exposed in many portions of the district. For convenience of description, these will be referred to as the Nullagine Beds. This formation, the actual base of which is rarely seen, forms an important feature in the geology of Pilbara and none plays so prominent a part in the landscape. The Nullagine Beds cannot be exactly correlated with those yet described in any of the previous official reports on the geology of Western Australia. In their lithological characters and general behaviour they resemble very strongly the quartzites, etc., which form that continuous formation extending from Wyndham to Mount Hart, a prominent summit on the King Leopold Range, in Kimberley, to which reference has been made in a former report.
>
> If a comparison between two regions, separated by almost five degrees of latitude, be of any value in correlating strata, then there seems to be very strong reasons for identifying the two series of beds. On the strength, therefore, of the lithological and structural similarity to those of the Leopold Range, the Nullagine Beds are assumed to be of the same age, viz., Cambrian; but in view of the deficiency of our knowledge of these beds it is obvious that this assumption is more or less guesswork.

The reference to a former report is to the Annual Report of the Geological Survey for 1901, page 8, where Maitland states—

> The staple formation in the country traversed is made up of a series of quartzites, sandstones, fine conglomerates, and shales, disposed in a series of broad anticlinal folds. These beds extend as one continuous formation from Wyndham to Mount Hart, a prominent summit on the King Leopold Range. No fossils were met with in any of the sedimentary rocks, so their position in the geological scale can only be approximately determined. The quartzites of the King Leopold and Mueller Ranges were shown on the map accompanying Mr. Hardman's reports as being of Lower Silurian or Cambrian Age; no geological work having been carried out since the date of that gentleman's examination, no apparent reason can be found to alter them from the position to which he assigned them.

We draw attention to these statements made many years ago because, though knowledge regarding the Nullagine Series in the "North-West," *i.e.*, roughly between latitudes 20° and 26° has greatly increased, particularly by Talbot's work,† still we know very little more about the relation to the Cambrian beds of the series in the Kimberley, which is lithologically similar to the "North-West" Nullagines: in other words we are not certain whether the Kimberley Nullagines are Lower Cambrian or are Pre-Cambrian. In discussing the Cambrian in Western Australia a short note was given on the relationship between the fossiliferous Cambrian rocks of the Kimberley and the rocks underlying them which so closely resemble the Nullagines of the "North-West."

It may further be noted that outliers of horizontal or gently inclined unaltered sedimentary rocks with associated volcanics, which are correlated with the Nullagines, of course merely from lithological resemblance, have been found as far south as Billeranga Hills and Mt. Singleton (about lat. 29° 20). In a recent address to the Royal Society of Western Australia Mr. A. Montgomery drew attention—for the first time we believe—to the fact that the Nullagine outliers together with the occurrence, in areas mainly covered by Nullagines, of inliers of the Mosquito Creek and Kalgoorlie Series might reasonably lead to the conclusions that (a) the Nullagines were laid down on an almost level surface (produced, Mr. Montgomery believes, by marine erosion), which extended from the Kimberley to latitude 29°.

(b) The Nullagines and whatever other formations were deposited over them have been entirely or almost entirely removed during the long period of Western Australia's existence as a land area (which may date from the Cretaceous or even earlier).

(c) The old pre-Nullagine surface has been but slightly eaten into during the later erosion period which, as stated above, may have begun in Cretaceous.

BORING FOR COAL IN ERADU DISTRICT BY STATE AID.

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

Summary of Previous Boring.

Carboniferous strata in the Greenough District were first recognised by the late T. Gregory in 1860, though the probability of coal being found was first suggested by the late H. P. Woodward in 1888.

Woodward based his opinion on the similarity of the strata to those of the Irwin River series.

The first deep bore was started at the 47½ mile peg on the railway line in 1904, the bore reaching a depth of 1,417 feet without locating coal.

Two years later a calyx bore was put down in the bed of the Greenough River some mile distant north of Eradu Railway Station. There a six-foot seam of coal was passed through at a depth of 116-122 feet.

An analysis of this coal is as follows:—

Moisture, 9.59.
Volatile Hydrocarbons, 40.28.
Fixed Carbon, 37.97.
Ash, 12.16.
Calorific Value B.T.U. 9,900.

Following this last bore some shallow hand bores were sunk in the same locality to ascertain the dip which, on the evidence obtained, proved to be E.S.E.

Hindley's bore was then started about one mile distant from the calyx bore on this dip, but though the hole reached a depth of 736 feet, no coal was

* Geol. Surv. W.A., Bull. No. 15, p. 10.

† Geol. Surv. W.A., Bulls. 83, 85, and 87.

found. Shortly afterwards a further attempt was made to locate the coal seams by drilling a hole to a depth of 1,006 feet, two miles south of Eradu on the west side of the Greenough River. This bore, known as Musk's Bore, though it passed through unquestionable coal measures also failed to locate any coal seams.

About this time a series of shallow bores was sunk along Kockatea Creek, most of which bottomed on granite, though one of the most westerly, No. 27, passed through a black carbonaceous shale 10 feet thick, at a depth of 120 feet.*

No further boring was done until the year 1926, when it was decided to further test the field in order to locate the extension of the seam found in the calyx bore sunk in the Greenough River bed, and if possible ascertain more accurately the dip, bearing in mind always the possibility of locating other seams.

A calyx plant was installed and nine holes put down, the logs of which, as supplied by the foreman, together with the analyses of the coal struck in the various bores, are as follows:—

LOG OF BORE CORES RAISED FROM No. 1 CALYX BORE AT ERADU

(1 mile West from Eradu Siding on Railway Reserve).

Boring ceased 17th Nov., 1926.

No. of Sample.	Depth of Core.	Description of Core.
	ft. in. ft in.	
1	30 0 to 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 feet.
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.
	803 9 ,, 804 1	Band of pyrites
19	804 1 ,, 832 0	Fine grey shale to bottom of hole.

All the coal core was forwarded direct to the Government Mineralogist and Analyst for analysis.

Log by T. Blatchford.

PROXIMATE ANALYSES—No. 1 CALYX BORE, ERADU.

	3096/26	3097/26	3098/26
No. ...	3096/26	3097/26	3098/26
Depth ...	170′ to 180′ 3″	181′ 6″ to 183′	188′ 4″ to 190′ 3″
Proximate Analysis—	%	%	%
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 of B.T.U.	...	5,493	...
Colour of ash	Light brown.	Dirty white.	Brownish white.

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

No. 2 COAL BORE, ERADU.

Commenced 20–1–1927. Completed 23–3–1927.

Depth of Core.	Description.
ft. in. ft. in.	
0 0 to 14 0	Yellow sand.
14 0 ,, 27 10	Yellow sandy clay.
27 10 ,, 76 0	White sandstone
76 0 ,, 90 0	Reddish sandstone.
90 0 ,, 109 0	Soft sandstone with bands of clay.
109 0 ,, 109 6	Conglomerate.
109 6 ,, 110 9	Tough grey shale.
110 9 ,, 112 0	Dark shale.
112 0 ,, 127 0	Grey shale
127 0 ,, 135 0	Smutty carbonaceous matter.
135 0 ,, 138 6	Gray shale
138 6 ,, 139 6	Smutty carbonaceous matter.
139 6 ,, 144 8	Gray shale.
144 8 ,, 151 6	Coarse grit with shale bands.
151 6 ,, 153 0	Dark shale.
153 0 ,, 156 0	Carbonaceous shale or brown coal.
156 0 ,, 163 0	Gray shale.
163 0 ,, 191 0	Gritty sandstone with conglomerate boulders and pyrites.
191 0 ,, 194 0	Grey shale.
194 0 ,, 208 0	Coarse sandstone with bands of shale.
208 0 ,, 261 0	Soft coarse sandstone with bands of shale and boulders.
261 0 ,, 314 0	Soft coarse sandstone with shale bands.
314 0 ,, 350 0	Soft dark sandstone.

PROXIMATE ANALYSIS—No. 2 BORE, ERADU.

No.	992/27	993/27	994/27
Depth ...	127′ to 135′	138′ 6″ to 139′ 6″	153′ to 156′
Proximate Analysis—	%	%	%
Moisture	12·20	8·00	9·40
Volatile matter ...	26·89	24·76	21·48
Fixed carbon ...	21·22	22·89	28·52
Ash	39·69	44·35	40·60
	100·00	100·00	100·00
Calorific Value—B.T.U. ...	Not determined	Not determined	·5699

The ash in these coals is far too great for any of them to be of value as a fuel.

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

(Analyst: H. Bowley.)

* For full particulars of this boring, the reader is referred to Miscellaneous reports in Bulletin 59, G.S. W.A., by H. P. Woodward, and Bulletin 38, G.S. W.A., by W. D. Campbell.

— Plan Shewing Bore Sites —
— At —
— ERADU —
— Scale:- 40 Chains = 1 Inch —

— LEGEND —

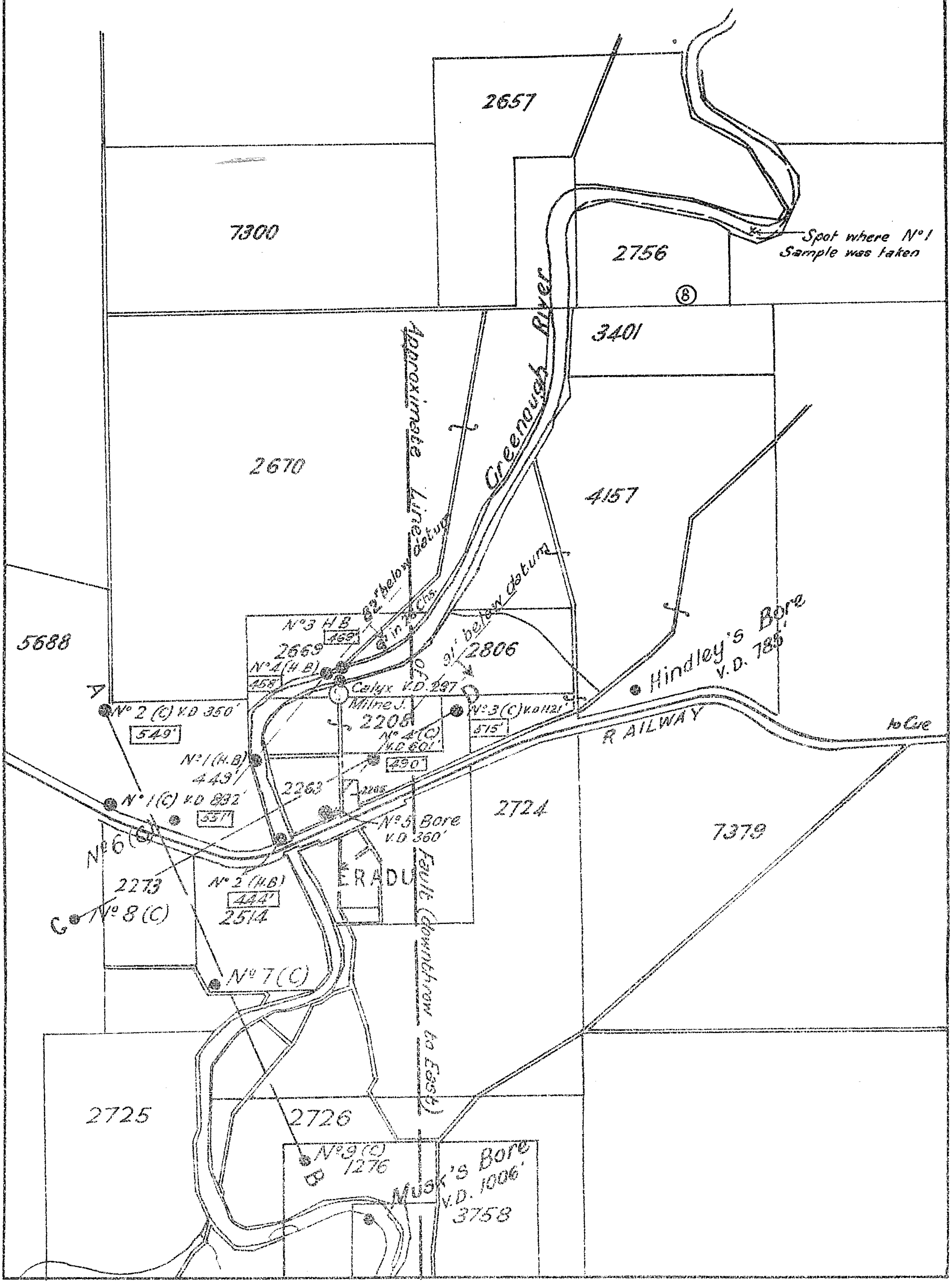
⑥ Bore Sites Suggested

523' Height above Sea Level

(C) Calyx

(H.B) Hand Bore

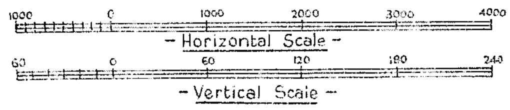
(V.D) Vertical Depth

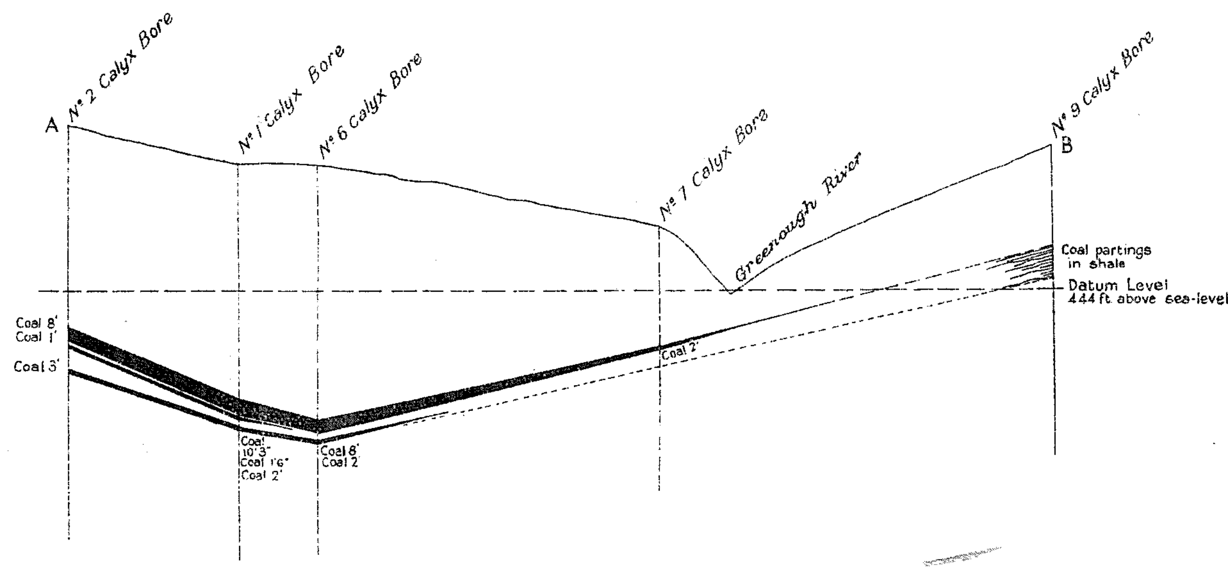


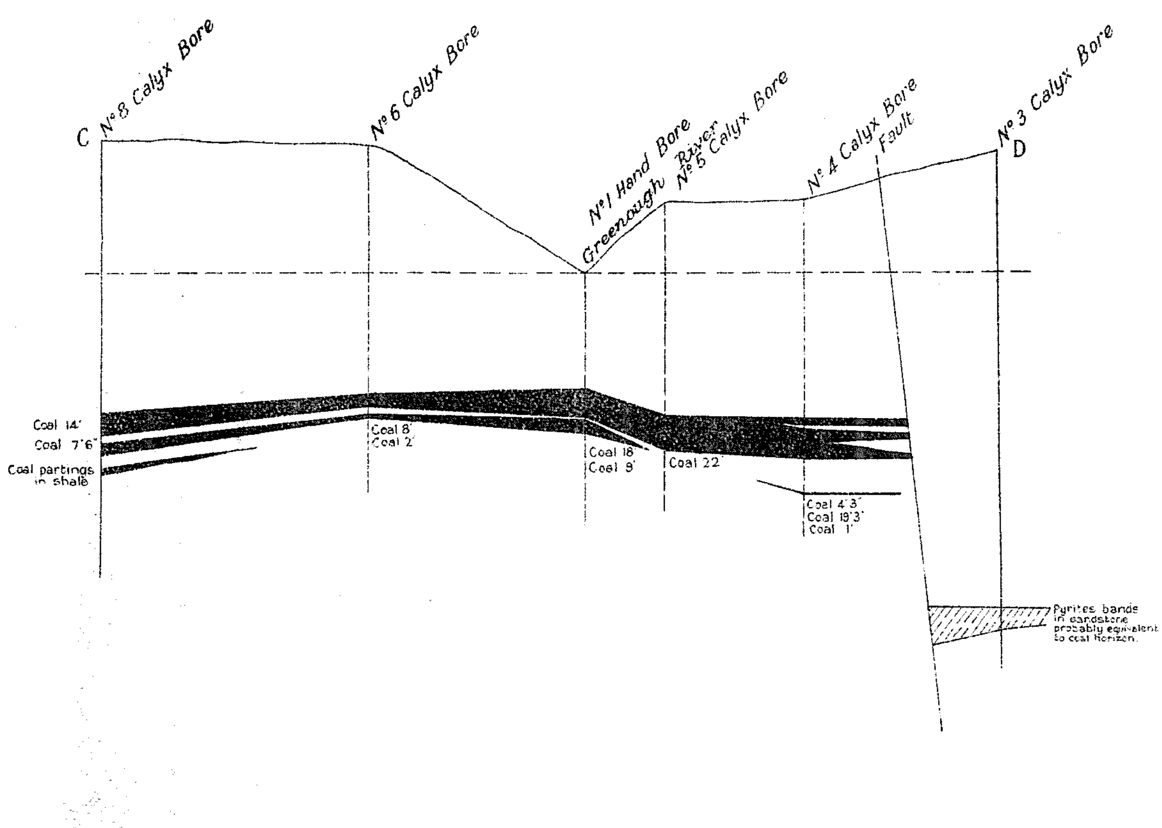
— Cross Sections —

— Eradu Coal Seams —

— on lines A-B & C-D of plan —

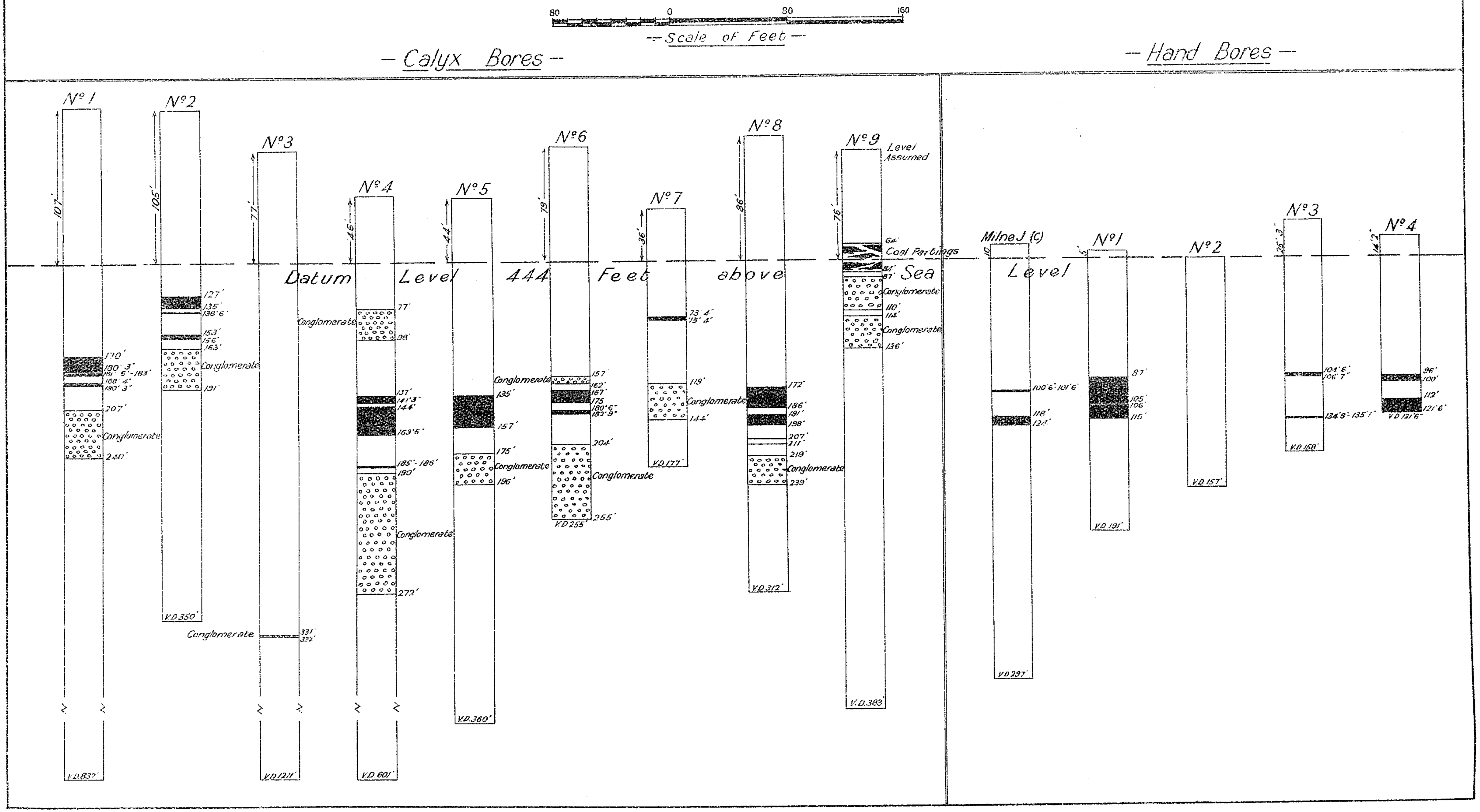


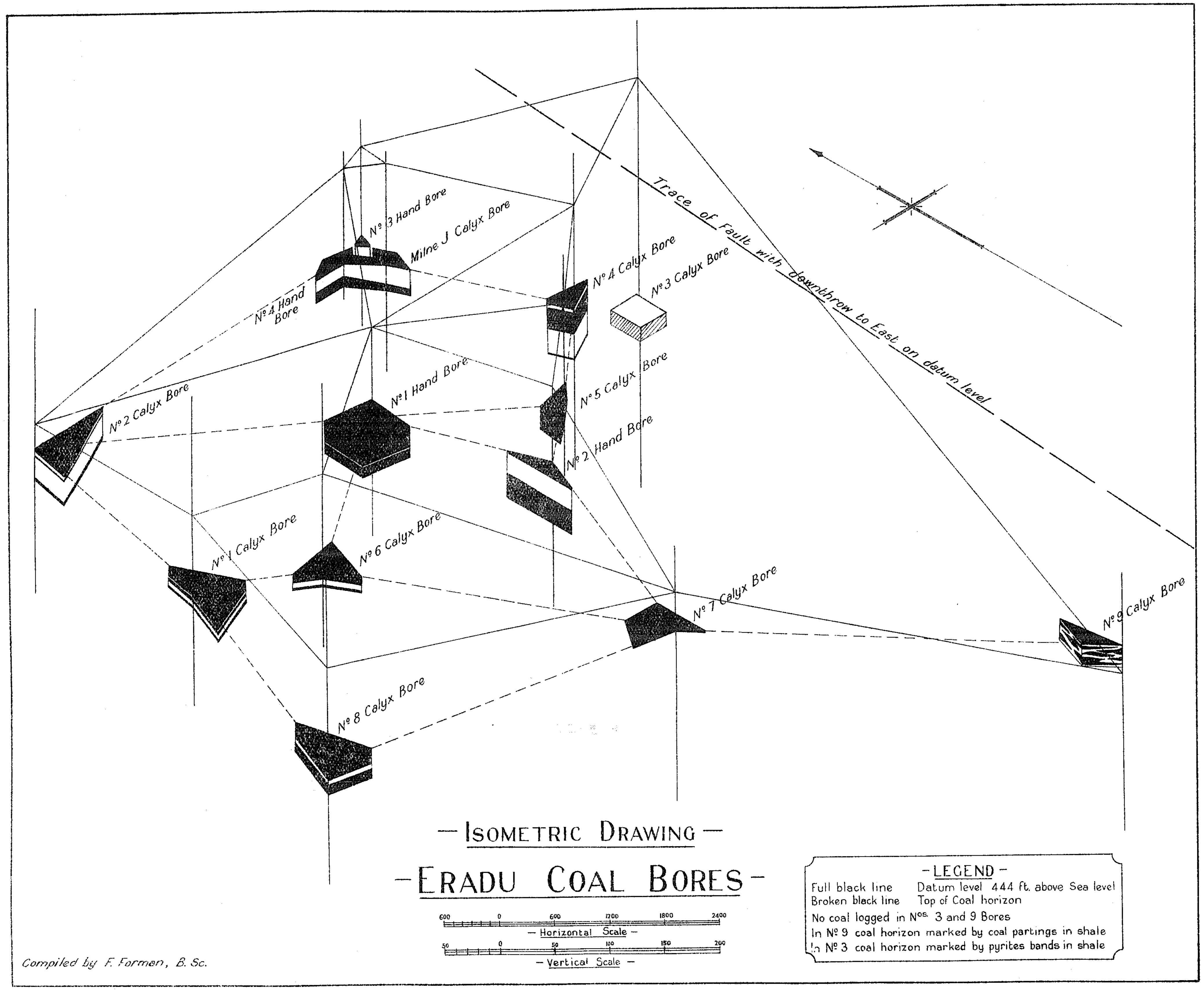




Compiled by F. Forman, B. Sc.

PLAN SHEWING SURFACE LEVEL OF BORES AT ERADU & THICKNESS & RELATIVE DEPTHS OF MAIN COAL SEAMS





— Isometric Drawing —

– Eradu Coal Bores –

– LEGEND –

Full black line — Datum level 444 ft. above Sea level
Broken black line — Top of Coal horizon
No coal logged in Nos. 3 and 9 Bores
In Nº 9 coal horizon marked by coal partings in shale
In Nº 3 coal horizon marked by pyrites bands in shale

Compiled by F. Forman, B. Sc.

LOG OF BORE No. 3, ERADU.

Commenced 24th Oct., 1927—Completed 5th May, 1928.

Depth of Core. ft. in.			ft. in.		Description.
0	0	to	2	0	Sand.
2	0	,,	6	6	Red sandy loam.
6	6	,,	14	3	Hard ironstone.
14	3	,,	18	0	Ferruginous sandstone.
18	0	,,	21	3	Hard gray mudstone.
21	3	,,	31	0	Pink sandstone.
31	0	,,	33	6	Ironstone.
33	6	,,	40	6	Coarse ferruginous sandstone.
40	6	,,	43	0	Chocolate-coloured clay.
43	0	,,	44	0	Ironstone.
44	0	,,	68	6	Soft chocolate-coloured sandy clay.
68	6	,,	69	0	Ironstone.
69	0	,,	70	0	Chocolate-coloured sandy clay.
70	0	,,	71	0	Ironstone.
71	0	,,	74	0	Chocolate-coloured sandy clay.
74	0	,,	75	0	Very hard ironstone.
75	0	,,	90	0	Tough greasy chocolate-coloured clay.
108	0	,,	109	0	Very tough shaley clay.
109	0	,,	110	6	Carbonaceous shale.
110	6	,,	118	6	Gray sandy shale.
118	6	,,	120	0	Soft dark sandstone.
120	0	,,	141	6	Very fine light gray shale.
141	6	,,	150	6	Soft brown sandstone.
150	6	,,	151	6	Light gray shale.
151	6	,,	177	0	Soft brown sandstone.
177	0	,,	179	0	Light gray shale.
179	0	,,	255	0	Soft whitish sandstone with bands of white shale.
255	0	,,	256	0	Band of pyrites.
256	0	,,	288	3	Soft whitish sandstone with bands of white shale.
288	3	,,	289	6	Band of pyrites.
289	6	,,	293	6	Soft whitish sandstone with bands of white shale.
293	6	,,	296	1	Band of pyrites.
296	1	,,	300	0	Soft whitish sandstone with bands of white shale.
300	0	,,	301	3	Hard band of pyrites.
301	3	,,	320	8	Soft white sandstone.
320	8	,,	321	6	Very hard band of pyrites.
321	6	,,	326	0	Soft white sandstone with lumps of pryites.
326	0	,,	331	0	White sandy shale with pyrites.
331	0	,,	332	0	White sandy shale and rounded boulders.
332	0	,,	372	0	Soft black sandy shale.
372	0	,,	417	0	Soft dark sandstone.
417	0	,,	463	0	Very soft dark sandstone.
463	0	,,	465	0	Dark arenaceous shale.
465	0	,,	471	0	Soft dark sandstone.
471	0	,,	484	6	Dark arenaceous shale with pyrites.
484	6	,,	496	0	Soft dark sandstone.
496	0	,,	498	0	Dark arenaceous shale.
498	0	,,	506	0	Soft dark sandstone.
506	0	,,	507	0	Dark sandy shale.
507	0	,,	630	0	Very soft sandstone with shale bands.
630	0	,,	643	0	Soft dark arenaceous shale.
643	0	,,	768	0	Very soft fine sandstone with bands of shale.
768	0	,,	768	9	Band of pyrites.
768	9	,,	810	0	Tough dark shale.
810	0	,,	1,211	0	Tough dark shale with thin bands of mudstone.

LOG OF No. 4 COAL BORE AT ERADU.

Commenced 12th May, 1927.
Completed 21st Sept., 1927.

Depth of Core. ft. in.			ft. in.		Description.
0	0	to	11	0	Red loam.
11	0	,,	23	0	Ferruginous sandstone.
23	0	,,	25	6	Hard band of ironstone.
25	6	,,	27	6	Ferruginous sandstone.
27	6	,,	28	0	Band of ironstone.
28	0	,,	46	0	Ferruginous sandstone.
46	0	,,	77	0	White sandstone.
77	0	,,	98	0	Sandstone with boulders.
98	0	,,	107	0	Tough white mudstone.
107	0	,,	132	0	Soft sandstone.
132	0	,,	135	0	Sandy clay.
135	0	,,	137	0	Dark shale.

LOG OF NO. 4 COAL BORE AT ERADU.—*continued.*

Depth of Core. ft. ins.			ft. ins.		Description.
137	9	to	141	3	Smutty coal.
141	3	,,	144	0	Dark shale.
144	0	,,	163	6	Smutty coal.
163	6	,,	169	0	Black shale with carbonaceous seams.
169	0	,,	185	6	Soft sandstone with pyrites.
185	6	,,	186	0	Coal.
186	0	,,	189	0	Fine grey sandstone.
189	0	,,	190	0	Dark shale.
190	0	,,	212	0	Soft white sandstone with small boulders.
212	0	,,	272	0	White sand with boulders.
272	0	,,	294	3	Soft white sandstone.
294	3	,,	334	6	Gray shale.
334	6	,,	337	0	Soft sandy shale.
337	0	,,	342	0	Gray shale.
342	0	,,	370	0	Soft dark sandstone.
370	0	,,	432	6	Soft dark sandstone with bands of shale.
432	6	,,	434	0	Dark shale.
434	0	,,	448	6	Soft dark sandstone with bands of shale
448	6	,,	453	0	Dark shale.
453	0	,,	510	0	Soft dark sandstone with bands of shale
510	0	,,	601	0	Soft dark sandstone.

PROXIMATE ANALYSIS AND CALORIFIC VALUE OF FOUR SAMPLES OF COAL FROM ERADU.

No. 4 Bore, Eradu.

Second seam cut at 144ft. Thickness of seam 19ft. 6in. Total length of core 12ft.

The core was divided into four equal portions of 3ft. each and sampled.

Lab. No. ...	1588/27 Top 3ft.	1589/27 2nd 3ft.	1590/27 3rd 3ft.	1591/27 Bottom 3ft.
Proximate Analysis :	%	%	%	%
Moisture ...	32·23	35·78	22·78	27·58
Volatile matter...	24·11	22·64	22·51	22·38
Fixed carbon ...	35·64	33·81	32·86	28·08
Ash	8·02	7·77	11·85	21·96
	100·00	100·00	100·00	100·00

Colour of Ash—Creamy white.

Calorific Value—				
B.T.U	7028	6155	6310	Not determined.

Moisture determined on samples air-dried for two days after taking out of core boxes. Experiments are being made to see if the coal would dry still further on exposure to the air, as if the water percentage were lower the top half of the seam would be a fair commercial coal. As it is, it is of much better quality than any coal previously struck in the vicinity of Eradu.

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

Analyst : H. Bowley.

PROXIMATE ANALYSIS AND CALORIFIC VALUE—No. 4 BORE, ERADU.

Depth 137ft. Thickness 4ft. 3in.
No. 1858/27.
Sample air-dried for 19 days.

Proximate Analysis—

Moisture	16·24	per cent.
Volatile matter ...	24·10	,,
Fixed carbon	31·91	,,
Ash	27·75	,,
	100·00	,,

Calorific Value—
B.T.U. 5,742

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

Analyst : H. Bowley.

No. 5 BORE FOR COAL AT ERADU.

Commenced 9th June, 1928.
Completed 14th July, 1928.

Depth of Core. ft. in.			ft. in.		Description.
0	0	to	2	0	Red loam.
2	0	,,	10	4	Yellow clay.
10	4	,,	14	0	Ferruginous sandstone.
14	0	,,	23	0	Brown clay.
23	0	,,	46	6	Ferruginous sandstone with clay lumps.
46	6	,,	47	2	Band of ironstone.
47	2	,,	108	0	White sandstone.
108	0	,,	112	0	White mudstone.
112	0	,,	119	0	Yellow sandstone showing streaks of a more ferruginous nature.
119	0	,,	130	8	Sandy clay ironstained.
130	8	,,	131	4	Dark sandy shale.
131	4	,,	135	0	Tough carbonaceous shale.
135	0	,,	157	0	Coal.
157	0	,,	162	0	Tough carbonaceous shale.
162	0	,,	166	0	Gray shale.
166	0	,,	169	0	Hard arenaceous shale.
169	0	,,	170	0	Coarse grained sandstone.
170	0	,,	175	0	Gray puggy shale.
175	0	,,	190	0	Sandstone with boulders.
190	0	,,	196	0	Conglomerate.
196	0	,,	199	0	Carbonaceous shale.
199	0	,,	207	0	Gray arenaceous shale.
207	0	,,	222	6	Soft gritty sandstone.
222	6	,,	292	0	Gray arenaceous shale.
292	0	,,	360	0	Soft dark sandstone with shale bands.

PROXIMATE ANALYSES—No. 5 BORE, ERADU.

Length of Core—17ft. 6in. Depth—135ft. to 157ft.

Lab. No. ...	1894 Top 3ft. 7in.	1895 Next 3ft. 7in.	1896 Next 3ft. 7in.	1897 Next 3ft. 7in.	1898 Bottom 3ft. 2in.
	%	%	%	%	%
Moisture ...	28·26	28·90	27·70	28·87	26·39
Volatile matter	21·96	21·31	20·85	23·07	22·16
Fixed carbon...	31·78	33·69	32·63	34·82	32·71
Ash	18·00	16·10	18·82	13·24	18·74
	100·00	100·00	100·00	100·00	100·00
Calorific Value	...	...	...	6649	...

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

Analyst: H. Bowley.

No. 6 COAL BORE AT ERADU.

Commenced 14th May, 1929.
Completed 4th June, 1929.

Depth of Core. ft. in.			ft. in.		Description.
0	0	to	13	0	Yellow surface sand with clay.
13	0	,,	93	0	Tough brown and chocolate clay with thin bands of soft sandstone.
93	0	,,	122	0	Soft white sandstone.
122	0	,,	144	0	Soft reddish sandstone.
144	0	,,	157	0	Conglomerate.
157	0	,,	162	0	Soft reddish sandstone with boulders.
162	0	,,	164	0	Gray clay,
164	0	,,	164	6	Ironstone band.
164	6	,,	167	0	Sandy clay.
167	0	,,	175	0	Coal.
175	0	,,	178	0	Gritty sandstone slightly argillaceous.
178	0	,,	180	6	Carbonaceous shale.
180	6	,,	182	9	Coal.
182	9	,,	192	9	Coarse-grained sandstone with bands of clay.
192	9	,,	193	3	Black shale.
193	3	,,	194	0	Carbonaceous shale.
194	0	,,	204	4	Tough gray shale.
204	4	,,	255	0	Coarse-grained sandstone with boulders

No. 7 COAL BORE AT ERADU.

Commenced 21st June, 1929.
Completed 2nd July, 1929.

Depth of Core. ft. in.			ft. in.		Description of Core.
0	0	to	3	6	Yellow sandy loam.
3	6	,,	32	0	Yellow sandy clay.
32	0	,,	44	0	Soft white sandstone.
44	0	,,	51	0	White sandy clay.
51	0	,,	66	0	Soft yellow sandstone.
66	0	,,	72	0	Chocolate and gray clay.
72	0	,,	73	4	Dark shale.
73	4	,,	75	4	Coal.
75	4	,,	79	8	Gray shale.
79	8	,,	90	4	Coarse-grained white sandstone.
90	4	,,	93	0	Gray shale.
93	0	,,	112	0	Coarse-grained gray sandstone.
112	0	,,	113	0	Gray shale.
113	0	,,	119	0	Coarse gray sandstone.
119	0	,,	144	0	Gray sandstone with boulders.
144	0	,,	147	0	Gray sandstone with bands of shale.
147	0	,,	177	0	Coarse gray sandstone.

No. 7 BORE, ERADU.

Depth—73ft. 4in. to 75ft. 4in.

No. 2939/29.

Carbonaceous shale.

Proximate Analysis :—

Moisture	31·50	per cent.
Volatile hydrocarbons and combined water	23·20	,,
Fixed carbon	13·37	,,
Ash	31·93	,,
	100·00	,,

Analyst: D. G. Murray.

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

No. 8 COAL BORE, ERADU.

Depth of Core. ft. in.			ft. in.		Description of Core.
0	0	to	4	0	Sand.
4	0	,,	18	0	Yellow sandy clay.
18	0	,,	36	6	Yellow sandstone.
36	6	,,	71	0	White sandstone.
71	0	,,	76	0	Soft brown sandstone.
76	0	,,	105	9	Soft white sandstone.
105	9	,,	110	3	Soft white sandstone with bands of white clay.
110	3	,,	140	0	Soft white sandstone.
140	0	,,	162	0	Pink sandstone.
162	0	,,	165	0	Brown sandstone.
165	0	,,	166	6	Hard ironstone band.
166	6	,,	169	0	Soft red sandstone.
169	0	,,	172	0	Chocolate clay.
172	0	,,	186	0	Coal.
186	0	,,	190	0	Chocolate clay.
190	0	,,	191	0	Black shale.
191	0	,,	198	6	Coal.
198	6	,,	207	0	Tough gray shale.
207	0	,,	211	0	Carbonaceous shale with coal partings.
211	0	,,	215	0	Tough gray shale.
215	0	,,	219	0	Fine sandstone.
219	0	,,	239	0	Gritty sandstone with boulders.
239	0	,,	241	0	Sandy shale.
241	0	,,	312	0	Soft dark sandstone with bands of shale.

No. 8 BORE, ERADU.

Lab. No.—3789/29.

No. 1 Seam.—Depth 172ft. to 186ft. Core—2ft.

Proximate Analysis :

Moisture	23·30	per cent.
Volatile hydrocarbons ...	25·08	,,
Fixed carbon	21·44	,,
Ash	30·18	,,
	100·00	,,

No. 2 Seam.—Depth 191ft. to 198ft. 6in. Core 7ft. Divided into three equal sections—

Lab. No.	3790/29 Top Section.	3791/29 Middle Section.	3792/29 Bottom Section.
Proximate Analysis—	%	%	%
Moisture	22·21	22·93	15·21
Volatile Hydrocarbons	22·11	24·14	21·79
Fixed Carbon ...	33·63	36·53	20·79
Ash	22·05	16·40	42·21
	100·00	100·00	100·00

Analyst: H. Bowley

(Sgd.) EDWARD S. SIMPSON,
Government Mineralogist and Analyst.

No. 9 COAL BORE AT ERADU.

Commenced 16th September, 1929.
Completed 16th October, 1929.

(Surface approximately 50ft. above surface at No. 7 Bore.)

Depth of Core. ft. in.		ft. in.	Description.
0 0	to	2 0	Ironstone gravel.
2 0	,,	8 0	Clay with ironstone boulders.
8 0	,,	10 0	Hard ironstone.
10 0	,,	44 0	Yellow clay with ironstone boulders.
44 0	,,	48 0	Yellow sandy clay.
48 0	,,	59 0	Fine pink and yellow sandstone.
59 0	,,	64 0	Coarse soft sandstone.
64 0	,,	84 0	Carbonaceous shale with coal bands.
84 0	,,	87 0	Soft sandy yellow clay.
87 0	,,	110 0	White sandstone with rounded boulders.
110 0	,,	114 0	Brown shale.
114 0	,,	136 0	White sandstone with rounded boulders.
136 0	,,	137 6	Gray shale.
137 6	,,	159 0	White sandstone.
159 0	,,	176 0	Black shale.
176 0	,,	196 0	Soft fine grey sandstone.
196 0	,,	202 0	Soft coarse grey sandstone.
202 0	,,	383 0	Dark sandstone with bands of shale.

NOTE.—Carbonaceous shale 64-84ft. not analysed.

In addition to the logs, plans and sections showing the locality of the bores, dip of the coal seams and conglomerate beds, and reduced levels of the bore holes are also attached.

The data so far obtained from these nine bores have definitely proved that the dip of the coal in the area tested is irregular, and that there is considerable troughing, also that the coal beds are more or less lenticular.

The failure to obtain coal in No. 3, Hindley's and Musk's bore, may be due to tailing out of the coal seam, but more probably to a fault striking parallel with the general direction of the course of the river. The general direction of the dip of the coal may, however, be safely regarded as being towards the south-east with a north-east, south-west strike. Owing to the absence of definite coal seams in the deep bores, No. 3, Hindley's and Musk's, also the deep bores still further east at the 47½ mile post, any future boring would best be carried out to the north-west to ascertain whether there may not be coal seams at deeper horizons, or to test by shallow bores, first the country lying at least several miles to the south-east and look for fresh seams where there are strong indications of coal occurring.

The most disappointing aspect of the recent boring is the high percentage of ash and moisture in the coal itself, and the fact that none of the seams have reached even the grade of that found originally in the river calyx bore which was distinctly encouraging.

Of the present series only one is worthy of consideration, viz., the top section of the seam found in No. 4 bore which gave a calorific value of 7028 B.T.U.

REPORT ON THE REPUTED DISCOVERY OF A STRUCTURE SUITABLE FOR BORING IN SEARCH OF OIL, BYRO PLAINS (South of the Wooramel River).

F. R. Feldtmann, Field Geologist.

In accordance with instructions from the Under Secretary for Mines, I accompanied Dr. Woolnough, Geological Adviser to the Commonwealth Government, and Mr. H. W. B. Talbot, to Byro Plains, immediately south of Wooramel River and near the southern end of the North-West Artesian Basin. Mr. Talbot, who had made a geological examination of the area, with a view to its oil-bearing possibilities, on behalf of a Perth Syndicate, had reported the discovery of a dome structure, suitable for a a bore site, at a point about 5½ miles south of Survey Station R25 on Wooramel River (Lands Department Litho. 73/300), and about 15 miles W.S.W. of Bogadi outcamp on Byro Station. The object of the trip was to confirm, or otherwise, Mr. Talbot's observations.

Except for brief reconnaissance trips by H. P. Woodward and A. Gibb Maitland, this area has not been examined by officers of the Geological Survey and no detailed geological mapping has been done. The approximate eastern boundary of the Permo-Carboniferous rocks occupying the area, compiled from Mr. Maitland's notes, was shown on the geological maps of the State published in 1919 and 1920, but observations made during the recent trip indicate that the boundary south of the Wooramel River is somewhat farther west than is shown on these maps. Broad mapping of the area between Sandford and Wooramel Rivers is desirable. In the vicinity of Wooramel River the eastern boundary of the Permo-Carboniferous rocks is probably a short distance east of the Stock Route.

Notes made by Mr. Maitland, and the observations of Dr. Woolnough, Mr. Talbot and myself, show that the area east and south-east of the Permo-Carboniferous rocks is occupied partly by granite, partly by ferruginous quartzites resembling the jaspers of the Goldfields, but possibly belonging to the Mosquito Creek Series, and these rocks probably mainly form the floor on which the Permo-Carboniferous sediments were laid down. Mr. Talbot, whose experience of the Nullagine Series is greater than that of any other geologist, is of the opinion that Mt. Rebecca, about 9½ miles west of the Byro homestead, consists of quartzite of the Nullagine type and similar quartzite dipping west at about 20° was noted during the recent trip on Earilier Hill, 7½ miles N.N.E. of Mt. Rebecca and about half way along the track between Byro homestead and Mearearbundie outcamp. These hills were formerly included in the Permo-Carboniferous area. It is possible, therefore, that in places the Permo-Carboniferous rocks are underlain by sediments of the Nullagine Series, separating them from the older granite and Mosquito Creek Series.

The area examined consists of an almost level plain extending east and west for several miles, partly enclosed by low breakaways and broken in places by buttes and small mesas capped by laterite. Outcrops are fairly common, even on the flat, but are masked, to some extent, by debris in which occasional rounded pebbles, probably glacial erratics, occur.

The Permo-Carboniferous rocks of Byro Plains consist of sandstones, and to a minor extent, grits; dark-grey shales, in which are thin bands of gypsum in places; and limestones. Fossils,§ including various species of spirifers, are numerous in places, particularly in the bed of Wooramel River.

The dip of the Permo-Carboniferous rocks is very low. In the eastern portion of the area the prevailing dip, according to Mr. Talbot's observations, is E.S.E. at about 2°-3°, except in the extreme east, near the margin where the dip is westward, but in the western portion the dips are in directions approximately radiating outwards from the point located by Mr. Talbot.

The total thickness of the Permo-Carboniferous rocks in the Byro area has not been determined. Four bores have been put down for Messrs. Darlôt Bros. in this area, in search of water: No. 1 Bore, at Bogadi outcamp to a depth of 1,253 feet; No. 2 (Boolgarloo Bore), about 8 miles west of Murray Peak, to a depth of 2,218 feet; Bindalya Bore, about 6½ miles south of Bogadi to a depth of 235 feet; and Breakaway Bore, 4 miles south of Bindalya Bore and about 6½ miles N.E. of Murray Peak, to a depth of 303 feet.

According to the logs these bores are entirely in sedimentary rocks, consisting mainly of sandstones and shales, 1,155 feet of shales being stated to occur in No. 1 Bore between 45 feet and 1,200 feet, the remainder of the bore being in sandstone. A large supply of brackish water, which rose to 120 feet from the surface, was struck in this bore at 1,160 feet. In No. 2 Bore, 185 feet of black shale was stated to occur between the depths of 45 feet and 230 feet, and approximately 64 feet of shale between 1,961 feet and 2,025 feet. Highly saline water was encountered at 80 feet, and between 2,090 feet and 2,101 feet salt water, which rose to 141 feet from the surface, was encountered. The determinations of the last 9 feet of this bore are somewhat doubtful, and it is possible that this portion is in the older rocks.

The Bindalya and Breakaway bores are stated to be entirely in sandstone except for about 2 feet of black sand at the bottom of Breakaway Bore.

The only specimens from these bores in the possession of the Survey are fragments from between 490 feet and 1,230 feet from No. 1 Bore, and a specimen of purplish-grey ferruginous sandstone, weathering to a pale yellowish grey with traces of fossil cavities from 1,170 feet in No. 2 Bore.

Between 490 feet and 1,150 feet the No. 1 Bore specimens consist entirely of dark grey shale, in part reduced to clay. Fragments from between 1,150 and 1,170 feet consist of fine-grained compact pale grey sandstone, and the depth between 1,170 feet and 1,230 feet is represented by loose, fine apparently clayey sand, probably from argillaceous sandstone. The occurrence of sandstone between 1,150 feet and 1,170 feet reduces the total thickness of shale in No. 1 Bore to 1,105 feet.

In 1924, the North-West Artesian Basin was examined by Dr. F. G. Clapp, the American oil geologist, on behalf of Mr. A. E. Broué, of Sydney. Dr. Clapp summed up the possibilities of the basin as follows: * "Not a trace of oil is known ever to have been found in any of the two score artesian wells drilled between one and three thousand feet deep. Only traces of natural gas have been reported in any of them, and these could not be substantiated at the time of the writer's inspection. So far as observed, the shales in North-West Basin are entirely inadequate to act as a suitable cover to hold oil in the thousands of feet of sandstones that exist there, even if oil ever existed in these rocks. Sources of origin may have existed but are of theoretical interest only. Structures exist, but these are inconsequential, since other fundamental conditions are unfavourable."

Dr. Clapp includes a list of artesian bores put down in the basin, but does not include those of Byro Station, of the existence of which he was apparently unaware. He dismissed the records of shales in the bores with the statement † that : "in the region any fine-grained material is generally termed 'shale,' hence such reports were not considered important from the standpoint of oil occurrence."

Conclusions.

The examination of the area by Dr. Woolnough and myself confirms the existence of a dome structure at the point located by Mr. Talbot. The records of the bores put down on Byro Station indicate that a considerable thickness of shale suitable to form a cover for oil-bearing strata, should such exist, occurs in this area, and in addition to the exposures noted on Mr. Talbot's map, weathered fragments of shale were noted in places by Dr. Woolnough and myself. On the other hand, no trace of gas or other evidence of oil has been reported from the bores. These, however, are situated at considerable distances from the dome, and, moreover, the total thickness of the sedimentary rocks is unknown.

The Permo-Carboniferous rocks have been faulted subsequently to their deposition. Two faults are shown on Mr. Talbot's map, one a short distance east of Survey Station R20 striking N.N.E. and dipping E.S.E. at 65°, and one west of Callytharra Spring striking W.N.W. and dipping S.S.E. A third well-marked fault which had previously escaped Mr. Talbot's notice was observed, during the recent visit, north of the dome. This fault strikes on the average about N. 29°E., and dips between 70 and 80° W.N.W. It must pass very close to the crest of the dome. The throw of these faults has not been determined and their effect on underlying oil pools, should such ever have existed, is unknown.

Although a dome structure undoubtedly exists at the point located, in my opinion further detailed geological and topographical work in this area, with the object of locating other favourable structures and such faults as may exist, is advisable before boring is undertaken.

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* Clapp, F. G.—Oil prospects of the North-West Basin of Western Australia. Bull. Am. Inst. Pet. Geol., Vol. 10, No. 11, p. 1,149.

† op. cit., p. 1,148.

§ List of Fossils collected by H. W. B. Talbot and F. R. Feldtmann from the Wooramel River District, W.A., in March, 1929, and identified by Miss L. Hosking, B.A., of the University of W.A., is appended at the end of the Report (p. 113).

NOTES ON THE GEOLOGY AND PETROLEUM PROSPECTS OF THE DESERT BASIN OF W.A.

F. G. Forman, B.Sc.

The writer, having recently returned from an observational tour of some of the leading petroleum-producing centres of the United States of America, it was suggested by the Government Geologist that he comment on the Geology and Petroleum Prospects of the Desert Basin, in the light of the most recent discoveries in that area, and from information obtained in actually producing areas. It is with these points in mind that the following notes are written.

The Desert Basin Area is physiographically and geologically described by Mr. Blatchford in Bulletin 93,* but it is thought best to give a brief description of these features in order that the discussion which is to follow may be more easily understood.

The Desert Basin of W.A.† is an extensive peneplain over 125,000 sq. miles in area. It is bounded on the north-east and east by the King Leopold Plateau; on the south-east and south by the interior plateau of the Eastern Division; and on the north and north-west by the Indian Ocean, from Swan Point on the north to Wallal on the south.

The principal streams in the area are the Fitzroy River and its tributaries, draining most of the southern flanks of the northern tableland, and finally discharging into King Sound. The remainder of the area is practically without rivers or permanent surface waters of any kind, and consists mainly of sand ridge country bearing a growth of sturdy desert grass or spinifex.

Structurally the Desert Basin is a geosynclinal unit, occupied by rocks of Upper and Lower Carboniferous age, which are probably underlain by Devonian strata, and cover up an extension of the Cambrian rocks of the Ord Basin.

The junction of the Carboniferous rocks of the Basin with the Cambrian and other rocks of the King Leopold Plateau is marked by an extensive fault which can be traced for a distance of over 200 miles and having a vertical displacement of some 2,000 feet near Price's Creek in the Rough Range. On the south-east, south and west the Basin sediments give way to the metamorphic rocks of the Nullagine Formation, while along the coastal strip they are overlain by sediments of Jurassic age, which in turn are covered, in places, by late Tertiary formations.

Taking the Basin as a whole, rock exposures are very few and widely scattered. In the greater part of the area, especially towards the inner portions, the solid rock is covered by thick deposits of wind-blown sand, which effectively hide the dip; and except where widely scattered and small more resistant areas stand above the general level of the plain, the unravelling of geological conditions by surface observations is an almost hopeless task.

Surface dips indicate that there is a regional dip basinwards. There are minor folds of an anticlinal nature close to the north-east fringe of the Basin, while in the valleys of the Fitzroy River and Christmas Creek a second line of major folds has been mapped.

The Carboniferous rocks of the Basin may be divided on lithological grounds into three groups. The Upper or Poole Range Beds consisting of sandstones and occasional shale beds, now found only on the higher ridges capping the lower strata. They are distinguished by their peculiar form of weathering into conical, rather than flat-topped, hills.

Beneath the Poole Range Beds and making with them a conformable junction are the Grant Range Beds, consisting of rather coarse-grained sandstones interbedded with extensive shales and minor fossiliferous limestone beds. In several localities distinct beds of tillite, containing glaciated boulders, have been noted; while false bedding of the sediments and ripple marking are not uncommon. This series has a proved thickness of over 2,000 feet.

The Poole Range and the Grant Range Beds lie unconformably on the Upper Limestone members of the Lower Carboniferous rocks. The Lower Limestones, where examined at exposures, are massive—though at times well bedded—and are rich with fossil remains, chiefly of coral, polyzoa and other types.

At several localities in the Fitzroy Basin the sediments have been intruded by leucitite lavas in the form of volcanic necks or elongated vents. The largest of these has a length of some twenty chains The leucites are considered to be of Tertiary age owing to their close correspondence to similar intrusions of that age in Java.

The strata of Jurassic age, which overlie the lower rocks along the sea front, need not be further considered as they are of no importance in the present discussion.

There have been, at least, two important earth movements which affect the Basin. The first of these was the rise of the King Leopold Plateau with a corresponding subsidence and faulting of the flanks. The second and much later movement was the general subsidence of the plateau giving the Carboniferous basin its present synclinal form, and causing the development of folding and minor faulting. These movements have caused the development of two series of folds: one minor series close to the main fault on the north-east edge of the Basin, the second and more pronounced series at some distance from the Basin rim, close to the Fitzroy River and Christmas Creek.

A good example of the minor series of folding is seen in the structure which has been mapped by Talbot in the Lower Limestone Beds at Price's Creek. Examples of the second occur at Grant Range, Mount Wynne, St. George Range, Poole Range, and others recently discovered, one south of Mt. Erskine and a second close to Godfrey's Tank on the Canning Stock Route.

Amongst petroleum geologists of the present day it is agreed that certain fundamental criteria for oil occurrence must be reasonably satisfied before a new area can be considered, with any degree of optimism, as a likely place for the development of an oil field.

These fundamental criteria ‡ may be set down as follows:—

1. Do "surface indications" (seepages, etc.), exist?
2. Are the rocks of sedimentry origin?
3. Is the age of the strata (in part at least) similar to that prevailing in some known oil or gas field?
4. Does a possible source of origin exist? If this be not apparent, may it nevertheless be present?
5. Do porous beds or reservoirs exist in which oil may be held in commercial quantities?

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* G.S. W.A., Bulletin 93—" The Geology of Portion of the Kimberley Division with special reference to the Fitzroy Basin and the Possibilities of Occurrence of Mineral Oil," by T. Blatchford, B.A. (1927).

† Map I. For detailed map of area *see* Bulletin 93.

‡ Bulletin A.A.P.G., Vol. II., No. 7 (1927)—" Fundamental Criteria for Oil Occurrence," by F. G. Clapp.

6. If so, does sufficient cover exist above those beds to prevent oil or gas from escaping to the surface and from being lost?
7. Are the strata so slightly metamorphosed by heat or pressure that the oil has presumably not been driven away?
8. Does geological structure exist suitable for concentrating oil or gas in commercial quantity?
9. Are the hydrostatic conditions such as may not prohibit the accumulation of oil in pools?

Applying the above criteria to the Desert Basin, we find that they are all either definitely satisfied or that there is no great doubt of their so being.

Condition 1 does not cause any difficulty. Although only one small surface seepage is reported, from Price's Creek, the absence of extensive surface seepages simply indicates that beds containing much oil have not been exposed at the surface or that faulting has not been intensive enough to cause loss of oil from deeply buried reservoirs.

Conditions 2 and 3 are definitely satisfied, as we have in the Desert Basin an area of over 125,000 sq. miles composed almost entirely of sediments of Carboniferous and possibly Devonian age, corresponding to the producing areas of the Mid-Continent Oil Field of the United States of America and of other producing areas.

Possible sources of origin exist in the abundant limestones of both the Upper and Lower Carboniferous strata. Shale beds also have an extensive existence in the strata and may also be considered a possible source. However, any lengthy discussion of this problem seems unnecessary, as undoubted shows of petroleum have already been recovered from the strata of this area. Traces of bitumen and heavy oil were noted in bores put down in the Upper Carboniferous rocks at Mount Wynne. At Price's Creek undoubted oil shows have been obtained from bores in the lower Carboniferous sandstone. Fair showings of heavy mineral oil have also been obtained from the Upper Carboniferous formations at a depth of about 2,000 feet in the Freney Kimberley Oil Company's bore at Poole Range.

For porous reservoir rocks we need only look as far as the extensive sandstones of the Carboniferous beds. These undoubtedly have the requisite porosity as they yield abundant flows of artesian water.

Efficient cover beds are provided by the extensive shale zones which have been cut in most of the bores put down in search for oil. The presence of shales of sufficient extent to form an effective seal to prevent the upwards migration of the oil has been doubted by several geologists who have visited the area. There now appear to be no grounds for such doubts, as extensive shale beds have definitely been shown to exist. As an indication of their thickness a bore put down on "Cherabin" Station, close to the St. George Range, might be mentioned; this bore having passed through several hundred feet of shales.

The metamorphism of the rocks of the Desert Basin has gone no further than the normal compaction and cementation of sandstones and the formation of normal shales from marine muds and oozes. The injection of the Tertiary leucite has caused baking of the rocks in their immediate vicinity, but as this metamorphic action does not extend beyond the immediate vicinity of the leucite pipes it can have no adverse effect on the petroleum possibilities of the Basin sediments as a whole.

Every geologist who has visited and critically examined the structures in the Fitzroy River and Christmas Creek area has agreed that the structures are excellent, with, so far as can be determined by examination of surface outcrops, a satisfactory closure on all sides.

The question of hydrostatic condition of the reservoirs is probably the one on which there is at the present time least positive information. This question is an important one; as, unless the structures have sufficiently big closures to prevent the removal of their petroleum contents by flushing due to the circulation of underground water, which undoubtedly exists, there is every chance of the greater part of the petroleum contents having disappeared from the structures.

The behaviour of the water in the Freney Kimberley Oil Company's Poole Range bore throws some light on this question. On one occasion when undoubted oil sands were pierced by the drill and oil shows obtained, the water in the bore fell some fifteen or sixteen feet, finally building up to its normal level. This fact seems to indicate that the pressure within the oil sands was less than that of the column of artesian water above. This being so, it seems impossible that the water above could have had access to the oil sands below, otherwise their pressure conditions would have been the same. This seems to indicate that the hydrostatic conditions in the oil sands already penetrated, are favourable.

Certain visiting geologists have, after a reconnaissance of parts of the Desert Basin, held out very little hope of oil being obtained in commercial quantities in this area. While all agreed that excellent structures existed, several were not satisfied by the evidence available to them that the other fundamental conditions were reasonably satisfied. With the facts as they are now known, it seems hardly likely that these men would not reconsider the whole question.

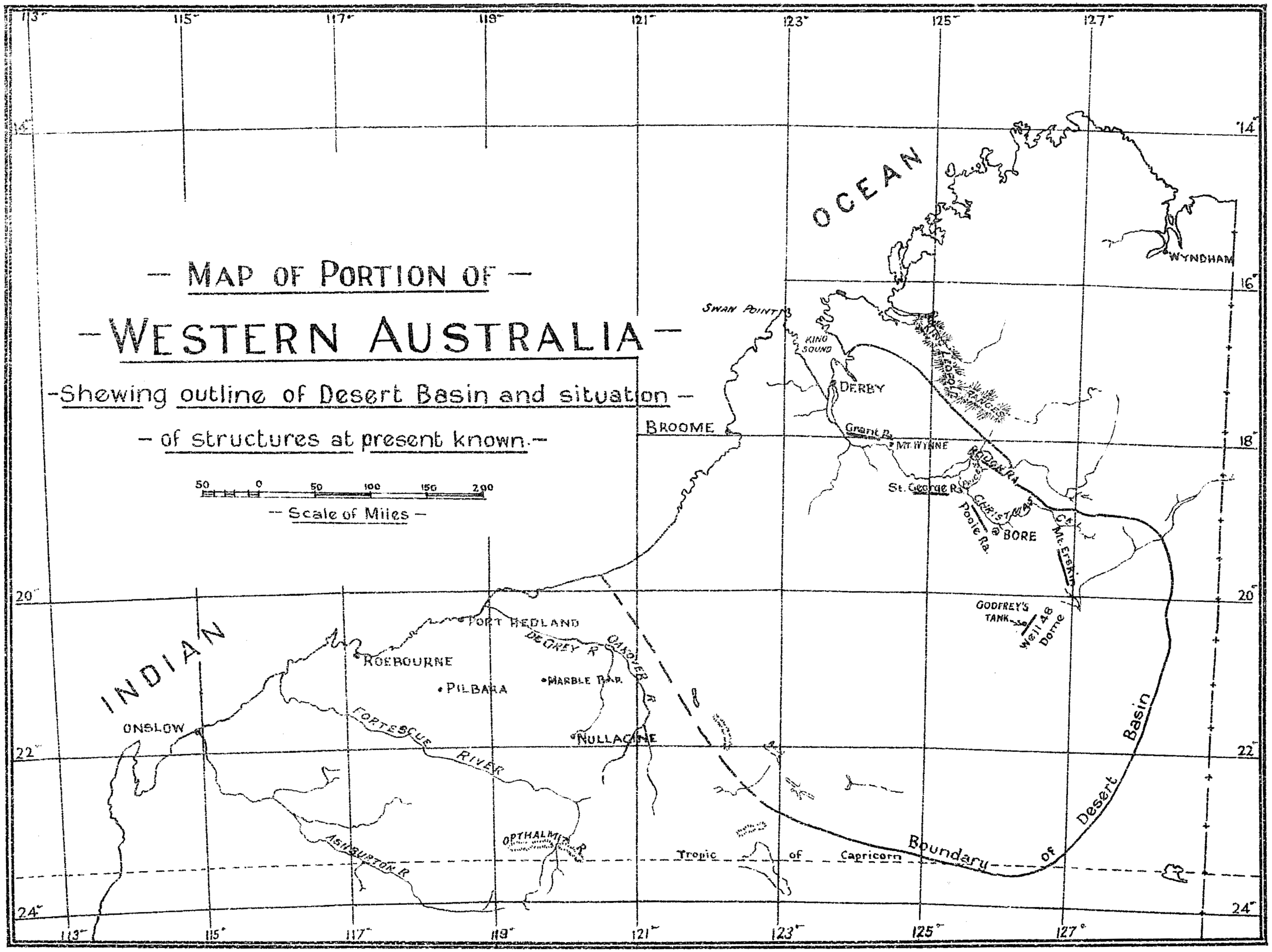
Maps 2 and 3 show the outlines of two basin structures, one the West Texas Permian Basin, the other the Big Horn Basin of Cretaceous age in Wyoming Both these areas contain commercial oil pools and it will be at once noticed that the producing structures in each case lie on general lines in the basin, which are roughly parallel to the rim. Many other similar examples could be quoted but these two should serve to illustrate the point.

In sedimentary basins the existence of axes of folding roughly parallel to the basin edge is to be expected, as a consequence of the forces brought into action at the time of the formation of the main synclinal form.

Blatchford has noticed the marked parallelism of the major line of foldings to the main fault line on the north-east edge of the Desert Basin, and recent investigations by him have led to an extension of this line of folding as far south as Mt. Erskine. A structure still further south has been located by Leo. J. Jones * 1¾ miles east of No. 48 Well, Canning Stock Route.

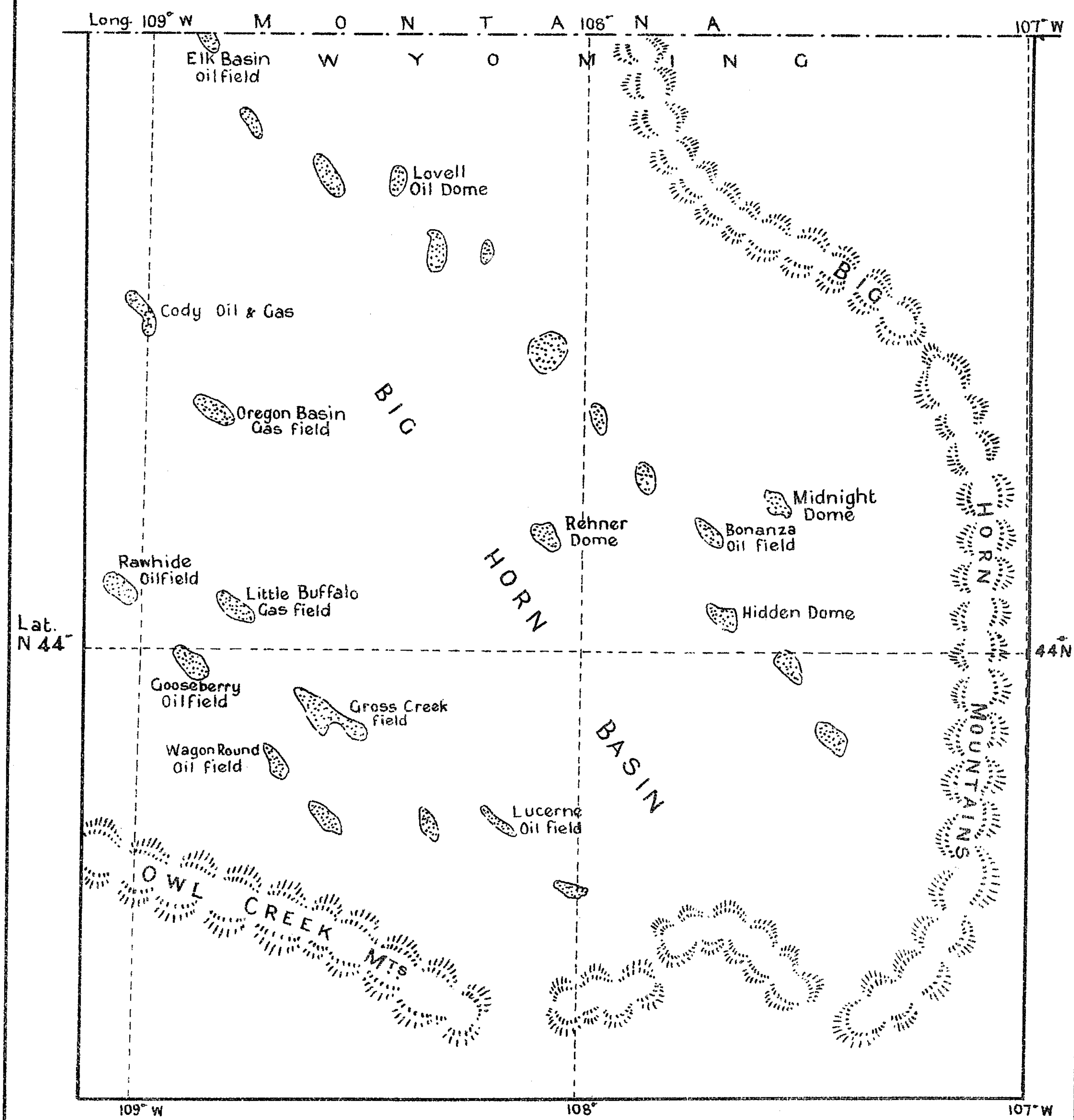
Detailed examination of the Desert Basin for reservoir conditions has so far been practically confined to a strip of country 250 miles long by about 90 miles wide, on the north-east edge of the Basin. This leaves the whole of the southern and western parts of the

* "Report on Petroleum Prospecting Area 21H," by Leo J. Jones, Geologist. Geological Survey of New South Wales.



— MAP OF PORTION OF —
— WESTERN AUSTRALIA —
— Shewing outline of Desert Basin and situation —
— of structures at present known —
50 0 50 100 150 200
— Scale of Miles —
OCEAN
INDIAN
WYNDHAM
SWAN POINT
KING SOUND
DERBY
BROOME
Grant R.
MT. WYNNE
St. George Ra.
BORE
Poole Ra.
Mt. Erskine
GODFREY'S TANK
Well 48 Dome
PORT HEDLAND
DE GREY R.
OAKOVER R.
ROEBOURNE
PILBARA
MARBLE BAR
ONSLOW
FORTESCUE RIVER
NULLAGINE
OPTHALMIA R.
ASHBURTON R.
Tropic of Capricorn
Boundary of Desert Basin
113° 115° 117° 119° 121° 123° 125° 127°
14° 16° 18° 20° 22° 24°

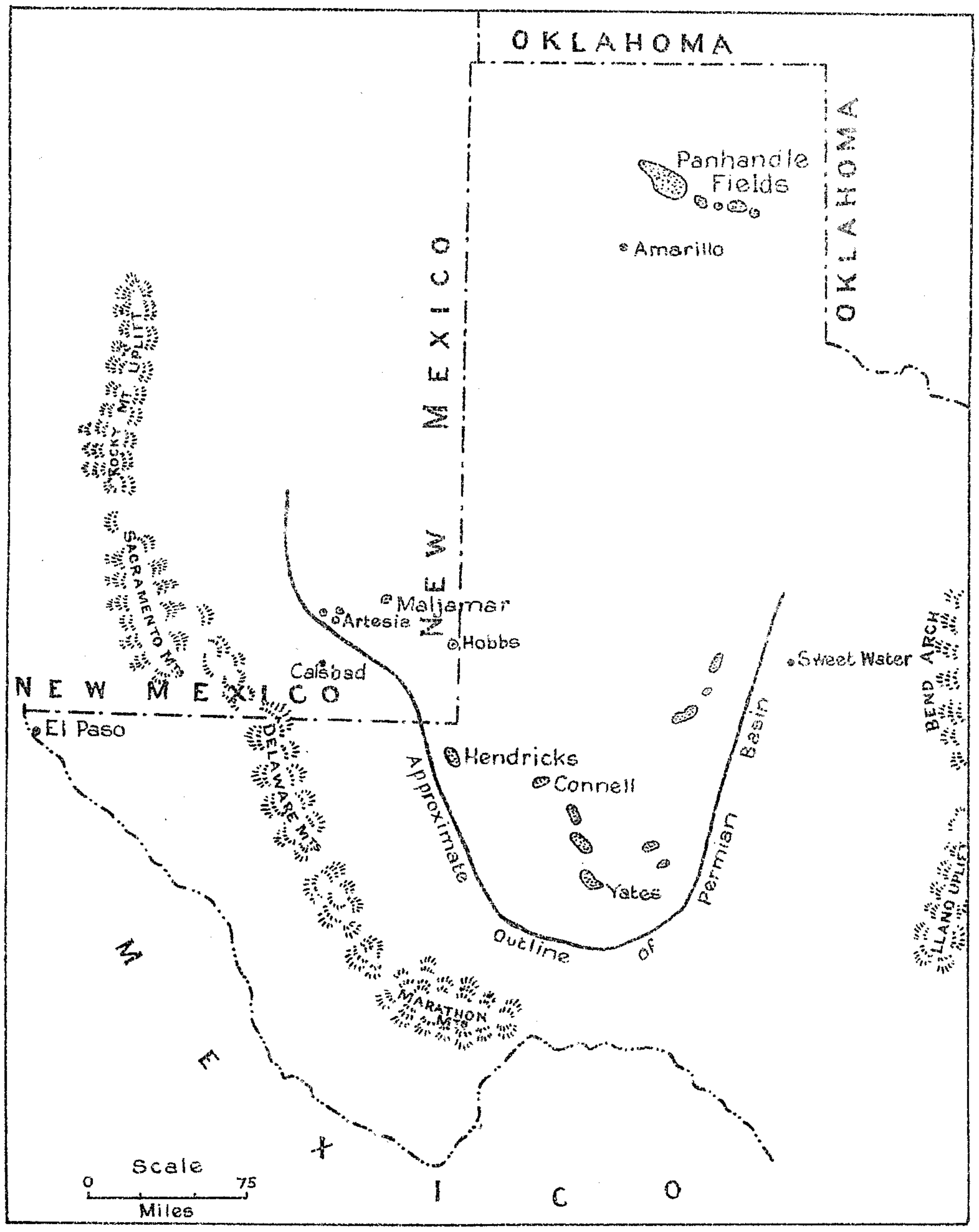
—Sketch Map—
PART OF
— BIG HORN BASIN —
— WYOMING —
— *Shewing general parallelism of Oil* —
— *fields to Basin rim.* —



— Sketch Map —

— West Texas Permian Basin —

— Shewing relation to uplifts and arrangement —
— of oil-fields parallel to rim of Basin —



Basin yet to be examined, and most of this country, from a detailed structural point of view at least, is almost entirely unknown. This area should certainly be examined with the object of locating structures lying parallel to the periphery of the Basin and some distance from its edge, similar to the line of folding already mapped in the Fitzroy River-Christmas Creek Area.

Another line of investigation which might produce results would be the projection into the Basin of any main trend lines existing in the older rocks outside the Basin; the object being to locate structures owing their origin to Carboniferous or Post Carboniferous movements along such pre-existing lines of weakness.

It should be borne in mind that closed anticlinal folds are not the only suitable reservoirs for petroleum. Monoclines and terraces, due to flattening of regional dip, offer distinct possibilities where there are indications that closure has been completed, whether by faulting movements, by the uneven porosity of reservoir rocks, or by the lensing of the formations.

That the proving of an oil field is not a matter of a few months, and that it may possibly call for years of search, is shown by the early history of the West Texas Permian Basin, to-day one of the leading producing districts of the American Mid-Continent region.

Until 1920 this district was not regarded with much favour as a potential oil district. Some hundreds of wells had been drilled with little more than a few small showings of oil and gas as a result. In 1920 a "Wildcat" well, which had been located purely by chance well away from the intended location, was brought into production with a flow of 10 barrels of oil per day. This production, insignificant in any but a new field, stimulated interest in the district and development was rapid, so that by the end of 1928 the daily output of the fields in the West Texas Basin was over 350,000 barrels. This figure was much less than the potential flow of the wells, as production was limited by pipe-line capacity and the closing in of wells to prevent flooding of markets.

PETROLOGY.

ANNUAL REPORT FOR 1929.

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

I am pleased to submit the following report on work carried out in this Department during the year 1929.

The Government carried on a consistent scheme of boring all through the year, and as a result much of the petrological work was devoted to an examination of the cores from the various bores. The Geological survey of the Kalgoorlie Goldfield was continued during 1929 by Mr. Feldtmann and I was closely associated with him in petrologically examining the rocks of that area. Petrographic investigations were also made for Government Departments and for the general public. Details are as follows:—

1. Petrological examination of cores from the Big Bell Mine, Cue.
2. Petrological examination of cores from the Little Bell Mine, Cue.
3. Petrological examination of cores from bores at Norseman.
4. Petrological examination of cores from the Carbine Mine.
5. Petrological examination of cores from the Prophecy Mine, Bamboo Creek.
6. Petrological examination of core from the Kitchener Mine, Bamboo Creek.
7. Petrological examination of core from various bores at Braeside.
8. Petrological examination of cores from the Enterprise Mine, Kalgoorlie.
9. Petrological determinations in connection with the geological survey of the Kalgoorlie Goldfield.
10. Petrological examination of some ore from Wiluna.

1.—BORING AT BIG BELL GOLD MINE, CUE.

Boring was continued at this mine throughout the year. The reports on Nos. 1, 2, and 2 (New) were published in the Annual Report for 1928. This year core was petrologically examined from five extra bores, viz., Nos. 3, 4, 5, 6 and 7.

The petrological investigations, combined with a study of the values shown in the Government Analyst's assay certificate, show that:—

1. The lodestuff in all the bores is the same—physically, mineralogically, and lithologically, viz., a powerfully schisted and granulated pyritic muscovite quartz schist with distinctive white pearly lustred faces, parallel to the planes of schistosity. This schist is riddled with veins and veinlets of glassy quartz, alaskite and pegmatite.
2. The lodestuff persists to over 500 feet in vertical depth. At this depth the channel is just as strong as anywhere else.
3. The values continue to this depth (500 feet vertical).
4. The dip of the hanging wall of the lode channel—as indicated by a petrological examination of the cores from the Nos. 1, 5 and 6 bores—is more likely to be in the vicinity of 63 degrees than vertical.
5. The immediate footwall is generally a more massive white muscovite quartzitic rock, and
6. In the footwall the bores ultimately pass into dense dark green to black siliceous, garnetiferous biotite-actinolite schist with considerable zoisite in places.

The following are the details of the boring:—

No. 3 Bore, Big Bell Mine.

1. This is the most southerly bore put down. Its angle of inclination was 45 degrees, and its depth along the incline was 255 feet.

2. The core from this bore showed some interesting features, viz.:—

(a) It was distinctly auriferous from the start—44 feet to 219 feet, *i.e.*, 175 feet along the angle of inclination to the bore.

(b) The usual distinctive and characteristic lode-stuff, viz.: granulated pyritic white quartz muscovite schist extended from about 111 feet to 219 feet.

(c) Nevertheless, the ferruginous biotite and, in places white schist, in (a) from 44 to 111 feet, *i.e.*, 67 feet contained values as good as most of the distinctive lodestuff, thus making a total of 175 feet of continuous values from 44 feet to 219 feet.

(d) The assay results of (a), (b) and (c), together with cuttings from 90 to 111 feet; 111 to 199 feet 6 inches; and 199 feet 6 inches to 216 feet, are shown in the attached table. (Table I.)

3. This bore stopped in the white quartzitic muscovite-bearing rock. It did not extend to the dark actinolite-zoisite rocks that are to be expected in the footwall.

TABLE I.

BIG BELL MINE—CUE.

Assay Values—No. 3 Bore.

Depth in feet.	Core received.	Nature of Rock.	Gold per ton.	Silver per ton.
ft. in. ft. in.	ft. in.		oz. dwt. grs.	
44 0 to 46 6	1 0	Coarse decomposed biotite schist	0 4 22	
46 6 ,, 50 0	1 0	Decomposed white schist	0 1 2	
50 0 ,, 56 0	2 5	Rotten granite	0 2 2	
56 0 ,, 57 0	0 3	White schist with ¼-inch quartz vein	0 5 9	
57 0 ,, 61 0	1 0	White schist	0 7 15	
61 0 ,, 80 2	2 6	Ferruginous schist—may be intercalated basic schist	0 0 21	
80 2 ,, 81 0	0 9	Ferruginous white schist	0 5 21	
81 0 ,, 85 0	1 0	Ferruginous white schist with quartz vein	0 5 9	
85 0 ,, 90 0	1 6	Ferruginous white schist	0 0 14	
90 0 ,, 93 0	1 0	White schist—slightly ferruginous	Trace	
93 0 ,, 96 0	1 0	Ferruginous schist	0 0 21	
96 0 ,, 99 0	2 0	Ferruginous schist	0 0 10	
99 0 ,, 111 0	2 0	Slightly ferruginous white schist	0 0 14	
111 0 ,, 117 0	2 0	Pyritic granular white schist (typical lode)	0 0 21	
117 0 ,, 122 0	1 6	Pyritic white schist with pegmatite and quartz	0 0 14	
122 0 ,, 128 0	2 6	Pyritic white schist with pegmatite and quartz	0 4 12	
128 0 ,, 134 0	3 6	Granulated pyritic schist	0 0 17	
134 0 ,, 139 8	3 0	Granulated pyritic schist	1 1 19	
139 8 ,, 148 0	2 0	Granulated pyritic schist } Good-looking lode stuff	0 15 11	
148 0 ,, 152 0	1 0	Granulated pyritic schist	0 9 3	
152 0 ,, 156 0	2 0	Slightly pyritic white schist	0 0 21	
156 0 ,, 161 0	3 0	Pyritic schist with pegmatite	0 3 11	
161 0 ,, 168 0	3 0	Pyritic granular schist with pegmatite	0 0 10	
168 0 ,, 176 0	2 0	Pyritic granular schist with pegmatite	0 1 18	
176 0 ,, 186 0	2 0	Pyritic granular schist with pegmatite	0 1 21	
186 0 ,, 192 0	5 0	Pyritic granular schist with pegmatite	0 2 21	
192 0 ,, 200 0	4 0	Pyritic granular schist with pegmatite	0 1 7	
200 0 ,, 206 0	3 0	Slightly pyritic ironstained white schist	0 1 15	
206 0 ,, 213 0	3 6	Slightly pyritic ironstained white schist	0 1 7	
213 0 ,, 219 0	4 6	Slightly pyritic ironstained white schist	0 1 7	
			Gold per ton.	Silver per ton.
			oz. dwt. gr.	ozs. dwt. grs.
219 0 ,, 221 6	2 0	Slightly pyritic white schist	0 0 14	0 3 16
221 6 ,, 226 6	3 6	More massive quartzite with some schist	0 0 17	0 4 6
226 6 ,, 230 3	3 0	Dense white rock with a little pegmatite	0 0 5	0 1 2
230 3 ,, 232 6	2 0	White rock with a little schist	*Nil*	0 0 10
232 6 ,, 237 9	4 0	A band of typical white granulated quartz schist ...	*Nil*	0 0 21
237 9 ,, 243 0	3 0	Dark schist with a quartz vein	Trace	0 2 14
243 0 ,, 249 0	4 6	Massive white graywacke	*Nil*	0 0 14
249 0 ,, 255 0	5 0	Massive white graywacke, but on dark side and somewhat schisted	*Nil*	0 3 6

No. 4 Bore, Big Bell Mine.

1. The *main lode* seems to have extended from 111 feet to 176 feet, *i.e.*, 65 feet along the angle of inclination of the bore, viz., 45 degrees.

2. *Assays.*—The following are the results:—

Depth in feet.					Core received.	Gold per ton.		
ft.	in.		ft.	in.	inches.	oz.	dwt.	grs.
87	0	to	89	0	...	0	0	10
89	0	,,	91	0	...	0	0	5
91	0	,,	93	0	...		*nil*	
93	0	,,	97	0	...		trace	
97	0	,,	99	0	...	0	0	5
99	0	,,	101	0	...	0	0	8
101	0	,,	103	10	...	0	2	18
103	10	,,	111	0	...		trace	
111	0	,,	114	6	3	0	0	21
114	6	,,	116	6	4	0	0	5
116	6	,,	118	6	5	0	1	5
118	6	,,	120	7	1¾	0	4	3
120	7	,,	122	8	7	0	7	20
122	8	,,	124	9	8	0	17	0
124	9	,,	126	10	9	0	3	9
126	10	,,	128	11	15	0	0	5
128	11	,,	131	0	1½	0	1	18
131	0	,,	132	4	10	0	0	17
132	4	,,	135	0	3	0	0	10
135	0	,,	137	2	2	0	0	5
137	2	,,	140	5	3	0	2	4
140	5	,,	143	7	10	0	0	21
143	7	,,	146	2	2½	0	0	5
146	2	,,	149	0	10½	0	17	15
149	0	,,	152	0	27	0	19	4
152	0	,,	154	0	8	0	0	8
154	0	,,	156	0	8	0	3	9
156	0	,,	158	0	10½	0	0	8
158	0	,,	160	0	4½	0	0	8
160	0	,,	162	6	13	0	2	14
162	6	,,	165	0	9	0	3	1
165	0	,,	167	0	3½	0	11	11
167	0	,,	168	0	6	0	3	6
168	0	,,	168	6	5	0	0	10
168	6	,,	171	6	15	0	0	10
171	6	,,	172	10	6½		*nil*	
172	10	,,	173	10	9		trace	
173	10	,,	175	4	9	0	0	5
175	4	,,	176	0	8	0	1	2

In addition to the above, the whole of the core from 176 to 218 feet was assayed. Nineteen assays were made and not one of them showed any gold at all. This is evidently footwall country.

3. This bore is the furthest north of the seven bores put down. It is 200 feet northerly from the No. 1 Bore and 60 feet northerly from the open cut. The results above show that values and lode formation persist as far north as this bore.

No. 5 Bore, Big Bell Mine.

1. This bore was commenced at a point 37 feet south of No. 1 Bore, but 237 feet on the hanging wall of the lode. The angle of depression was 60 degrees. The bottom of the hole along the angle of inclination was 690 feet.

2. *Rock Formations*—

Depth in feet.					Nature of Rock.
ft.	in.		ft.	in.	
59	6	to	260	00	White schisted sandstone with bands of biotite schist—hangingwall country.
260	0	,,	263	4	*Lodestuff.*—Granulated to saccharoidal quartz-muscovite schist impregnated with grains of iron pyrites and traversed by glassy quartz veinlets parallel to the planes of schistosity.
363	4	,,	367	0	Coarse quartz-mica-felspar pegmatite.
367	0	,,	412	0	Dense white to gray and somewhat schisted quartzite with some muscovite.
412	0	,,	690	0	Dark-green to black siliceous and garnetiferous biotite-actinolite schist grading gradually at about 590 feet into a very dense dark green siliceous actinolite-zoisite rock—microscopically schistose.

3. *Assays.*—The main and only lode in this bore lies between 260 and 363 feet 4 inches.

The returns are as follow:—

Depth in feet.					Gold per Ton.		
ft.	in.		ft.	in.	oz.	dwt.	grs.
260	0	to	264	0	0	1	5
264	0	,,	268	0	0	1	12
268	0	,,	272	0	0	0	14
272	0	,,	275	10	0	0	21
275	10	,,	280	0	0	0	21
280	0	,,	284	0	0	1	12
284	0	,,	288	0	1	1	7
288	0	,,	292	8	0	0	5
292	8	,,	295	8	0	9	3
295	8	,,	297	8	0	2	3
297	8	,,	300	0	0	1	0
300	0	,,	304	0	0	4	12
304	0	,,	307	10	0	6	23
307	10	,,	312	0	0	1	0
312	0	,,	316	0	0	1	0
316	0	,,	320	0	0	1	10
320	0	,,	324	0	0	2	21
324	0	,,	328	0	0	5	6
328	0	,,	332	0	0	3	11
332	0	,,	336	0	0	2	14
336	0	,,	340	0	0	4	22
340	0	,,	343	4	0	7	3
343	4	,,	348	0	0	0	21
348	0	,,	351	0	0	1	10
351	0	,,	352	0	0	6	23
352	0	,,	356	0	0	2	2
356	0	,,	360	0	0	0	3
360	0	,,	363	4	0	1	5

For some reason, quite a lot of this core was assayed with negative results, as follow:—

Between 393ft. 5in. and 487ft. seven assays of core from the following depths were made: 593ft. 5in. to 394ft. 5in., 411ft. 4in. to 412ft. 9in., 412ft. 9in. to 415ft. 6in., 416ft. 3in. to 417ft. 6in., 421ft. 8in. to 425ft. 10in., 463ft. to 465ft. and 486ft. to 487ft.

No gold was found in these samples.

Between 506ft. and 557ft. was all assayed.

Twenty-six assays were made and no gold was detected anywhere.

Between 590ft. 8in. and 656ft. 5in. was all assayed in 2ft. sections but no gold was detected.

4. *The Lodestuff.*—Of the first five bores this is the deepest level, viz., 260 to 363 feet 4 inches, at which the lode has been cut. It is identical with the lodestuff in the Nos. 1, 2, 2 (new), 3, and 4 bores. The lodestuff is noted for its granularity, schistosity, abundance of muscovite scales, impregnation with granular iron pyrites, and presence of glassy quartz alaskite, and pegmatitic veinlets and veins. The specimen from 317 feet shows the characteristic and astonishing parallelism of the muscovite rods.

5. *General Remarks.*—This bore is of interest because, so far, it is the deepest that has been put down. Petrographical investigations combined with assay results show that—

(a) the lode is lithologically and mineralogically identical with that found in the Nos. 1, 2, 2 (new), 3 and 4 bores.

(b) The lode is maintaining the same specific characters and similar values at this depth.

(c) The footwall of the lode is a non-pyritic grayish-white, dense, and somewhat schisted quartzite, with a width of about 49 feet from 363 to 412 feet.

(d) Beyond this dense grayish white band of quartzite the country rock is made of dark green to black siliceous and garnetiferous biotite-actinolite schist, which passes into exceedingly dense siliceous dark-green actinolite-zoisite rock.

(e) The actinolite-zoisite rocks of the footwall country are devoid of gold. They are probably the equivalents of the fine-grained granulitic zoisite-quartz epidiorite described by Mr. Farquharson from an outcrop on the eastern side of the lode.

(f) The Nos. 1 and 2 (new) bores revealed the presence of dense actinolite-zoisite rocks in the footwall. This band of rock seems therefore to be continuous from the surface to the deepest point yet reached in the bores.

No. 6 Bore, Big Bell Mine.

1. This bore was commenced immediately behind No. 5 bore at a point 470 feet at right angles from the hanging wall of the lode.

2. The angle of depression was 60 degrees.

3. The total depth along the angle of inclination was 616 feet 9 inches.

4. *Rock Formations.*—This bore started in moderately fresh rock. The formations met with are as follow:—

Depth in feet.					Nature of Rock.
ft.	in.		ft.	in.	
0	0	to	495	0	White to grey saccharoidal micaceous (black and white) banded sandstone schist, darkened in numerous places by much biotite. It consists of innumerable quartz grains with some felspar, occasional ragged piece of chlorite, frequently much biotite and a few garnets. At 467 feet is a small band of beautiful zoisite-biotite schist traversed by a glassy quartz vein.
495	0	,,	604	0	*Lode Channel.*—A powerfully schisted and granulated muscovite sandstone zone impregnated with iron pyrites and traversed by glassy quartz alaskite, and pegmatitic veins and veinlets. The *Main Lode* extends from 495 to 586 feet.
604	0	,,	616	9	Faintly banded dense white to grey and somewhat schisted quartzite (arkosic) with a little muscovite.

5. *Assays.*—Judging from results the main auriferous channel extends from 495 to 603.6 feet, *i.e.*, 108 feet 6 inches. The results are as follow:—

Depth in feet.					Gold per ton.		
ft.	in.		ft.	in.	ozs.	dwt.	grs.
495	0	to	497	0	0	4	14
497	0	,,	498	7½	0	1	18
498	7½	,,	500	3	0	11	23
500	3	,,	502	0	1	1	5
502	0	,,	504	0	0	0	3
504	0	,,	506	0	0	0	3
506	0	,,	508	0	0	1	18
508	0	,,	510	0	0	16	3
510	0	,,	512	0	0	1	21
512	0	,,	514	0	0	0	5
514	0	,,	516	0	0	4	19
516	0	,,	518	0	0	1	15
518	0	,,	520	0	Trace (under 3. grs)		
520	0	,,	522	0	0	0	10
522	0	,,	524	0	Trace		
524	0	,,	526	0	0	0	3
526	0	,,	528	0	0	1	10
528	0	,,	530	0	0	2	14
530	0	,,	532	0	0	0	17
532	0	,,	534	0	0	2	17
534	0	,,	536	0	0	7	18
536	0	,,	538	2	0	10	19
538	2	,,	540	4	0	8	15
540	4	,,	542	4	Trace (under 3 grs.)		
542	4	,,	544	4	0	0	21
544	4	,,	546	4	0	1	5
546	4	,,	548	0	0	3	22
548	0	,,	549	10	0	3	11
549	10	,,	551	9	0	1	7
551	9	,,	552	6	0	6	8
552	6	,,	554	0	0	0	5
554	0	,,	556	0	0	2	17
556	0	,,	558	0	0	8	20
558	0	,,	560	4	0	12	0
560	4	,,	562	9	0	18	0
562	9	,,	565	3	0	4	9
565	3	,,	567	2	0	4	6
567	2	,,	569	4	0	13	16
569	4	,,	571	6	0	2	14
571	6	,,	573	9	0	5	6
573	9	,,	576	0	0	0	5
576	0	,,	578	3	0	1	21
578	3	,,	580	6	0	1	21
580	6	,,	582	6	0	0	10
582	6	,,	584	0	0	1	15
584	0	,,	586	0	0	2	9
586	0	,,	588	0	*Nil*		
588	0	,,	590	10	0	0	5
590	10	,,	593	8	Trace		
593	8	,,	595	0	0	0	5
595	0	,,	597	0	0	0	3
597	0	,,	599	0	0	0	21
599	0	,,	601	0	Trace		
601	0	,,	603	6	0	0	3

From the above results it will be seen that the last 15 feet 6 inches on the footwall side of the channel is very poor. The Main Lode Channel extends from 495 to 586 feet, *i.e.* 91 feet; nevertheless, petrological examination shows that the true lodestuff extends to 604 feet, and this poorness on the footwall side may be only local.

Forty-nine feet of hangingwall rock was assayed from 446 to 495 feet. With the exception of 2 dwt. 9 gr. between 456 and 458 feet, and 10 gr. between 477 and 479 feet, the whole of this rock contained less than ¼ dwt. (6 gr.) of gold per ton.

6. *The Lodestuff.*—This was the same as in all the other bores, viz., granulated and powerfully schisted pyritic micaceous sandstone traversed by glassy quartz, alaskite and pegmatitic veins and veinlets. The lode extended 109 feet from 495 to 604 feet along the inclination of the bore. At 509 feet it contained a considerable amount of microcline. At 502 feet was a quartz-muscovite-microcline vein heavily charged with iron pyrites.

7. *General Remarks.*—The petrological examination shows that the lode formation at these depths (495-604 feet) is still well-defined and powerfully schisted. The bore finished in the dense white quartzitic rock and did not reach the dark actinolite-zoisite rock.

No. 7 Bore, Big Bell Mine.

1. This was the last bore put down by the Government. Its angle of inclination was 60 degrees, and its depth along this angle was 642 feet, or a vertical depth of 556 feet.

2. *Lode Material and Values.*—Judging from assay results the lode extended from 462 to 618 feet, *i.e.*, 156 feet along the angle of inclination of the bore.

The values are as follow:—

Depth in feet.					Core received.	Gold per ton.		
ft.	in.		ft.	in.	inches.	oz.	dwt.	grs.
462	0	to	464	0	...		trace	
464	0	,,	466	0	...	0	0	5
466	0	,,	468	0	...	0	10	16
468	0	,,	470	0	...	0	0	3
470	0	,,	472	0	...	0	1	18
472	0	,,	474	0	...	0	0	3
474	0	,,	476	0	...	0	0	13
476	0	,,	478	0	...	0	0	10
478	0	,,	480	0	...	0	0	5
480	0	,,	482	0	...		*Nil*	
482	0	,,	484	0	...	0	0	3
484	0	,,	486	0	...	0	0	10
486	0	,,	488	0	...	0	0	21
488	0	,,	492	0	...		*Nil*	
492	0	,,	494	0	...	0	0	10
494	0	,,	496	0	...	0	0	5
496	0	,,	498	0	...	0	5	9
498	0	,,	500	0	...	0	0	10
500	0	,,	504	0	...	0	0	14
504	0	,,	506	0	...	0	3	22
506	0	,,	508	0	...	0	4	1
508	0	,,	510	0	...	0	9	14
510	0	,,	512	0	...	0	1	12
512	0	,,	514	0	...	0	3	1
514	0	,,	516	0	...	0	8	1
516	0	,,	517	0	...	0	2	12
517	0	,,	520	8	18	0	9	14
520	8	,,	523	3	12	0	1	5
523	3	,,	525	9	10	0	10	11
525	9	,,	528	0	...	0	7	6
528	0	,,	529	4	9	0	0	3
529	4	,,	532	3	6	0	0	13
532	3	,,	533	11	7		*Nil*	
533	11	,,	537	0	18	0	0	5
537	0	,,	538	0	...	0	0	10
538	0	,,	540	0	...	0	2	2
540	0	,,	542	0	...	0	2	2
542	0	,,	544	0	...	0	5	9
544	0	,,	546	0	...	0	5	6
546	0	,,	548	0	...	0	2	14
548	0	,,	550	0	...	0	1	5
550	0	,,	552	0	...	0	1	2
552	0	,,	554	0	...	0	0	21
554	0	,,	556	0	...	0	0	5
556	0	,,	558	0	...	0	6	0
558	0	,,	560	0	...	0	0	21
560	0	,,	562	0	...	0	0	21
562	0	,,	564	0	...	0	1	23
564	0	,,	566	0	...	0	0	17
566	0	,,	568	0	...	0	7	10
568	0	,,	570	0	...	0	0	13
570	0	,,	572	0	...	0	3	5
572	0	,,	574	0	...	0	3	6
574	0	,,	576	0	...	0	17	15
576	0	,,	578	0	7½	0	5	9
578	0	,,	580	0	...	0	2	14
580	0	,,	582	0	...	0	1	15
582	0	,,	584	0	...	0	2	12
584	0	,,	586	0	...	0	6	13
586	0	,,	588	0	...	0	1	7
588	0	,,	590	0	...	0	2	14
590	0	,,	592	0	...	0	3	6
592	0	,,	594	0	...	0	10	16
594	0	,,	596	0	...	0	5	21
596	0	,,	598	0	...	0	1	21
598	0	,,	600	0	...		*Nil*	
600	0	,,	602	0	...		trace	
602	0	,,	604	0	...	0	1	5
604	0	,,	605	9	...		trace	
605	9	,,	609	6	9		trace	
609	6	,,	612	0	...		trace	
612	0	,,	614	0	...	0	2	21
614	0	,,	616	0	...	0	2	9
616	0	,,	618	0	...	0	1	15
618	0	,,	620	0	...		*Nil*	
620	0	,,	622	4	...		trace	
622	4	,,	623	3	4½		*Nil*	
623	3	,,	625	9	...		*Nil*	
625	9	,,	628	3	...		*Nil*	
628	3	,,	630	9	...		*Nil*	

Of the remainder of the core assayed, from 618 to 630 feet 9 inches, five assays yielded no gold at all, and one gave a trace.

In addition to the above, average assays were made of 359 feet 7 inches of country on the hanging-wall side of the lode between depths of 101 feet 5 inches and 461 feet. Eighty-eight assays were made, but no gold whatever was disclosed.

3. *Rock Formations.*—The only rock formation seen was that between 25 and 461 feet. This was all the usual typical hangingwall country. It consisted of somewhat banded white to dark micaceous (white) sandstone schist with bands of biotite sandstone schist containing garnets in places. Occasional glassy quartz and pegmatite veins were noted. The last 4 feet, from 457 to 461 feet, was a coarse-grained biotite quartz schist.

4. This bore is of interest (a) because it has proved the existence of the lode to a vertical depth of over 500 feet (535 feet, provided there is no deflection in the bore), and (b) because the values apparently continue in depth. These facts are in accord with the petrological evidence regarding this unusual type of ore deposit.

2.—BORING AT LITTLE BELL GOLD MINE, CUE.

Final Report on 3 Bores.

1. Three bores, Nos. 1, 2 and 3, were put down on the Little Bell Gold Mine, Lease 2050, immediately adjoining the Big Bell Lease on the southeast.

2. The bores are as follow:—

No.	Angle of Depression deg.	Inclined depth. ft.	in.	Vertical depth. feet.
1	60	331	0	286·6
2	60	316	0	273·6
3	60	407	8	352·4

3. The attached plan shows the relative positions of these bores.

No. 1 Bore.

1. Rock Formations.—The rock matter passed through is as follows:—

Depth in feet.	Nature of Rock.
140ft. to 196ft. ...	White clayey schist.
196ft. to 273ft. ...	Dark schist, in places ferruginous and containing a considerable amount of coarse biotite schist with garnets in places. This rock is lithologically similar to part of the formation met with in the Big Bell bore.
273ft. to 289ft. ...	Coarse-grained biotite quartz schist. with a glassy pyritic quartz vein at 275 feet.
289ft. to 331ft. ...	Muscovite quartz schist with some glassy quartz veins and pyrites. The last six feet from 325ft.-331ft. is more dense and quartzitic.

2. Assays.—Quite a lot of this core was assayed. The following is a summary of the results:—

Depth in feet.					Core received.		Gold per ton.		
ft.	in.		ft.	in.	ft.	in.	oz.	dwt.	grs.
140	0	to	201	3	all assayed			*Nil*	
201	3	,,	209	3	2	0	0	3	6
209	3	,,	213	3	0	10	0	3	1
213	3	,,	218	3	2	4		*Nil*	
218	3	,,	223	3	1	2	0	3	11
223	3	,,	255	6	averaged			*Nil*	
255	6	,,	257	10	1	7	0	0	8
257	10	,,	261	0	1	2	0	0	3
261	0	,,	329	2	averaged		*Nil* and traces		
329	2	,,	331	0	1	6	0	0	21

The above assays show that, with the exception of 12 feet from 201 feet 3 inches to 213 feet 3 inches, and 5 feet from 218 feet 3 inches to 223 feet 3 inches, the rest of the core contained practically nothing.

3. Petrological examination shows that the best values—the best being less than 4 dwts.—were found in the dark biotite schist rock. The formation between 289 and 331 feet, lithologically similar to the auriferous rock in the Big Bell Mine, is unpayable in this bore.

No. 2 Bore.

1. This bore was started about 370 feet northwesterly from No. 1 Bore.

2. Rock Formations.—The rock matter passed through is as follows:—

Depth in feet.	Nature of Rock.
192ft. to 248ft. ...	A mixture of biotite and muscovite quartz schist with glassy quartz veins, pegmatitic veins and a little tourmaline-bearing granite veins. A fair amount of biotite schist is intercalated with the white muscovite quartz schist.
248ft. to 275ft. ...	Coarse-grained biotite schist.
275ft. to 316ft. ...	Muscovite quartz-schist with a fair amount of iron pyrites in places and glassy quartz veins. The bore ended in muscovite quartz schist.

3. Assays.—The whole of the core between 190 and 316 feet was averaged and assayed. The following is the summary of the results:—

Depth in feet.					Core received.		Gold per ton.		
ft.	in.		ft.	in.	ft.	in.	oz.	dwt.	grs.
190	0	to	194	0	1	3	0	3	1
194	0	,,	205	8	...		*Nil* and traces		
205	8	,,	207	7	0	9	0	0	14
207	7	,,	209	6	0	9	0	5	19
209	6	,,	212	7	0	9	0	0	21
212	7	,,	215	2	0	9	0	0	17
215	2	,,	218	0	0	9	0	2	21
218	0	,,	220	4	1	2	0	2	4
220	4	,,	224	0	0	8	0	2	4
224	0	,,	226	5	0	8	0	2	14
226	5	,,	228	10	1	5	0	13	12
228	10	,,	130	9	0	10	0	0	10
230	9	,,	233	2	0	2	0	0	10
233	2	,,	236	0	2	4	*Nil* and trace		
236	0	,,	238	0	1	5	0	0	5
238	0	,,	244	0	...		*Nil*		
244	0	,,	246	0	1	1	0	2	0
246	0	,,	250	8	...		*Nil*		
250	8	,,	252	8	1	9	0	0	3
252	8	,,	254	9	2	0	0	2	17
254	9	,,	256	10	2	0	0	1	18
256	10	,,	258	10	2	0	0	2	9
258	10	,,	261	0	2	0	0	0	10
261	0	,,	263	0	2	0	0	0	5
263	0	,,	272	9	...		*Nil*		
272	9	,,	276	8	...		trace		
276	8	,,	278	8	1	3	0	0	14
278	8	,,	280	6	1	3	*Nil*		
280	6	,,	281	10	0	5	0	0	5
281	10	,,	283	5	1	1	0	1	10
283	5	,,	285	1	1	1	0	0	5
285	1	,,	287	0	1	8	0	0	10
287	0	,,	289	0	1	7	0	0	3
289	0	,,	291	2	1	5	0	0	3
291	2	,,	293	5	0	2	0	0	5
293	5	,,	295	7	1	10	0	0	10
295	7	,,	298	0	1	11	0	2	2
298	0	,,	300	0	2	0	0	0	3
300	0	,,	302	0	1	7	trace		
302	0	,,	316	0	...		*Nil*		

4. The assay results show that gold is more or less distributed over 110 feet along the inclination of the bore, from 190 to 300 feet; in other words, this bore has disclosed a very low-grade formation. The best run of ore is from 207 feet 7 inches to 228 feet 10 inches, *i.e.,* 21 feet 3 inches, ranging from 21 gr. to 13 dwt. 12 gr. per ton.

5. The schist in this bore is distinctly more granulated—like Big Bell ore—than the rock from No. 1 Bore. The ore, that assayed 13 dwt. 12 gr. (226 feet 5 inches to 228 feet 10 inches), was distinctly granulated and pyritic.

6. The values between 244 feet and 263 feet came from coarse-grained biotite quartz schist. This is important because it shows that the gold is not always confined to the white granulated muscovite quartz schist. It has already been noted that the gold in the Big Bell Mine was occasionally found in the biotite schist which occurred mainly in the hanging wall of the Big Bell lode and occasionally in layers intercalated with the white granulated pyritic lode stuff.

7. The white muscovite quartz schist from 275 feet to 315 feet 3 inches contained a fair amount of iron pyrites in places, also glassy quartz veins. This pyritic schist is lithologically the same as the Big Bell lodestuff, but in this bore the assay values were very low.

No. 3 Bore.

1. This bore is the nearest to the Big Bell boundary, and is situated about 135 feet north-westerly from No. 2 Bore.

2. Rock Formations.—The rock matter passed through is as follows:—

Depth in feet.	Nature of Rock.
184ft. to 313ft. ...	Banded white muscovite-biotite sandstone schist with an occasional glassy quartz vein.
313ft. to 352ft. ...	Coarse-grained biotite-quartz schist.
352ft. to 398ft. ...	Muscovite sandstone schist, somewhat granulated and pyritic. From 368ft. to 392ft. is strongly pyritic and granulated; these 24ft. are typical of Big Bell ore.
398ft. to 407ft. 8in.	Dense white muscovite-bearing quartzite.

3. Assays.—One hundred and nine (109) assays were made of core from this bore. The results may be summarised as follow:—

Depth in feet.					Core received.	Gold per ton.		
ft.	in.		ft.	in.	inches.	oz.	dwt.	grs.
184	0	to	313	0	...	trace		
313	0	,,	315	0	21	*Nil*		
315	0	,,	319	0	45	trace		
319	0	,,	322	5	24	trace		
322	5	,,	325	4	30	0	0	10
325	4	,,	336	7	...	*Nil*		
336	7	,,	338	8	24	0	0	5
338	8	,,	360	0	...	*Nil*		
360	0	,,	362	0	11	0	1	5
362	0	,,	364	0	14	0	0	13
364	0	,,	366	0	24	0	0	10
366	0	,,	368	0	23	0	0	14
368	0	,,	382	0	...	*Nil*		
382	0	,,	384	0	20	0	0	17
384	0	,,	386	0	24	0	2	0
386	0	,,	388	0	24	0	2	14
388	0	,,	390	0	24	0	1	12
390	0	,,	392	0	23	0	0	17
392	0	,,	394	0	20	0	2	21
394	0	,,	407	8	...	*Nil*		

From the above results it may be seen that there were only two auriferous patches: (1) 8 feet, from 360 feet to 368 feet, and (2) 12 feet, from 382 to

394 feet. Both of these are very low grade, the highest assay being 2 dwt. 21 gr. per ton. From 184 to 360 feet (176 feet along the inclination of the bore) the assays revealed practically no gold.

4. Although the Big Bell ore channel is clearly recognisable between 368 and 392 feet, the values are very low.

Summary and Conclusions from Examination of Core from the Three Bores on Little Bell Gold Mine.

1. The country rock of the Little Bell Mine is lithologically the same as that on the Big Bell Mine. Biotite and muscovite schists, with garnets, glassy quartz veins and so on are found in both bores.

2. The bores in the Little Bell Mine did not go far enough to cut the dark green zoisite hornblende rocks that occur in the footwall country of the Big Bell Mine.

3. In the vicinity of the Little Bell Bores, when compared with the Big Bell area, there is a diminution in (a) metamorphic action in the form of schisting, pyritification and granulation of the rock, (b) intrusive action in the form of injections of auriferous pegmatitic, alaskitic, and glassy quartz veins with sulphide of iron, and (c) a consequent all-round lowering of values.

3.—BORING AT NORSEMAN.

No. 1 Bore, Mararoa Gold Mine.

1. This bore was put down vertically to test the lode between 600 and 700 feet. The bottom of the bore reached 700 feet.

2. The bore was in a dense, fine-grained amphibolite rock (cut by felsite dykes) to about 590 feet. At 590 feet a strongly schisted channel was entered and continued to 675 feet. This channel contained the main quartz reef from 609 feet 8 inches to 621 feet 9 inches; a small reef from 647 to 650 feet; and a quartz vein from 671 feet to 672 feet 3 inches. From 675 feet to the end of the bore—700 feet—the core was made of chloritised coarse-grained epidiorite.

3. Ore Deposits.—The main ore deposit was a white quartz reef with, in places, patches and grains of iron pyrites. The assay results are as follow:—

ft.	in.		ft.	in.	
609	8	to	610	4	Gold, a trace (under 5 gr. per ton).
610	4	,,	612	2	Gold, a trace (under 5 gr. per ton).
612	2	,,	613	8	Gold, 10 gr. per ton.
613	8	,,	616	2	Gold, 5 dwt. 21 gr. per ton.
616	2	,,	618	9	Gold, 11 dwt. 2 gr. per ton.
618	9	,,	620	0	Gold, 8 dwt. 10 gr. per ton.
620	0	,,	621	9	Gold, 4 dwt. 1 gr. per ton.

Three feet of white quartz reef, from 647 to 650 feet, assayed:—

ft.	in.		ft.	in.	
647	0	to	648	6	Gold, 10 gr. per ton.
648	6	,,	650	0	Gold, 10 gr. per ton.

The quartz vein from 671 feet to 672 feet 3 inches contained no gold.

The felsite dyke from 400 to 417 feet was averaged, but the assay results showed it to be non-auriferous.

4. The following is the succession of rocks cut in this bore:—

ft.	in.		ft.	in.	
0	0	to	116	0	Dense fine-grained greenstone
116	0	,,	180	0	Gray felsite dyke.
180	0	,,	400	0	Dense fine-grained amphibolite.
400	0	,,	417	0	Gray felsite dyke.
417	0	,,	590	0	Dense fine-grained amphibolite.
590	0	,,	609	8	Chloritised hornblende schist.
609	8	,,	621	9	Main quartz reef.
621	9	,,	647	0	Chloritic hornblende schist.
647	0	,,	650	0	White quartz reef.
650	0	,,	671	0	Chloritic hornblende schist.
671	0	,,	672	3	Quartz vein.
672	3	,,	675	0	Chloritic hornblende schist.
675	0	,,	700	0	Coarse-grained greenstone—epidiorite

5. The petrographic investigations indicate the existence of a very powerful schisted channel between 590 and 675 feet.

This channel is intimately related to the ore deposits, for it acted as the main line of weakness along which the openings formed in which the white quartz of the main and subsidiary reefs was deposited.

The "channel" rock is a chlorite-actinolite-hornblende schist. It is made up of layers of chlorite, actinolite, and some hornblende with quartz mozaics. It is evident that this schist channel has formed from the crushing, breaking-down and schisting of the chloritised coarse-grained epidiorite—typically developed at 675 feet. This epidiorite is made up of plates of pale green uralite, some of which is strongly chloritised. Felspar is common, but it is not saussuritised.

No. 2 Bore, Mararoa Gold Mine.

1. This bore was put down vertically with a view to cutting the reef at about 200 feet.

2. *Assays.*—With the exception of 1 foot 2 inches of quartz between 62 feet and 63 feet 2 inches, no distinctive quartz veins were cut. This sample assayed 1 dwt. 2 gr. of gold per ton.

This bore disclosed a powerful schist channel from 30 to 141 feet. The schisting was excessive from 126 to 141 feet, and showed signs of quartz. In consequence, assays were made of core from the following depths: 126-129 feet, 132-133 feet 6 inches, 135-138 feet, and 138-141 feet. The results showed no gold at all.

A little schisted rock was cut between 194 feet 6 inches and 196 feet. It yielded no gold on assaying.

3. The rock formations passed through are as follow:—

ft.	in.		ft.	in.	
0	0	to	30	0	(2 feet of core). Rotten brownish greenstone.
30	0	,,	62	0	Actinolite schist.
62	0	,,	63	2	White quartz.
63	2	,,	141	0	Actinolite schist.
141	0	,,	213	0	Excessively fine-grained amphibolite.
213	0	,,	298	0	(end of bore). Coarser-grained epidiorite.

No. 3 Bore.

1. This bore was put down to test the reef on the Viking Gold Mine below the No. 7 level.

2. The vertical depth of this bore is 545 feet.

3. The whole of this bore was in basic epidiorite of varying texture. The first 200 feet was in coarse-grained epidiorite; the last 345 feet being mostly fine-grained epidiorite.

4. *Ore Deposits.*—It should first be pointed out that the powerful schist channel met with in the Nos. 1 and 2 bores was not revealed by petrological examination. One may take it, therefore, that the

schist channel which contains the reefs in the Mararoa line of lode is absent in this bore. The only indications of ore are as follow:—

ft.	in.		ft.	in.	
181	7	to	183	7	Quartz.
525	9	,,	526	3	White quartz.
529	10	,,	531	0	Siliceous lodestuff with some white quartz.

All this core was assayed, but it contained neither gold nor silver.

5. The succession of rock formations is as follows:—

ft.	in		ft.	in.	
28	6	to	181	7	Coarse-grained basic epidiorite. The rock was more or less fresh at the surface.
181	7	,,	183	7	White quartz (no gold).
183	7	,,	210	0	Coarse-grained basic epidiorite.
210	0	,,	290	0	Dolerite amphibolite.
290	0	,,	400	0	Coarse-grained epidiorite.
400	0	,,	525	9	Fine-grained epidiorite—felspar microlites in a mass of fine-grained hornblende.
525	9	,,	526	3	White quartz vein (no gold).
526	3	,,	529	10	Fine-grained epidiorite.
529	10	,,	531	0	Siliceous lodestuff with some white quartz.
531	0	,,	545	0	Fine-grained epidiorite.

4. BORING AT CARBINE MINE.

1. One vertical bore was put down at this mine with a view to cutting the lode at a depth of about 550 feet.

2. This bore was completed at a vertical depth of 663 feet 4 inches.

3. From 433 feet 6 inches to 438 feet, and again from 450 to 453 feet the core consisted of quartzose material mixed with greenstone. It was all assayed but contained no gold or silver. Apart from this quartzose material the remainder of the core contained no metallic mineralisation or other evidence of lode or reef formation.

4. The zone of oxidation extended to 114 feet. The rest of the bore was in one rock formation, viz., a greenstone derived from very basic rocks. This greenstone ranged from a fine-grained chloritic actinolitic rock through almost pure chlorite rocks to chlorite-carbonate schists. A feature was the numerous pseudo-phenocrysts of biotite and hornblende in the chlorite-carbonate rocks.

5. BORING AT PROPHECY MINE, BAMBOO CREEK.

1. This bore was put down in a westerly direction. Its angle of depression was 45 degrees.

2. The total depth reached along the angle of depression was 475 feet.

3. Throughout its whole length this bore was in one class of rock, viz., a serpentinous talcose rock with carbonated modifications, similar to the country at Kitchener mine. Carbonate veins and veinlets are common.

4. Between 354 and 360 feet the greenstone was so riddled with carbonate veinlets that it was thought advisable to test it by assaying. Three samples were assayed, with the following results:—

354 to 356 feet	... ...	Gold: nil.
356 ,, 358 ,,	... ...	Gold: nil.
358 ,, 360 ,,	... ...	Gold: nil.

5. Apart from the powerfully carbonated zone referred to in (4) the bore passed through no lodestuff, veins, or mineralised zones that warranted assaying.

6.—BORING AT KITCHENER MINE, BAMBOO CREEK.

No. 1 Bore.

1. I have examined the core received from this bore between 40 feet and 328 feet, and what was left of the core after selection of samples for assay between 328 and 396 feet.

2. The country rock is similar to that reported on from the No. 2 Bore, viz., talcose-serpentine rock and its modifications.

3. The bore reached a depth of 482 feet.

4. Forty-eight assays were made of practically the whole of the core between 328 and 482 feet, but there was no gold in any of them.

No. 2 Bore.

1. This bore was put down at an angle of depression of 60 degrees.

2. It reached a total depth of 500 feet.

3. The bore passed through one rock formation, chiefly a dark-green strongly talcose serpentine with scattered grains of carbonates. This rock is not consistent, but is liable to change—mainly carbonation, e.g., at 390 feet it is essentially a talc carbonate rock, talc predominating in a heterogeneous mass of brightly polarising scales. At 210 feet it is an almost pure carbonate rock.

4. None of the rock in this bore showed sufficient mineralisation to be regarded as lodestuff. However, five assays were made of (a) rock riddled with carbonate veinlets, (b) quartz and carbonate veins mixed with country rock, (c) and in one place talcose serpentine with grains of iron pyrites. The results showed no gold at all. The depths from which the samples were taken are as follow: 190ft.-191ft. 6in., 222ft.-224ft., 242ft.-243ft., 318ft.-342ft., and 391ft.-392ft.

7. BORING AT BRAESIDE.

The petrographical examination of cores from Braeside revealed much that was of interest, and cores were received from the following bores:—

No. 1, Ragged Hill, from 365 to 386 feet, and 3 pieces from 385, 430 and 500 feet.
No. 3, Ragged Hill: Three pieces from 402, 433, and 443 feet.
No. 1 Bore, M.L. 291: From 342 to 385 feet.
No. 2 Bore, M.L. 291: From 76 to 110 feet.
Barker's bore: From 280 to 320 feet.
Kennedy Junior Lease.*

No. 1 Ragged Hill Bore.

The rock examined came from between 365 and 386 feet, and specimens from 385, 430 and 500 feet respectively. The succession of rocks is as follows:—

ft.		ft.	
365	to	376	Typical greenstone: chloritised and carbonated basalt.
376	,,	382	Brecciated zone with some amygdaloidal greenstone.
382	,,	386	Amygdaloidal greenstone after basalt.

* For locality plan of these bores see G.S.W.A., A.R. 1928.

At 365 feet the typical rock is a greenstone representing a chloritised and carbonated basalt. It consists of felspar microlites and small altered laths lying in all azimuths and separated by a heterogeneous mass of shapeless carbonates and chlorite. Veins of carbonates traverse this rock.

From 376 to 382 feet is a brecciated zone evidently caused by a shattering of the greenstone and the later passage of siliceous solutions containing some lead sulphide. Fragments of (a) amygdaloidal greenstone, and (b) dark brown felsite (silicified and bleached greenstone) cut by glassy quartz veins, are set in the quartz. The silica is microcrystalline to chalcedonic and contains veinlets of galena.

Specimen 385 forms the typical footwall rock of the shattered and brecciated zone. It is an amygdaloidal greenstone after basalt. Macroscopically it is a dark green fine-grained rock showing cleavage facets of felspar. Microscopically it is made up of small laths and microlites of felspar lying in all azimuths in a mass of chlorite and carbonates. Mixed quartz-carbonate veins traverse this rock. The specimens from 430 and 500 feet respectively indicate that the bore is still in greenstone.

No. 3 Bore, Ragged Hill.

Only three pieces of core were received from this bore. They have been reported on. The rocks referred to are:—

402ft.—Footwall just entering lode. A dense dark-green very fine-grained amygdaloidal basalt. The amygdules contain chlorite and quartz mosaics. The groundmass is considerably chloritised.

433ft.—Hanging wall just through the lode. Also a chloritised basalt, with red veinlets of ferruginous carbonates.

443ft.—Maximum depth obtained. Still in chloritised basalt.

No. 1 Bore, M.L. 291.

According to a report from the Government Analyst 4 inches of this core at 366 feet showed small specks of galena. The four inches of core assayed: lead 2.16 per cent.; zinc, nil; gold, nil; silver 1 dwt. 7 gr. per ton.

The core received by me came from between 342 and 385 feet. The bore passed through the following succession:—

342 to 355ft.—Amygdaloidal chloritised basalt. The amygdules were not abundant, and were filled with chlorite and calcite. Under the microscope the rock consists of abundant scales of chlorite and grains of leucoxene scattered throughout a mass of water-clear to clouded altered felspar with patches of secondary silica.

355 to 362ft.—Breccia of white silica with traces of galena and bleached leucoxenised amygdaloidal basalt. The basalt has been cut to pieces and shattered and then invaded by galeniferous siliceous solutions which cemented the whole mass into a breccia. Later carbonate veins cut the siliceous mass and breccia.

362 to 375ft. 6ins.—Amygdaloidal chloritised leucoxenic basalt with small patches of breccia and silicification. Galena-bearing veins cut this basalt. At 366ft. 7ins. a piece of core sectioned showed the contact of silicified leucoxenised and chloritised basalt with a siliceous vein made of both cryptocrystalline and microcrystalline silica. The silica was traversed by a network of microscopic veinlets of galena, and contained crystallised pyrites along its contact with the basalt. It was from this zone that the core assayed by the Government Analyst came.

383 to 385ft.—Amygdaloidal chloritised basalt with carbonate veins containing a little lead and copper sulphide.

No. 2 Bore, M.L. 291.

The core received from this bore came from between 76 and 110 feet. This bore contained a distinct argentiferous lead lode containing some zinc. It was made of somewhat granular galena mixed with greenstone but details cannot be given as the lode material was not seen intact.

The following are the assay results of core from 92 feet 8 inches to 100 feet submitted by the Government Analyst:—

Depth.	Lead. %	Zinc. %	Silver. oz.	dwt.	grs.	Gold.
92ft. 8in. to 94ft.	47·66	4·54	1	3	21	Nil.
94ft. to 95ft.	45·45	6·86	1	4	16	Nil.
95ft. to 96ft.	52·13	5·95	1	9	9	Nil.
96ft. to 97ft.	56·47	6·07	1	10	16	Nil.
97ft. to 98ft.	51·02	7·57	1	9	22	Nil.
98ft. to 99ft.	36·55	4·10	1	0	11	Nil.
99ft. to 100ft.	51·11	3·50	1	3	13	Nil.

The examination of the core from this bore gave the following results:—

76ft. to 79ft.	Dark basaltic rock with quartz patches. The basalt has been shattered and penetrated by siliceous solutions which have cemented the whole mass into a breccia.
79ft. to 80ft.	Shattered white glassy quartz.
80ft. to 82ft.	Shattered basaltic greenstone riddled with veins and veinlets of quartz.
82ft. to 85ft.	White glassy quartz with a little fine-grained galena and blende.
85ft. to 86ft.	Black basaltic greenstone.
87ft. to 89ft. 6ins. ...	Breccia.
89ft. 6in. to 92ft. 8in. ...	Brecciated lode material with veinlets of microcystalline silica containing shapeless ragged pieces of galena. Rotten greenstone—some carbonated, altered and impregnated with a little galena and pyrites—is mixed with the silica.
92ft. 8ins. to 100ft. —	*Zinciferous and Argentiferous Galena Lode.*—(Assays given above).
100ft. to 110ft. ...	Amygdaloidal and somewhat shattered basaltic greenstone with patches of breccia.

Baker's Bore.

Core was received from this bore between 280 and 320 feet.

From 280 to 305 feet the core consisted of highly chloritised and carbonated basaltic greenstone. The felspars have been almost destroyed though relicts remain, together with traces of amygdules.

From 305 to 320 feet is still more highly altered silicified basaltic rock with much quartz and carbonates.

Kennedy Junior Lease.

Core was received from between 373 and 417 feet. The rock from this bore was entirely different from all the other bores. It contained no lode material, altered basaltic greenstone or breccia. On the other hand it is a perfectly fresh black dolerite made of augite and fresh plagioclase.

Concluding Remarks.—The petrological investigations indicate that the country rock at Ragged Hill, M.L. 291, and Barker's Bore is made of altered chloritic amygdaloidal basalts, while that on Kennedy Junior Lease is entirely different and probably newer in age, viz., fresh dolerite.

The one marked feature revealed by the microscope is the pronounced zone of shattering which traverses the amygdules. Siliceous alkaline and carbonated solutions containing lead, zinc, silver and a little copper traversed this zone and deposited their contents, not only in the zone of brecciation, but in veins and veinlets in the amygdules associated with that zone. The formation of ore was apparently controlled by selective deposition, and in No. 2 Bore on M.L. 291 the concentration of lead sulphide was sufficient to make a distinctive lode.

Another feature is the occasional presence in places of a curious rock, to all intents and purposes a pinkish-brown felsite. It was recorded from the Ragged Hill and Barker's bores. For some time it appeared to be a dyke rock genetically connected with the lead-bearing solutions. But I was able finally to obtain sufficient evidence to indicate that it is the chloritised amygdaloidal basalt that has been intensely silicified and bleached by the action of the alkaline siliceous solutions that traversed the shattered channel. Fragments have been recognised as common constituents of the breccia, while in other places it may be seen grading into the darker greenstone from a typical brown rock.

The trachytic or bostonitic appearance of the rock under the microscope was quite misleading. It consisted of numerous laths and microlites of felspar, many with extinction angles straight, others with a maximum of 13 degrees and a refractive index less than balsam. These are set in a greatly silicified base of cryptocrystalline silica mainly.

The Government Analyst kindly submitted the following analysis:—

Silica	70·75
Alumina	15·09
Fe_2O_3	*1·36
CaO	·61
MgO	·50
Na_2O	2·20
K_2O	8·08
TiO_2	·81
Undetermined	·60
	100·00

*Including some FeO.

The siliceousness is immediately apparent, and if the potash, soda, and lime are allotted to felspar we get:—

	%
Orthoclase	47·73
Albite	18·60
Anorthite	3·01

It was only along the shatter zones that this rock was noted.

8.—REPORT ON BORING AT ENTERPRISE G.M., KALGOORLIE.

Introduction.—With a view to prospecting the deep levels, and searching for the downward extension of the ore-body known to exist at a depth of 504 feet and on which a winze was sunk from the 365 feet level, three horizontal bores were put out in a westerly and southerly direction from the 773 feet level in the Hainault Mine (752 in the Enterprise Mine).

The bores are as follow:—

No. 4—S. 26° 18′ west ...	Length 207ft. 6ins.
No. 5—S. 60° west ...	Length 195ft. 5ins.
No. 6—Due South ...	Length 250ft.

General Geology of 752ft. Level.

The rock formations recognised, in these three bores, for economic purposes are as follow:—

1.—Quartz dolerite greenstone.
2.—Bleached quartz dolerite greenstone.
3.—Greyish white rock from 181ft. to 189ft. 9ins. in No. 5 Bore.
4.—Dyke rock—felsite (keratophyre).
5.—Lode formation.

1. *Quartz Dolerite Greenstone.*—This is the normal standard country rock of the Golden Mile. It is represented by 1/4770 at the commencement (5 feet) of the No. 4 Bore, where it continues from 0 to 104 feet. In the No. 5 Bore it is found between 0 and 108 feet, and in the No. 6 Bore from 0 to 95 feet.

In hand specimens it is a dark-green and somewhat mottled rock showing laths of altered felspar in a greenish admixture of chlorite and carbonates.

Under the microscope it consists of well-shaped ash-coloured rectilinear pseudomorphs of saussurite after felspar—pure white in reflected light and in places containing grains of magnetite. The ilmenite is mostly changed to leucoxene. Clear areas between the felspars are made of carbonates with some sericite. The rock is stained by green chlorite. Primary quartz plates, more or less broken up, are prominent.

2. *Bleached Quartz Dolerite Greenstone.*—This is mostly a cream or pinkish-coloured rock. The name is used to include Mr. Feldtmann's bleached greenstone (with dominant iron pyrites) and bleached magnetite rock (with dominant magnetite). This rock is important, especially the cream to white form with spots of magnetite, for the magnetite-bearing variety not only forms the rock enclosing the important lodes, but it is the rock from which the lode is formed directly by the addition of pyrites, gold, and so on.

In all the bore sections—Figures 1, 2, and 3—I have indicated a so-called "magnetite zone" which contains the lodes.

In hand specimens the rock is cream to white-coloured, somewhat pyritic quartz dolerite greenstone, showing in places "sheeny" (sericitised) surfaces with many "spots" of magnetite and yellowish-white skeletal forms of leucoxene.

Under the microscope the bulk of the rock is made of water-clear material, studded with carbonates. The former is mostly albitised felspar with a little but not much sericite and some fine-textured silica mosaic. Primary quartz, much cut to pieces and absorbed, is present. Albitisation and carbonation seem to dominate, together with a complete leaching of ilmenite and recrystallisation of magnetite. The magnetite occurs as irregular-shaped grains—in places somewhat segregated. Most of the magnetite has crystallised out separately, but some of it appears certainly to replace the leucoxene—as iron pyrites is known to do. A little pyrites may be seen. In the No. 5 Bore the bleached quartz dolerite greenstone about 170 feet takes on the appearance of a creamy-coloured felsite with black spots of magnetite.

3. *Greyish-white Rock from 181 feet to 189 feet 9 inches in No. 5 Bore.*—This is such a distinctive-looking rock that it is regarded separately. It is really only a variety of (2)—bleached quartz dolerite greenstone. It is a dense and almost felsitic greyish-white rock showing marked skeletal leucoxene and occasional quartz specks—also a slight bright-green staining in places.

Under the microscope the leucoxene is in skeletal masses—perfect creamy-white. The rock is essentially a mass of carbonate with a very little sericite. The primary quartz has been practically all absorbed, though distinct relicts may be recognised—mostly as isolated pieces. At 189 feet 7 inches the leucoxene has been almost crushed out of existence, but it is still recognisable. More sericite is present. This white rock is characterised by a total absence of magnetite with only traces of pyrites. More crushing would convert this rock into a carbonate-sericite schist. The intense alteration of this rock and obliteration of the magnetite may be due to its contact with the dyke and its proximity to the main ore channel at 752 feet level, where it strikes the dyke.

4. *Dyke Rock—Felsite* (*Keratophyre*).—The only bore that cut this rock was No. 5. It entered the dyke at 189 feet 9 inches and finished in dyke at 195 feet 5 inches. The first 4 feet of dyke rock—189 feet 9 inches-193 feet 9 inches—was lodestuff.

In hand specimens it is virtually a dense grayish felsite with a sub-resinous lustre and cut by minute quartz veinlets.

Under the microscope it is a more or less homogeneous mass of carbonates with sericite, traces of felspar microlites and some quartz.

5. *Lode Formation.*—Definite and distinct lode formations were cut on the 752 feet level at three points, viz., A, B and C, shown on plan, Plate I. These lodes occurred in:—

1. Bleached quartz dolerite greenstone at B and C, and
2. Dyke rock at A.

1. The lodes in bleached quartz dolerite greenstone (with magnetite) occurred at B and C. The lode material at both points B and C is lithologically the same, viz., dark gray siliceous pyritic and sericitised lodestuff. It has been formed by the complete carbonation, pyritification and in part silicification of the bleached magnetite-bearing quartz dolerite greenstone.

The ore consists of plates of very fine textured sulphide, which has been formed by replacement of the leucoxene. In addition, small patches, grains and crystals of iron pyrites are distributed throughout the ore. These are set in a mass of carbonates, secondary silica and some sericite. Primary quartz still exists in the form of large broken plates and "archipelagoes." In places some carbonated water-clear albite was recognised. A small shear track was noted. Well marked micropegmatite occurs in the ore between 105′ 8″ and 109′ in the No. 6 Bore.

The rock immediately adjoining the footwall shear plane of the lode at B. was a magnetite-bearing cream-coloured bleached quartz dolerite greenstone. The ilmenite has been completely changed to leucoxene and the latter mineral not only had a crushed drawn-out appearance, but it was distinctly replaced by magnetite. The footwall rock contains numerous irregular-shaped grains and patches of magnetite. The amount of fine-grained pyrites was small. The rock was otherwise made up largely of carbonates, much carbonated albite, shattered and replaced primary quartz, a little secondary silica and sericite scales. The addition of pyrites and gold—perhaps with more sericitization—to this rock makes lodestuff. In the change ilmenite apparently goes to leucoxene, then to magnetite, and finally pyrites (with or without the magnetite stage). The lodestuff at B, 178 feet along the No. 4 Bore, is controlled by a well-marked shear line. It is regarded as the main shear channel that controls the orebody at the 752 foot level, and may reasonably be linked up with the schisted lode in the dyke at "A." The assay results show that the perfect lodestuff at B is 4 feet wide, but the walls are impregnated sufficiently to make approximately an auriferous channel over about 12 feet in width.

The lodestuff at C, between 100ft. 8ins. and 111ft. 3ins. in No. 6 Bore, is quite typical and lithologically similar to that at B. It is hard to connect this lode with anything else on the evidence available. It may be the downward extension of Smith and Well's Lode or it may be entirely new. So far as the petrographic aspect is concerned, lodes B and C are of truly deep-seated origin.

Lode formation in dyke rock at A. This rock was cut at 189ft. 9ins. in the No. 5 Bore, exactly at the point where the bleached quartz dolerite greenstone contacts with the dyke. It extended over four feet in width to 193ft. 9ins. The ore is simply a pyritic gray carbonated schist in hand specimens.

Under the microscope, it is a mass of shapeless carbonate with sericite scales, a little quartz and grains of pyrites—with a tendency for arrangement along foliation planes.

This lode, in strongly schisted dyke rock, suggests the northerly extension of the lode at B. If this is so, it is reasonable to expect the main ore body at 752 feet to lie between the points A and B, for at these points the occurrences are quite analogous to those at points X and Y on the 365 foot level.

Description of Individual Bores.

No. 4 Bore.

Rock Formations.—As shown in the diagram, Figure 1, this bore started in normal quartz dolerite greenstone of mottled appearance and continued in this rock to 104 feet. From 104 feet to the end of the bore—207 feet 6 inches—the rock was a pale-coloured bleached quartz dolerite greenstone, studded with grains of magnetite and containing more or less pyrites. The dyke rock was not cut in this bore, but it would have been better had the bore been pushed on to meet the dyke.

Lode Formations and Values.—At three places along this bore there were definite signs of lodestuff, viz:—

(1) 130 to 132 feet.—Between these two points the core assayed 13 dwts. 1 gr. of gold per ton. Mr. Feldtmann described this core as "intensely pyritic, practically lode." In my notes I noted between these points "heavily pyritic rock, consisting of patches of fine sulphide in bleached quartz dolerite greenstone—virtually lodestuff."

(2) 146 to 148 feet.—Between these points the assay results were:—

ft. in.		ft. in.		Gold per ton. dwt.	grs.
146 0	to	148 0	... ...	1	21
148 0	,,	150 0	... ...	0	14
150 0	,,	152 0	... ...	5	8

Mr. Feldtmann describes the rock between 145ft. 8ins. and 151ft. 1in. in such terms as, "intensely pyritic sericitic lode; very fine-grained cherty lode with finely disseminated pyrite, bleached magnetite rock and white quartz vein with a little carbonate and pyrite." I noted "real siliceous pyritic lodestuff from 145ft. 8in. to 147ft. with fine sulphide in strongly-bleached greenstone."

(3) At 178 feet a well-marked shear track was cut, and there were three feet of distinct lode from 178 to 181 feet. For three feet on the eastern side and six feet on the western side of the lode, a zone of impregnation was noted, thus making about 12 feet of an auriferous* zone between 175 and 187 feet. The assay values from this zone are:—

Core.

ft. in.		ft. in.		Gold per ton. dwt.	grs.
154 9	to	177 0	... ...	0	14
177 0	„	179 0	... ...	5	11
179 0	„	181 0	... ...	4	6
181 0	„	183 0	... ...	2	1
183 0	„	185 0	... ...	1	21

It is reasonable to suggest that this is the main channel, and it is possible that it connects us with the lodestuff cut in the dyke met with in the No. 5 Bore at 189ft. 9in.

The Company was good enough to supply the following assay results of core from the No. 4 Bore, as follows:—

No.		Depth. ft. in.		ft. in.		Assay result: Gold. dwts.	grs.
1	from	129 0	to	130 0	... ...	0	14
2	„	130 0	„	132 0	... ...	13	1
3	„	132 0	„	134 0	... ...	0	18
4	„	134 0	„	136 0	... ...	0	18
5	„	136 0	„	138 0	... ...	0	16
6	„	138 0	„	140 0	... ...	0	14
7	„	140 0	„	142 0	... ...	0	16
8	„	142 0	„	144 0	... ...	0	16
9	„	144 0	„	146 0	... ...	0	16
10	„	146 0	„	148 0	... ...	1	21
11	„	148 0	„	150 0	... ...	0	14
12	„	150 0	„	152 0	... ...	5	8
13	„	157 0	„	160 0	... ...	0	12
14	„	167 0	„	170 0	... ...	0	12
15	„	174 9	„	177 0	... ...	0	14
16	„	177 0	„	179 0	... ...	5	11
17	„	179 0	„	181 0	... ...	4	6
18	„	181 0	„	183 0	... ...	2	1
19	„	183 0	„	185 0	... ...	1	21
20	„	115 0	„	117 0	... ...	1	20
21	„	117 0	„	119 0	... ...	0	18
22	„	119 0	„	121 0	... ...	0	20
23	„	121 0	„	123 0	... ...	1	0
24	„	123 0	„	125 0	... ...	0	16
25	„	125 0	„	127 0	... ...	0	13

No. 5 Bore.

The No. 5 Bore was started in quartz dolerite greenstone, in which it continued to about 108 feet. Some magnetite occurred in part of this greenstone (Mr. Feldtmann's magnetite rock).

From 108 to 181 feet the core consisted of more or less bleached quartz dolerite greenstone, containing magnetite and, in places, pyrites. From 181 to 189ft. 9in. there occurs a remarkable perfectly bleached quartz dolerite greenstone, pale-gray and felsitic without magnetite and showing prominent leucoxene with traces of primary quartz. At 189ft. 9in. the bore entered a dense grayish felsite dyke which continued to the end of the bore, viz., 195ft. 5in.

Lode Formation and Value: (a) The most important discovery in this bore was the four feet of schisted pyritic lode between 189ft. 9in. and 193ft. 9in. at the place where the intensely-bleached greenstone immediately contacts with the large felsitic dyke. The schisted zone is 4 feet wide and quite strong. It indicates the almost certain northerly extension of the main lode channel met with at 178ft. in No. 4 bore. The lode material consisted of schisted carbonated and sericitised dyke (keratophyre?) with white quartz veins parallel with the planes of schistosity. This discovery may be regarded as the most definite indication of the possible presence of the main ore channel so far met with the boring at the 752ft. level. The lode material assayed 23s. 10d. per ton.

(b) In addition to the lode in the dyke, only at one place—110 feet—was any trace of pure lodestuff met with in the bleached quartz dolerite greenstone. At this point there was distinct lodestuff with traces of incipient shear planes. Mr. Feldtmann describes the rock from 110ft. to 110ft. 2in. as "crumbled fragments of which 65 per cent. was bleached magnetite rock, and 35 per cent. highly pyritic and practically lode." The core from 107ft. 8in. to 112ft. 2in. only assayed from traces to 14 grains of gold per ton.

(c) From 145 to 153 feet the core assayed 5s. 3d. per ton. Mr. Feldtmann says this core contained planes with sericite and tourmaline. Between 149ft. and 152ft. 6in. it was highly pyritised.

(d) From 165ft. 9in. to 167ft. 6in. the rock was distinctly auriferous and contained gold to the value of 7s. 5d. per ton. The rock was pyritic and for the most part heavily-bleached quartz dolerite greenstone, cut by glassy quartz veins, and in one place a vein of quartz, chlorite and pale-brown carbonate. Some of the rock had the appearance of incipient lodestuff and was suggestive of vein-altered wall rock. This occurrence may possibly be attributed to the proximity of the main channel to the southward and the dyke, which is only 23 feet away.

No. 6 Bore.

The No. 6 Bore started in normal quartz dolerite greenstone, which continued (with slight bleaching between 83 and 86 feet) right up to within 5 feet (95 feet) of the lode. At 95 feet the rock became strongly bleached with introduction of magnetite and some pyrites, and finally passes into lode at 100ft. 8in. From 100ft. 8in. to 111ft. 3in., *i.e.*, 10ft. 7in.,† the core passed through typical lodestuff. Bleached rock then continued from 111ft. 3in. to 195ft. At 195ft. the rock is practically quartz dolerite greenstone which continued to the end of the bore—250ft. No dyke rock was met with in this bore.

Lode Formation and Values.—A prominent lode, marked "C" on plan (Plate I.), was cut in this bore between 100ft. 8in. and 111ft. 3in. It consisted of nice looking dark-gray siliceous, pyritic, and silicified lodestuff. The pyrites is in patches, grains and streaks along minute shear lines. The assay values given by the company are as follows:—

Distance along Bore. ft. in.		ft. in.		Gold per ton. dwt.	grs.
100 8	to	103 8	... ...	2	18
103 8	„	105 8	... ...	6	1
105 8	„	109 0	... ...	11	12
109 0	„	110 6	... ...	10	10
110 6	„	111 3	... ...	2	21

* All values in this report are from assays made by the Company.

† 3ft. 6in. of this core was lost.

In addition to the above lode, values were met with under the following conditions:—

(1) From 114ft. 7in. to 114ft. 10in. was 3 inches of true lodestuff assaying 5 dwts. 2 grs. of gold per ton. This is probably a "dropper" or "feeder" connected with the chief lode met with in this bore, between 100ft. 8in. and 111ft. 3in.; or it may indicate an increased width of auriferous channel.

(2) From 123ft. 2in. to 125ft. 2in. the core assayed 1 dwt. 10 grs. of gold per ton. This section of core is described by Mr. Feldtmann as "practically bleached quartz dolerite greenstone with magnetite, streaky with very much dark bluish iron ore, probably haematite. Only about one inch of rock containing a fair amount of pyrite and approaching lode."

(3) From 132 to 135ft. 2in. the core assayed 1 dwt. 3 grs. of gold per ton. Mr. Feldtmann describes the section as consisting of "slightly streaky and veined bleached quartz dolerite greenstone with magnetite. A fair amount of sericite, some pyrite, and probably some haematite, are present. Clusters of tourmaline needles occur in places."

(4) From 190ft. 6in. to 191ft. 11in. in the core assayed 2 dwts. 1 gr. of gold per ton. This zone consisted of powerfully bleached quartz dolerite greenstone of white to pink colour and traversed by a small group of distinct shear tracks. This locality is important because it may represent the southern extension of the line of weakness which controls the main ore body met with in the No. 4 Bore at 178 feet.

General Remarks and Conclusions.

Some interesting scientific and economic features have resulted from a detailed petrographical investigation of the cores from the three bores put out at the 752 feet level of the Enterprise Gold Mine.

These may be enumerated as follow:—

(1) The boring has revealed the definite existence of lode channel and values at 773 feet (Hainault) vertical depth (752 feet Enterprise), 250 feet below the deepest workings in the Enterprise Mine.

(2) A careful examination of the core from the No. 5 Bore has shown (a) that the dyke rock has been thrown back 189 feet 9 inches from the Hainault boundary. At the point A shown on the plan, Plate I., the main lode channel enters the dyke where it is well schisted, pyritic, and contains gold to the value of 23s. 10d. per ton. The schisted channel is here (point A) 4 feet wide, and its existence proves that the dynamic forces have broken the dyke rock down into schist and so formed a line of weakness for the passage of auriferous solutions.

(3) The examination of the No. 4 Bore proved the existence of a well-marked shear line at 178 feet as shown at B in the plan, Plate I. At this point true lodestuff exists from 178-181 feet, and if the impregnations on either side of this lode be taken into consideration, a 12-ft. auriferous channel exists —as shown by the assay results indicated on the geological section through the bore—Figure 1. This shear line may be regarded as the guiding feature in the main trunk channel that controls the ore bodies at the 504ft., 365ft., and 270ft. levels.

(4) The petrographic investigations show that lithologically, microscopically, and mineralogically, the ore in the channel at points A and B on the 752ft. level is identical with the ore in the channel at the northern and southern extensions of the ore-body (X and Y, Plate I.) at the 365ft. level. It is therefore reasonable to suggest that the real ore-body, should values continue, lies between points A and B at the 752ft. level—Plate I.

(5) The economic deductions drawn from the petrographic examination, coupled with plotting of the results, are that the keratophyre dyke is the controlling element in the Enterprise ore shoot. There has been a concentration of ore solutions up against the dyke on its footwall side, and for about 100 feet back (southerly) from the dyke the rock has been extensively replaced and metasomatised so as to form a large body of ore.

(6) A first glance at the plan, Plate I., is likely to give a false impression and make one believe that the pitch of the ore shoot is roughly 25° east of south. For this reason too much reliance was placed on No. 6 Bore. The position now appears to be that, owing to the controlling part played by the dyke, the pitch is more likely to be as indicated on the plan, Plate I.; considerably to the east of south.

(7) After all, if bores had been put out at 365 and 504 feet, to cut the lode at these levels, 100 feet southerly from where the lode channel enters the dyke, they would in all probability not have met with results any better than those in No. 4 Bore at 752 feet.

(8) The ground between points A and B at 752 feet should certainly be tested, and the lode at 504 feet should be driven northward until the channel enters the dyke.

(9) There is no doubt whatever about the deep-seated origin of the ore in the lodes at A, B, and C at 752 feet and it should certainly continue to greater depths.

In conclusion it might be stated that even now this mine has not been sufficiently prospected, for apart from the possibilities between A and B at 752 feet and the existence of the main Enterprise Shoot, the lode at 100 feet 8 inches to 111 feet 3 inches is of considerable interest. It may or may not be the downward extension of Smith and Wells' lode. On the other hand it may be a new lode all together. It now remains to consider the position of this mine with regard to lodes known to exist in the Hainault, South Kalgurli, and Perseverance mines.

9.—PETROGRAPHICAL DETERMINATIONS IN CONNECTION WITH THE GEOLOGICAL SURVEY OF KALGOORLIE.

This work was carried on continuously throughout the year in conjunction with Mr. Feldtmann, who is conducting the field work.

10.—PETROGRAPHICAL EXAMINATION OF SOME ORE FROM WILUNA.

Two interesting samples of ore in the dyke rock were examined. A description of them is as follows:—

(1) Macroscopically this rock (ore) is a fine-textured grey to white mass of silica and carbonates, impregnated with small grains and occasional crystals of iron pyrites and needle-like forms of mispickel. This mass encloses pale olive-green lumps of

highly altered dyke rock, cut by minute quartz veinlets. The ore is really a breccia made of fragments of dyke rock cemented by carbonate-quartz veins, the whole mass containing iron pyrites and mispickel. Microscopically the breccia is seen to consist of fragments of dyke rock strongly impregnated with rounded grains and occasional crystals of iron pyrites with subordinate needle-like forms of mispickel. The dyke rock is cut by two sets of veins and veinlets. In places these veins became sufficiently large and numerous to cut up the dyke rock in such fashion as to make a breccia out of it.

The older and ore-forming set of veins are made of carbonates mainly, with quartz, a little felspar, grains and crystals of iron pyrites and needle-like forms of mispickel. The sulphides, however, are mainly in the dyke fragments of the breccia.

In addition there is a newer set of veinlets of carbonates and quartz which cut through the older veins and are themselves devoid of sulphides.

It was the solutions from the older veins that metasomatically altered and impregnated the dyke rock and lumps in the breccia with very fine-grained iron pyrites and small needles of mispickel.

(2) Macroscopically this ore is a breccia made of lumps and patches of greatly bleached dyke rock strongly impregnated with grains of iron pyrites and rods of mispickel. The whole of these lumps are cemented by glassy white quartz and chalcedony together with carbonates in the form of patches and veins. Small grains of iron pyrites and rods of mispickel occur in the cementing material. Microscopically the rock is seen to consist of bleached carbonated dyke rock (keratophyre?) made up of abundant small microlites of carbonated plagioclase lying in all azimuths, in a carbonated cryptocrystalline groundmass of probably quartz and felspar. Grains and occasional crystals of iron pyrites, together with small needle-like forms of mispickel, are scattered throughout the bleached dyke rock. Patches and veins of carbonates and quartz with a little felspar and pyrites occur in places; a prominent vein of carbonates, quartz, chalcedony and a little pyrites formed a feature in this section.

General Remarks.—In the Annual Report for 1925, page 23, I divided the rocks at the Wiluna mine into (a) quartz dolerite greenstone; (b) fine-grained greenstone ("calc schist"); (c) felsite (keratophyre?); and (d) porphyrite.

The main ore body occurs in (a) and (b), though low-grade ore was recorded from (c). Samples 2 and 3 are the same, viz., ore formed in (c), *i.e.*, brecciated dyke (keratophyre?) impregnated with iron pyrites and mispickel.

It would be interesting if the ore in dyke rock carries payable values.

APPENDIX.

LIST OF FOSSILS COLLECTED BY H. W. B. TALBOT AND F. R. FELDTMANN FROM THE WOORAMEL RIVER DISTRICT, W.A., IN MARCH, 1929, AND IDENTIFIED BY MISS L. HOSKING, B.A., OF THE UNIVERSITY OF W.A.

Bogadi Outcamp, seven miles south of Survey Station R18, Wooramel:

- Spirifer rostalinus (n. sp.) casts, Hosking. (1/4692.)
- Spirifer rostalinus var auritus (var. nov.), Hosking. (1/4693.)
- Spirifer (?) byroensis, Glauert, cast. (1/4694.)
- Deltopecten subquinquelineatus var. comptus, Dana. (1/4697), (1/4698), and (1/4699).
- Fragment of cast of (?)Ptychomphalina. (1/4696.)
- Conularia cf. C. Warthi, Waagen. (1/4695.)

Two Miles E.S.E. of Survey Station R20:

- Dielasma cymbaeformis, Morris. (1/4644.)
- Spirifer rostalinus (n. sp.), Hosking. (1/4640), (1/4641.)
- Cardiomorpha blatchfordi (n. sp.), Hosking. (1/4642.)
- Deltopecten subquinquelineatus var comptus, Dana. (1/4643.)
- Ptychomphalina maitlandi, Eth. fil. (1/4646.)
- Conularia cf. C. Warthi, Waagen. (1/4645.)

South Bank of Wooramel, three miles above Survey Station R20, Wooramel:

- Aulosteges ingens (n. sp.). (a. in F. R. Feldtmann's Colln.)
- Spirifer rostalinus var crassus (var. nov.), Hosking. (1/4649.)
- Deltopecten subquinquelineatus var comptus, Dana. (1/4648.)
- Ptychomphalina maitlandi, Eth. fil. (1/4647.)

Creek half mile west of Callytharra Springs:

- Clisiophyllum talboti (n. sp.), Hosking. (1/4660.)
- Pleurophyllum australe. Hinde. (8491 Univ. Colln.) and (1/4700.)
- Crinoid plate and section of stem. (1/4652.)
- Crinoid stems. (1/4663.)
- (?) Coscinum. (1/4651.)
- Polyzoa including:—
  - E. Fenestella horlogia, Bretnall
  - D. Aetomacladia ambrosoides, Bretnall
  - I. Sulcoretepora meridianus, Eth. fil

  } (1/4664.)
- Chonetes pratti, Davidson. (1/4657.)
- Cleiothyris macleayana, Eth. fil. (1/4650.)
- Dielasma sp. (1/4662.)
- Productus semireticulatus, Martin. (1/4654.)
- Productus subquadratus, Morris. (1/4655.)
- Productus tenuistriatus var foordi, Eth. fil. (1/4656.)
- Prodctus tennistriatus var foordi, Eth. fil. (cast). (1/4653.)
- Reticularia lineata, Martin. (1/4661.)
- Spirifer hardmani, Foord. (1/4659—a.)
- Spirifer musakheylensis, Davidson. Young specimen. (1/4659.)
- Spiriferella australasica, Eth. fil. (1/4658.)

South Bank of Wooramel, quarter mile above Callytharra Springs.

- Crinoid stems. (1/4675.)
- Fenestella fossula, Lonsdale. (1/4670.)
- Chonetes pratti, Davidson. (1/4672.)
- Cleiothyris macleayana, Eth. fil. (1/4671.)
- Productus semireticulatus, Martin. (1/4668.)
- Productus tenuistriatus var foordi, Eth. fil. (1/4669.)
- Productus "undatus," Defrance. (1/4667.)
- Reticularia lineata, Martin. (1/4674.)
- Spiriferella australasica, Eth. fil. (1/4666.)
- Strophalosia (n. sp.). (1/4673.)

**From one mile from South Bank of Wooramel*, one mile above Callytharra Springs:

- Shale containing crinoid stems, echinoid plate and polyzoa, including:— (1/4679.)
  - A. Fenestella fossula, Lonsdale.
  - B. Rhombopora multigranulata, Bretnall.
  - C. Streblotrypa marmionensis, Eth. fil.
  - D. Aetomacladia ambrosoides, Bretnall.
  - E. Fenestella horlogia, Bretnall.
- Cleiothyris macleayana, Eth. fil. and Productus "undatus," Defrance. (1/4677.)
- Deltopecten subquinquelineatus var comptus, Dana. (1/4678.)

South Bank of Wooramel, below Callytharra Springs:

- Pleurophyllum australe, Hinde. (1/4700.)
- Crinoid stems, one enlarged by fungal growth (cf. Bull. 10 G.S.W.A. p. 25, pl. 4). (1/4685.)
- Polyzoa A—E as above, also H. Rhombopora mammillata, Bretnall. (1/4688.)
- Aulosteges spinosus (n. sp.), Hosking. (1/4687.)
- Chonetes pratti, Davidson. (1/4684.)
- Cleiothyris macleayana, Eth. fil. (1/4686.)
- Productus tenuistriatus var foordi, Eth. fil. (1/4683.)
- Spirifer musakheylensis var australis, Foord. (1/4680.) Young specimen.
- Spiriferella australasica, Eth. fil. (1/4681.)
- Cardiomorpha (?) blatchfordi (n. sp.), Hosking. (1/4701.)
- Parallelodon sp. (1/4682.)

South Bank of Wooramel, one mile above Callytharra Springs:

- Productus "undatus," Defrance. (1/4689.)
- Productus semireticulatus, Martin; and Spiriferella australasica, Eth. fil. (1/4691.)
- Productus tenuistriatus var foordi, Eth. fil. (1/4690.)

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* There has been some mistake in the labelling of these specimens, as according to Mr. Talbot no fossils were collected at this locality.

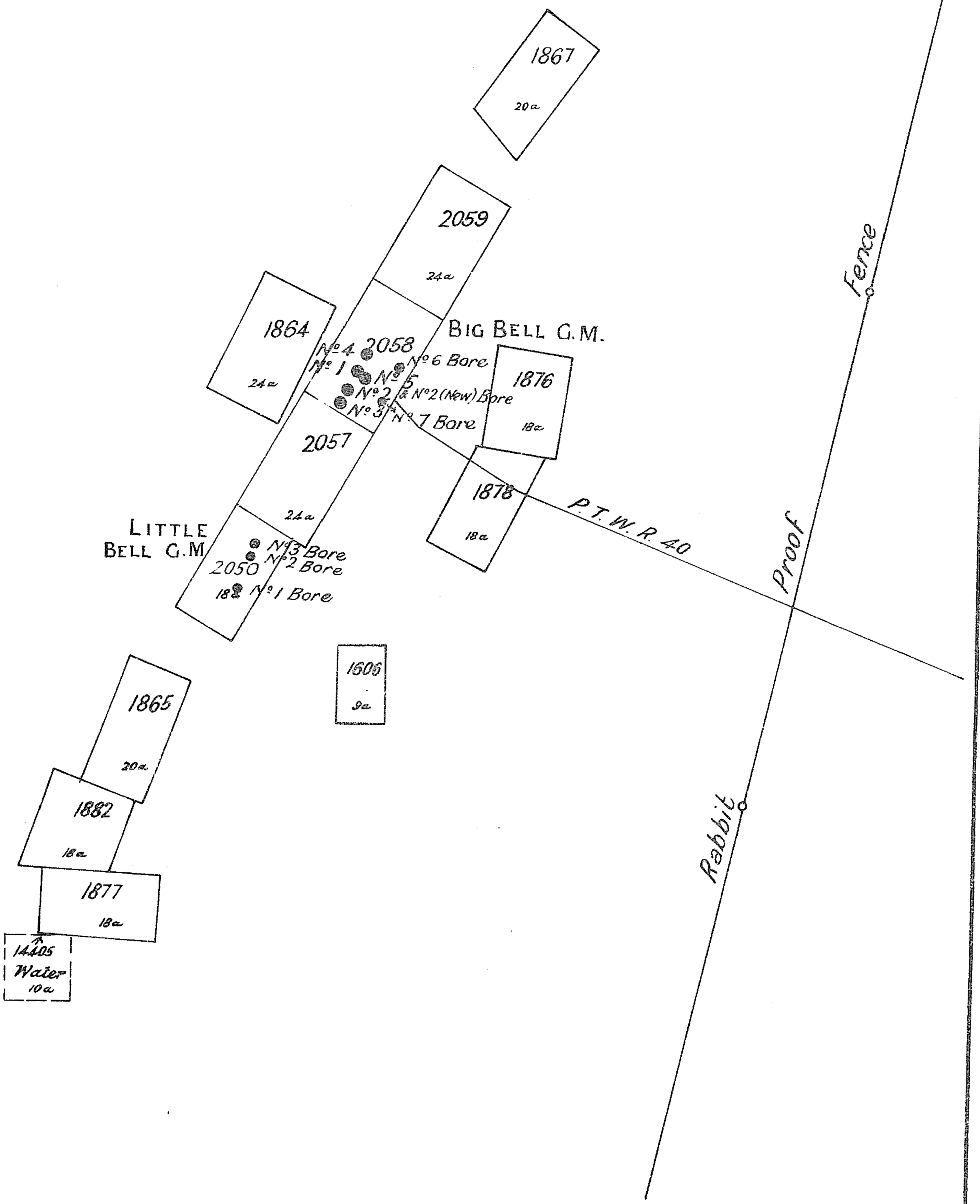
Notes on the fossils listed above, with descriptions and illustrations of new species, are to be published shortly.

INDEX.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.

Locality Plan
of Bores at
Big Bell
Coodardie

— Scale :- 20 Chs. to an In. —



— Section Nº 3 Bore —

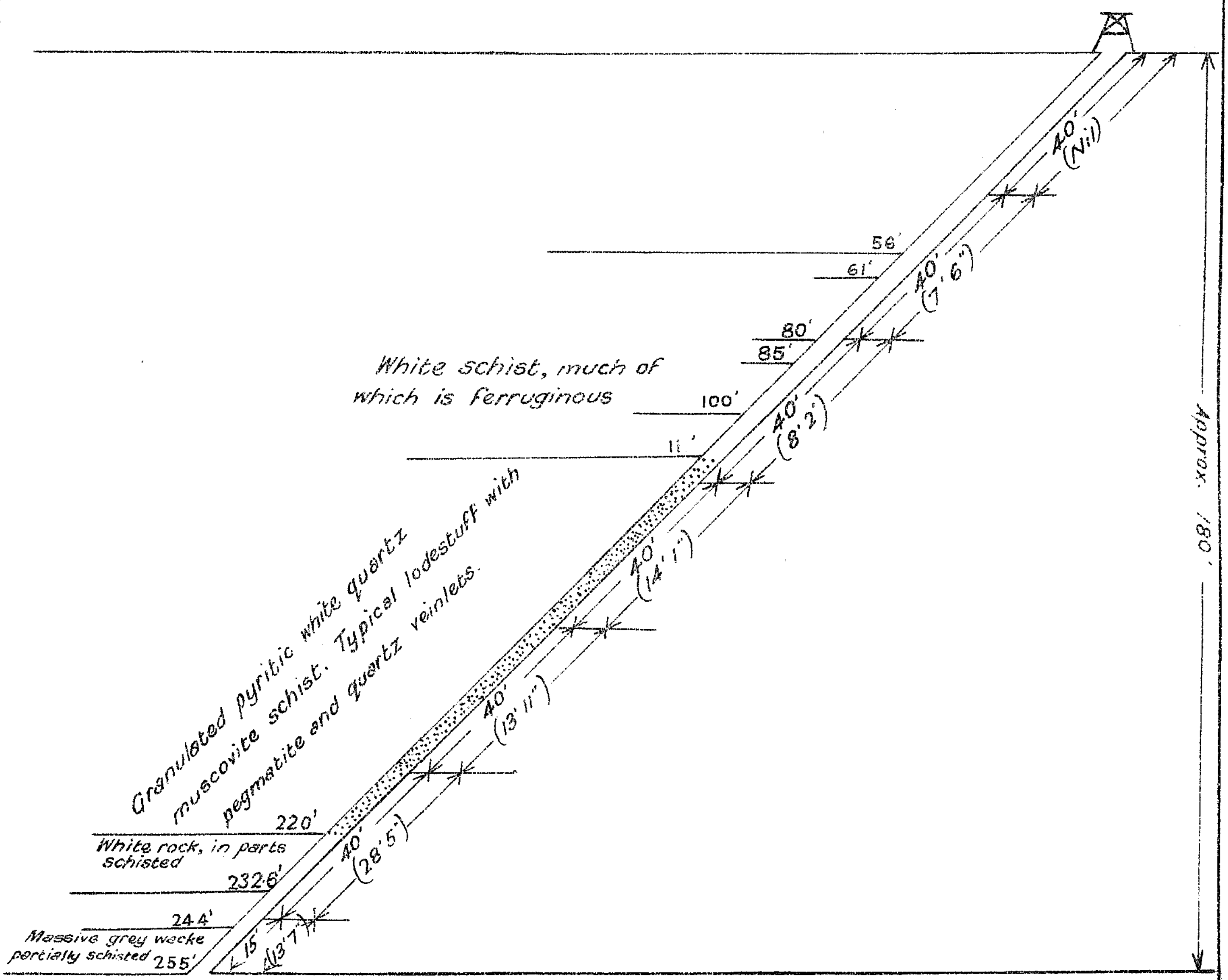
— Big Bell G. M. —

— Cue —

— Scale:- 32 Ft. = 1 In. —

Depressed at an angle of 45°

Commenced 17. 1. 29.
Completed 4. 2. 29.



Note:-
The figures in brackets indicate the length of cores recovered from the corresponding section of boring.

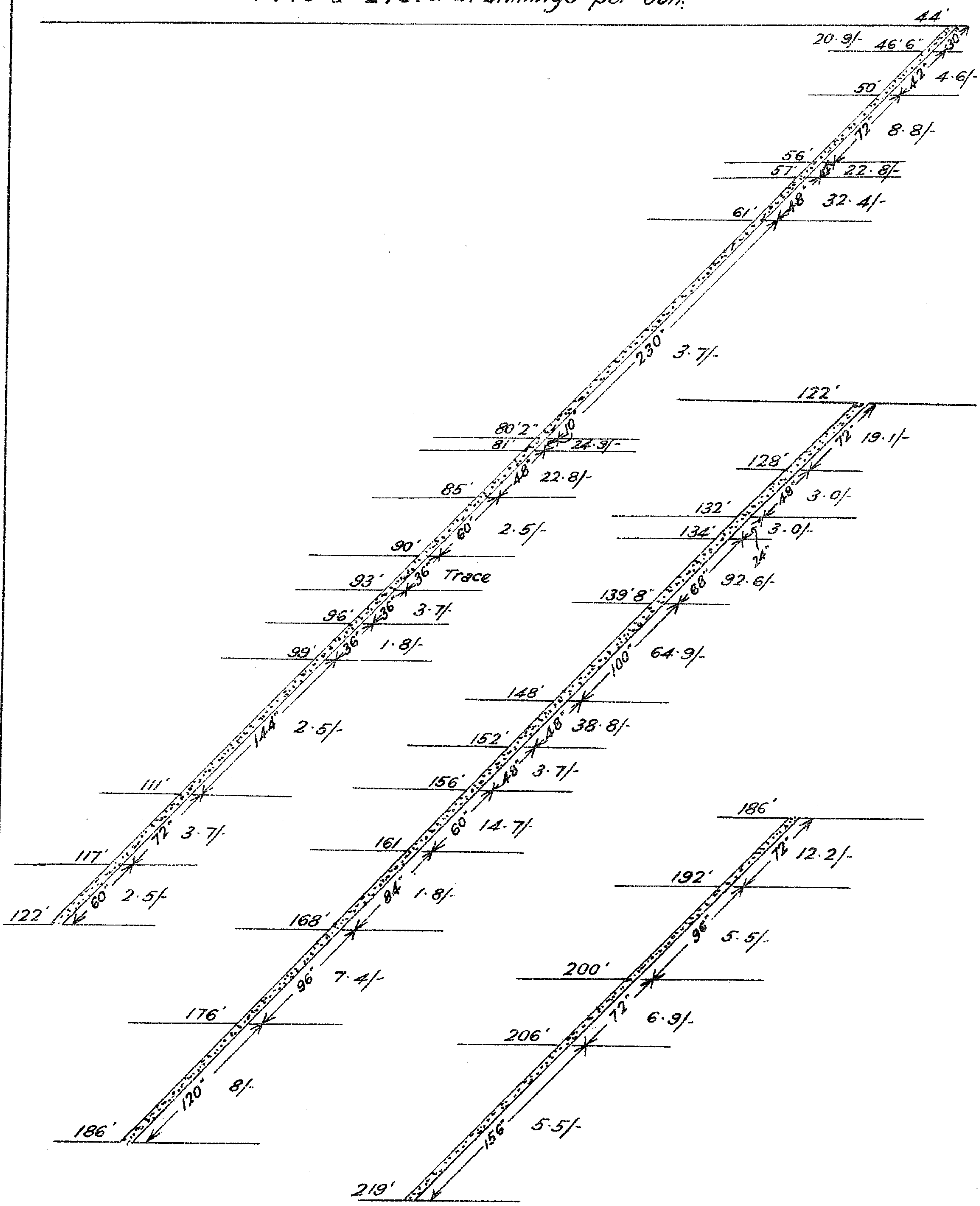
– Nº 3 Bore –

– BIG BELL G.M. –

– CUE –

– Scale :- 8 Ft. = 1 In. –

Chart of Assay values in lode material pierced between 44 ft & 219 ft. in shillings per ton.



— Section Nº 4 Bore —

— BIG BELL G.M. —

— CUE —

— Scale :- 30 Ft. = 1 In. —

Commenced 12. 2. 29.

Completed 1. 3. 29.

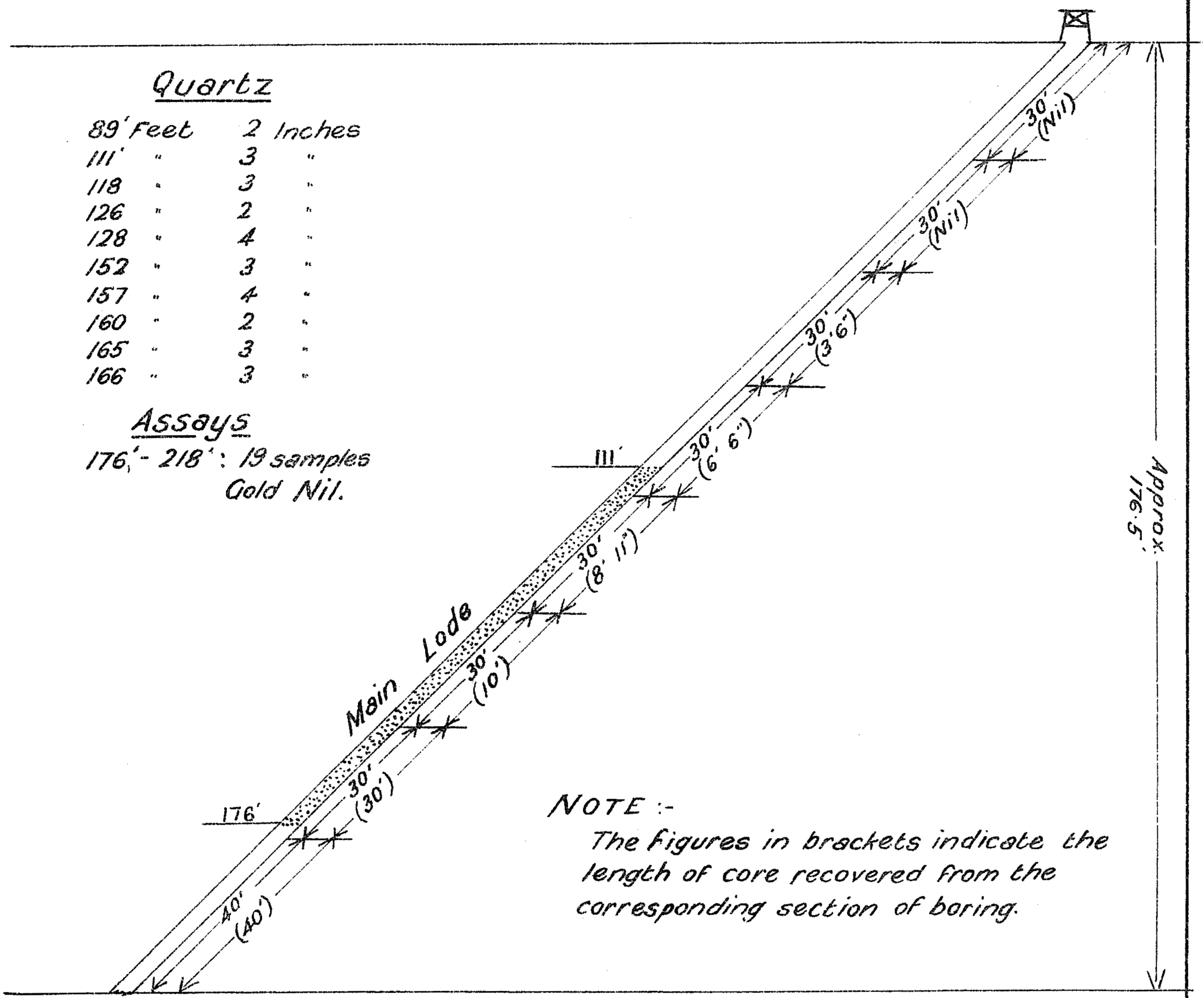
Depressed at an angle of 45°

Quartz

89' Feet	2 Inches
111' "	3 "
118 "	3 "
126 "	2 "
128 "	4 "
152 "	3 "
157 "	4 "
160 "	2 "
165 "	3 "
166 "	3 "

Assays

176' - 218' : 19 samples Gold Nil.



NOTE :- The figures in brackets indicate the length of core recovered from the corresponding section of boring.

Extract from Petrologist's Report :-

This bore is the furthest North of the seven bores put down. It is 200 feet Northerly from the Nº 1 Bore & 60 feet Northerly from the open cut. The results above show that values and lode formation persist as far North as this bore.

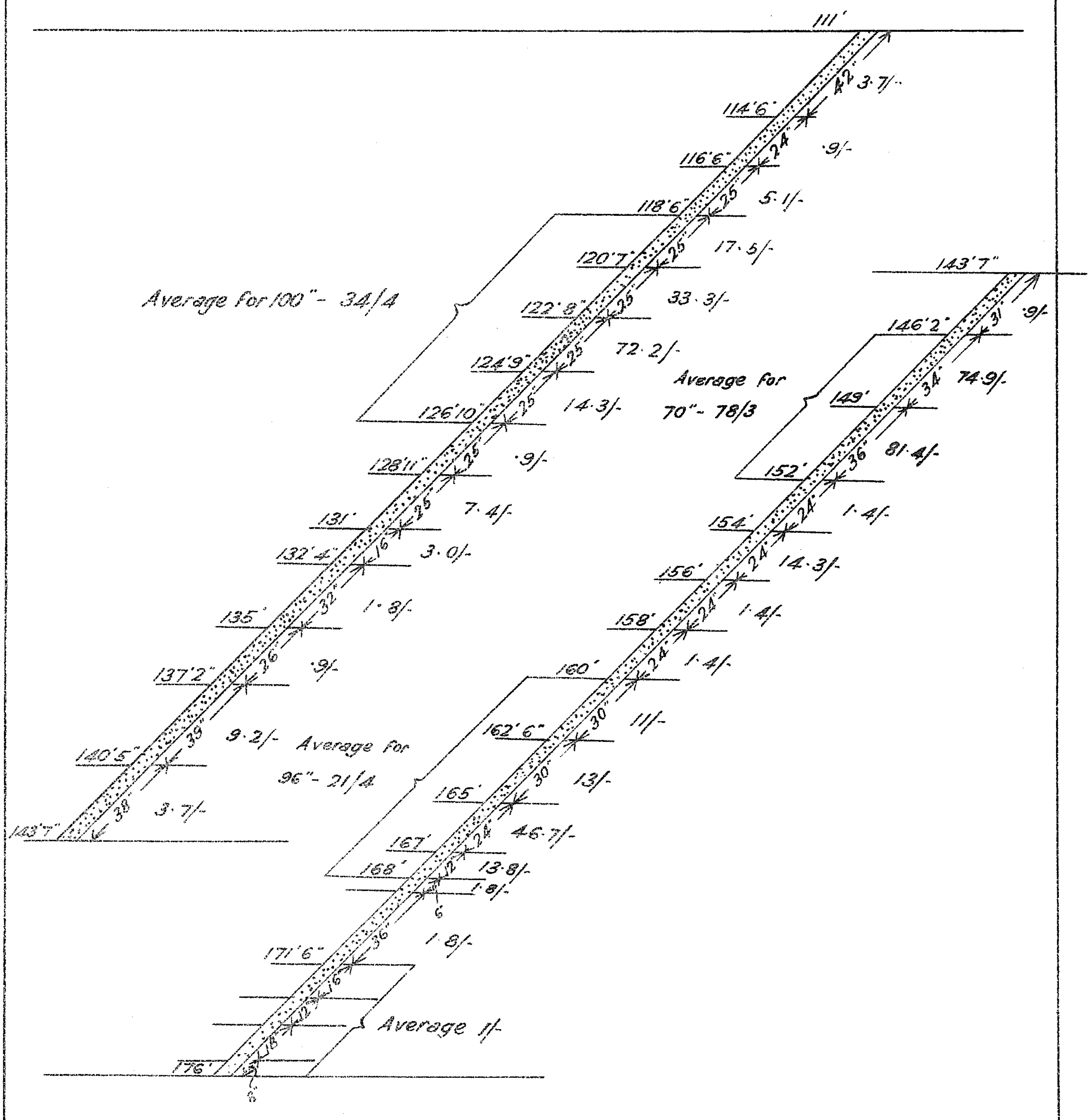
— No. 4 Bore —

— Big Bell G.M. —

— Cue —

— Scale :- 4 Ft. = 1 In. —

Assay chart of values pierced between 111' and 176' in shillings per ton.



—Section Nº 5 Bore—

—Big Bell G. M.—

—Cue—

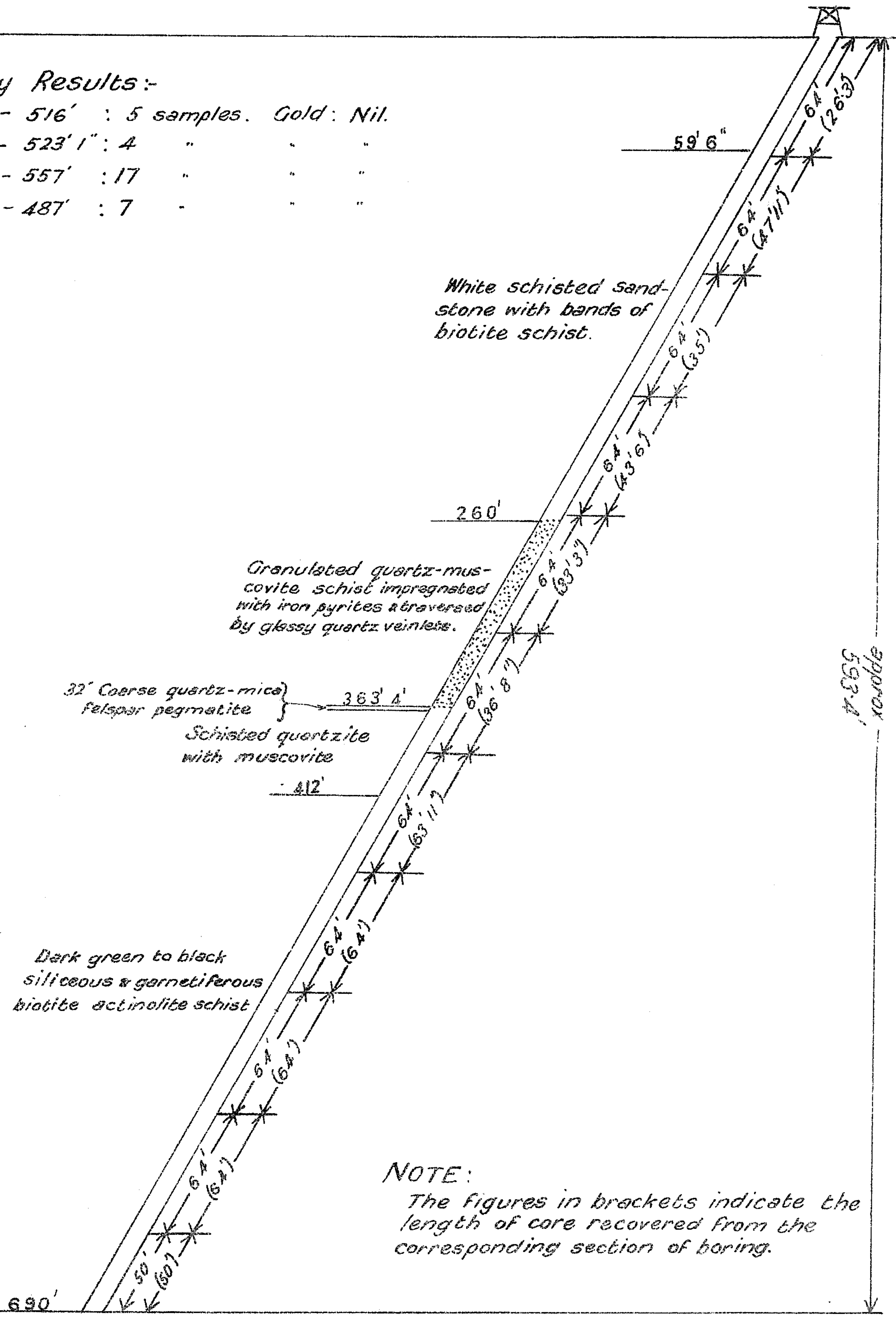
—Scale: 64 Ft. = 1 In.—

Depressed at an angle of 60°

Commenced 9. 3. 29.
Completed 4. 5. 29.

Assay Results:-

506′ – 516′	: 5 samples.	Gold:	Nil.
516′ – 523′ 1″	: 4	"	"
523′ 1″ – 557′	: 17	"	"
393′ 5″ – 487′	: 7	"	"



NOTE: The figures in brackets indicate the length of core recovered from the corresponding section of boring.

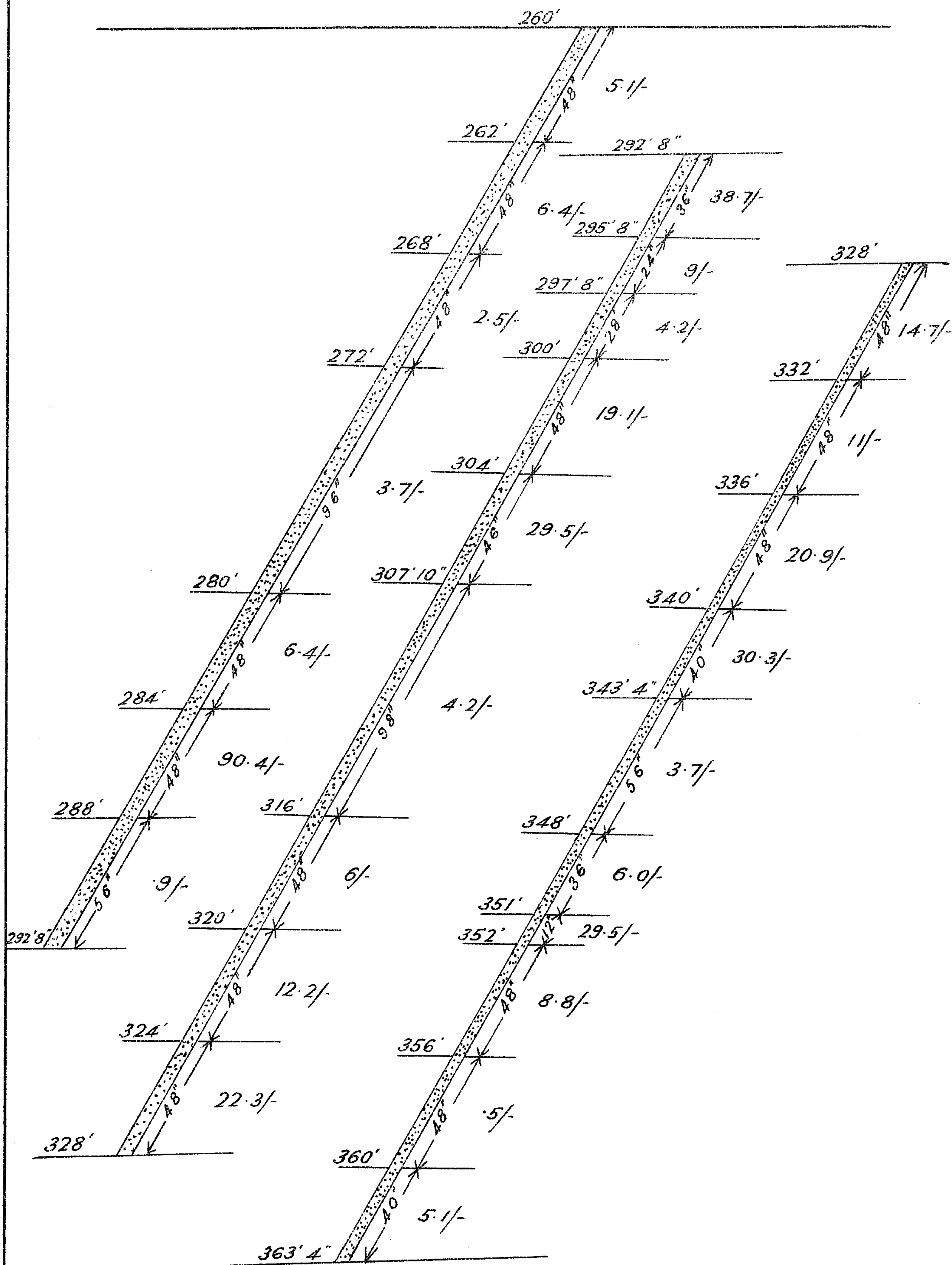
– Nº 5 Bore –

— BIG BELL G.M. —

— CUE —

— Scale:- 4 Ft. = 1 In. —

Chart of assay values in ore pierced between 260' and 363' 4", in shillings per ton.



– Section Nº 6 Bore –

– BIG BELL G. M. –

– CUE –

– Scale :- 64 Ft. = 1 In. –

Commenced 17. 5. 29

Completed 10. 7. 29.

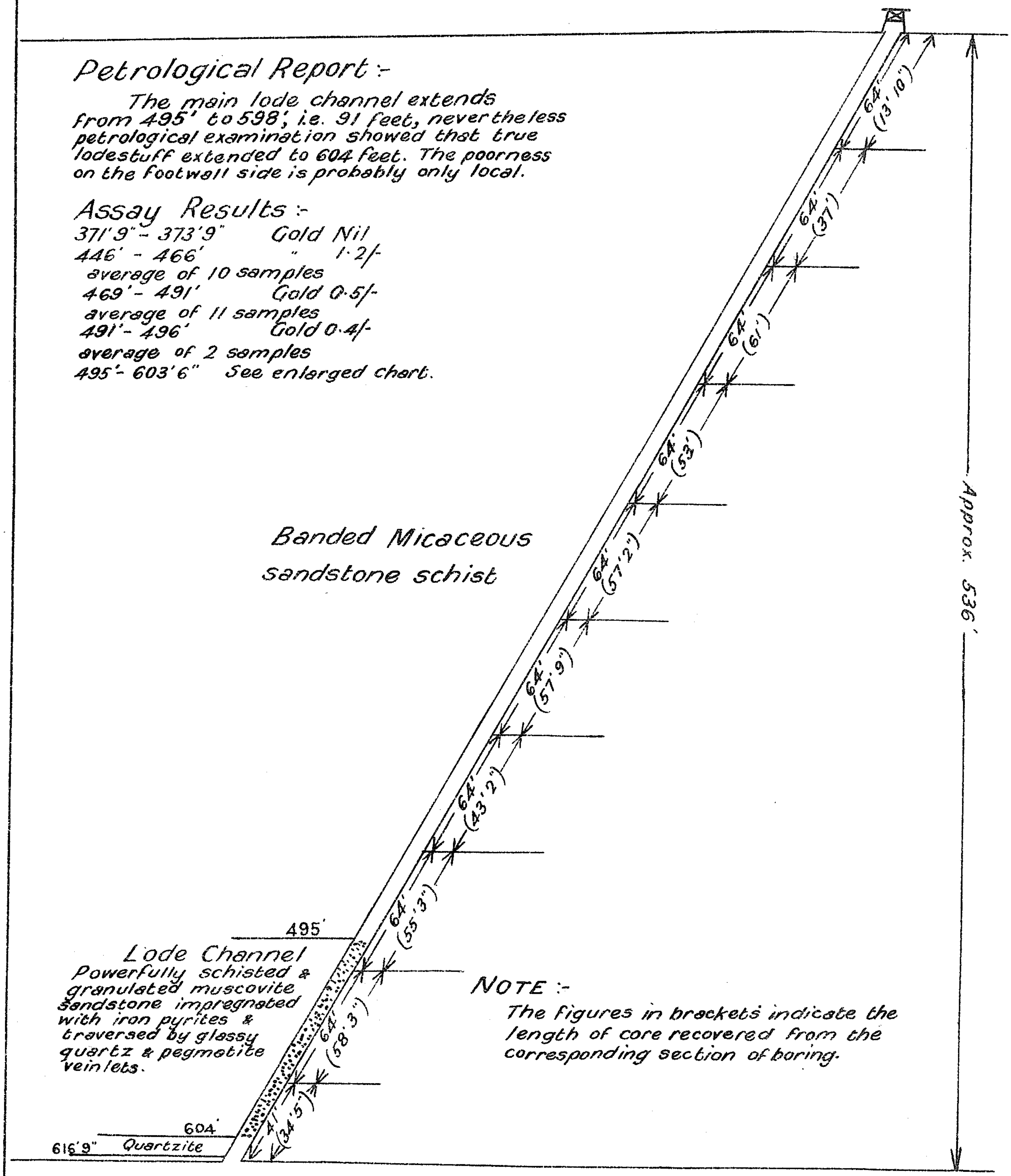
Depressed at an angle of 60°

Petrological Report :-

The main lode channel extends from 495' to 598', i.e. 91 feet, nevertheless petrological examination showed that true lodestuff extended to 604 feet. The poorness on the footwall side is probably only local.

Assay Results :-

371'9" - 373'9" Gold Nil
446' - 466' " 1·2/-
average of 10 samples
469' - 491' Gold 0·5/-
average of 11 samples
491' - 496' Gold 0·4/-
average of 2 samples
495' - 603'6" See enlarged chart.



NOTE :-
The figures in brackets indicate the length of core recovered from the corresponding section of boring.

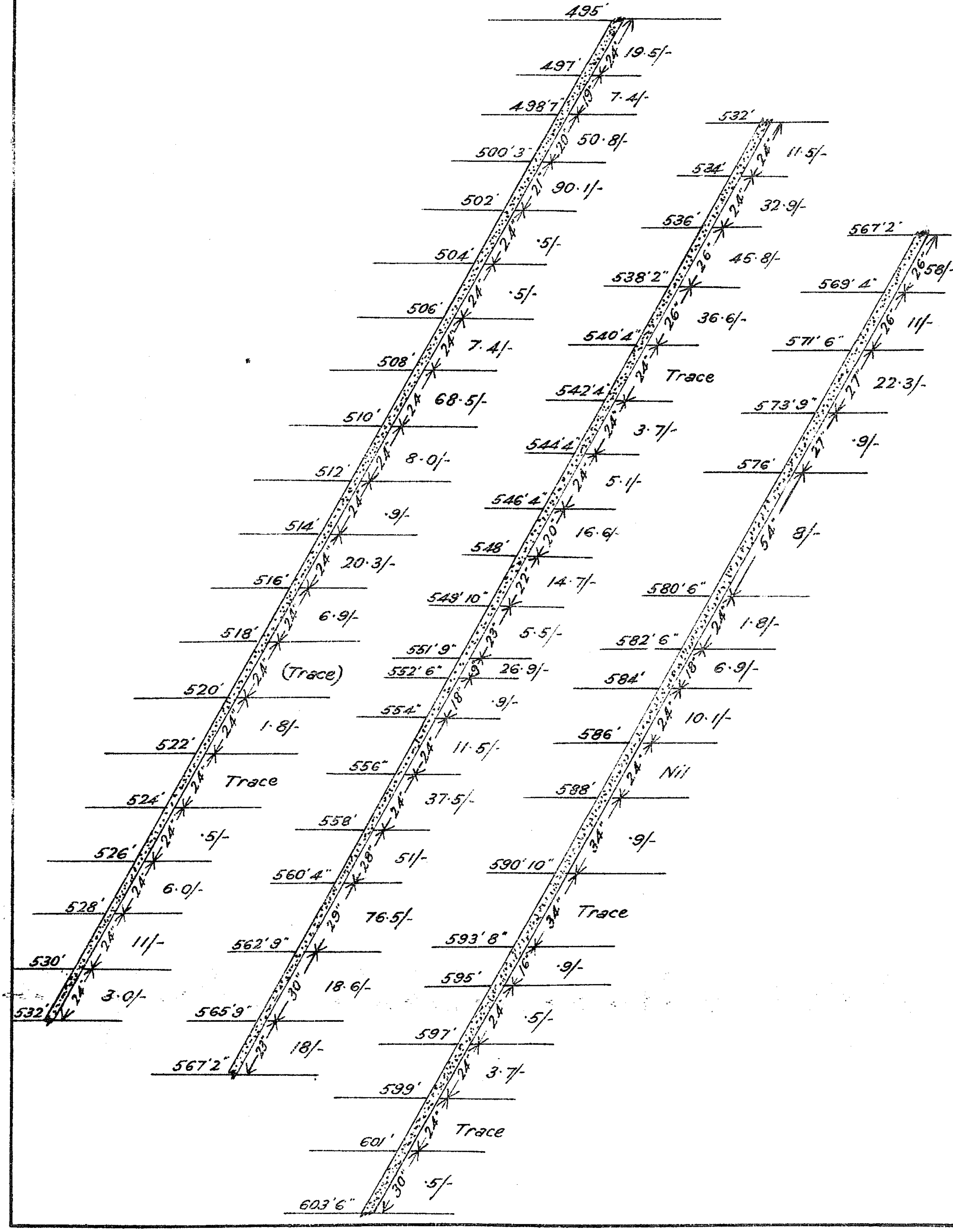
— Nº 6 Bore —

— BIG BELL G.M. —

— CUE —

— Scale :- 4 Ft. = 1 In. —

Chart of assay values in ore pierced between 495' and 603'6", in shillings per ton.



— Section Nº 7 Bore —

— Big Bell G. M. —

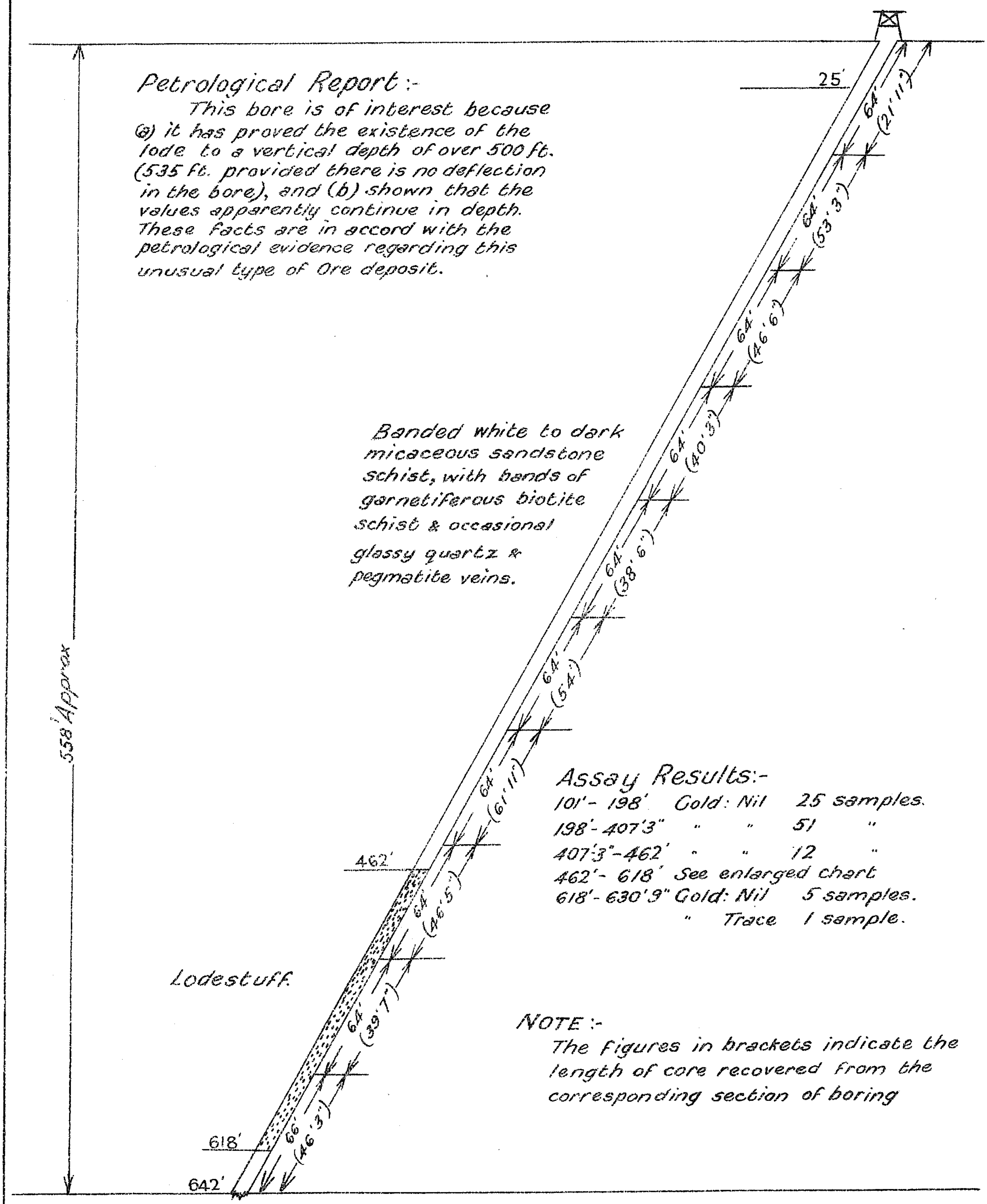
— Cue —

— Scale:- 64 Ft. = 1 In. —

Commenced 19. 7. 29.

Depressed at an angle of 60°

Completed 29. 8. 29.



Petrological Report :-

This bore is of interest because (a) it has proved the existence of the lode to a vertical depth of over 500 ft. (535 ft. provided there is no deflection in the bore), and (b) shown that the values apparently continue in depth. These facts are in accord with the petrological evidence regarding this unusual type of Ore deposit.

Assay Results:-

101' - 198'	Gold: Nil	25	samples.
198' - 407'3"	" "	51	"
407'3" - 462'	" "	12	"
462' - 618'	See enlarged chart		
618' - 630'9"	Gold: Nil	5	samples.
	" Trace	1	sample.

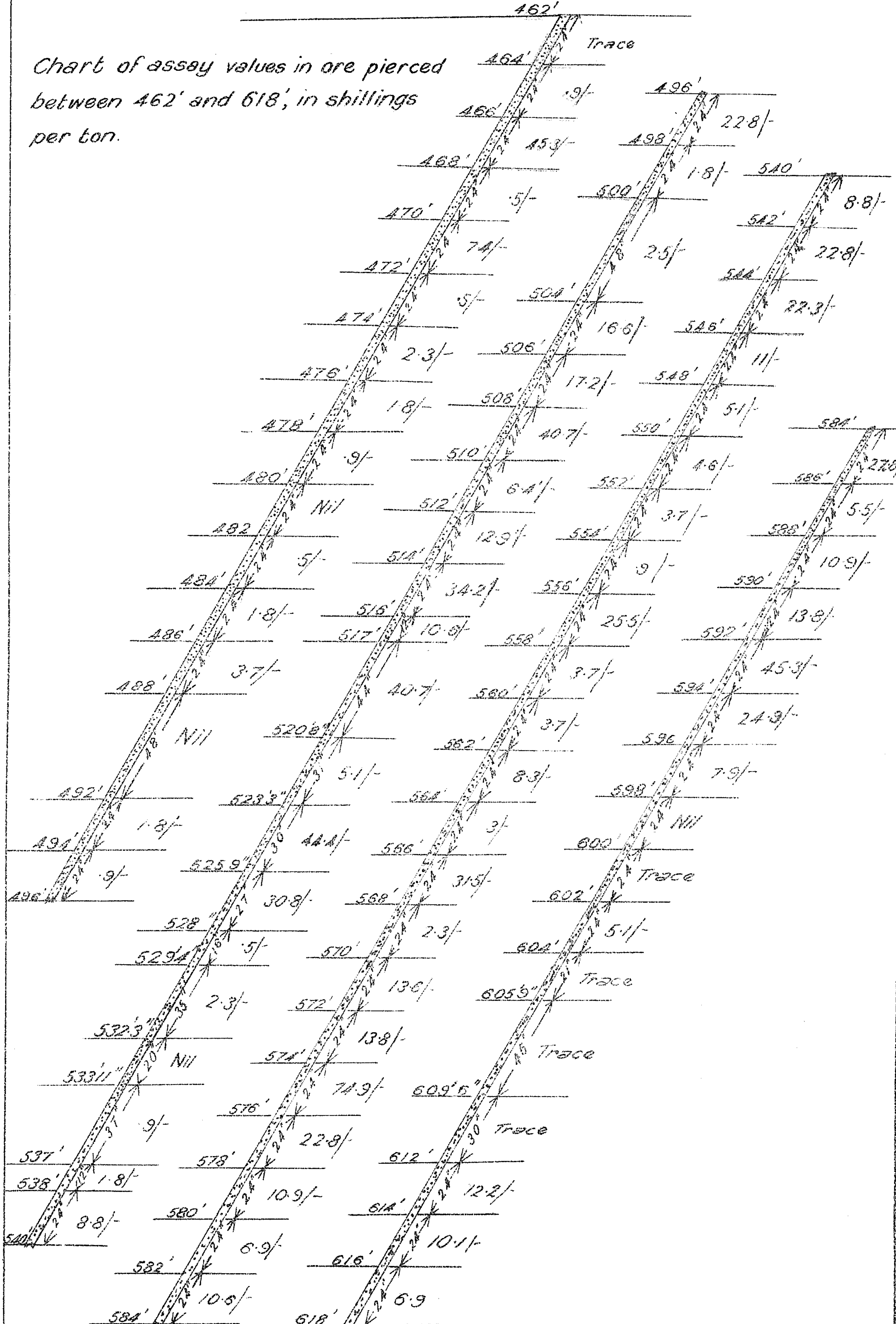
NOTE :-
The figures in brackets indicate the length of core recovered from the corresponding section of boring

—Nº 7 Bore—

—BIG BELL G. M.—

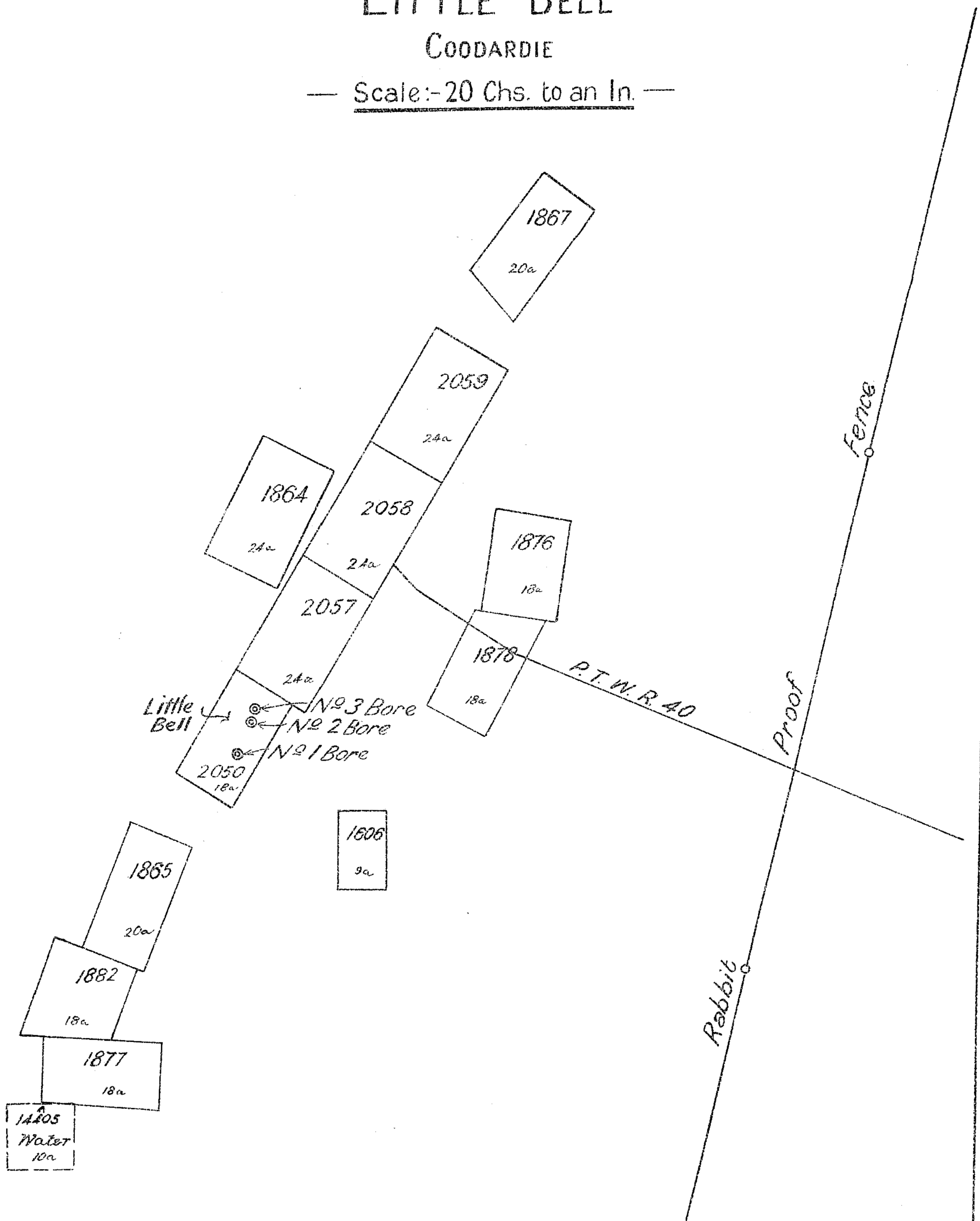
—Scale: 4 Ft. = 1 In.—

Chart of assay values in ore pierced between 462' and 618', in shillings per ton.



Locality Plan
of Bores at
LITTLE BELL
COODARDIE

— Scale:- 20 Chs. to an In. —



– Section Nº1 Bore –

—LITTLE BELL G.M.—

– CUE –

—Scale:- 32 Ft. = 1 In.—

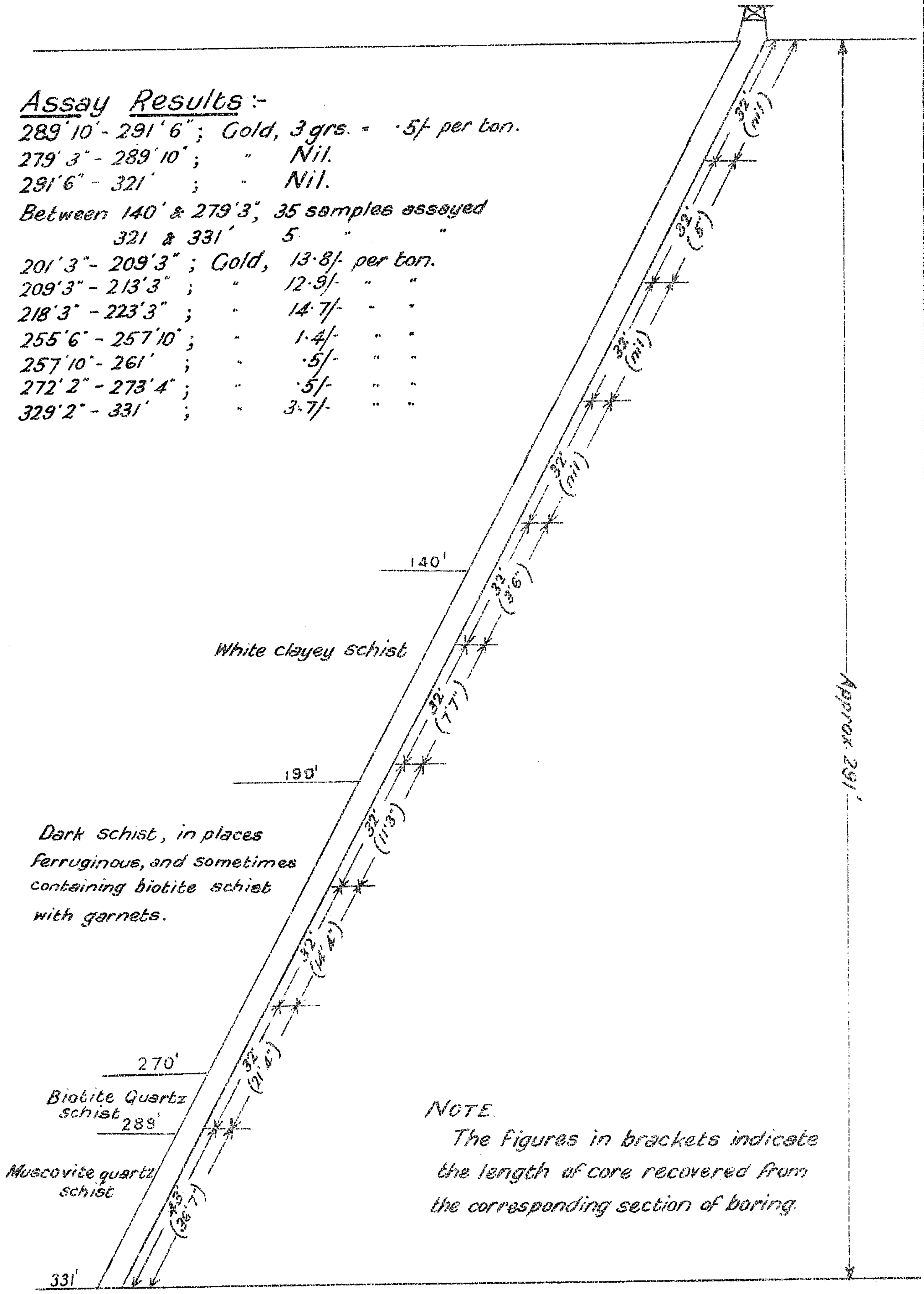
Depressed at an angle of 60°

Commenced 11. 9. 29.
Completed 23. 9. 29

Assay Results:-

289' 10" - 291' 6" ; Gold, 3 grs. = ·5/- per ton.
279' 3" - 289' 10" ; " Nil.
291' 6" - 321' ; " Nil.
Between 140' & 279' 3", 35 samples assayed
321 & 331' 5 " "

201' 3" - 209' 3" ;	Gold,	13·8/-	per ton.
209' 3" - 213' 3" ;	"	12·9/-	" "
218' 3" - 223' 3" ;	"	14·7/-	" "
255' 6" - 257' 10" ;	"	1·4/-	" "
257' 10" - 261' ;	"	·5/-	" "
272' 2" - 273' 4" ;	"	·5/-	" "
329' 2" - 331' ;	"	3·7/-	" "



NOTE
The figures in brackets indicate the length of core recovered from the corresponding section of boring.

—Section No 2 Bore—

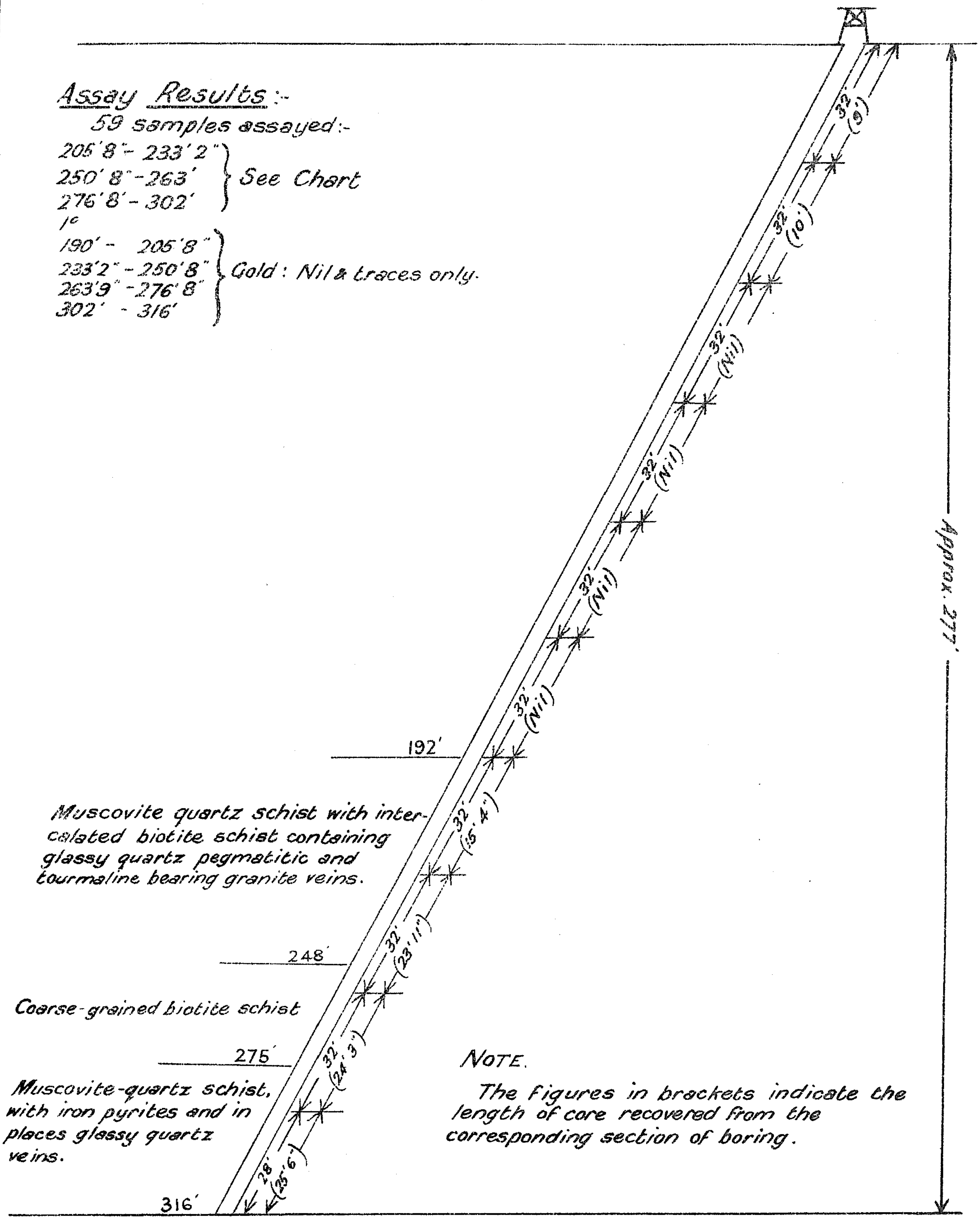
—LITTLE BELL G.M.L.—

—CUE—

—Scale:-32 Ft.=1 In.—

Depressed at an angle of 60°

Commenced 30. 9. 29.
Completed 10. 10. 29.



Assay Results:-

59 samples assayed:-

205'8" – 233'2"
250'8" – 263'
276'8" – 302'
} See Chart

1c

190' – 205'8"
233'2" – 250'8"
263'9" – 276'8"
302' – 316'
} Gold: Nil & traces only.

NOTE.

The figures in brackets indicate the length of core recovered from the corresponding section of boring.

— Nº 2 Bore —

— LITTLE BELL G.M.L. —

— CUE —

— Scale :- 4 Ft. = 1 In. —

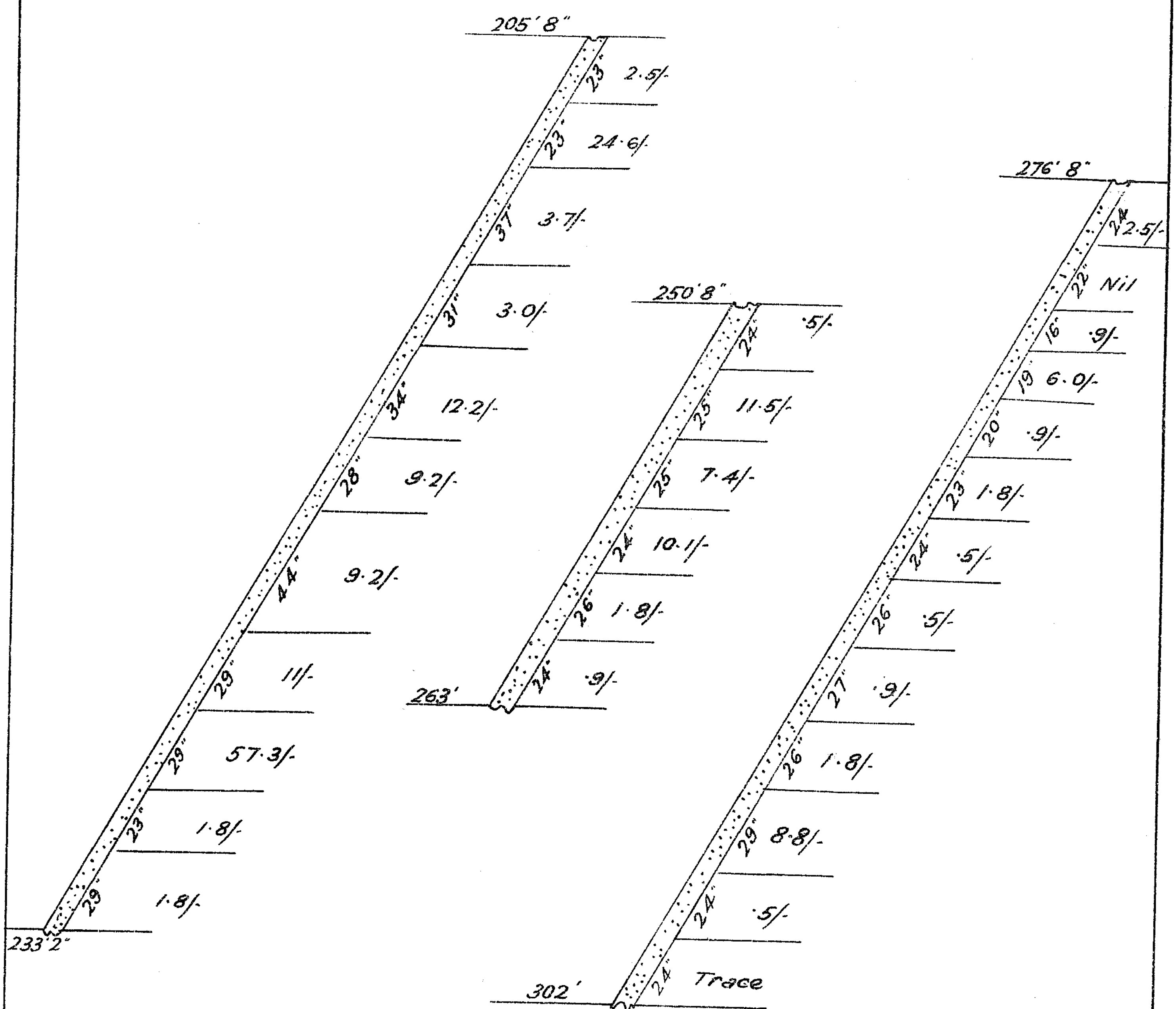


Chart of values in ore pierced between 205' 8" & 302', in shillings per ton.

- Section No 3 Bore -

- LITTLE BELL G. M. L. -

- CUE -

- Scale: 40 Ft. = 1 In. -

Depressed at an angle of 60°

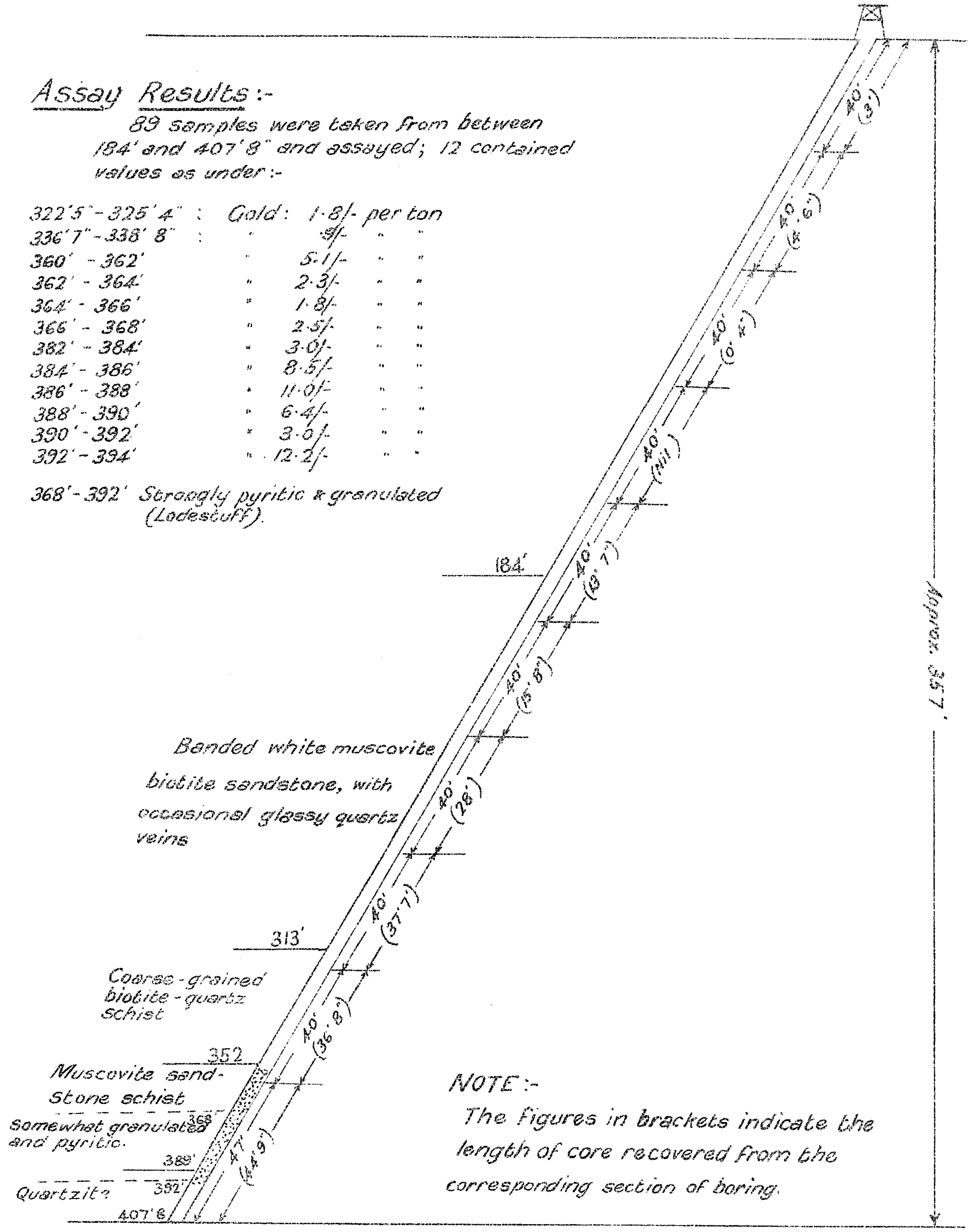
Commenced 17. 10. 29.
Completed 2. 11. 29

Assay Results:-

89 samples were taken from between 184' and 407' 8" and assayed; 12 contained values as under:-

322' 5" - 325' 4"	Gold:	1·8/-	per ton
336' 7" - 338' 8"	"	9/-	" "
360' - 362'	"	5·1/-	" "
362' - 364'	"	2·3/-	" "
364' - 366'	"	1·8/-	" "
366' - 368'	"	2·5/-	" "
382' - 384'	"	3·0/-	" "
384' - 386'	"	8·5/-	" "
386' - 388'	"	11·0/-	" "
388' - 390'	"	6·4/-	" "
390' - 392'	"	3·0/-	" "
392' - 394'	"	12·2/-	" "

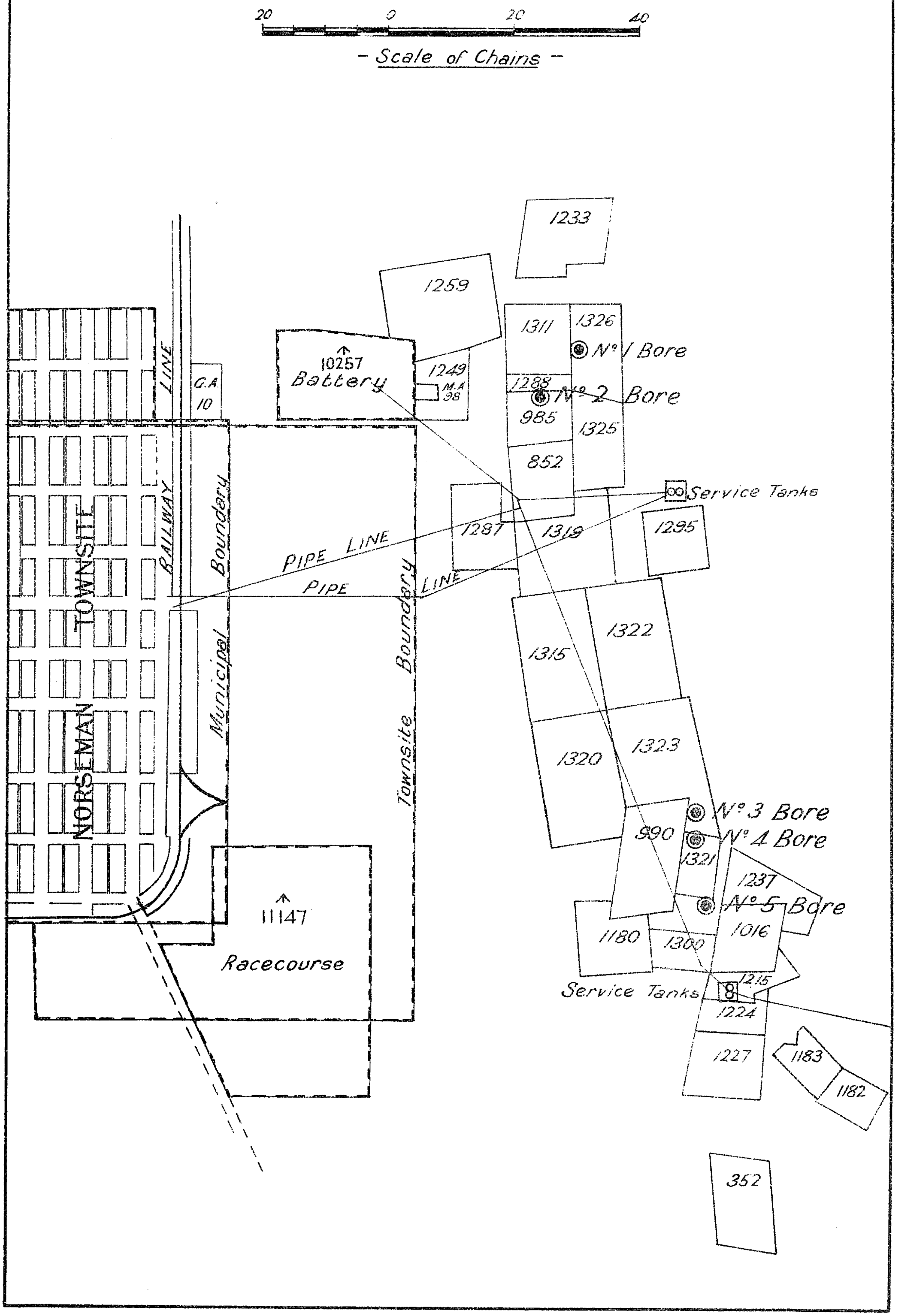
368' - 392' Strongly pyritic & granulated (Lodestuff).



NOTE:- The figures in brackets indicate the length of core recovered from the corresponding section of boring.

Locality Plan of Bores

NORSEMAN



–Section Nº 1 Bore –

– NORSEMAN –

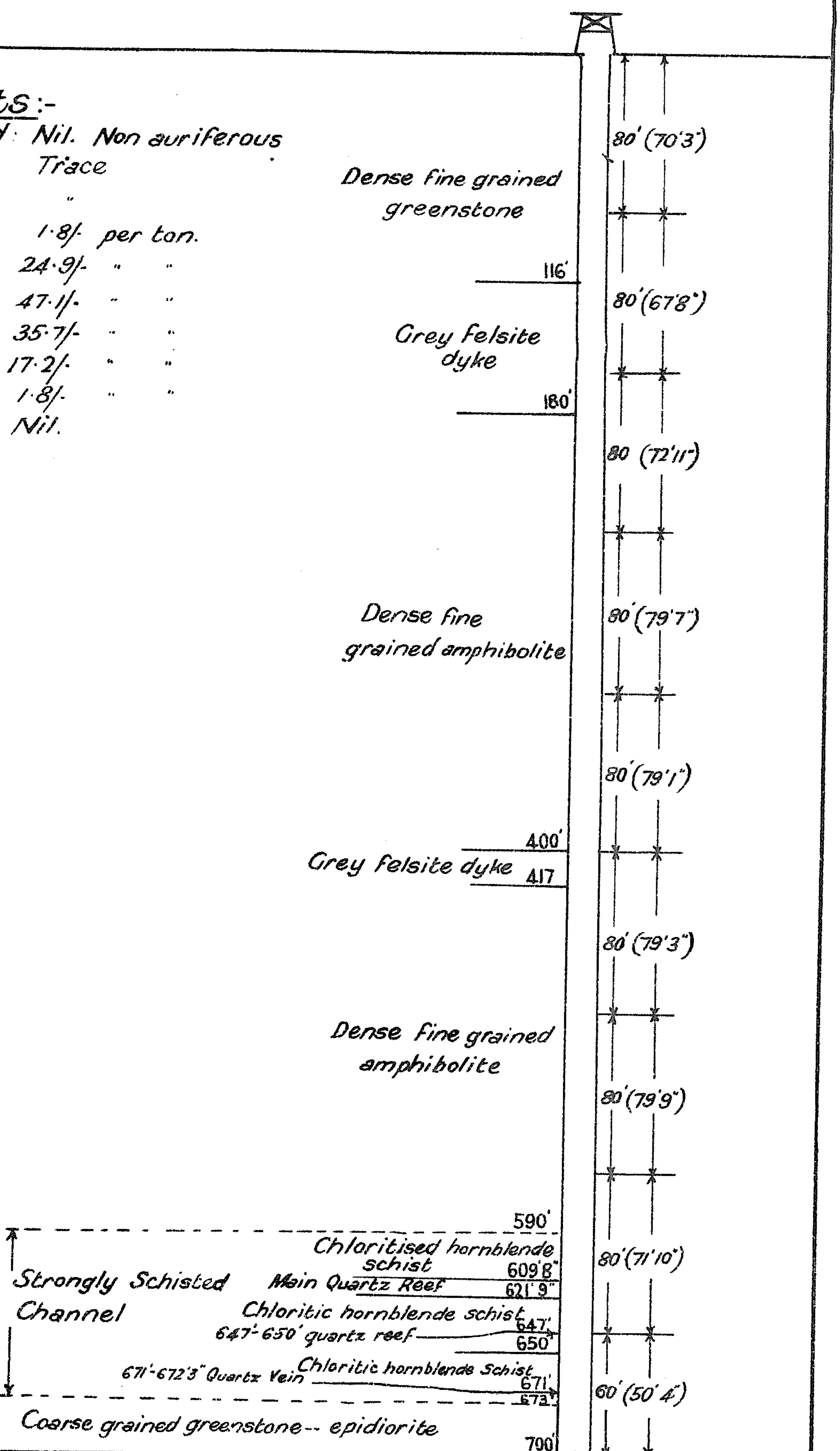
– Scale :- 80 Ft = 1 In –

Vertical

Commenced 24. 4. 29.
Completed 29. 7. 29.

Assay Results :-

400' - 417	Gold	Nil.	Non auriferous
609' 8" - 610' 4"	"	Trace	
610' 4" - 612' 2"	"	"	
612' 2" - 613' 8"	"	1·8/-	per ton.
613' 8" - 616' 2"	"	24·9/-	" "
616' 2" - 618' 9"	"	47·1/-	" "
618' 9" - 620'	"	35·7/-	" "
620' - 621' 9"	"	17·2/-	" "
647' - 650'	"	1·8/-	" "
671' - 672' 3"	"	Nil.	



NOTE :- The figures in brackets indicate the length of core recovered from the corresponding section of boring.

—Section No. 2 Bore —

— MARAROA G.M.L.—

— NORSEMAN —

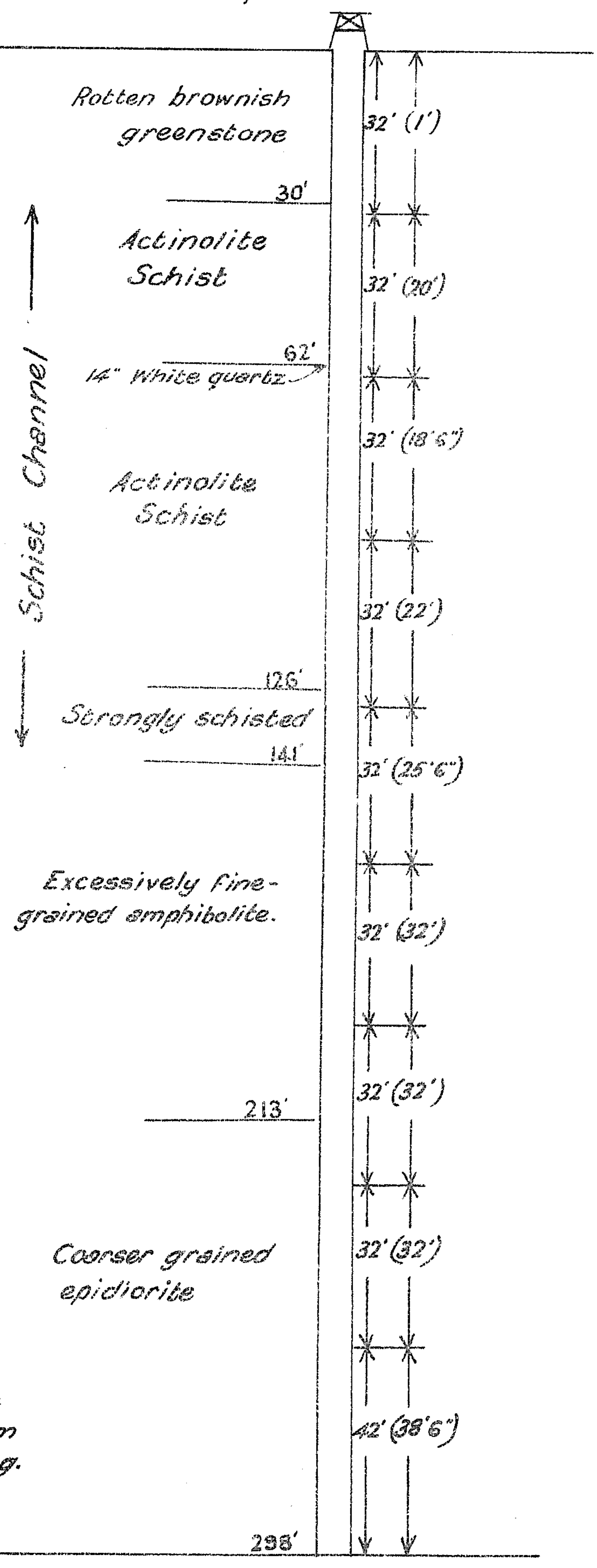
— Scale:- 32 Ft. = 1 In.—

Commenced 6. 8. 29.
Completed 27. 8. 29.

Vertical

Assay Results :-

62' - 63'2"	Gold :	4·6/- per ton.	
126' - 129'	"	Nil	
132' - 133'6"	"	"	
135' - 141'	"	"	
194' - 196'	"	"	



NOTE :-
The figures in brackets indicate the length of core recovered from the corresponding section of boring.

Section No 3 Bore

VIKING G.M.L.

NORSEMAN

Scale:- 60 Ft. = 1 In.

Vertical.

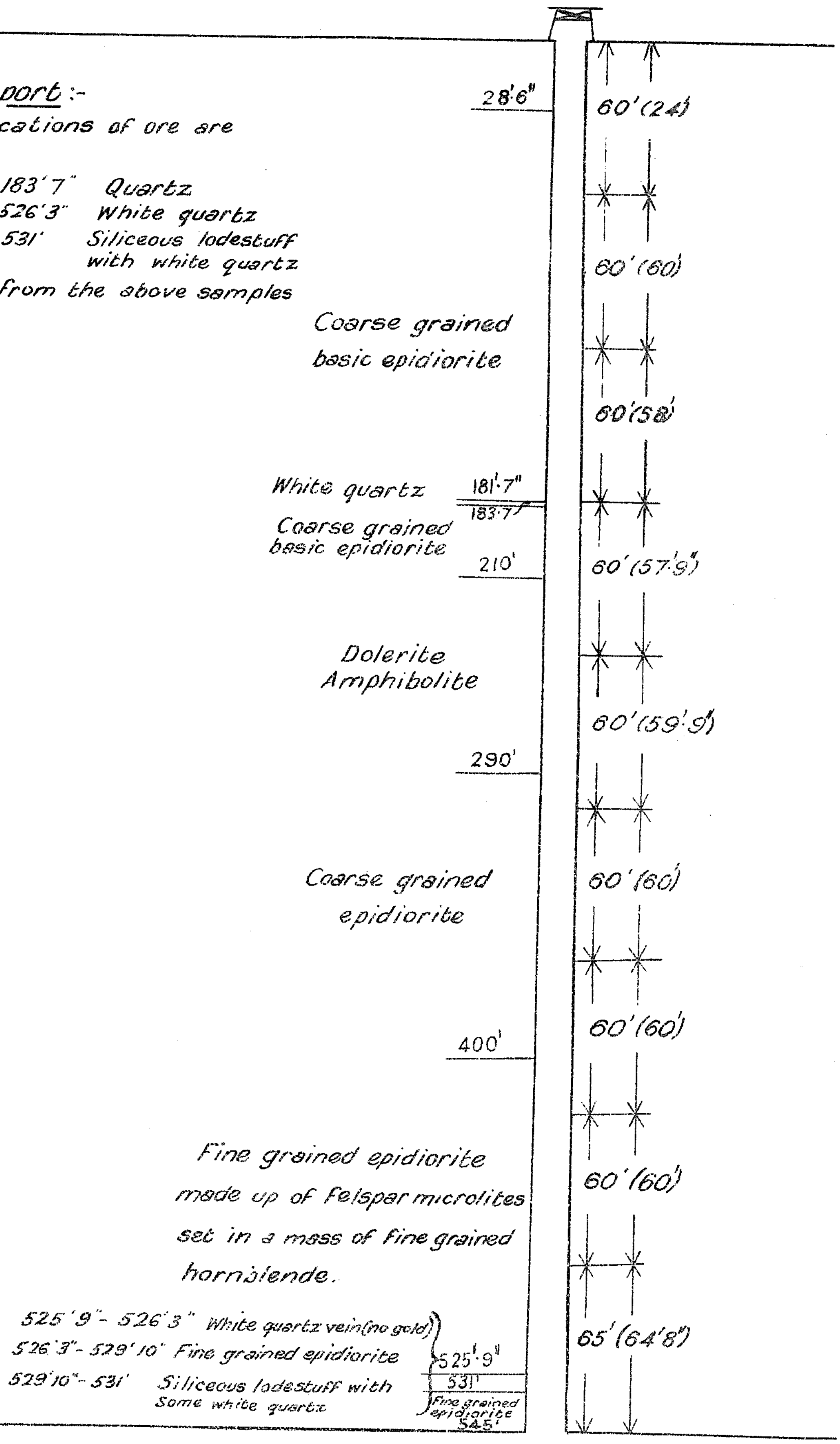
Commenced 4. 9. 29.
Completed 22. 11. 29.

Petrological Report:-

The only indications of ore are as follows:-

181'7" - 183'7" Quartz
525'9" - 526'3" White quartz
529'10" - 531' Siliceous lodestuff with white quartz

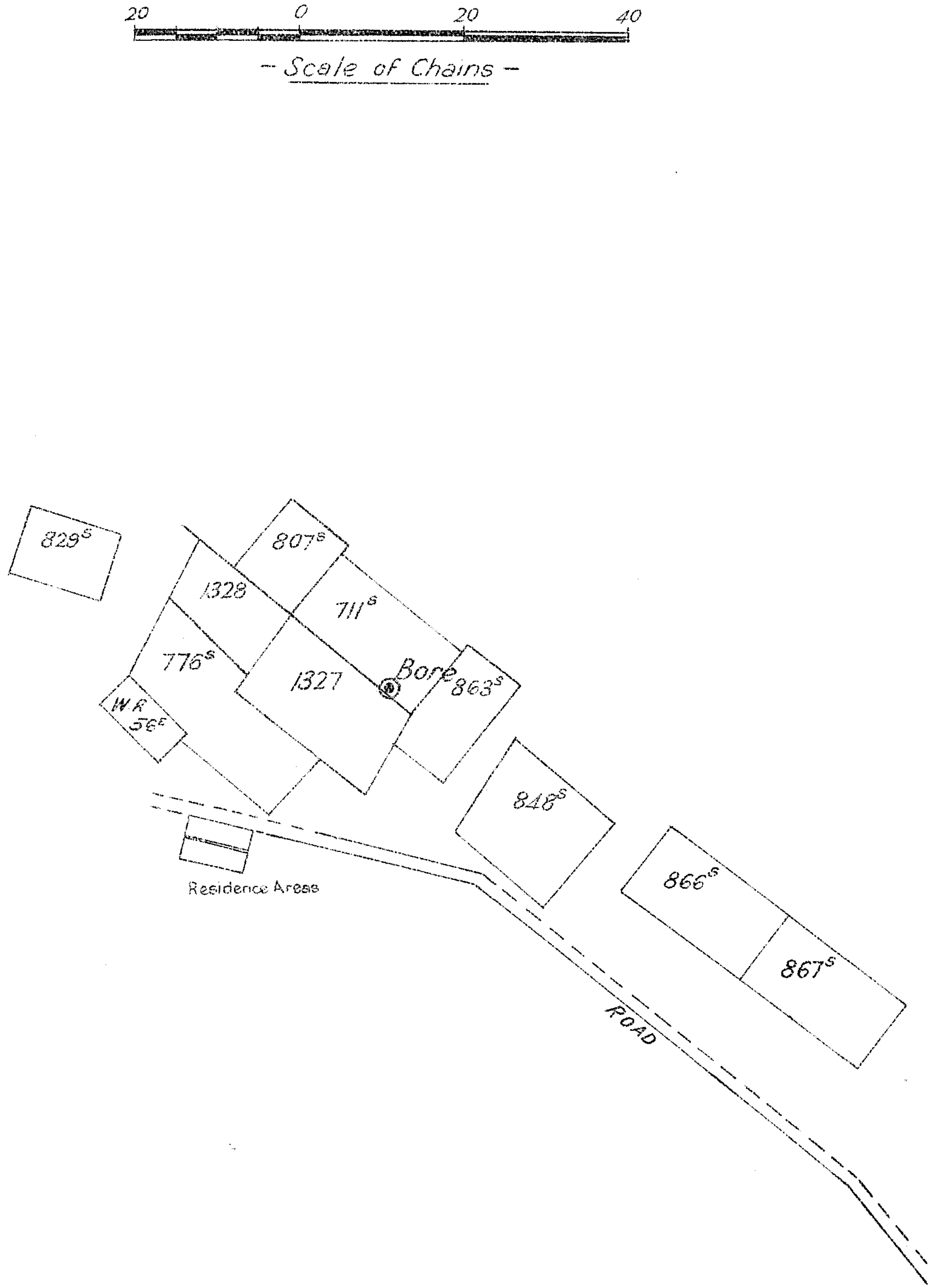
Assay results from the above samples showed no gold.



NOTE:- The figures in brackets indicate the length of core recovered from the corresponding section of boring.

Locality Plan Shewing Bore

CARBINE



Section of Bore

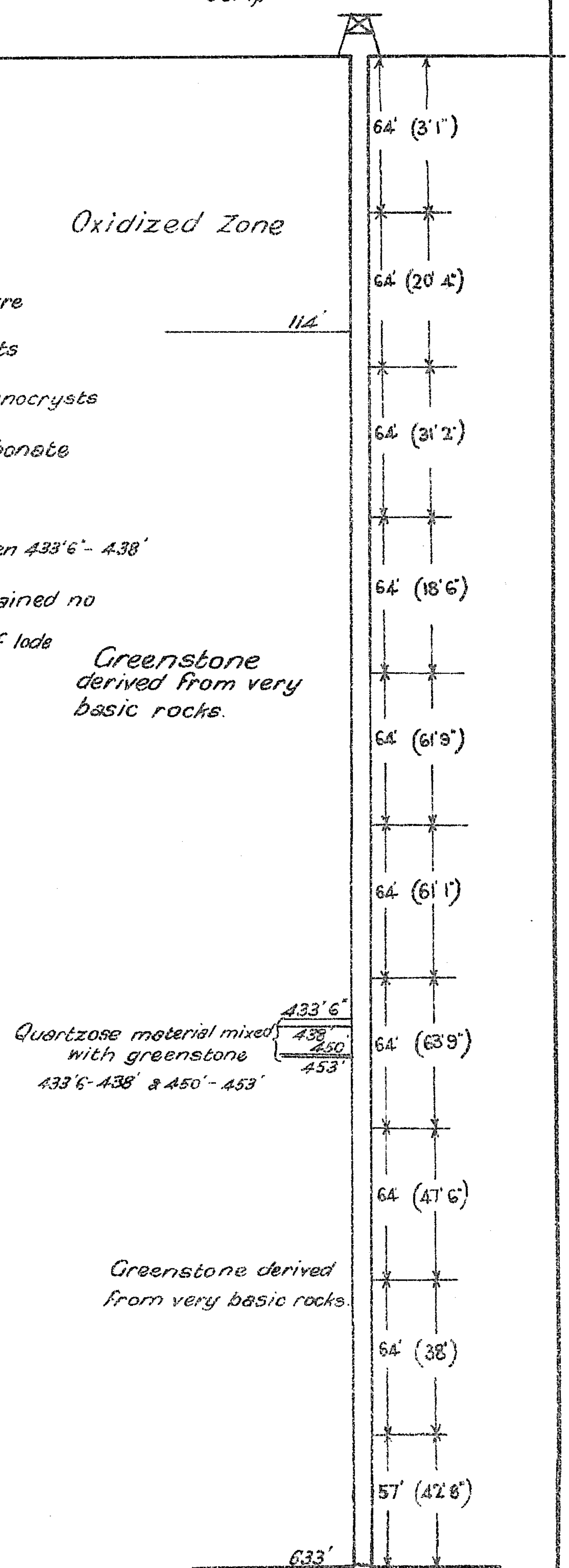
CARBINE G.M.

CARBINE

Scale 64 Ft. = 1 In.

Vertical.

Commenced 13. 3. 29.
Completed 23. 5. 29.



Extract from Petrologist's report:-

"The greenstone ranged from a fine grained chloritic actinolitic rock through almost pure chloritic rocks to chloritic carbonate schists

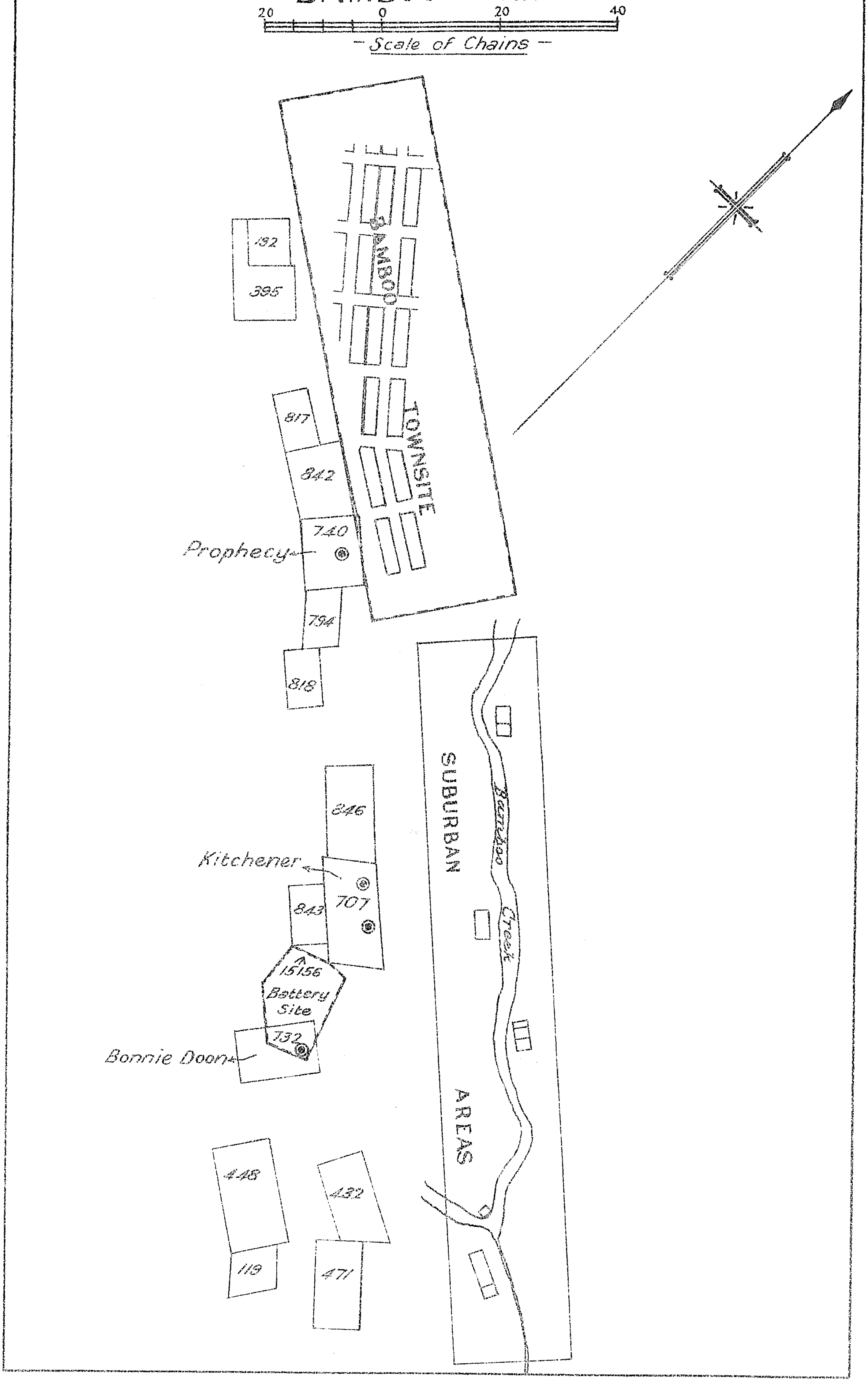
A feature was the numerous pseudo-phenocrysts of biotite & horneblende in the chlorite-carbonate rocks"

Apart from the quartzose material, between 433'6" - 438' & 450'-453', the remainder of the core contained no metallic mineralization or other evidence of lode or reef formation.

Assays:-

433'6" - 438' : Gold & Silver - nil.
450' - 453' : Gold & Silver - nil.

Locality Plan of Bores
BAMBOO CREEK



Section of Bore

PROPHECY G.M.L.

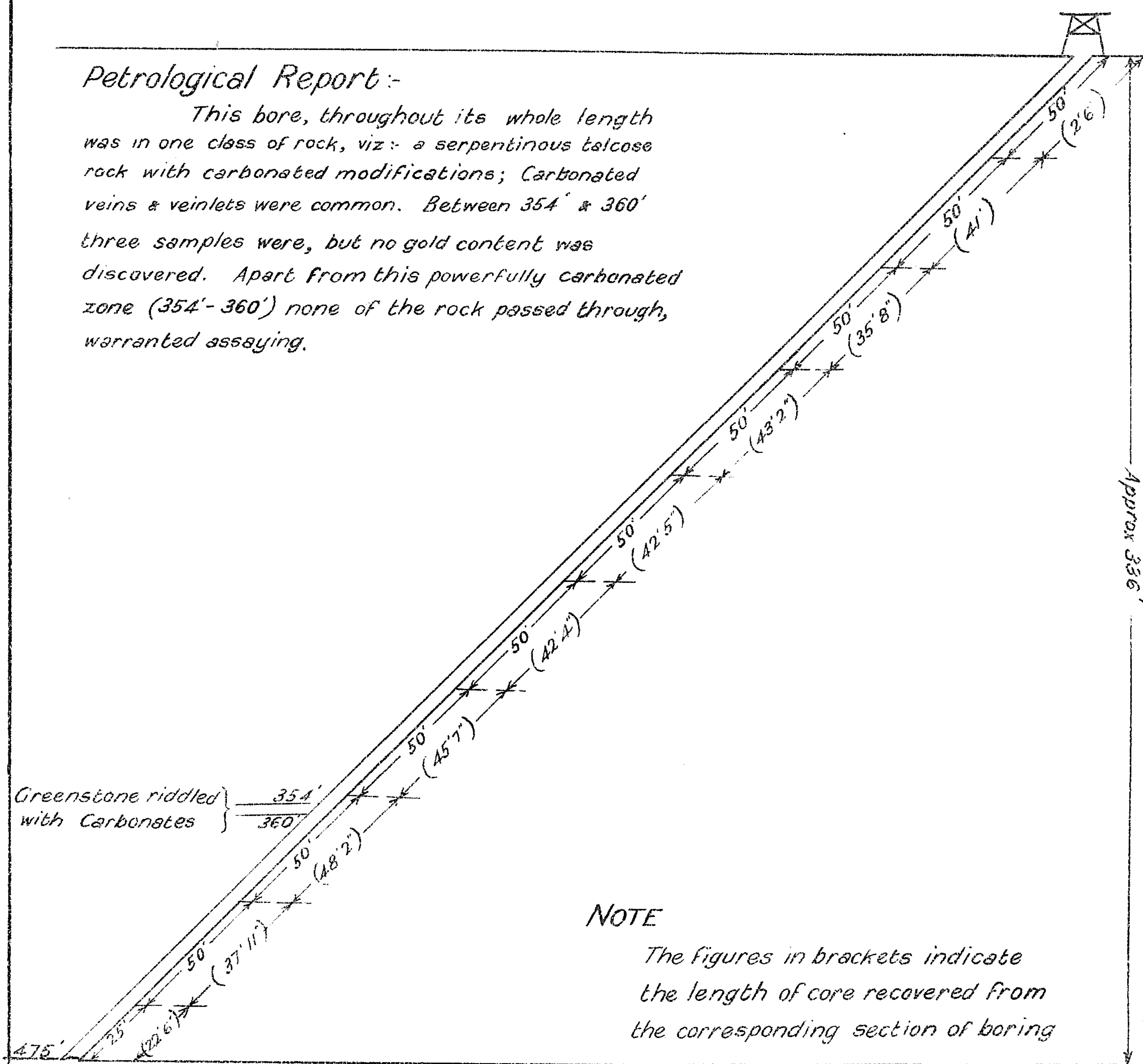
BAMBOO CREEK

50 0 50 100

— Scale of Feet —

Depressed at an angle of 45°

Commenced 22. 4. 29.
Completed 18. 5. 29.



Petrological Report:-

This bore, throughout its whole length was in one class of rock, viz:- a serpentinous talcose rock with carbonated modifications; Carbonated veins & veinlets were common. Between 354' & 360' three samples were, but no gold content was discovered. Apart from this powerfully carbonated zone (354'-360') none of the rock passed through, warranted assaying.

NOTE

The figures in brackets indicate the length of core recovered from the corresponding section of boring

– Section Nº1 Bore –

– KITCHENER G.M.L. –

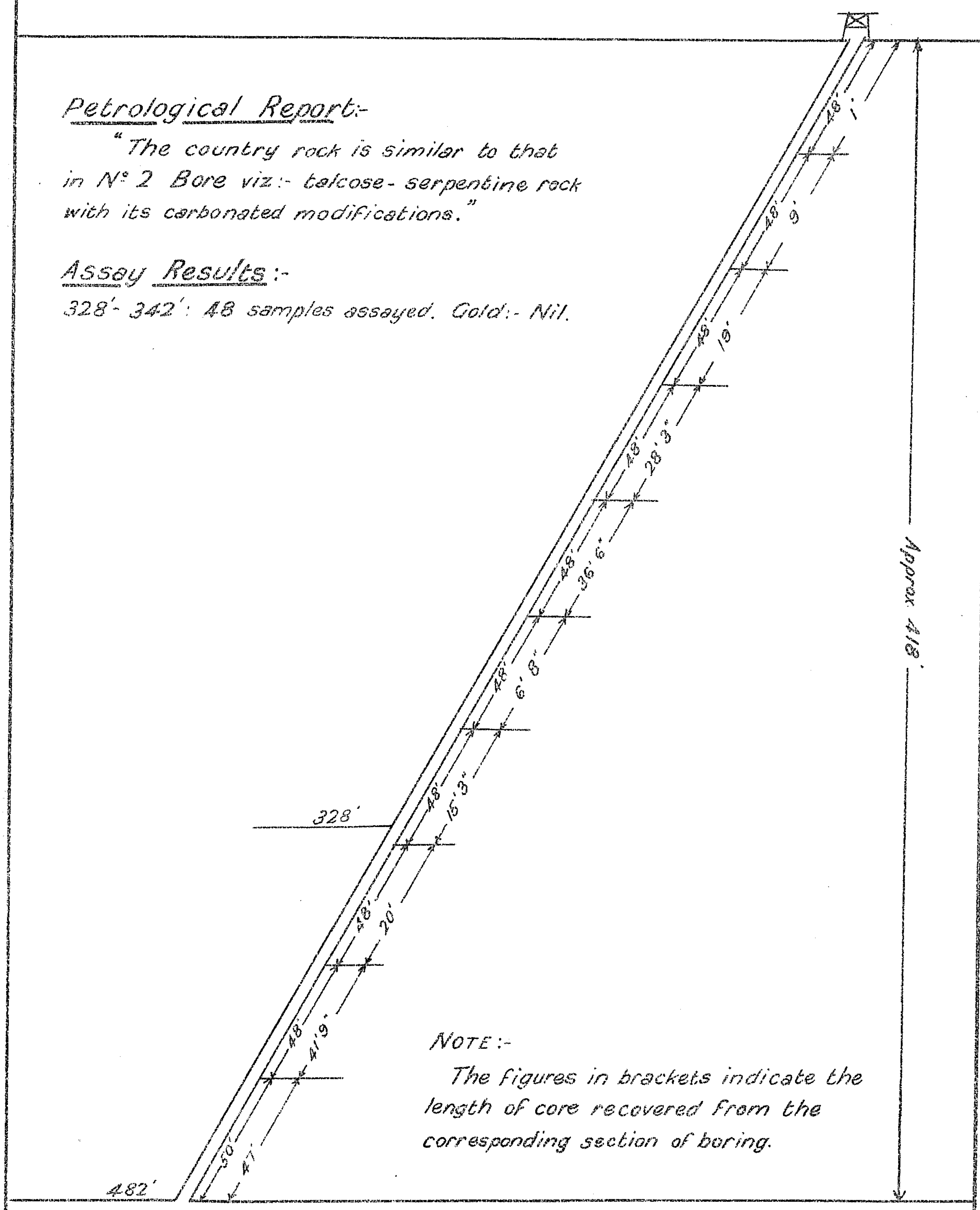
– BAMBOO CREEK –

– Scale:- 48 ft. = 1 In. –

Depressed at an angle of 60°

Commenced 15. 3. 29

Completed 11. 4. 29



Petrological Report:-

"The country rock is similar to that in Nº 2 Bore viz:- talcose-serpentine rock with its carbonated modifications."

Assay Results:-

328'-342': 48 samples assayed. Gold:- Nil.

NOTE:-

The figures in brackets indicate the length of core recovered from the corresponding section of boring.

—Section Nº 2 Bore—

—KITCHENER G.M.L.—

—BAMBOO CREEK—

—Scale:- 48 ft. = 1 in.—

Depressed at an angle of 60°

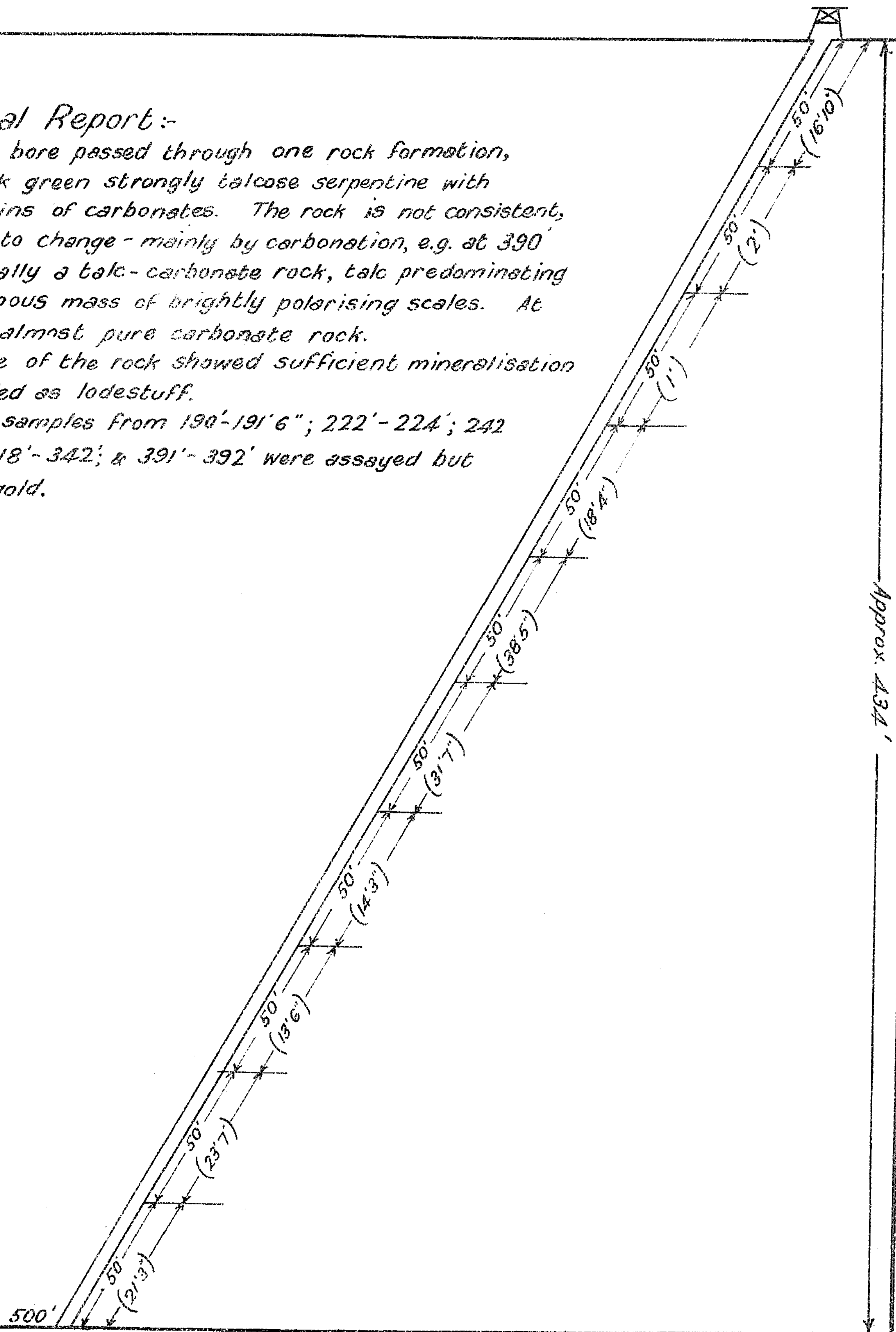
Commenced 21. 3. 29
Completed 25. 4. 29

Petrological Report:-

This bore passed through one rock formation, chiefly a dark green strongly talcose serpentine with scattered grains of carbonates. The rock is not consistent, but is liable to change - mainly by carbonation, e.g. at 390' it is essentially a talc - carbonate rock, talc predominating in a hetrogenous mass of brightly polarising scales. At 210' it is an almost pure carbonate rock.

None of the rock showed sufficient mineralisation to be regarded as lodestuff.

Five samples from 190'-191'6"; 222'-224'; 242 242'-243'; 318'-342'; & 391'-392' were assayed but yielded no gold.

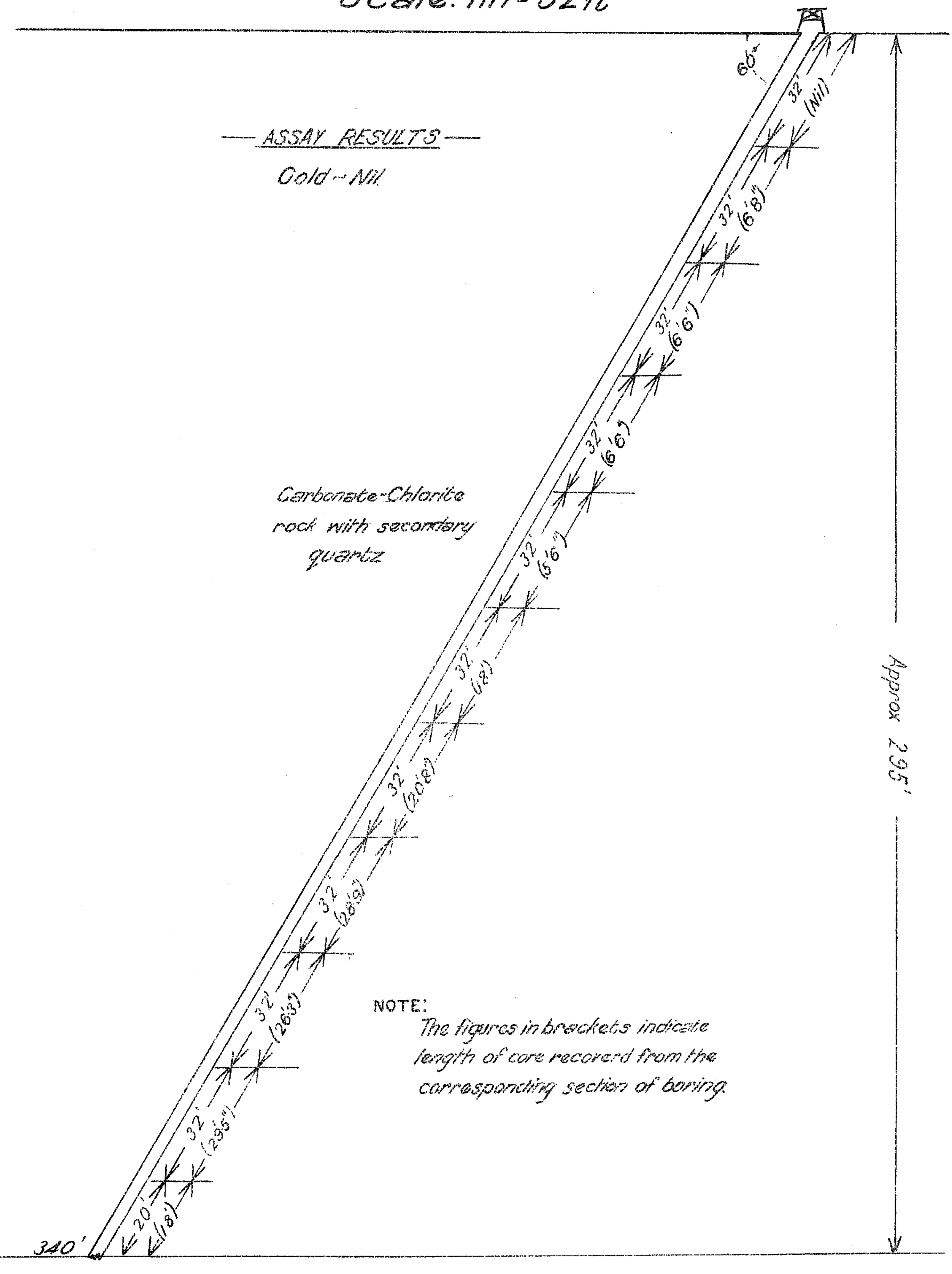


Section of Bore

BONNIE DOON G.M.

Bamboo Creek

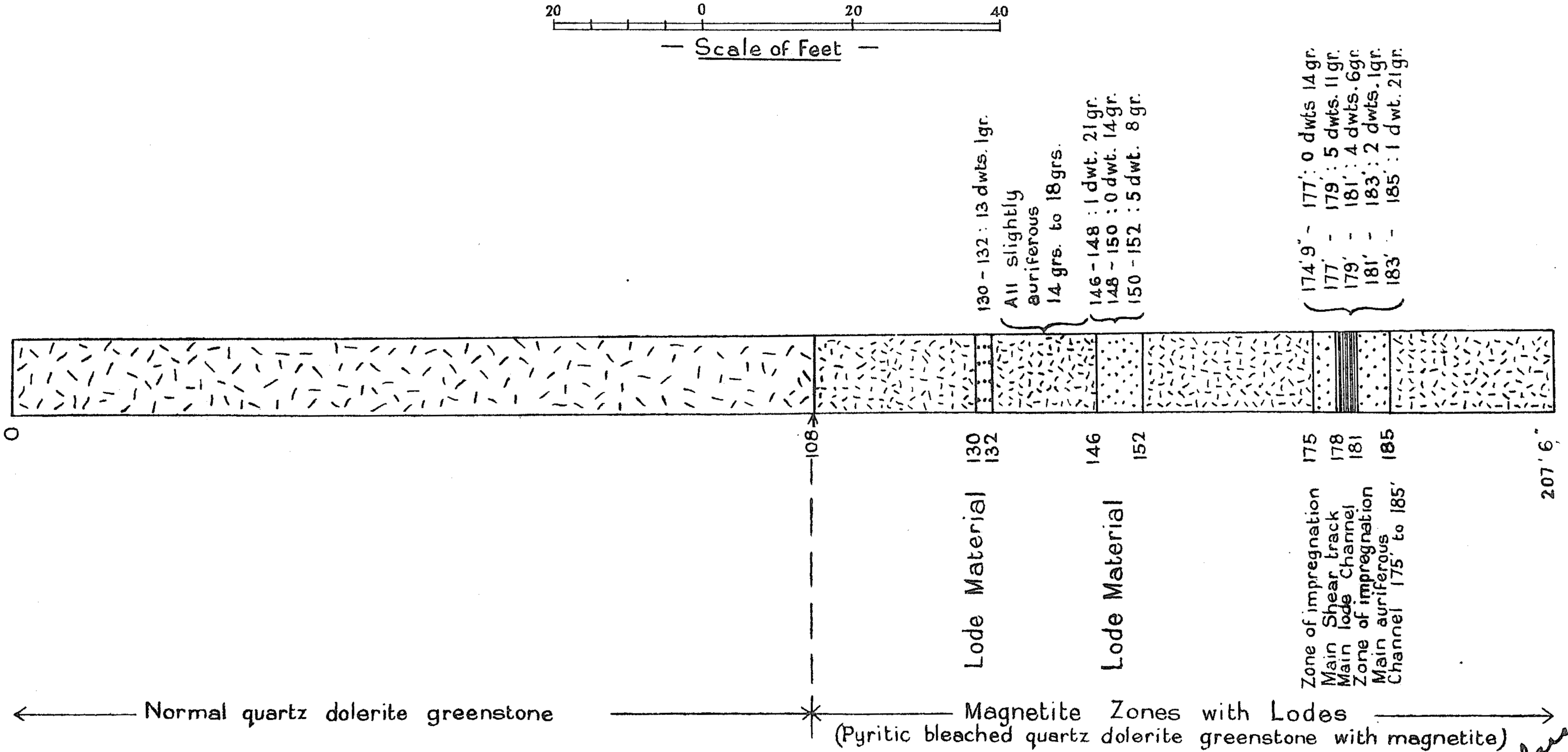
Scale: 1in = 32 ft



ENTERPRISE GOLD MINE, KALGOORLIE

Geological Section through Nº 4 Horizontal Bore

from 773 ft level, Hainault G.M. (752 ft. v.d. Enterprise G.M.).



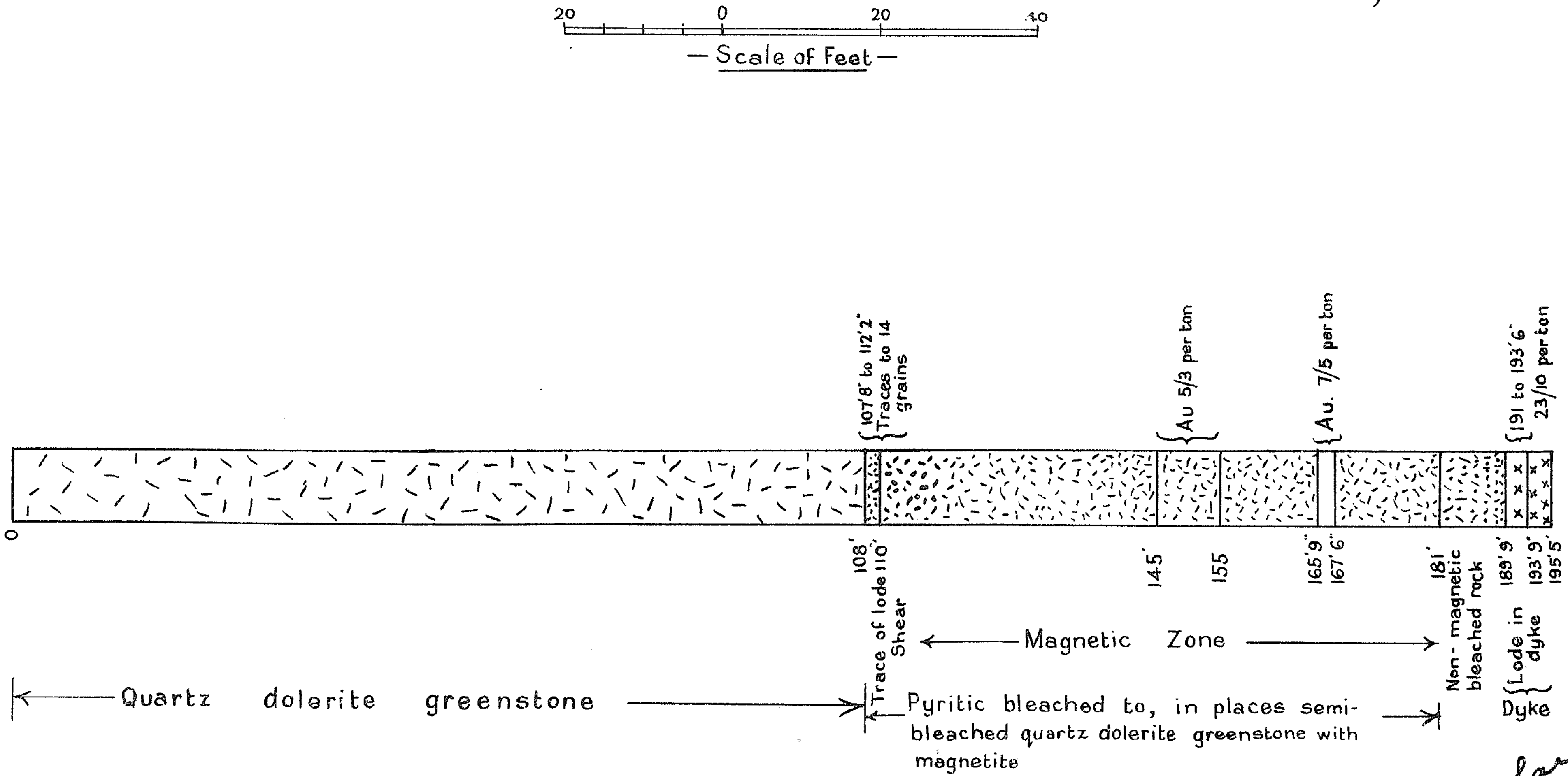
- FIGURE I -

E. de C. Clarke (signature)

ENTERPRISE GOLD MINE, KALGOORLIE

Geological Section through Nº 5 Horizontal Bore

from 773 ft. level, Hainault G.M. (752 ft. v.d. Enterprise G.M.)

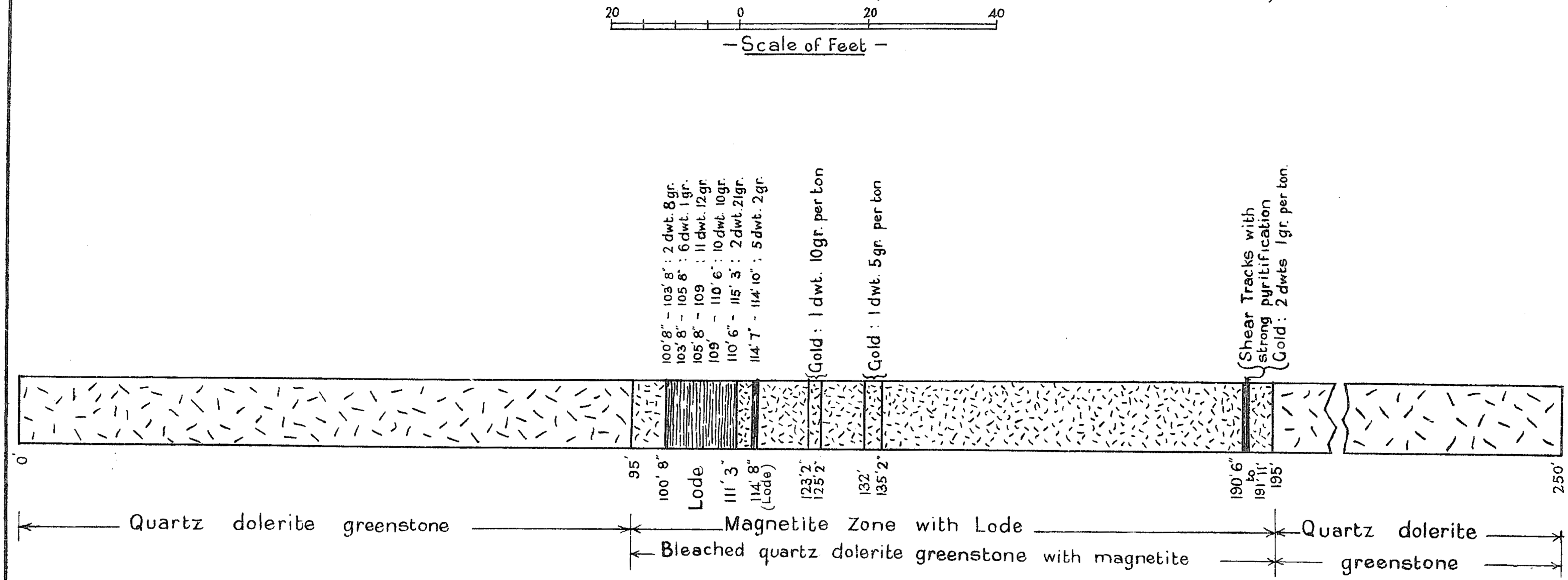


— FIGURE II —

ENTERPRISE GOLD MINE, KALGOORLIE

Geological Section through Nº 6 Horizontal Bore

from 773 ft. level, Hainault G. M. (752 ft. v.d. Enterprise G.M.)



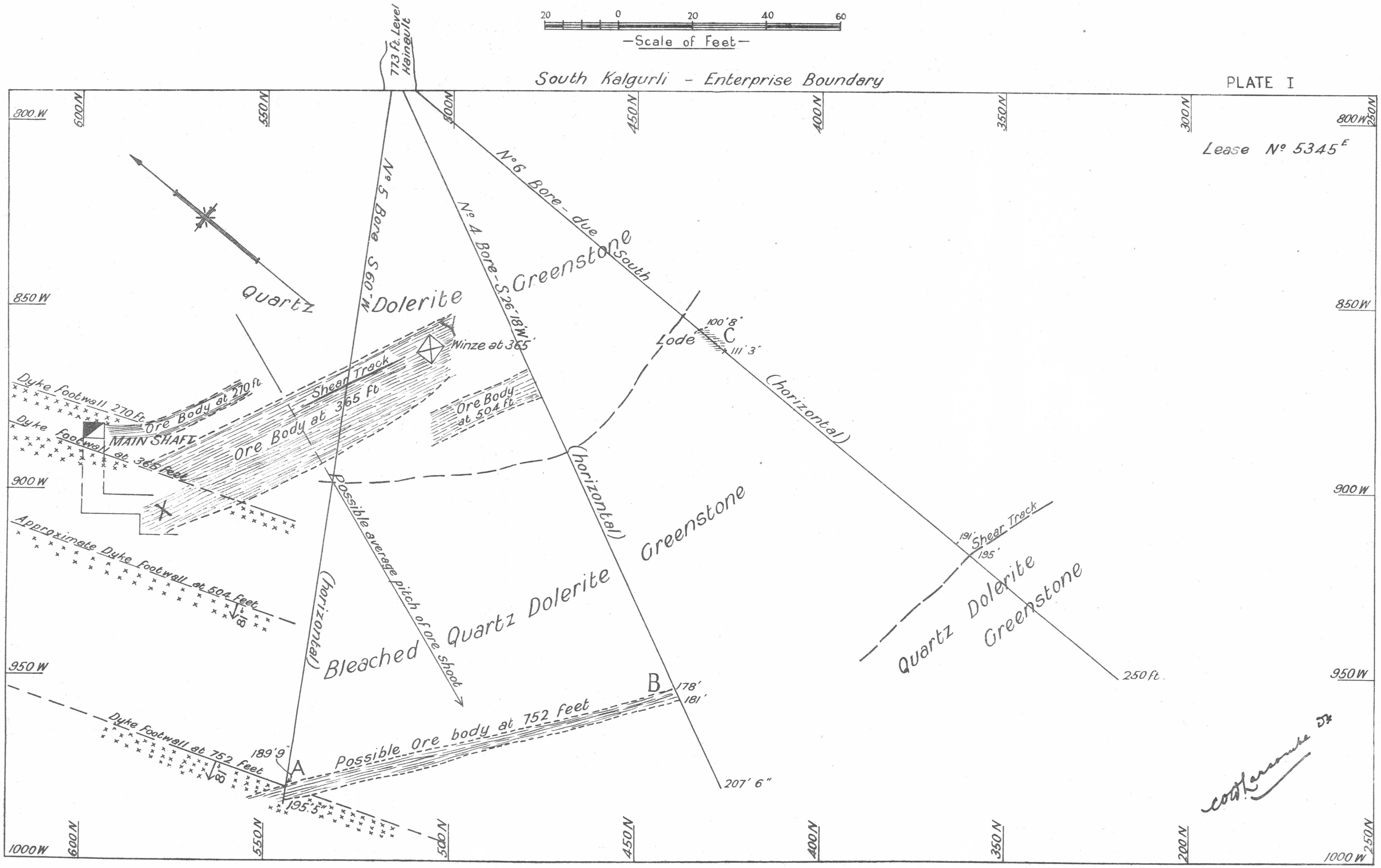
— FIGURE III —

C. O. G. Larcombe

Geological Plan

ENTERPRISE GOLD MINE

Shewing three bores at 752 Ft. Level with position of dyke and ore bodies at different levels

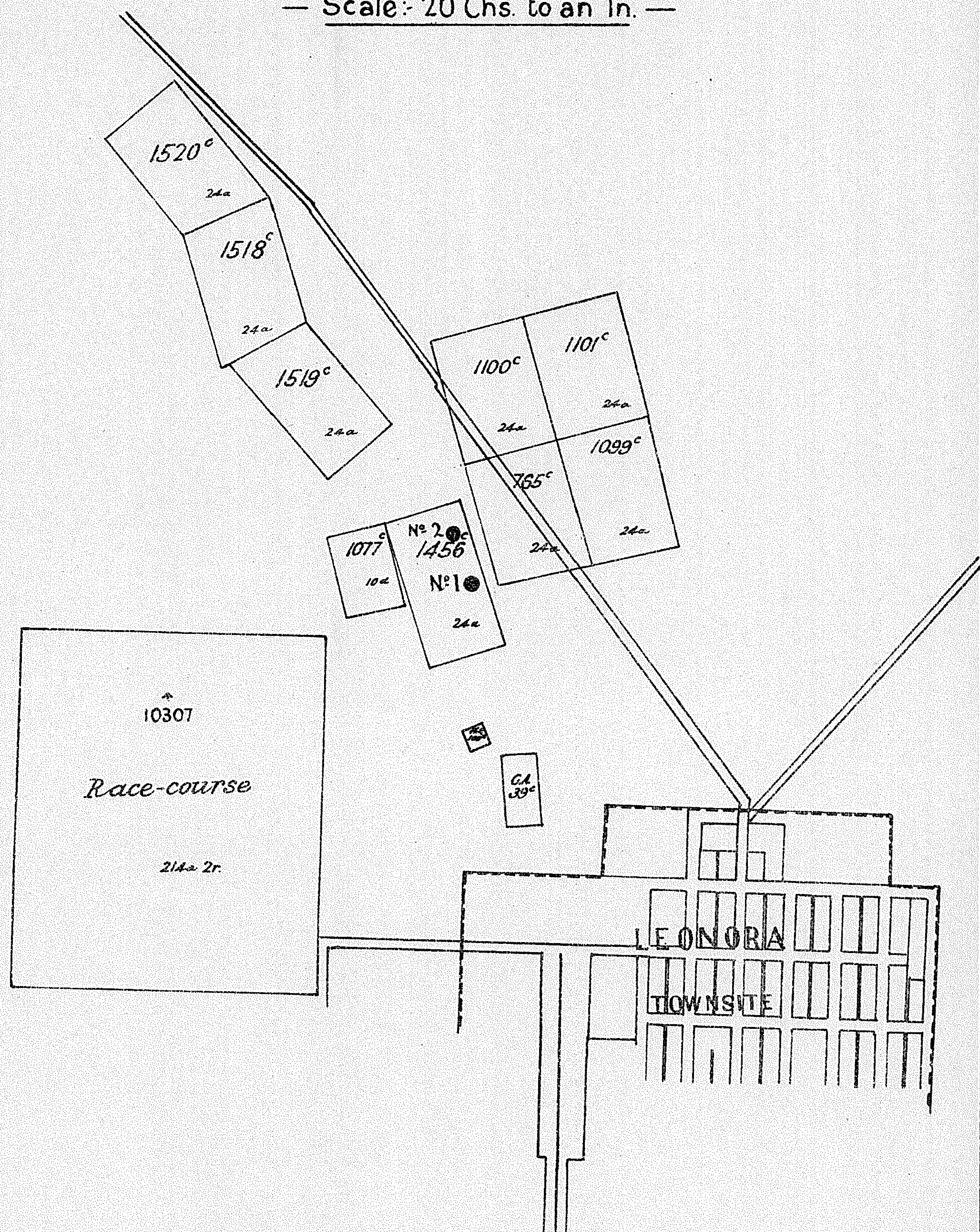


Locality Plan
of Bores at

HARBOUR LIGHTS

LEONORA

— Scale:- 20 Chs. to an In. —



– Section Nº 2 Bore –

– HARBOUR LIGHTS G.M.L. –

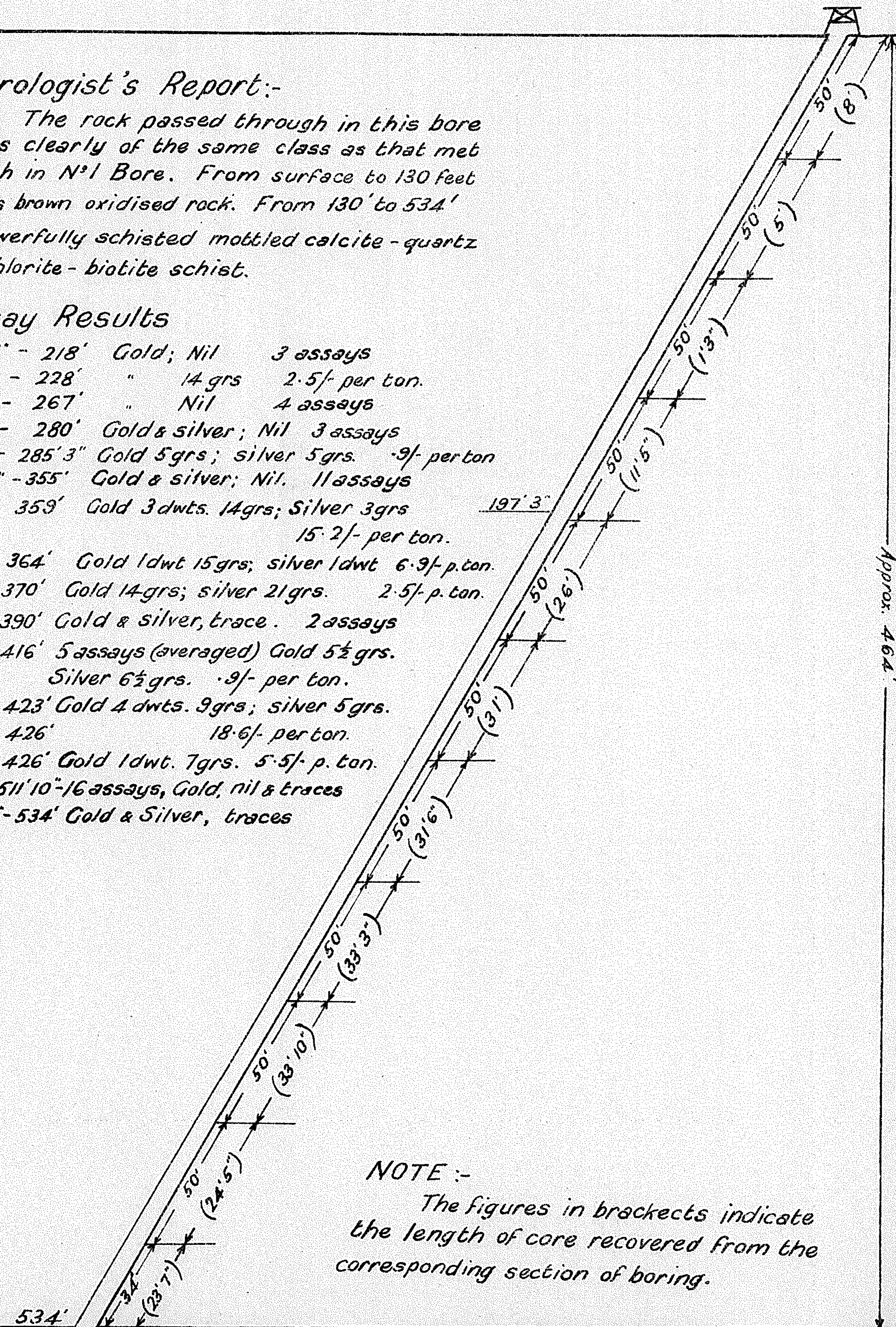
– LEONORA –

– Scale:- 50 Ft. = 1 In. –

Commenced 8. 12. 28

Completed 4. 2. 29

Depressed at an angle of 60°



Petrologist's Report:-

The rock passed through in this bore was clearly of the same class as that met with in Nº1 Bore. From surface to 130 feet was brown oxidised rock. From 130' to 534' powerfully schisted mottled calcite - quartz - chlorite - biotite schist.

Assay Results

197' 3" - 218' Gold; Nil 3 assays
218' - 228' " 14 grs 2·5/- per ton.
228' - 267' " Nil 4 assays
267' - 280' Gold & silver; Nil 3 assays
280' - 285' 3" Gold 5 grs; silver 5 grs. ·9/- per ton
285' 3" - 355' Gold & silver; Nil. 11 assays
355' - 359' Gold 3 dwts. 14 grs; Silver 3 grs 15·2/- per ton.
359' - 364' Gold 1 dwt 15 grs; silver 1 dwt 6·9/- p. ton.
364' - 370' Gold 14 grs; silver 21 grs. 2·5/- p. ton.
370' - 390' Gold & silver, trace. 2 assays
390' - 416' 5 assays (averaged) Gold 5½ grs. Silver 6½ grs. ·9/- per ton.
416 - 423' Gold 4 dwts. 9 grs; silver 5 grs.
423' - 426' 18·6/- per ton.
423 - 426' Gold 1 dwt. 7 grs. 5·5/- p. ton.
426' - 511' 10" - 16 assays, Gold, nil & traces
511' 10" - 534' Gold & Silver, traces

NOTE :-
The figures in brackets indicate the length of core recovered from the corresponding section of boring.

Section Nº 9 Bore

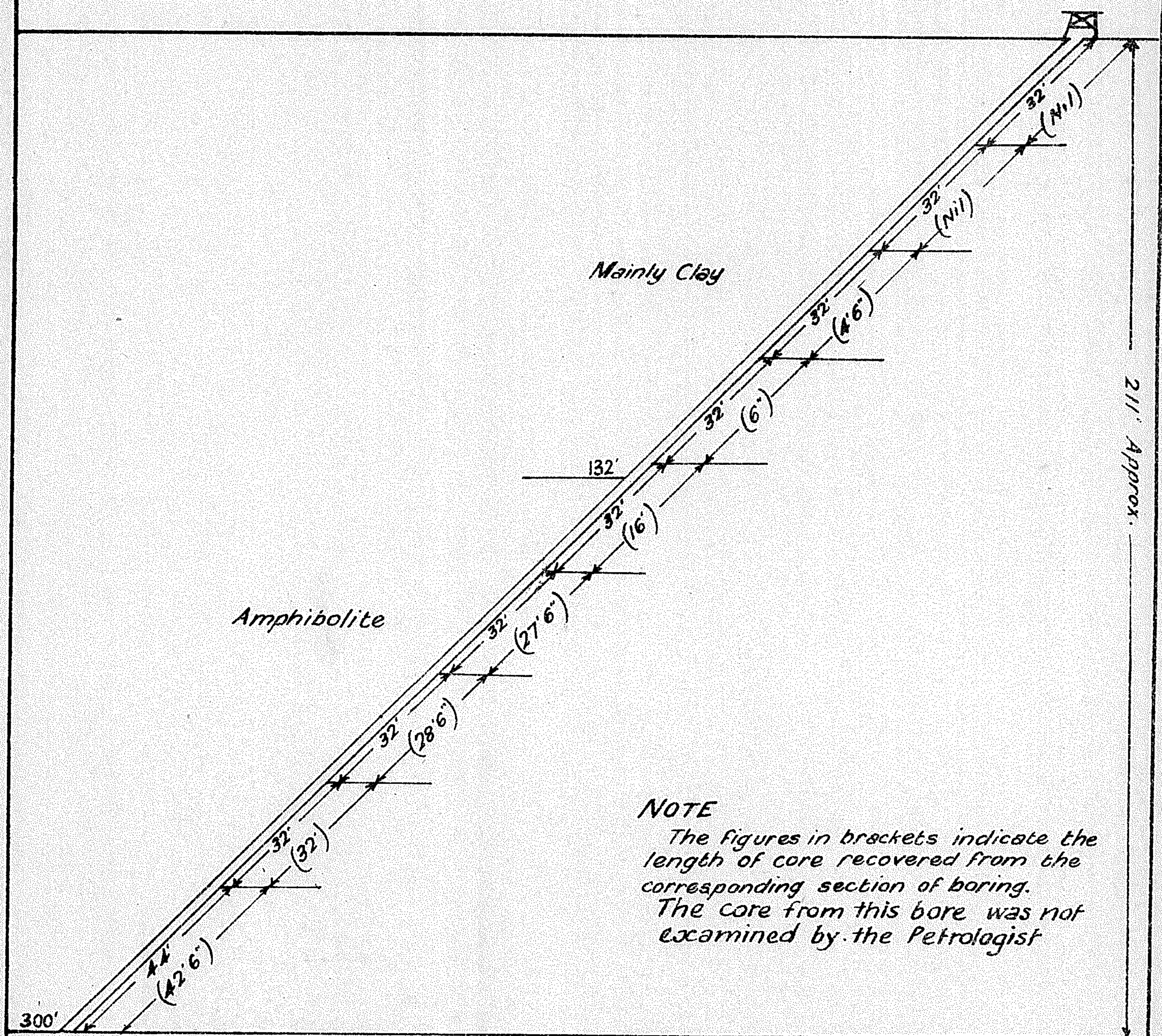
Kapanga Lease

Greenbushes

Scale:- 32 Ft. = 1 In.

Depressed at an angle of 45°

Commenced 16. 1. 29.
Completed 1. 2. 29.



NOTE

The figures in brackets indicate the length of core recovered from the corresponding section of boring.

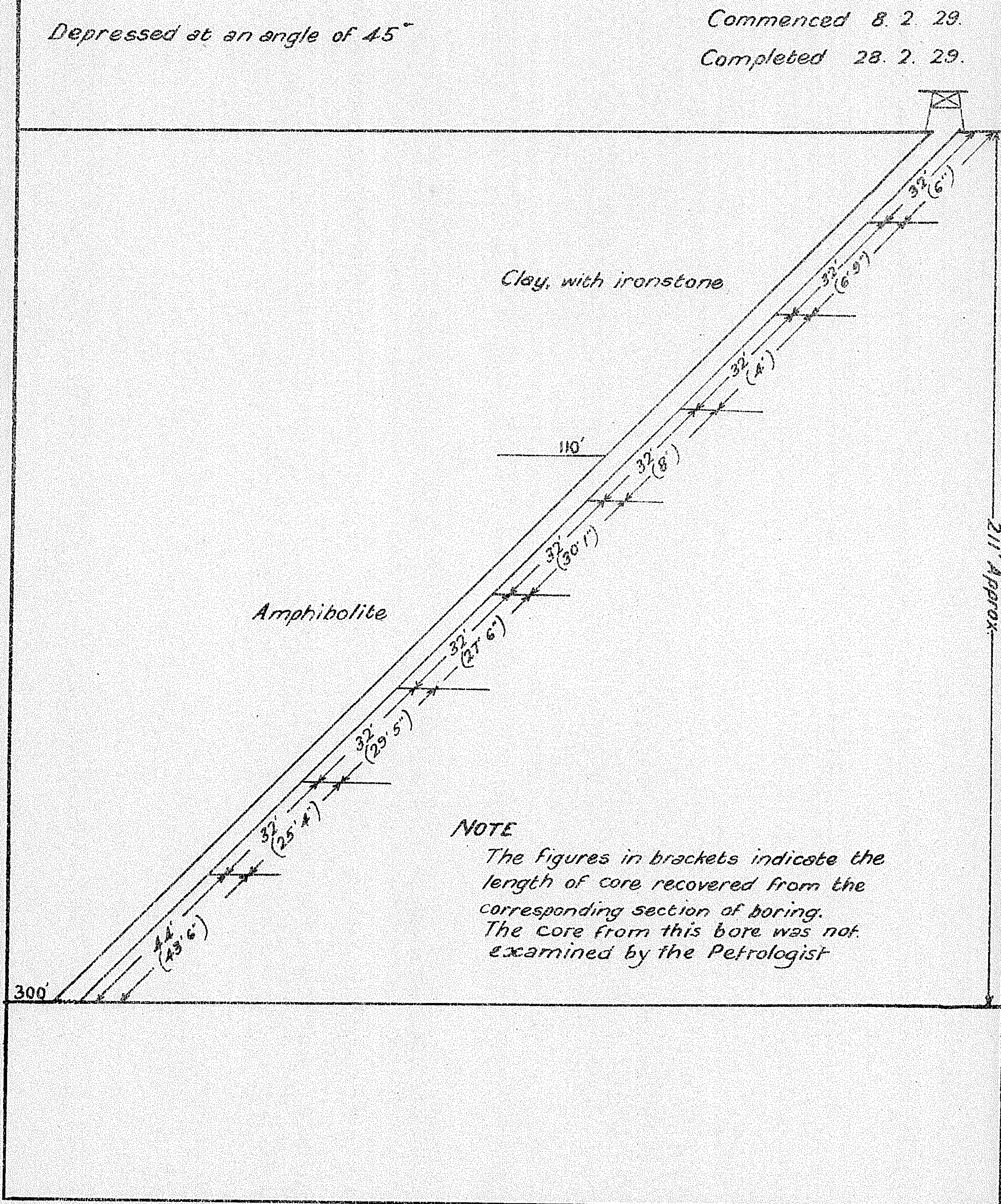
The core from this bore was not examined by the Petrologist

— Section No. 10 Bore —

— KAPANGA LEASE —

— GREENBUSHES —

— Scale :- 32 Ft. = 1 In. —



NOTE

The figures in brackets indicate the length of core recovered from the corresponding section of boring.
The core from this bore was not examined by the Petrologist

– Section Nº 11 Bore –

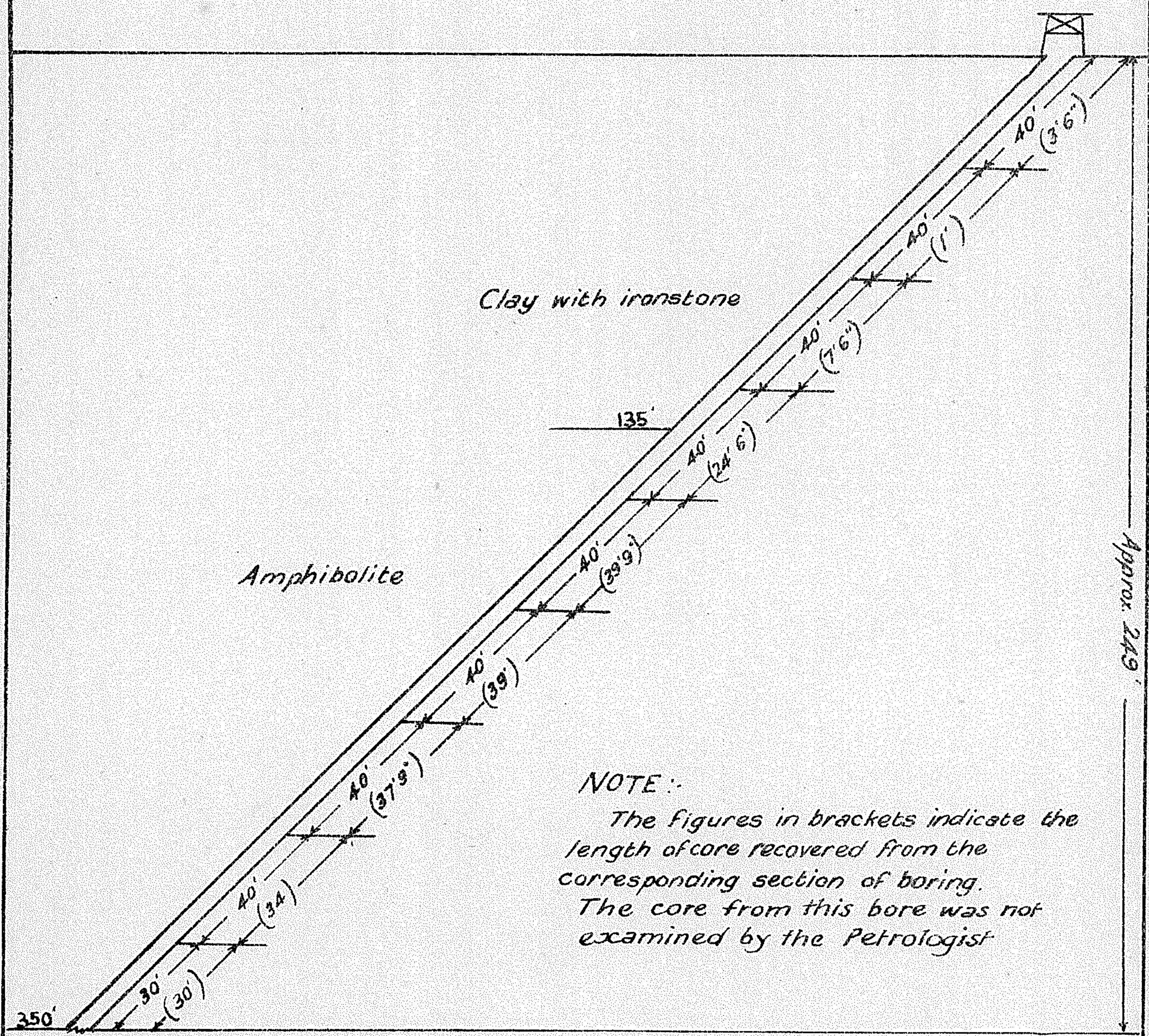
– KAPANGA LEASE –

– GREENBUSHES –

– Scale: 40 Ft. = 1 In. –

Depressed at an angle of 45°

Commenced 8. 3. 29.
Completed 27. 3. 29.



NOTE:-
The figures in brackets indicate the length of core recovered from the corresponding section of boring.
The core from this bore was not examined by the Petrologist