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THE POSSIBILITY OF OIL DISCOVERY IN QUEENSLAND.

R E P O R T

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THE POSSIBILITY OF OIL DISCOVERY IN QUEENSLAND.

I. INTRODUCTORY.

A. GENERAL.

During the three months spent in Queensland investigating local geological conditions and collecting information for the purpose of this Report, I visited the following areas, in each of which some drilling for oil has been accomplished :—

1. Beaudesert and Boonah.
2. Laguna Beach, near Tewantin.
3. Wolston, between Brisbane and Ipswich.
4. Ruthven, in the neighbourhood of Longreach.
5. The country north of the railway line between Miles and Roma, around Juandah, Orallo, and Injune.

The objects in view were—First, to obtain a general idea of the nature of the geological formations present in these areas. Second, to discover what general structural conditions exist and if these conditions are such that oil may have accumulated in favorable areas. Third, to observe personally in typical cases the nature and mode of occurrence of such manifestations of oil and gas as are known in Queensland. Finally, to consider such evidence as I was able to obtain in the light of experiences and knowledge gained on other oilfield areas in the world with the idea of coming to some conclusion as to the possibility of discovering oil or natural gas, or both, in payable quantities in Queensland; and, if so, to make what helpful suggestions I could that may facilitate and hasten such discoveries.

In the course of my work I received much assistance and information from the Minister of Mines, the Department of Mines, the Geological Survey Department, Professor H. C. Richards, Dr. H. I. Jensen, and Mr. R. E. Allen, Field Manager of the Lander Oil Company. Dr. Jensen accompanied me on my visit to the Beaudesert and Boonah districts, where his wide knowledge of the country was to my great advantage. The remaining areas were visited in the company of Mr. Lionel C. Ball, Deputy Chief Government Geologist, who is in charge of oil investigations for the Queensland Government. Mr. Ball had been over most of the ground previously, so I was able to discuss with him problems as they arose in the field, and to obtain from him valuable information on matters which he had already investigated with characteristic thoroughness, and in this way much time was saved. Finally, we owe thanks to the Commissioner for Railways, without whose assistance the investigation of areas on branch lines of railway would have entailed much trouble and delay.

B. GEOLOGICAL.

The geology of each of the areas dealt with has been worked out by members of the staff of the Geological Survey of Queensland, sometimes in more or less detail, as in the Beaudesert, Boonah, and Wolston districts, sometimes in a more general way, as in the remaining areas. Dr. Jensen, while a member of the staff of the Queensland Geological Survey, spent considerable time on the geological reconnaissance of a tract of country which embraced areas 4 and 5, embodying his results in a map and a report (unpublished) which I have not yet seen. The geological conditions, therefore, were fairly well known, and have been previously described. This Report will therefore treat of them but briefly, and will concentrate chiefly on such matters as affect the problem of oil discovery.

II. THE BEAUDESERT AND BOONAH AREAS.

A. GEOLOGICAL SEQUENCE.

Mr. C. C. Morton, of the Queensland Geological Survey, has dealt with the geology and the petroleum possibilities of this area in a very able sketch.* Briefly, the sequence exposed is as follows :—

Formation.	Description of Strata.	Thickness.
Alluvium..	Alluvial clays and water sands	100 feet
Tertiary ..	Blue and red clays, sometimes calcareous, with ostracods. Thin carbonaceous bed ..	100 feet
	Basalts	} Variable, may reach 8,000 feet
	Acid Volcanics	
	Gabbroid and doleritic intrusives	
	<i>Probable Unconformity.</i>	
Jurassic	Upper (?) Walloon Coal Measures. Fresh water series, sandstones predominating, false-bedded, sometimes massive, sometimes flaggy, more or less calcareous; calcareous and carbonaceous shales and concretionary ironstone bands with plant remains, <i>Cladophlebis australis</i> , <i>Taeniopteris spathulata</i>	} At least 2,000 feet exposed
	Coal seams	
	All very lenticular	} Approximately 4,000 feet exposed
	Lower (?) Bundamba Sandstone Series. Massive sandstones, false-bedded, varying from coarse siliceous grits, sometimes conglomeritic, to fine felspathic beds. Some thin carbonaceous shales, especially in lower beds exposed. Fossil wood preserved as siliceous casts	

Dr. Jensen would place the Bundamba Series in the Upper Triassic owing to the fact that some of the thin carbonaceous shales in the lower part of the series contain plant remains which bear an Ipswich aspect. On the other hand, the Bundamba sandstones apparently merge, without unconformity, into the overlying Walloons, so that where the base of the Walloons happens to consist of massive sandstones it is impossible to draw a line between them. There is, however, little room for controversy, and the classification is rather one of convenience than otherwise. The line of division between the Upper Triassic and the Lower Jurassic beds probably comes somewhere in the Bundamba Sandstone Series, and since it is obviously impossible to make a line of division in a group of massive and mostly barren sandstones, the Series must be included in one or other of the divisions according to the inclinations of the observer. I have, therefore, adopted the classification of the Geological Survey of Queensland.

B. STRUCTURE.

Structurally, the country around Beaudesert and Boonah may be divided into three almost equal portions, a central anticlinal area, the axis of which runs almost due north and south through Mt. Jubbera, near Overflow, and the small town of Rathdowney, with corresponding synclinal depressions on either side. Beaudesert being situated near the trough of the eastern syncline. Boonah being a little to the east of the trough of the western syncline. This anticline is sometimes called the Overflow Anticline. The folding is decidedly asymmetrical, the dips on the eastern margin of the anticline being as high as from 40° to 65°, those on the western side averaging about 10° before the beds flatten out in the lower portions of the syncline. The beds outcropping along the axis of the anticline consist of the massive sandstones of the Bundamba Series, which are badly cut up by erosion and weathering. The Walloon coal measures, sometimes concealed by alluvium, and, near Beaudesert, overlain by Tertiary deposits (lake beds?) occupy the synclines. The anticline pitches to the south, where the sedimentary strata pass under immense sheets of basalt and acid volcanic rocks, and are thus, together with any structural features present, concealed. There is evidence, however, that the folding becomes less marked in this direction, the beds either flattening or else the forces which were at work to produce the strong simple folds to the north were dissipated in the formation of a series of smaller folds, which is a very common phenomenon where a strong folding movement is dying out. It is very evident that the Walloon measures originally passed right over the axis of the anticline, and have been subsequently eroded from it, so that now they are only found in the basins on either side, although the folding movements have been so comparatively recent that the streams have been able to retain their ancient channels cutting down through the beds as fast as they were being elevated, so they now occupy gorge-like valleys which cut transversely across the axis of folding through the rough hills and peaks formed by the arching and erosion of the massive Bundamba grits. Numerous igneous dykes and sills break the

* "A Geological Reconnaissance of the Upper Logan and Albert River Watersheds, South Moreton District, with Special Reference to Petroleum Possibilities,"—Q.G.M.J., vol. XXIV., No. 278, 14th July, 1923, pp. 244-249.

continuity of the strata around Beaudesert, causing considerable zones of contact metamorphism in places. Similar conditions exist near Boonah also, although to the north of Boonah, in the vicinity of Roadvale, there is a considerable tract of country which seems to be clear of such disturbing features. In this district some subsidiary folding is observable in the Walloon Series in the western synclinal area.

C. PETROLEUM.

It is a pity that the finely developed central fold, the Overflow anticline, should be developed in such an unpromising series as the Bundamba sandstones, otherwise this structural area would have been good prospecting ground. Morton, in the paper referred to, adequately sets out good reasons against the favorable consideration of the folded area occupied by the Bundamba. A thick porous series of this character is hopeless. It is not at all certain that the Ipswich Coal Series underlies the Bundamba in this area. There is reason to suppose that it does not. In any event, the Ipswich beds have never been seriously considered as containing petroleum horizons. Nothing that has been recorded in the boring and sinking for coal has indicated the possible presence of oil, while Morton points out that in the neighbouring Logan and Albert districts the coals of Ipswich age have carbon ratios of from 63 to 72, which indicates a degree of metamorphism in these beds which is quite unfavorable to the presence of oil accumulations. Since I must refer to the question of carbon ratios frequently, a brief statement of the carbon-ratio theory is necessary at this point.

A paper by Fuller* sets forth this hypothesis, which has been developed since White† first suggested it in 1915, more concisely and clearly than I have found elsewhere. The following extract has been much quoted :—

In general, it has been found that in the oilfields throughout the world, the occurrence of 70 per cent. fixed carbon in pure coal (ash and water eliminated) establishes a dead-line as regards petroleum and natural gas, for although slight accumulations of these products may be found outside of this line, no instances of commercial deposits are known. With lower carbon ratios oil and gas may be expected, the amount and quality varying with the degree of metamorphism as expressed by the percentage of fixed carbon in coals. The comparative promises of the various zones are roughly indicated below :—

					Relative Chance of Finding Oil.
Zone of 50-55 carbon ratios	..	..	..	..	100
Zone of 55-60 carbon ratios	..	..	..	..	10
Zone of 60-65 carbon ratios	..	..	..	..	1

As a matter of fact the chances above 60 per cent. are probably even less than indicated, there being no known oilfield of importance above this ratio, although several small high gravity pools occur near the 60 per cent. line at points in the Appalachians.

While there is still some doubt as to whether this generalization holds good as universally as many American geologists believe, and investigation is still desirable in many oilfield areas outside of the United States, it has been worked out in its practical application so accurately in many of the oilfields of America that it must be accepted by all who are working towards oilfield development, even if it be accepted at present with caution. While the prospector must use the carbon-ratio hypothesis as a useful guide, he must not be led away from the consideration of all other factors, historical, structural, and physical, which may offer themselves for observation and study in the area with which he is dealing.

Apart, therefore, from the absence of any indications of the presence of petroleum in the Bundamba Series, and the underlying Ipswich formation, if it be present in this area, other conditions obtain which discourage the belief that oil might possibly be obtained by drilling on the Overflow anticline. It is necessary, therefore, to consider the areas on either side of the anticline which are occupied by Walloon strata. The only drilling for oil accomplished so far has been in the neighbourhood of Beaudesert. This was undertaken on account of the discovery of slight showings of oil in a shallow water well 85 feet deep, some 3 miles to the south of the town. On visiting this area, I found several shallow water wells, which had been put down by the local farmers, and two shallow wells—one 375 feet deep and the other 160 feet deep—which had been put down on Mr. Dunn's farm with the idea of prospecting for oil. On pumping the water from some of these wells a very thin, pale, iridescent film, of a nature which would indicate the presence of a small amount of very light oil, could be noticed on the surface of the water. Analyses of waters and sludges from the bores made by Mr. Henderson, the Government Analyst in Brisbane, and quoted by Mr. Ball,‡ who visited this area on two occasions while drilling was in progress, show very small percentages of oil to be present, varying from .0009 per cent. to .013 per cent. Mr. Henderson describes the residue as of the nature of mineral grease or wax. A little gas is reported to have been present in the 375-ft. borehole. Although the three bores put down on Dunn's farm are grouped together in the space of about 1 acre, it is worthy of remark that the

* Fuller, M. L. "Relation of Oil to Carbon-ratios of Pennsylvania Coals in North Texas."—Econ. Geol., vol. XIV., No. 7, 1919, pp. 536-542. See also "Carbon-ratios in Carboniferous Coals of Oklahoma and their Relation to Petroleum,"—Econ. Geol., vol. XV., No. 3, 1920, pp. 225-235.

† White, David. "Some Relations in Origin between Coal and Petroleum,"—Jour. Wash. Acad. Sc., vol. V., No. 6, 1915, pp. 189-212.

‡ Ball, Lionel C. Report on Oil Prospecting at Beaudesert.—Q.G.M.J., vol. XXV., No. 293, 15th Oct., 1924, pp. 362-365.

last bore, which was carried to a depth of 160 feet, encountered rather a different sequence, and met with none of these slight showings of oil at all. This suggests that there may be a concealed fault between this bore and the other two. The bores passed through an alluvial cover into Tertiary clays which are calcareous in places. The deeper bore may have penetrated into the upper beds of the underlying Walloons, but this is by no means certain. Igneous intrusions come to the surface near the road a few hundred feet away.

Summing up the facts: Very light showings of oil have been found in the beds penetrated by the shallow bores near Beaudesert. They may have originated in the thin carbonaceous layers in the Tertiary cover, but this is too insignificant in its local development to be considered a possible source for commercial supplies of oil. We must look for this in the Walloon Series.

The few analyses made of the coals present in the Walloon coal measures of this area give favorable carbon-ratio results. Morton (*loc. cit.*) gives the composition of one such coal as ascertained by the Government Analyst to be—

Moisture	..	..	..	1.9 per cent.
Volatile matter	..	..	..	33.3 per cent.
Fixed carbon	..	..	..	35.8 per cent.
Ash	..	..	..	29.0 per cent.
Total				100.00 per cent.

and states that it is in close agreement with a sample quoted earlier by Marks, a former member of the staff of the Geological Survey. The carbon-ratio works out at 51.80. The nature of the Walloon Series is not unfavorable to oil formation, while lenticular masses of both porous and impervious strata are present.

On the other hand, it must not be overlooked that the search is for oil in payable quantities, and such quantities cannot be expected in the trough of a very decided synclinal area such as that around Beaudesert where these bores are situated. It is not even a "dry" syncline. All the conditions and all the facts disclosed point to the porous beds of the synclinal area being impregnated with water. Under such conditions, small showings of oil are exceedingly common: in fact, it should be noted that small showings of oil and gas are very widely distributed in the earth's crust in strata of the nature of the Walloon Series. There is little or no difficulty in obtaining evidences of oil of this character; the difficulties arise when we endeavour to locate accumulations of oil in such quantities that they will pay to work. The salinity of the waters coming to the surface near the edges of the Walloon basin has been regarded as, perhaps, a favorable sign. Mr. Ball remarks that there is no marked salinity in the waters obtained from the wells around Dunn's farm, and quotes analyses to support his statement. In any case, the presence of salt water in beds of this character does not necessarily connote the presence of accumulations of oil. Oil accumulations are usually associated with salt water in the same strata, but the converse is not necessarily true. Salt water is not always accompanied by the presence of oil. Many occurrences known to me not only in Australia but in Europe (e.g., some of the occurrences of brine in England), Asia (especially in India and Arabia), and America (for example in the Tertiary beds in Eastern Texas), are definitely not associated with supplies of petroleum. As an indication of petroleum, the presence of salt water in strata should not be relied upon too much. Moreover, where oil is present it usually rests upon the body of salt water that is present also, so that if the salt water is able to make its way to the surface in places it usually carries some of the oil with it, and is therefore frequently associated with oil seepages, or oil is associated with seepages of salt water, as in Papua, Trinidad, Texas, and Burma. Now, conditions are such in the area under investigation that there are plenty of opportunities for such seepages to occur either from the edges of the basin where the strata are exposed by erosion or where igneous dykes have pierced and fractured the strata, or where faulting or jointing occur. No such seepages have been noted. If the oil were of an asphaltic character such seepages could not be overlooked. Even if oil with a paraffin base were present, which is more likely to occur in this area, careful search would reveal the presence of seepages or impregnations in outcropping porous beds. I look upon the absence of these positive signs, where conditions are such as exist in the Beaudesert area, as being decisively against the presence of oil in anything like commercial quantities. I am in full agreement with Mr. Morton when he states that oil may have been present in the Walloon Series in this district in bygone ages, but that the enormous amount of erosion, which must have taken place in removing this series completely from the crest of the Overflow anticline, would allow any large quantities of oil, which may formerly have been present, to escape and be completely lost. Mr. Ball suggests that oil may have found its way into the boreholes from the drilling plant. This is very possible, though in this case I am not sure that the oil present is of this nature. I am of the opinion that the oil may be actually in process of slow formation from the carbonaceous matter present in the

beds, possibly from that proved by drilling to exist in the Tertiary clays, but I can find no grounds whatever upon which to base any expectation of its existence in sufficient quantities to warrant the expenditure of money in drilling for it.

A similar line of argument holds good for the Walloon country around Boonah, notwithstanding the fact that the geological conditions are somewhat more favorable over an area in the vicinity of Roadvale. A little N. and W. of Roadvale station Dr. Jensen pointed out to me evidences of subsidiary folding in the synclinal area occupied by the Walloon Series. Anticlinal folding exists, the closure of which may eventually be defined by mapping in sufficient detail; but, again, there is a complete absence of the presence of petroleum in places where I would expect such evidences. There are brine springs escaping from the lower members of the Walloon Series exposed near the road running from Wyaralong to Boonah, but the escaping salt water carries with it no evidences of the presence of petroleum. The beds are well exposed here in places; igneous intrusions are numerous and often very considerable around the area, and yet they pierce the Walloon strata without carrying with them or allowing to escape any signs of petroleum. Apart from the structure the evidences are entirely negative, so that taking everything into consideration, the chances are considerably more than 100 to 1 against the finding of oil in profitable amounts, even should detailed geological work prove satisfactory closures to the structures that exist.

III. LAGUNA BEACH, NEAR TEWANTIN.

A. GEOLOGY.

The 30-mile stretch of coastal sands forming a shallow curve between Noosa Head, at Tewantin, and the lighthouse-capped headland at Double Island Point, almost due N., is called Laguna Beach. Noosa Head owes its existence to dykes of andesite and a small boss of granodiorite, which are intrusive into grits which have been metamorphosed and hardened to an extent which enables them to offer good resistance to the action of the pounding sea. Double Island Point is a bold headland formed of tough andesitic lavas thrust well out from the main line of the coast, and looking very much like an island which the land has captured and with an outstretched arm is holding from the sea. This is literally true, for examination makes it very clear that Double Island was really an island not so very long ago, and has only become a peninsula within recent times. Between these two points is a flat stretch of, what I should call, dead sand dunes, a series of ridges formed entirely of loosely consolidated sands. They extend from the andesitic intrusion of Halls Hill, a few miles to the N.E. of Tewantin, northwards to the southern margins of Wide Bay, and are approximately bounded inland to the W. by the N. and S. line followed by the Noosa River and Tin Can Inlet. The dunes appear to increase in height and development as we proceed N. South of Wide Bay the old dune formations extend inland for, probably, 10 miles,

1. Laguna Beach and Ridges of Old Sand Dune Area from Double Island Point Lighthouse.

Photo., A. W.

and attain to elevations which exceed 800 feet above sea level. These old sand dunes have probably, some definite system of distribution and alignment, a knowledge of which would probably throw much light upon their origin and history. The existing topographical maps are not sufficiently detailed to render much assistance. Looked at from the beach they appear to form

ridges running parallel with the coast. As a matter of fact there are one or two ridges, of later age than those further inland, which run parallel to the existing coast-line for some distance. These are best seen some 10 miles S. of Double Island Point. The inner ridge is usually higher than the one nearer the shore, and along the shore itself new and living ridges are struggling to raise themselves in places. These coastal ridges disappear towards both extremities of the beach. A study of what is happening on the beach to-day may help to explain the marginal ridges. The sea is undercutting the shoreward faces of the dunes, forming steep cliffs, from which large patches of soft sand are constantly slipping. This material is being redistributed. It banks up across the mouths of gullies, which run out on the coast, and tends to form new ridges on the beach in front of the older dunes.

Viewed from above, as from the summit of the lighthouse tower at Double Island Point, the old dunes can be seen forming parallel ridges which run almost E. and W., or approximately at right angles to the coast and parallel to the southern margin of Wide Bay. Passing over the coastal dunes some 10 miles to the S. we find again that the ridges tend to run inland rather than to follow the coast. Some nice little problems in recent geology and physical geography are waiting to be worked out in this region.

The result of the distribution of the dune ridges described above is that the gullies between the inland dunes, which are the natural lines of drainage, are frequently blocked by transverse barriers, formed by the coastal dunes, and form warm, damp, swampy depressions in which grow large trees and palms, together with a dense undergrowth of canes and creepers, the whole resembling the tropical jungles of the coastal swamp areas of New Guinea. The barriers being formed of loose porous sands, the drainage waters soak through to the coast and emerge between or just above tide levels as bubbling springs in the beach sands or as soaks of fresh water which may cover large areas. These soaks frequently carry with them a large percentage of iron oxides in partial solution, which form characteristic greasy, red, iridescent films and deposits which have frequently been mistaken for seepages of petroleum.

2. Gully showing section of Old Dune Deposits near Boring Sites, Laguna Beach.

Photo., L. C. Ball.

The whole of this dune area is covered with vegetation; grasses near the coast with *Casuarina* and *Banksia*, patches of mangrove in swampy areas, larger eucalypts and other timbers, often fine, well-formed trees, inland. The history of the area seems to have been as follows:—For some reason or other, possibly a change in the elevation of this part of the coast, the causes leading to the formation of the sand dunes became weakened. Grasses and other dune plants took hold in the loose sand and tended to form both humus and a protecting cover. As humus developed, *Casuarina*, *Banksia*, and other small scrub obtained a footing, iron began to concentrate around the plant roots, and some cementation of the sand grains resulted. Thus the protection afforded by the cover of vegetation became more and more permanent and effective, until the dunes became fixed and little affected by wind and rain, and forest trees from the landward side gradually encroached upon the area. As sand dunes they were then dead, and had become more or less permanent deposits. I have described these conditions in some detail because they have a bearing upon our problem.

Examining the cliff sections along the coast we find that they consist almost entirely of fine-grained loose sands, sometimes partly cemented with iron which, in various stages of hydration, shows itself in stains of brown, pinks, and reds of various shades, so that they are known locally as the "Painted Sands." Where the forest and scrubs have taken hold in the surface beds the sands contain humus and organic matter, and the colour becomes a dark sooty brown. Mr. Ball thinks that this colouring is due to forest fires. Such fires would, of course, augment the supply of carbonaceous material, charcoal, sooty matter, and ash in the covering beds, but the ordinary phenomena of growth and decay and the wear and tear of the life of the scrubs and forests would bring about the effects noted. Traversing the area from east to west, we found that the surface sands below the trees show universally this dark and dirty colour due to the presence of humus and carbonaceous matter. Where such accumulations have been in excess of the average, and have been protected, as in water-logged depressions, dirt beds are formed which may be covered by fresh encroachments of sand in any revival of activity in dune formation sometimes accompanying oscillations in the land levels. Such beds are to be seen in the sand-dune areas of South Australia, and in the dune areas around the estuaries of the Dee and the Mersey in England. The sands show rough, irregular stratification typical of such deposits. Some of the beds appear to be folded into low anticlines and synclines when traced along the beach cliffs for some distance, but I consider this to be due entirely to the shifting character of dune formations. Both hills and valleys "walk," so to speak, in the direction of the prevailing winds when the dunes are "living" things. Dunes are really wind ripples on a large scale, and cliff sections show stages of growth and rest, old troughs and crests. The rhythmic effects of wind action is shown in these cliff sections just as it is on a smaller scale in a piece of ripple-marked sandstone affected by the action of water the wave motion of which produces similar effects.

Just south of the andesite mass of Double Island Point the coastal cliffs are formed of a different type of deposit. More or less well-stratified beds of rather well-consolidated calcareous grits lie against the lavas and apparently dip at a low angle to the south. The beds consist of sand grains and broken shell fragments. They are typical beach deposits—a mixture of wind-blown sand and comminuted shell fragments such as accumulate under the action of wave and wind on reef-fringed shores. We found nothing to indicate the age of these beds. They appear to have been elevated somewhat by a rise of the Double Island Point mass, and to have formed the beaches around that mass when it was at a lower level with regard to the sea. Such material was probably carried by tidal scour from neighbouring coral shoal areas and deposited against the obstructing mass formed by the igneous rocks, such accumulations in a shallow and rising channel eventually linking the old islands with the sand dunes of the coast. In the absence of any evidence to the contrary, I regard these beds as contemporaneous with the old sand-dune formations.

The boreholes have proved that the soft, fine, consolidated sands of the old dune formation exist to a depth of approximately 200 feet below sea level. This proves that this part of the coast-line has been depressed to this extent in Post-Tertiary times. While such a depression of the coast-line might cause some sagging of the beds between Double Island Point and Noosa Head, that could only occur if the igneous masses at those points had not sunk to the same extent as the rest of the coastal fringe. There is evidence that subsidence has affected the whole of the coast of Queensland in Post-Tertiary times. The movement is really part of extremely slow oscillations, evidence of which is often to be found on continental margins. At present we know too little about the areas affected to say very definitely whether the movement is uniform or whether it varies according to the nature and age of the rocks which are the fundamental beds of any particular part of the coast. In any case, I should not expect to find that such movements were accompanied by such lateral pressures as would cause incipient folding in the soft surface strata of Post-Tertiary age such as those with which we are dealing.

A typical cliff section taken near the edge of the beach near the southern group of boreholes reveals the presence of a bed which must be described. The section is—

White and red ferruginous sands, false-bedded, with dirt beds, i.e.,	
sand and humus	200 feet
Oil shale, containing lignitic matter and little altered wood	3 feet
Fine sticky clay	2 inches
Fine white soft sands	Several feet exposed

An excellent description of the oil shale has been given by Mr. L. C. Ball, Deputy Chief Government Geologist, who has visited this area on several occasions. Mr. Ball has not only made original contributions to the geology of the area, but has carefully recorded the results obtained by drilling, and stated his conclusions as to the prospects of finding oil. The following extract is from one of Mr. Ball's reports :—*

A lenticular bed of oil shale is exposed at the base of the cliffs near the earlier boreholes, and another smaller lens shows in the face of the cliff, 50 feet above high-water mark, about 6 miles down the beach towards Tewantin; but neither has been shown to extend for more than a few chains laterally. The latter is 18 inches to 2 feet thick, and consists of pale-buff to dark-brown hardened silt with coaly streaks. The former has been proved to a depth of 5 feet, though only the upper part now is uncovered. The material exposed has a dark-brown to black fine-grained clayey matrix, it is soft and has a greasy streak, and on exposure to the atmosphere bleaches slightly while shrinking and cracking in all directions owing to dehydration. A sample collected by me in December last contained 8 per cent. bitumen, and on destructive distillation yielded 19 gallons of dark-brown liquid per ton, but it was not certified that the shale contained any free oil. The report of the Government Analyst is appended :—

Proximate analysis—

Moisture, 7.6 per cent.; volatile matter, 40.3 per cent.; fixed carbon, 17.3 per cent.; and ash, 34.8 per cent.

Extraction by solvents—

Bitumen, soluble in chloroform, 8.2 per cent., of which 4.7 per cent. is soluble in petrol.

Destructive distillation—

A dark-brown liquid, equivalent to 19 gall. per ton. Nitrogen equivalent to 0.38 per cent. of ammonia (F.E.C.).

Several fragments of rotten, but not carbonized, wood were found embedded in the oil shale at the 5-ft. hole; and concerning specimens collected by me, Mr. W. D. Francis, Assistant Botanist at the Botanic Museum, Brisbane, writes :—

From the extremely eccentric structure of the specimen when examined in cross section it is evidently a part of a buttressed root. Some microscopic examinations of the material were made, and I have been able to identify it as part of the buttressed root of *Ceriops Candolleana*. This is a mangrove which is found on muddy shores of the sea in Queensland and tropical Asia. The buttresses are seen in this species when it is only about 4 feet in height, and they form a conspicuous feature in the facies of the tree.

Mr. Ball considers that the oil shales represent muds deposited in estuarine waters. The beds are not only lenticular, but the lenses are distinctly concavo-convex, the concave side being above, i.e., they are saucer-like in shape. This confirms Mr. Ball's opinion. They were probably deposited in the swampy estuary of a gully running between transverse sand ridges to the sea, which subsequently became choked and filled by the movement of the sand. Alternatively, they may be found, when examined in more detail, to represent one of the old swampy areas which still exist behind the sand ridges fringing the coast, that has been brought near to the shore line by depression, filled in by the coastal dune sand, and subsequently cut through and exposed by the action of the sea. I am told that good samples of this oil shale have yielded up to 35 gallons of oil to the ton on distillation, which must be regarded as a good result. Although the bed has suffered comparatively little compression and alteration, and still holds a very high percentage of moisture, it shows many of the characteristics of a true oil shale which is remarkable considering its comparatively recent origin. It demonstrates beautifully the mode of origin of oil shales and is a type of deposit which has not often been noted in Recent or Post-Tertiary sediments.

All around this area of sand dunes and Post-Tertiary deposits on the landward side Ball has shown that the beds outcropping at the surface consist of sandstones, grits, conglomerates, and shales of Triassic age, a northern development of the Ipswich formation. The sandstones are sometimes argillaceous, and the shales carbonaceous, while seams of coal have also been found in them. These beds are penetrated by igneous intrusions in places, and have undergone considerable metamorphism, so that they are often considerably indurated. The beds have been considerably disturbed by folding, and dips up to 30° have been noted. Similar strata have been proved to underlie the Post-Tertiary sands in the deeper bores along the beach at a depth of about 200 feet. These also contain thin seams of coal between the depths of 400 feet and 657 feet. Fragments of fossil plants obtained by Mr. Ball from a shale bed at 269 feet in borehole No. 5 have

* Ball, Lionel C. "Report on Oil Prospecting near Tewantin,"—Q.G.M.J., vol. XXV., No. 293, 15th Oct., 1924, pp. 355-356.

been determined as *Thinnfeldia*, which is taken to indicate a Triassic horizon. Other fragments from a depth of 510 feet in borehole 1 N also indicate beds of Mesozoic age, but are not sufficiently well preserved to determine the horizon.

Looking at the area in a general way, the Post-Tertiary deposits appear to have accumulated in a basin-like tract of country formed by a depression in the older sedimentary rocks of the Ipswich formation.

B. PETROLEUM.

Mr. Ball* gives the logs of six boreholes which have been sunk in the vicinity of the beach by two prospecting companies. Five are grouped about 21 miles north of Tewantin, the sixth being about 25 miles north. They vary in depth from 37 feet to 678 feet. For the purpose of this Report, the log of the sixth bore will be quoted, in a modified form from Mr. Ball's reports, since it penetrated to a greater depth than any of the others, and, therefore, gives a better idea of the underlying strata. Mr. Ball is himself quoting from the field log as kept by the field manager, adding a few interpolations of his own:—

Borehole No. 1 N. (of the Queensland Coastal Oil Concessions, North, N.L.)—

To 165 feet	..	Sand.							
At 165 feet	..	Clay and sand with some wood.							
To 183 feet	..	Red sandstone with clay and pink shale.							
At 183 feet	..	Waterworn pebbles.							
To 197 feet	..	Hard rough sand with gravelly quartz (non-bituminous), a little water showing oily substance at 185 feet.							
To 211 feet	..	Soft clay, sandstone, and shale. Oil (greasy stuff) showing freely on water.							
To 239½ feet	..	Very hard sandstone with shale bands. No sign of oil.							
To 249 feet	..	Hard sandstone with some seams of clay. Oil and black scums on water.							
To 263 feet	..	Dark non-bituminous shales.† Analysis bitumen 0.007 per cent.							
At 265 feet	..	Soft sandstone. Brown scum showed only in spots.							
To 300 feet	..	Dark-blue and grey shales, bituminous in places. Some thin coal streaks.							
To 305 feet	..	Coarse, hard sandstone and shows of oil and gas.‡ Plenty of oil and gas bubbles.							
To 383 feet	..	Hard brown, black, and grey shales—darker shales sometimes bituminous. Grit band with clean bright coal attached at 345 feet.							
To 398 feet	..	Very hard sandstone. Some oil showing in places; little oil showing except in last 4 feet.							
To 409 feet	..	Hard grey shale and sandstone. At 403 feet sample of sludge (Smith's), 0.015 per cent. oil.							
To 496 feet	..	Very hard grey sandstones and grits. Some thin coal seams. Oil showing. At 413½ feet scum on bailings shows oil.							
		Sample from top water	..	..	..	..	..	0.002 per cent. oil	
		Sample from bottom	..	..	..	..	..	0.012 per cent. oil	
		At 414 feet—Sample of sludge skimmings	..	..	..	..	..	0.008 per cent. oil	
		At 415 feet—Sample of sludge skimmings	..	..	..	..	..	0.037 per cent. oil	
		At 415½ feet—							
		Taken before closing down at night—							
		Top water scum	..	..	..	..	..	0.011 per cent. oil	
		Bottom	..	..	..	..	..	0.002 per cent. oil	
		Samples taken after closing down at night—							
		Top water scum	..	..	..	..	..	0.011 per cent. oil	
		Bottom	..	..	..	..	..	0.006 per cent. oil	
		At 428 feet—Smith's sample	..	..	..	..	..	0.073 per cent. oil	
		At 447 feet—Top water scum	..	..	..	..	..	0.006 per cent. oil	
		At 448 feet—Top water scum	..	..	..	..	..	0.136 per cent. oil	
		At 448½ feet—Top water scum	..	..	..	..	..	0.101 per cent. oil	
		At 452 feet—Top water scum	..	..	..	..	..	0.167 per cent. oil	
		At 497 feet—Mr. Campbell's sample, black coaly scum	..	..	..	..	..	0.21 per cent. oil	
To 517 ft. 3 in...	..	Hard brown shales with thin coal partings. Heavy oil showing at top, little oil below.							
To 523 ft. 6 in...	..	Hard grey sandstone with thin coal seam. Little oil.							
To 537 feet	..	Hard brown shale and sandstone with thin coal seams. Little oil.							
To 560 feet	..	Hard brown and grey shales. With little oil.							
To 581 feet	..	Hard grey sandstones and shales with thin coal partings. No oil.							
To 590 feet	..	Brown shale. Oil showing freely.							
To 605 feet	..	Hard sandstone. No oil above. Waxy scum at base.							
To 632 feet	..	Hard black, brown, and grey shales. Little or no oil. At 608 feet shale bituminous.							
To 641 feet	..	Hard grey sandstone. No oil.							
To 653 feet	..	Brown shale and clayey sandstone with thin coal partings. No oil.							
To 678 feet	..	Hard grey sandstones with a little coal. Some oil showing at base.							

Some of the "oil showings" noted in the boreholes were very light indeed, small specks and streaks, which had the iridescent appearance of oil, appearing on the surface of samples of sludge and water and disappearing again after standing for a couple of hours. Mr. Ball noted such specks and streaks in samples in which the Government Analyst failed to detect any free

* Loc. cit., pp. 358-364.

† The Government Analyst reported that Mr. Ball's sample, skimmed from sludge, did not contain any free oil or petroleum residue, but that the total chloroform extract (bitumen) was 0.007 per cent. (of which 0.006 per cent. was petroleum and 0.001 per cent. asphaltene) derived from a small proportion of finely divided coal present.

‡ The clayey sludge showed a thin dark film which was stated to flash when touched by a flame. Careful experimentation proved that there is no flash, but that the sudden formation of a clear space about the point of impact is due to surface tension. On close inspection, minute iridescent spots and streaks of oil, quite possibly from the tools, were distinguishable.

oil whatever. It is so easy for a little oil to get into the boring from drilling line, casing joints, drilling tools, &c., that such small showings must be regarded with suspicion, especially where the drilling is in the comparatively loose barren and water-logged sands of the Post-Tertiary deposits. Lower down in the bores where carbonaceous matter and thin coal seams are encountered it is possible that very small amounts of oil are present in the strata, and some of the showings certainly suggest this. For example: Mr. Ball states that a sample sent in by Mr. Campbell was found by the Government Analyst to contain 2.3 per cent. of free oil, pale-yellow in colour, and having the consistency of mineral grease at 20°C. This suggests vaseline-like derivations from the coaly matter present such as is sometimes found near where such beds have been intruded by igneous rocks. While the Mesozoic strata have been intruded in the neighbourhood of the bore sites, the nearest observed intrusion is at least 10 miles distant, which is too far away to produce such direct results; on the other hand, areas of intrusion, concealed under the recent sandy covering, may occur in much closer proximity to the bore sites. Analyses show that the thin coaly seams present have undergone considerable metamorphism. The coaly scum from 497 feet, which gave 0.21 per cent. of free oil (see log quoted above), was obtained not far below the sample which gave 2.3 per cent. free oil. Both oils had the consistency of mineral grease at 20°C. The Government Analyst separated the coaly particles and air dried them before submitting them to analysis. They showed a fixed carbon-ratio of 80. Other samples of coal from 673 feet and 677 feet respectively gave carbon-ratios of 70 and 64.6 respectively, the average being 71.5, which is very high, and well beyond the limit of metamorphism for possible supplies of oil in commercial quantities. The carbon-ratio theory is only intended to apply to clean, bright, unweathered coals. Any attempt to use carbonaceous shales and dirty or weathered coals can only result in percentages which are very misleading. The percentage of ash is normally much higher in carbonaceous shales than in coals, so it is obvious that the figures given by Fuller cannot possibly apply to the case of shales. Moreover, as Mr. F. E. Connah, one of the Government Analyst's staff, points out to Mr. Ball,* the figures given for volatile matter in the analyses made of shales and dirty coals may include water of combination from the inorganic ground mass present, which again would vitiate results. Mr. Ball* very rightly draws attention to this with regard to analyses of coals obtained from similar beds in an old colliery at Weyba, near Tewantin, and at a depth of 345 feet in borehole I N, which give carbon-ratios of 48 and 46 respectively. Both results are obviously quite contradictory when compared with those obtained from clean samples as quoted above, which are in fair agreement when the nature of the materials submitted to analysis is taken into consideration. In any case they are too low to be of any value.

In conclusion, I must state that I do not consider that the presence of such small quantities of oil in these beds is of value in indicating the existence of commercial supplies of oil. Boring for oil in such circumstances is rank wild-catting. Now, wild-catting has played an important part in oilfield development, especially in known oil-producing regions and where structural features have been taken into account in the location of wells. Most of the successful wild-cat wells in Texas, Oklahoma, Arkansas, and Louisiana have been well situated on geologically located structures. Although oil-bearing strata have not been previously proved to underlie such structures, the general knowledge obtained from a geological study of the surrounding regions has shown that such oil-bearing strata may or should exist; on the other hand, not all wild-cat wells so located are successful, and many fine structures have been drilled deeply into water sands.

In this Laguna Beach district such structures as may exist in the Mesozoic beds, which have given the best evidences of oil, are concealed under a surface cover of recent sandy deposits so that they can neither be located nor studied at the surface. On general evidence the area is probably one of depression. While it is not my wish to discourage prospectors, I would suggest that there are, in Queensland, areas which are more worthy of attention. Long experience in oilfield practice has made it quite clear that no successful oil-producing company will drill on any area unless and until the geological structure is clearly defined and proved as nearly as possible to be favorable. Once again I should like to point out that the object of the search is not for small showings of oil—the so-called encouraging signs—but for commercial supplies, something that can be worked profitably not only for the prospecting company but for the State and for the Commonwealth of Australia itself. It is therefore of the utmost importance that attention should be directed towards and effort concentrated upon such areas as may exist where suitable types of sedimentary deposits have been laid down under suitable conditions; where subsequent folding of these deposits has developed in them suitable structures beneath which oil can have and may have accumulated; where igneous intrusives and other agencies of metamorphism have not so changed the nature of the original sediments as to give us coal seams with unduly high ratios of fixed carbon, and where all these things can, in the first instance, be studied directly at the surface and not inferred or guessed at. If such concentration of attention and effort should eventually

* Loc. cit. p. 357.

result in the discovery of a profitable oil-field we shall soon find out sufficient with regard to the conditions which exist underground in that field as to throw light upon many areas now partly cloaked and hidden under surface coverings such as exist to the north of Tewantin, and wild-catting can be directed upon more or less scientific lines.

Map showing position of Laguna Beach Boreholes, with Geologic and Physiographic Control, and with additions by Dr. Wade. Based on Mr. Lionel C. Ball's Sketch Map.

IV. WOLSTON.

A. GEOLOGY.

About 13 miles to the S.S.W. of Brisbane a comparatively small outlier of Tertiary sands and clays forms the capping of a hill some 90 feet above sea level immediately to the eastward of Wolston Station, on the Brisbane-Ipswich railway line. Pale-yellow sandy clays or shales, in flat lying beds, under a cover of loose sand, are exposed, and these beds contain many plant remains in places—casts of leaves resembling those of present day eucalypts are numerous, and we were fortunate in finding the fruit of some coniferous tree also. Although such forms are abundant in these beds no free carbonaceous matter was observable. What part of the Tertiary period these beds represent is at present unknown, but they are probably very late Tertiary deposits. To the westward of the railway line the Darra Cement Company has opened a quarry in a thick deposit of fine purple shales which are sometimes carbonaceous. The tram-line to the quarry runs through a cutting, the quarry opening into a kind of amphitheatre surrounded by walls of shale at the south end of the cutting. The cutting exposes about 12 feet of coarse, argillaceous, and rather soft sandstones overlain by a few feet of dark, weathered shales, which are on the same horizon as those quarried, though here they form the surface. The sandstones in the cutting are practically horizontal, though the line of junction between them and the overlying shales is very irregular, being in the form of crests and troughs, which look at first like a series of small symmetrical folds. On examining the junction more closely I believe that the irregularities observed are due to erosion, and that the shales here rest upon the eroded surface of the sandstones, though the unconformity may be only local. At the quarry end of the cutting the sandstones disappear abruptly, and the shales dip off sharply to the S.E. This is due to a fault which crosses the cutting at this point throwing down the beds to the S.E. In the quarry 70 feet of shales are being worked, and no sandstones are exposed. These shales pass under the sandy shales of Tertiary age which form the crest of the hill, and lie in horizontal beds so that a distinct unconformity is present between the shales of the quarry and the Tertiary shales above. A bore

has been sunk for oil on the top of the ridge, rather more than $\frac{1}{2}$ mile to the E. of the station. The bore is about 85 feet above sea level. The station is 47 feet above sea level, while the top of the shales in the quarry is probably somewhat higher than this. Thus the thickness of the Tertiary beds present in the borehole is probably less than 38 feet unless something takes place between these points which is not observable at the surface.

The oil bore has been sunk to a depth of 866 feet. Mr. E. C. Saint Smith, of the Geological Survey of Queensland, who visited, examined, and reported* on this area during drilling operations, classifies the strata passed through into—

Tertiary—Sandy clays	..	..	..	..	81 feet
Mesozoic (Triassic)	{	Bundamba.—Clay shales and sandstone, with basal conglomerate	..	..	246 feet
		Ipswich.—Clays, sandstones, and carbonaceous beds	..	..	To bottom of bore

Mr. Saint Smith suspects that the clays included in the Tertiary, below 29 feet, may belong to the Bundamba, and this is confirmed by the above reasoning from field evidence. Thus the thickness should be—

Tertiary strata	..	..	..	29 feet
Bundamba	..	..	..	298 feet.

Below these formations lies an old schistose series which is considered to be of Lower Palaeozoic age. These beds outcrop at the surface about 2 miles to the west of the bore, and have been proved in a boring for coal about 2 miles to the N.E. at a depth of less than 1,000 feet, so that it seems likely that they lie not very far below the bottom of the present borehole.

B. PETROLEUM.

The site for the borehole was selected by means of the divining rod, the diviner being of opinion that large quantities of oil would be obtained in the Tertiary beds. The results obtained by drilling rather upset this conclusion, for it is obviously impossible to obtain oil in commercial quantities from a thin cover which forms only the capping of a ridge. Even if these beds did originally contain oil, it could not be retained in such circumstances. However, this is got over by considering the underlying members of the Mesozoic system to be of Tertiary age and by naming them according to the various subdivisions of the Tertiary period, the limits of these subdivisions and their names still being chosen by the divining rod.

3. The Bore at Wolston.

Photo., A. W.

While there is no question whatever concerning the sincerity of the gentleman in question, the methods adopted are not those by which oilfields are likely to be discovered in Queensland, and the subdivisions of the strata must still depend upon the evidences supplied by the beds themselves, primarily upon fossils, and secondly upon correlations of the nature and sequence of strata as between one locality and another. Thus a geologist working on the strata exposed in the Ipswich coalfield should be able to recognize the Ipswich series if he should find it in an exposure some miles away. It will differ considerably in very many respects from Tertiary strata, and no good geologist would mistake one for the other. The structure of the area has never been

* Saint Smith, E. C. "Boring for Oil at Wolston."—Q.G.M.J., vol. XXIV., No. 273, 13th February, 1923, pp. 56-60

worked out in detail, though from a brief inspection it may be not altogether unfavorable, some evidence of folding accompanied by faulting being observable in the underlying Mesozoic beds. Some slight evidence of oil and gas, though not seen by myself, were reported by the drillers from the carbonaceous beds passed through, and these are confirmed with caution by Mr. Saint Smith. Some of the oil may have percolated into the hole from the drilling plant. For some time power was obtained from a motor tractor which is still standing near the borehole, the fuel being Texas fuel kerosene. I have proved conclusively, in more than one instance in working in oilfields, that oil which inevitably gets spilled and scattered around on the surface in such circumstances, and especially where the underlying beds are of a porous nature, will be carried to considerable distances both laterally and below the surface by percolating water. It would be surprising if some of this oil were not carried along to the walls of the borehole and, trickling down outside the casing, make its appearance in the sludge at the bottom. It would be interesting to discover, if possible, whether the percentage of oil noted in some of these borings increased after heavy rains, some time being allowed for migration to take place. However, there is no reason to suppose that some of these showings are not due to the presence of small quantities of oil associated with carbonaceous strata. The carbon-ratios of the coals present in these beds in the neighbouring Ipswich coalfield average around 70, which is too high for the expectation of commercial supplies of oil. Moreover, this series has been well explored by borings and shafts for coal, and these have revealed no evidence of the existence of oil in the strata. Oil finding is not an easy business. Much time and care must be spent on the careful study of strata and structural conditions before a site for a hole is selected. I do not think that oil will be found in Queensland by picking a site more or less at haphazard and boring upon it. Better sites can be picked than that at Wolston, which, in my opinion, is not so located as to be likely to prove successful.

While examining the shales in the Cement Company's quarry it occurred to me that they might yield some oil on distillation. I suggested to the manager that they should be tested. Similar shales have proved on examination to be quite good oil shales.

V. THE COUNTRY NORTH OF THE RAILWAY LINE BETWEEN MILES AND ROMA.

A. STRATIGRAPHICAL GEOLOGY.

In dealing with this section of Queensland, we can include also the area between Longreach and Isisford, in which the Ruthven bore is situated, since it is underlain by the Walloon strata, which constitute the most promising ground so far as oil prospects are concerned. In a general way the geology of this region is fairly simple. West of the Bunya Mountains, which run in a northerly direction a few miles to the E. of Dalby, the Walloon series outcrop over a strip of country about 50 miles in width, striking slightly N. of W. In the neighbourhood of Mitchell the outcrop swings around and takes on a more northerly direction, passing to the eastward of Blackall and Tambo, and crossing the Central Railway of Queensland near Jericho. The southern edge of the Walloons runs almost parallel with the Western Railway from Miles to Mitchell, a few miles to the N. of the line. The beds dip gently in southerly or south-westerly directions, and are overlain to the S. and W., apparently conformably, by the Cretaceous Marine series, above which the Cretaceous-Tertiary lies with marked discordancy of junction. Below the Walloon series lies the Bundamba sandstones, the basal conglomerate of which again appears to rest conformably upon the Triassic coal measures of the Ipswich series. A basal conglomerate, however, is a suspicious feature. In comparatively flat lying strata an unconformity may be present, though hard to distinguish. The Bundamba sandstone series constitutes another belt of outcrops which runs round the inner side of the reentrant angle formed by the Walloons. The only geological series with which we need to interest ourselves is the Walloon series, for it is from this series that the best evidences of the existence of oil and gas have been obtained in Queensland. (See map.) Dr. Jensen spent eighteen months doing reconnaissance work in this area when on the staff of the Queensland Geological Survey, and prepared a report and geological maps (unpublished). At the time of writing I have not seen the report, but some notes have been published independently. He estimates the thickness of the Walloon series north of Roma at 5,000 feet, and gives the following subdivisions of the strata* :—

Walloon Series ..	{	Upper ..	Shales and sandstones with minor inferior coal seams. Felspathic shales and carbonaceous beds interlaminated.—Orallo coal measures.
		Middle ..	Sandstone.
			Calcareous sandstone.
			Thick sandstone.
		Lower ..	Highly calcareous fresh water formation consisting of limestones, shales, calcareous sandstones, coals, and kerosene shales.
		Basal ..	Felspathic sandstone.

* Jensen, Dr. H. I. "Some Notes on the Perno-Carboniferous and Overlying Systems in Central Queensland."—Proc. of the Linn. Soc. of N.S.W. vol. XLVII, pt. 2, 1923, pp. 153-158.

In these he finds the following fossils :—*Cladophlebis australis*, *Taeniopteris spathulata*, *Otozamites feistmanteli*, *Sphenopteris superba*, *Neocalamites*, *Ptilophyllum pecten*, *Dictyophyllum davidi*. The Geological Survey of Queensland considers the whole series to have been deposited in fresh water, and it has the characteristics of a fresh water formation. It was certainly laid down in very shallow water. The strata are very false-bedded and lenticular, so much so that local dips have to be taken with great caution. Every kind of deposit, even some of the massive sandstones, tend to thin out or to change entirely in character when traced along the strike, becoming more closely bedded, with lenticular beds of shale intercalated along the planes of bedding. Pebble beds are developed in places in some of the sandstones, which may indicate local areas of contemporaneous erosion which are often to be found in such shallow water deposits. The traverses made by ourselves would suggest that while Dr. Jensen's subdivisions may hold good N. of Roma, they could not be taken altogether as a generalization of the sequence at present. Owing to the variable nature of the strata some modifications seem to be necessary from place to place as the beds are traced along their outcrops. However, the geology of this belt of Walloon country has been worked out in so little detail yet that any attempt to dogmatize with regard to a general sequence would be unscientific. Near Juandah, the terminus of the branch line of railway running northwards from Miles, sandy shales and mudstones are well developed in what we take to be the Middle Walloons. Massive sandstones are exposed near the town containing huge hemispherical concretions due to accumulations of iron and calcium carbonates in the sand. Concretionary ironstone lenses also occur sometimes, containing *Taeniopteris*, *Cladophlebis*, &c. The whole of the exposures show irregular false bedding.

North of Juandah, toward Taroom, sandy shales and sandstones alternate, the sandstone horizons forming low hills. Though the general direction of dip is to the S.E., there is some local folding into small anticlines and synclines. Carbonaceous matter is scattered through these beds in places and silicified wood is plentiful in some of the sandy shales. West of Juandah, in Woleebee Creek, we observed a coal seam of not very good quality, and about 3 feet in thickness. The dip was S.W. at about 10° . The seam occurs in sandy shales overlain by a massive sandstone which is full of fossil wood, tree trunks and stems, varying greatly in size and diameter, being preserved as sandy casts heavily stained with iron. This appears to occur in the Middle Walloons.

In Weringa Creek to the N.E. of Juandah another coal seam was observed, probably at a lower horizon. The coal here is of good quality, and is 18 inches to 2 feet in thickness. The seam extends right across the bed of the creek, and can be traced for some distance. It dips to the W. at about 4° , although some rolling is observable and reverse dips were noted. Underlying the coal seam were fine blue clay shales containing carbonaceous matter and fossil ferns.

4. Coal Seam in Walloon Beds, Weringa Creek, near Juandah

Photo., L. C. Ball

Six miles south of Juandah clayey shales with thin beds of sandstone outcrop. In a small quarry near the road these have been altered by heat, the shales being baked into porcellanites, and the sandstones so fused as to become scoriaceous and vesicular. Whole beds are shattered into a sort of breccia set in a fused slag. A thin coal seam near the floor of the quarry has been turned into coke. The occurrence looks like contact metamorphism, but no igneous rocks are observable in the vicinity. These metamorphosed beds can be traced toward the railway line,

which is close to the west. In the railway cutting faulting is observable, but again no igneous rocks are to be seen. A mile or two to the west of the line, Mount Lawton and the Mooyonee peaks rise sharply out of the rolling country. So far as we can discover, they have never been examined, but they look like outcrops of igneous rocks, probably basalts. If so, there may be a concealed dyke or sill close beneath the surface at the quarry. Similar porcellanites were observed near Beaudesert, where the cause was undoubtedly an underlying sill. Dr. Jensen tells me that he observed a similar occurrence near Taroom, and thinks that it may have been caused by an escape of natural gas which took fire and fused the surrounding rocks. There is no trace of gas escaping at present, and I think that the brecciation and fusing is too marked to be due to this cause. To produce the effects observed, the volume and pressure of gas would necessarily be great. I have seen gas escaping in great volume and under great pressure from beds not unlike those south of Juandah, but the result was that a very distinct crater was formed, and of this there is no sign. Such craters are usually circular and funnel-shaped. I have seen them between 30 and 40 feet in diameter and at least 20 feet deep. I think there would be some sign of crater formation if this occurrence was due to the escape and burning of natural gas. I am therefore inclined to believe that the phenomenon is due to the concealed presence of an igneous intrusive or spontaneous combustion in the underlying coal seam.

Dr. Jensen's traverse northward from Roma to beyond Injune represents the facts so far as I can judge. Our own observations made during a comparatively short stay in this district closely agree with his. Coal seams of inferior quality outcrop in, what he would call, the Upper Walloons, a few miles north of Roma. In his Lower Walloons a 5-ft. seam of coal of good quality, associated with highly carbonaceous shales, has been found in two bores about 2 miles south of Injune in shafts about 80 feet deep. A similar seam was found at Gunnewin, about 400 feet below the surface, 8 or 9 miles south of Injune. This is apparently the same seam, so the Walloons have a general dip to the south of about 40 feet to the mile.

Coal seams are also exposed south of the Divide in Bungil Creek and its tributaries, Downfall Creek, Bungeworgorai Creek and its tributaries, Flagstone Creek, possibly in the Lower Walloons, though their position south of the Divide and their proximity to a thick bed of massive sandstone suggests a Middle Walloon horizon. The dips generally are to the S.E., though there is some evidence of both folding and faulting in places. The bore near Gunnewin passed through speckled sandstones, the specks consisting of small fragments of carbonaceous matter scattered through

5. Folding in Coal Seam, Walloon Coal Measures, Bungeworgorai Creek, Orallo District.

Photo., A. W.

the rocks. We found similar sandstones outcropping a few miles to the west of Gunnewin. We were fortunate in finding the cores of the bore at Gunnewin, though it was impossible to get a section of the beds from them which would have been useful. The cores show, however, that bands of dark and highly carbonaceous shales are interbedded with the speckled sandstones. The beds are just as lenticular and false-bedded as in the Juandah district, a good section showing this being observed in a gorge on the Bungeworgorai Creek, some miles to the N.W. of Orallo.

6 Shales thinning out in Massive Sandstone Walloon Beds, Bungeworgorai Creek, Orallo District.

Photo., A. W.

I append two analyses made by the Government Analyst in Brisbane. One is of the Injune coal and the other of the carbonaceous shale associated with it. The latter proves to be an oil shale of good quality, which is worthy of note.

Jan. 3, 1925. Coal from Injune No. 2 shaft No. 450/G.S.

Specific Gravity, 1.24.

Oil yield (by destructive distillation), 40 gallons per ton.

Proximate Analysis—

Moisture	..	..	4.1 per cent.
Volatile matter	..	..	37.3 ..
Fixed carbon	..	..	17.0 ..
Ash ..	..	..	11.6 ..
			100.0 ..

Fixed carbon-ratio, 55.75.

Jan. 3, 1925. Shale from Injune, No. 1 Shaft, No. 451/G.S.

Specific Gravity, 1.47.

Oil yield (by destructive distillation), 42 gallons per ton.

Proximate Analysis—

Moisture	..	..	2.5 per cent.
Volatile matter	..	..	33.0 ..
Fixed carbon	..	..	26.6 ..
Ash ..	..	..	37.9 ..
			100.0

B. STRUCTURAL GEOLOGY.

Praetically no detailed geology, which would faeilitate the working out of minor struetures, has been done in this Walloon area, and sueh work will not be an easy task. The eountry consists mostly of low, rounded hills and broad depressions, together with extensive plain areas. It is covered for the most part with forest and serub, and in parts of the area, as in the eountry on either side of the railway line between Miles and Juandah, priekly pear has taken sueh hold as to be almost impenetrable except on horsebaek, and even then the horses suffer badly from the spines, which the rider cannot altogether avoid either. Again over wide areas outcrops are scanty and uncertain. The beds dip at low angles or are nearly horizontal, and are eovered with a mantle of soil or sand. In spite of all these difficulties I am of opinion that much could be accomplished by detailed surveys, and such surveys will be very necessary if satisfactory struetures are to be defined in this region. With the exception of the priekly pear, similar diffieulties have been overcome elsewhere, and it is surprising how structures reveal themselves and pieee together when isolated fragments of a territory, not too far apart, are worked out in accurate detail. Suffeient of the area was traversed and sufficient outcrops were observed for me to eome to the conelusion that both folding and faulting are present in these Walloon strata, and that detailed struetural mapping can be done in some areas. Some of the folding observed is on too small a scale to be considered in connexion with oil supplies, but there are some indications of larger structures in

places. Reverse dips were noted both near Juandah and Injune, and again with less certainty north of Orallo, though time would not permit of any attempt to follow up such indications. Dr. Jensen, with more time at his disposal, thinks that dome-like structures are present, for example, near Flagstone Creek, N.W. of Orallo, and near the head of Bungil Creek, while Mr. Ball tells me that he noted evidence of a similar structure in the neighbourhood of Tambo. Detailed mapping is the only way in which the existence of such structures can be confirmed and made certain. Some of the rounded hill forms have been taken as evidence of dome-like folding, the depressions being considered to be the corresponding basins in the strata. While this is sometimes true, it cannot be taken for granted unless confirmed by evidences of dip. In one or two cases we found evidences to show that hills might be formed by local thickenings in massive sandstones as on the Bungeworgorai Creek. Rather as a coincidence, we also found in the gorge section in the same creek some evidence of local folding underlying associated hill forms. Again, the hill immediately S.E. of the village of Juandah is rather synclinal than otherwise, so that our observations show that the determination of low folding by hill forms cannot be altogether relied upon in this area. The general southerly and south-easterly dips of the Walloon strata has already been referred to. The outcrops form part of the edge of the Great Artesian Water Basins of Central Queensland, some of the sandstones constituting the intake beds for the water supplies which lie at great depths in the centres of the basins.

C. SURFACE DEPOSITS.

A few brief notes on some of the surface deposits may be of interest.

Pebble beds are widely distributed over the surface between Miles and Taroom, and again in parts of the area north of Roma. A noteworthy concentration of pebbles is to be seen in a quarry about 1 mile west of Miles. My notes show that I first considered them to be river gravels, but their wide distribution made this difficult to accept subsequently. The pebbles consist chiefly of red quartzites, white quartz, some decomposed porphyrite and much silicified wood, all rounded and waterworn. The quartzites, quartz, and porphyrites appear to have travelled from the north-east, where there are outcroppings of similar rocks. The silicified wood need not have travelled far, for it occurs both in the sandy shales of the Walloons and the Marine Cretaceous above. Some specimens are faceted in a way that suggests ice action, while others very distinctly have the form of wind faceted stones often found in desert areas. The word "Dreikanter" has been applied to some of these forms, but some authorities limit the term to one particular shape of wind-faceted stone regardless of the fact that all the other forms are but modifications of the "Dreikanter" form caused by the shifting of the stone on the surface under the action of the wind. Coining a name, we might call these "Aeoliths" or "Aeocoigns."

These beds may represent old river courses, and, if so, would indicate that the major tributaries of the Darling once extended over the present "Divide," their head waters having been captured by the streams now flowing north from the "Divide." The "Divide" would therefore, be of comparatively recent origin, due probably to changes in elevation in this part of the continent.

On the other hand, these pebble beds and scatters of pebbles may be remnants of a basal conglomerate due to the wearing back of a cover of Marine Cretaceous from over the Walloon belt, and the pebbles which suggest glacial faceting may have been derived from the Permo-Carboniferous deposits which lie to the north-east.

D. IGNEOUS ROCKS.

The Walloon country is not unduly disturbed by the intrusions of igneous rocks. Andesitic basalts have pushed through the Walloons and form the bold mountains which run northwards from the neighbourhood of Toowoomba, and are known as the Bunya Mountains, east of Dalby. Another large area of basalt occurs to the north of Roma, being especially well developed in Mount Hutton and in the Carnarvon Range. Between these points several minor developments of basalt and porphyrites occur, some of which have not yet been mapped. A basalt dyke cuts through the Middle (?) Walloon strata at Gunnepwin, a few miles to the north of Orallo. Patches of basalt have been observed also at one or two places in Gubberamunda and near Yingerbay, eastward of Orallo. The Mooyonee Peaks and Mount Lawton, south-west of Juandah, are suspected to be basaltic hills, but they have only been inspected from a distance so far. However, wide areas are free from any sign of igneous intrusives, which cannot have affected the oil-bearing possibilities of the strata in this region to any serious extent.

E. PETROLEUM SURFACE EVIDENCES.

Any one who attempts to form an opinion as to the existence of petroleum in commercial quantities in the Walloon strata of this part of Queensland from surface evidences must find himself faced with very great difficulties. In the first place, no seepages of either oil or natural

gas have been observed throughout the whole extent of the area with which we are dealing. The value of such surface evidences is very great indeed. I know of very few oilfields the development of which has not been due either directly or indirectly to their presence. Some American oilfields have been quoted as showing no surface evidences, but in many of these cases outcrops of beds of the same geological age as those which were known to underlie these areas have contained sands which were impregnated to some extent with petroleum compounds or limestones which contained bitumen, and though these outcrops may occur at considerable distances from the developed oilfields, they have in large part given a clue the following up of which has led to the discovery of commercial supplies of oil. However, it cannot be denied that discoveries have been made without the known existence of such clues, though they have not been so numerous as some people believe. Everybody who makes use of petroleum products knows how quickly they discover any weaknesses in a containing vessel and show their presence on the outside. In nature it is the same. The petroleum takes advantage of any flaw in the beds which contain them. They often show themselves on the sides of igneous rocks which have pierced the beds. Sometimes such igneous rocks will pick up a certain amount of petroleum in passage through the strata. Lines of fracture, such as those formed by faults, and strongly developed joint planes often liberate a certain amount of oil, especially where water is escaping also. Again, where strata containing oil are tilted so as to form what are called monoclinal folds, or where an anticline is deeply eroded at its crest, the sands which contain oil at depth may be exposed at the surface and give some indication of their nature, either by allowing seepages of oil to exude or by being impregnated with dark asphaltic or tarry matter where the oil is asphaltic in character, or with lighter-coloured paraffins where the oil has the paraffin type of base. The latter are sometimes difficult to detect since the rock may be discoloured very little and possess only a very faint odour on being broken. However, even in this latter case the experienced prospector is usually able to detect the nature of the sand. Outcropping tar sands are not at all uncommon. They are known in many places in the United States and Canada, while beautiful examples exist in Europe also, some not at all connected with any producing field at present. The best examples of outcropping paraffin sands I know of exist in Macedonia and in the Andes, in South America. It may be objected that in the case of strata having a very low angle of dip frictional resistance would prevent the oil from migrating up the dip for such distances as would be required for it to reach the surface, but in actual field work I have seen such beds impregnated with petroleum where the strata were almost horizontal. Now these Walloon strata lie in the form of a low monoclinal fold dipping off north of Roma to the south or south-east at from 40 to 50 feet to the mile. Their edges must all come to the surface between Roma and a little distance north of Injune, but no evidences of the presence of petroleum have been found in any of the exposures that have been so far examined. Two conditions may exist to prevent any observable oil content being present in these outcrops. First, it is just possible that oil may be locked in by the lenticular nature of these deposits. Secondly, some of these sands are considered to be the intake beds for the water supplies that exist in the great artesian basins, and it is possible that the constant drainage of water down the dip of the sands has either washed down any traces of oil which may have existed or may have prevented it from migrating to the surface.

Another feature of the case must be considered. The Walloon strata are a fresh-water series, and until recently this type of deposit was considered to be and had been found unfavorable to the formation of oil in commercial quantities. Prof. Schuchert,* a well-known American geologist and author, has classified under the heading of "The Impossible Areas for Petroliferous Rocks"—

Practically all continental or fresh water deposits, relic seas, so long as they are partly salty, and saline lakes are excluded from this classification.

But within the last five or six years certain types of fresh water deposits have been found to contain appreciable quantities of oil, and several good fields have been opened up along the eastern flanks of the Rocky Mountains. What are the conditions, therefore, that have been found to be necessary before fresh water formations can be expected to contain paying quantities of oil? In the Rocky Mountain foothill region referred to the indications suggest fairly deep water conditions involving the accumulation of dark-blue carbonaceous shales in beds approaching 1,000 feet in thickness and permitting of fresh water limestones to be found at depth also. On the other hand, it must be noted that marine beds of Carboniferous age underlie the fresh water series, and these Carboniferous beds have not only been proved to contain oil in this region, but have been a prolific source of oil throughout the Mid-Continent oilfield area. Thus the possibility that the oil may have migrated into the fresh water series from the underlying marine Carboniferous formation can not altogether be overlooked.

* Petroliferous Provinces. Discussion of E. G. Woodruff's Paper.—Trans. Am. Inst. Min. Eng., Chicago Meeting, 1919.

In the Queensland area we have evidence of similar accumulations of carbonaceous shales, though I doubt if we have evidence of such settled conditions of deposition. The nature of the beds suggests fairly shallow water conditions throughout. We certainly have no evidence of a proved oil-bearing series beneath from which migration may have taken place. However, coals and a good development of carbonaceous shales do exist, and it becomes a question as to whether such beds can have been the source of sufficient bodies of oil as to be payable to work. If oil has originated in such quantities, are the structural conditions so satisfactory that the oil so formed may have accumulated in commercial quantities? This is another question which is difficult to answer. While I have suggested that such structures may exist, they require to be proved by much more detailed geological work than has been done up to the present time. It has been suggested that such structures may have to be proved by putting down a number of shallow or deep bores. Where strata are so lenticular, thinning and thickening from place to place, the results obtained by such boring may be very misleading. A structure which may appear to be that of a dome may turn out to be only a lense of sandstone or shale. A reference to the vertical sections of the three bores put down close together at Roma, shown in Mr. Cameron's work mentioned below, shows not only the lenticular nature of the strata below ground, but changes over short distances that must be regarded as astonishing. It is necessary, therefore, to know just how persistent beds are, and detailed geological survey work will throw much light upon this as well as upon the finer structural features present in the area.

F. SUB-SURFACE EVIDENCES.

Turning now from the argument which has been developed from the evidences presented at the surface, and dealing with conditions as they exist underground, we find that interest has always centred upon the results obtained by the series of deep bores put down at Roma. These results have been clearly set out and ably discussed by Mr. Cameron, formerly an officer of the Geological Survey in Queensland, and in this discussion several of the world's leading oil experts took part.*

Four wells were drilled at Roma between 1897 and 1922. All are situated within a comparatively small area (less than 2 acres, I should judge) of rising ground immediately to the west of the town and about 1,020 feet above sea level. Roma is situated a few miles to the south of the southern limit of the exposed Walloon belt, and is, therefore, on the Marine Cretaceous which overlies the Walloon strata with apparent conformity. Where the bores are situated, the Walloon strata are about 300 feet below the surface and the general dip to the south is very low, apparently not much greater than 2° . The first well was put down for water in 1897 only to 1,678 feet, so that no showings of gas are recorded in connexion with it. The other three all reached about the same depth, varying only between 3,709 and 3,713 feet. Each of the bores passed through alternations of sandstones and shales, considerable thicknesses of the latter being dark and carbonaceous. A 4-ft. seam of coal was met with at about 700 feet in the first two bores, but had apparently petered out in the third bore, which only records streaks of coal at this horizon. A number of coal seams were again met with between about 1,900 feet and 2,400 feet, but if the bore logs were at all accurately kept the variations in the strata, at points only 240 feet apart as these bores were, are really remarkable, and only confirm my opinion as to the danger that would be involved in attempting to locate structural conditions by means of shallow bores. No horizon at all is revealed in the bore logs that can be called consistent, every stratum showing signs of very marked lenticularity. Natural gas, accompanied by fresh water, was met with in the shales which form the basal beds of each of the deeper bores, but there seems to be some doubt as to the exact horizon from which it came as well as uncertainty as to whether the water is present in the strata along with the gas or whether it broke through from some other source. The best flow of gas was encountered in bore No. 3 at 3,702 feet. Mr. Henderson, the Government Analyst, tells me that at the time of his inspection he estimates the flow to have been in the neighbourhood of 10,000,000 cubic feet per day. In this connexion a few paragraphs should be quoted from the report of the Advisory Committee on the Development of the Gas Field at Roma. These paragraphs are of great importance, and combine much wisdom with caution. The Advisory Committee consisted of Messrs. W. E. Cameron, late Deputy Chief Government Geologist; J. B. Henderson, Government Analyst; and Arthur Moore, Officer in Charge of Drilling Operations.

YIELD OF GAS.

Paragraph 4.—In spite of the obstruction in the 8-in. bore, the yield of gas running free was enormous, certainly many millions of cubic feet per day. Owing to the presence of water with the gas, and there being no separator available, it was not possible to measure the flow of gas.

PETROL CONTENT OF GAS.

Paragraph 5.—Under adverse conditions both of temperature and pressure a yield of 1.2 units of petrol per 1,000 cubic feet was obtained. As this petrol contained no pentane and very little hexane (which constitute the lighter portion of petrol) it is almost certain that these constituents, when recovered with the others, will materially increase the yield and value of the petrol from the gas.

* Cameron, W. E., B.A. Petroleum and Natural Gas Prospects at Roma. Also Reports and Correspondence on Prospects for Petroleum and Proposals for Development, by Sir Beverton Redwood, Bart., Sir Thomas Robinson, K.C.M.G., Dr. A. C. Veatch, Wm. Hope Henderson, M.I.M.M., P. Charteris, A. Stewart W. H. Dalton, F.G.S., F.C.S., Lionel C. Ball, B.A., B.Sc. (Sydney).—Q.G.S. Publication No. 247.

PRESENCE OF OIL.

Paragraph 6.—Apart from the petrol absorbed from the gas no liquid oil has yet been noticed in any material yielded from this bore.

PROBABLE CONDITIONS OF GAS FIELD.

Paragraph 7.—From the data observed in this No. 4 bore, the records from Nos. 2 and 3 Roma bores, and from other facts, the Committee are of opinion that the gas yield is likely to prove of permanent value, that is that the yield of gas is likely to be enormous and to last for years. It exists in the strata at a static pressure which is very great and will probably prove to be in the region of 1,400 lbs. per square inch, which implies that the capacity of the sands for carrying gas is correspondingly great.

POSSIBLE PROXIMITY OF OIL.

Paragraph 8.—While natural gas fields result from petroleum deposits, some gas fields are known which do not yield any oil. Other natural gas fields yield oil only in small quantities and over small areas of the gas field. The finding of a natural gas containing petrol of the composition found at Roma is looked on as a very strong indication of the close proximity of oil. It is not, however, proof of such proximity, and is certainly no proof of the presence of oil in commercially payable quantities. The most that can be said is that the fact that the gas contains petrol materially increases the prospects of success in boring for oil.

An analysis of the gas at Roma is given by Mr. Cameron :—*

Paraffin series (including ethane 9.8 per cent.)	..	..	82.4 per cent.
Benzine series	..	..	5.0 "
Olefin series	..	..	1.5 "
Carbon monoxide	..	..	5.8 "
Carbon dioxide	..	..	1.5 "
Nitrogen and residual gas	..	..	3.4 "
Oxygen and hydrogen	..	..	0.00 "

It is a wet gas which is very suggestive of the presence of oil in the strata. No evidence of a structure can be found at Roma unless the rounded hill on which the bores are situated represents a local dome-shaped fold, but I am of opinion that some favourable structure exists since I think the presence of such large bodies of gas under such pressures in this locality connote the existence of favourable structural conditions. It may be that the gas is sealed in by the lenticularity of the beds, but such conditions are favourable to the accumulation of oil also. In such a case, however, the presence of the lens at depth cannot be ascertained by geological work at the surface, which is very unfortunate, for the only means of locating such a structure is the drilling of wild-cat wells, which is a very expensive and often a very disappointing business. The only other recorded instance of the existence of a wet natural gas in a bore in Queensland is one found by Mr. Ball at Ruthven, a few miles south of Longreach. Small quantities of gas are coming from an old bore which was drilled to 4,070 feet. The Government Analyst found a sample collected by Mr. Ball to contain—

Carbon dioxide	..	..	..	..	..	32.2 per cent.
Air	..	..	..	..	..	2.0 "
Methane	..	..	..	..	..	32.5 "
Higher paraffins (as ethane)	..	..	..	..	..	2.8 "
Inert gases	..	..	..	..	..	30.5 "
						<hr/> 100.0 "

Instances of the occurrence of methane in boreholes are fairly frequent, but since this is commonly connected with the presence of coal seams and carbonaceous beds such occurrences are of no importance in the quest for petroleum.

G. OCCURRENCES OF PETROLEUM.

Small showings of petroleum have been noted during the drilling of many wells in Queensland, but such showings have no serious significance as a rule. During our visit to the bore now being drilled at Orallo, Mr. Ball took a sample of the mud fluid being used in connexion with the work. The plant in use is a modern rotary, and the mud-laden fluid is circulated from the surface inside the drill pipe to the bottom of the hole and back again to the surface, bringing with it the débris produced by the rotation of the drilling bit, and also forming a coating on the walls of the borehole. The depth of the bore was 1,312 feet at the time, and no claim was made that the strata was oil-bearing. The sample taken by Mr. Ball was analyzed by the Government Analyst with the following results :—

Specific gravity at 26° C.	..	..	..	..	1.21
Weight of sample	..	..	..	..	700 grams
Weight of free oil in sample	..	..	..	..	0.44 grams
Percentage of free oil in sample	..	..	..	..	0.063.

The extracted oil had the consistency of mineral grease at 20° C.

* Loc. cit. p. 33.

Now there can be little doubt that the oil contained in this sample had found its way into the mud fluid from the operations being conducted at the surface. The percentage found by the Government Analyst bears a suspicious resemblance to the percentages quoted in connexion with the oil-boring operations, previously described, in other localities. The Government Analyst's description of the oil is also the same as in most of those cases. Such a practical test makes me more suspicious than ever of the small showings of oil recorded in many of the borings which have been dealt with.

The most interesting evidence of the existence of oil below the surface seen by us in Queensland was at Ruthven, a few miles to the south of Longreach in Central Queensland. A bore was put down for artesian water many years ago and reached a depth of 4,105 feet. We found hot water running from the casing-head into a 400-gal. tank. On the surface of the tank was a thick, dark, iridescent, oily film which looked like a dark-brown crude liquid petroleum at the temperature which we found to be 190° F. We collected a sample and allowed it to cool when it became solid. The Government Analyst has classed this material as Ozokerite. I append the results of two analyses of this substance made by him. The first is of a sample

collected by Mr. Ball on a previous visit. The second is an earlier analysis quoted in a report by Mr. Henderson.*

DIRTY BROWN WAX.

	<i>Analysis No. 1.</i>	<i>Analysis No. 2.</i>
Soluble in petrol ether (Petrolene)	96.9 per cent.	90.0 per cent.
Insoluble in petrol ether but soluble in chloro- form (Asphaltene)	2.6 per cent.	4.0 per cent.
Other organic matter	trace	0.7 per cent.
Mineral matter	0.5 per cent.	5.3 per cent.
	100.0 per cent.	100.0 per cent.

A small amount of gas is also present, an analysis of which has already been quoted.

The water which accompanies the oil was also analyzed, with the following results:—

Chlorine	3.5 grains per gallon
Sodium chloride	5.8 grains per gallon
Alkalinity as Calcium Carbonate	65.0 grains per gallon
Reaction to Litmus	Slight alkaline
Sulphates (SO ₃)	1.68 grains per gallon

The results of this analysis show that the water is not very saline, and is, therefore, not of the character usually associated with commercial supplies of oil. The bore records do not appear to have been accurately kept or preserved. It is not known whether the oil showing is coming from the water-bearing strata or from some other level. The bore, however, is regarded to have finished in Walloon strata. Similar material has been found in association with artesian waters at Springleigh (5,800 feet), near Blackall, and more recently (1925) in the town bore at Longreach (3,275 feet). Mr. Henderson gives the composition of the Ozokerite obtained from the Springleigh bore in the paper already mentioned.

Soluble in Petrol Ether (Petrolene)	65.5 per cent.
Soluble in Turps, then in Chloroform (Asphaltene).. ..	16.5 ..
Other organic matter (by difference)	5.2 ..
Inorganic residue	12.8 ..
	100.0 ..

The temperature of the water emerging from the Ruthven bore has been given as 190° F. Since the water has been flowing for many years, the pipes and the surrounding country rock must have now acquired the same temperature as the flowing water, so that very little loss of temperature can take place between the bottom of the bore and the surface. The surface temperature at the time when the temperature of the water was taken was about 80° F., so that the geothermal gradient of the bore must be less than 1° F. for every 36 feet. This is in close agreement with the results obtained by Mr. A. Moore, formerly driller in charge of the No. 4 bore, Roma. In this case he found the geothermal gradient to be 1° F. for 32.9 feet, which is almost exactly the same as that in the recently completed bore at Longreach. Such high geothermal gradients mean high temperatures at depth, and with such temperatures Mr. Moore considered the possibility that liquid oils, which may have been formerly present, at depth, may have become dissociated, the higher fractions being driven off as gases, leaving only heavy residues behind. Dr. Jensen also considered the same possibility at the greater depths, and the nature of the petroleum compounds obtained at Ruthven, Springleigh, and at Longreach from great depths tends to confirm these opinions.

The waters encountered in the first three bores at Roma all seem to have been fresh, so that if again the records were accurately kept, the chances are against any of the sands encountered proving to be oil sands between that point and the outcrops to the north. An analysis of the water now flowing from the bores at Roma is appended:—

Silica	1.6 gr.
Iron and Alumina	0.2 gr.
Calcium Carbonate	0.5 gr.
Magnesium Carbonate	0.3 gr.
Sodium Carbonate	23.0 gr.
Sodium Sulphate	8.9 gr.
Sodium Chloride	15.5 gr.

Total solids per gallon ∴ 50.0 gr.

To test the beds at Roma for oil something like 4,000 feet of drilling will be necessary. Many difficulties were encountered in the drilling of the deep bores already put down at Roma, though from a perusal of the history of the bores I do not think that any difficulties exist that are

* Henderson, J. B., Government Analyst. Notes on the Occurrence of Petroleum in Queensland. —Proc. Roy. Soc. Queensland., 28.4.1920, pp. 58-160.

7. The Lander Company's Bore at Orallo.

Photo., A. W.

greater than those frequently encountered and overcome in deep drilling elsewhere. With modern plant and the adoption of modern methods such troubles should be easily overcome, though drilling for oil to depths of 4,000 feet is still a serious and expensive business not to be embarked upon without ample supplies of capital and the most efficient of personnel.

8. Interior View of the Lander Company's Plant at Orallo.

Photo., L. C. Ball.

A definite oil sand is reported to have been struck in the first bore put down by the Lander Oil Company at Orallo. A sample shown to me has the characteristics of a true oil sand with some peculiarities which need not be discussed here. I append the log of this borehole which, if accurate, shows some very interesting and hopeful features. A second well is being drilled, and is down to about 2,500 feet at the time of writing, and is reported to be showing gas.* It is to be hoped that this bore, which is in good practical hands, will settle the question of the existence of oil in commercial quantities in this region.

* Since writing the above this second well has been abandoned as a dry hole.

Log of Well No. 1, Lander Oil Company Limited, Orallo Parish, County of Waldegrave, Queensland, Australia.

Elevation of derrick floor about 1,360 feet Lat.

Spudded 15th November, 1923.

220 ft. 15½ in., 70-in. casing.

2,138 ft. 10 in., 45-in. casing.

Cemented—7th April, 1924, 90 sacks of cement, which set in pipe and no shut-off was secured.

13¾-in. hole drilled to 2,140 feet.

From—	To—	Thickness.	Formation.
0	133	133	Surface clay, sand, and gravel
133	173	40	Yellow sand, with streaks of clay
173	178	5	White clay
178	188	10	Yellow sand
188	193	5	White clay
193	208	15	Yellow clay
208	220	12	Yellow sand
220	230	10	Blue shale
230	250	20	Blue sandy shale
250	260	10	Yellow sandy shale
260	300	40	Soft blue shale
300	315	15	Yellow sand
315	320	5	Conglomerate
320	385	65	Sandy blue shale
385	420	35	White limestone and gypsum
420	470	50	Sandy blue shale
470	510	40	Sticky blue shale
510	525	15	Sandy blue shale
525	545	20	White sandy limestone
545	575	30	Hard gray silty sand
575	605	30	Blue silty sand, streaks of shale
605	625	20	Gray limestone and gypsum
625	645	20	Gray sandy shale
645	665	20	Hard red sand and conglomerate
665	690	25	Gray sand
690	715	25	Lignite with streaks of sand
715	740	25	Gray shale
740	745	5	Tar sand
745	780	35	Sandy gray shale
780	787	7	Sticky gray shale
787	790	3	Gray sand
790	835	45	Brown sandy shale, streaks of sand
835	855	20	Brown shale, streaks of sand and gypsum
855	865	10	Sandy gray shale
865	880	15	Brown sandy shale
880	900	20	Sticky blue shell, streaks of sand
900	905	5	Brown shale
905	930	15	Sticky blue shell
930	940	10	Brown shale
940	960	20	Brown sandy shale, streaks of tough shale
960	1,000	40	Gray sandy shale, streaks of coal
1,000	1,035	35	Sticky blue shale
1,035	1,045	10	Brown shale
1,045	1,050	5	Coal
1,050	1,100	50	Brown shale, streaks of sand and shell
1,100	1,115	15	Brown shale
1,115	1,160	45	Gray shale, streaks of sand and shell
1,160	1,195	35	Brown shale, streaks of sand and gypsum
1,195	1,220	25	Tough brown shale
1,220	1,250	30	Sticky blue shale
1,250	1,298	45	Sticky brown shale
1,295	1,330	35	Hard gray shale, streaks of sand
1,330	1,337	7	Gray sand and gravel
1,337	1,347	10	Gray sand and shale
1,347	1,375	28	Sticky blue shale, streaks of shale
1,375	1,660	285	Blue sandy shale, streaks of gypsum and hard shale
1,660	1,680	30	Sticky blue shale
1,680	1,730	50	Sandy brown shale, streaks of gypsum
1,730	1,745	15	Sticky brown shale
1,745	1,760	15	Sandy brown shale
1,760	1,800	40	Sticky brown shale
1,800	1,825	25	Sandy brown shale with shells
1,825	1,835	10	Gray sandy shale
1,835	1,880	45	Brown shale
1,880	1,895	15	Brown sandy shale

Log of Well No. 1, Lander Oil Company Limited, Orallo Parish, County of Waldegrave, Queensland, Australia—continued.

From—	To—	Thickness.	Formation.
1,895	1,945	50	Brown sandy shale, streaks of gypsum and shell
1,945	1,950	5	Hard sandy brown shale
1,950	1,990	40	Sticky brown shale
1,990	2,003	13	Silty brown shale and shells
2,003	2,030	27	Brown sandy shale, streaks of shell
2,030	2,090	60	Tough brown shale, streaks of sand
2,090	2,100	10	Gray limestone
2,100	2,110	10	Hard brown shell
2,110	2,118	8	Hard sandy shale
2,118	2,129	11	Gray sand, showing oil and gas
2,129	2,140	11	Hard brown shale
2,140	2,150	10	Sandy brown shale
2,150	2,153	3	Hard gray shell
2,153	2,155	3	Grey sand, gas, and oil
2,155	2,198	43	Sandy brown shale, showing gas and oil
2,198	2,233	35	Brown oil sand

Finally a word must be said about the application of the carbon-ratio theory to this region. The only coal analysis available to me at the time of writing is the one already quoted of coal from the shaft at Injune. The ration of fixed carbon in this coal was 55.75, which indicates a very satisfactory stage of metamorphism in the coals for the presence of oil in the associated strata.

H. CONCLUSIONS.

Summing up I find that the evidences against the existence of oil in payable quantities in the region under consideration are :—

- (1) The entire absence of surface indications throughout the area.
- (2) The absence of brines in connexion with the showings of oil and the flows of wet gas which have been met with also in beds of sand which might otherwise be suspected to contain oil in places.
- (3) The uncertainty that exists in the absence of detailed geological information with regard to the existence of suitable structures which could contain oil in paying quantities and the difficulty of locating such structures.
- (4) The high geothermal gradients which result in high temperatures at depths of 3,000 feet and over which might result in dissociation of liquid petroleum, leaving only heavy residues at such depths as at Ruthven, Springleigh, and Longreach, together with accumulations of wet gas such as those which exist at Roma.

On the other hand, the favorable features are :—

- (1) The existence of quantities of wet gas under great pressure, the gas itself having been proved to be present in quantities which should pay for exploitation with the extraction of petrol by means of suitable extraction plant.
- (2) The proved existence of actual oil at depth in the Walloon strata along the edges of the Great Artesian Basin of Central Queensland.
- (3) The existence of suitable strata for the oil to have originated therein and the presence of very satisfactory fixed carbon-ratios in coal seams associated therewith.
- (4) The existence of both suitable storage and cover rocks in this area.
- (5) The possible, perhaps probable, presence of suitable geological structures for the accumulation of oil in paying quantities, and the absence of considerable faulting or folding in the strata.
- (6) The absence of undue interference with the strata by igneous intrusives.

The evidence indicates that there is hope of oil being present at moderate depths, where structural features are favorable. Adopting the method used by some oil geologists in estimating the value of such an area, I estimate that the chances of obtaining oil in this area are probably about 30 in 100, which means that the evidences are good enough to encourage further prospecting work. I suggest that an attempt should be made to geologically map this area in as great detail as possible, and that special attention be given to localities where there is any indication of suitable structural conditions. Even if natural gas only be obtained, provided that it is in such quantities as were proved to exist in the No. 3 bore at Roma, the exploitation of such gas should prove profitable, and would be likely to lead to the development of secondary industries in this part of Queensland. This certainly has been the case in parts of Texas and Louisiana. Natural gas fields at Amarillo, in the Panhandle of Texas, and at Monroe, in Louisiana, have proved profitable even though drilling has gone beyond the 3,000-ft. level.

It should be evident, however, that the work which is necessary before the search for oil in Queensland can be put on a proper basis so as to entail the proper chances of success is not work for small companies with limited means. A Government might embark upon the task, but, in view of the large expenditure entailed and the likelihood of many disappointments, such work might lead to much political opposition, especially in case of failure. With initial success political questioning would not seriously arise. It is the sort of work which only a large corporation having ample reserves of capital specially earmarked for such a purpose could seriously undertake, and it may be possible to attract the attention of such companies. Any such attention should, in my opinion, be encouraged by the granting of large areas for prospecting and for subsequent development. The new mining regulations with regard to petroleum now operating in Queensland allow fairly generous terms both for prospecting and for exploitation. The areas granted under prospecting licences might, perhaps, be rather greater with advantage, but the areas granted under lease for exploitation should be satisfactory; the number of leases so granted should not necessarily be limited to one, providing that the lessee shows energy and efficiency in carrying out the work of development. If success should attend the efforts of prospecting concerns the oil will still be in Australia, and the advantages derived from discoveries of payable quantities of oil will greatly benefit every industry in Australia, even though the discovering company may make considerable profits. It must be remembered that such companies face considerable losses in taking up this work and must be prepared to spend much money before success is obtained; nor must it be forgotten that such success is not at all certain. The possibility of ultimately gaining considerable profits therefore is the only consideration which could encourage such concerns to undertake the task.

The current rumour that large companies are interested in preventing oil from being discovered in Australia is based on a lack of understanding of the true position that the world is in with regard to oil to-day. We face a potential shortage. The life of the largest company is the life of its oil supplies which are being rapidly distributed and used, so that every company is more interested in locating new oilfields than in preventing them from being discovered.

I have found a tendency in some places to apply a saying that the "Cousin Jack" miner used to apply to gold—"Where it be there it be!" Such a philosophy is rather indicative of despair in the face of the difficulties which exist. Those who feel inclined to work on such a basis should be reminded of the rest of the saying—"and where it be there baint I!"

Many bores have been put down in this part of Queensland, and it is a pity that steps were not taken in the past to insist on the accurate keeping of logs and samples, and that copies of such logs and portions of such samples were not required to be sent to the Mines Department in Brisbane to be placed on record. The result is that much valuable information is lost to us which would have been of the greatest service in determining underground structures and tracing changes in the nature of the strata from place to place. Even accurate knowledge concerning the water horizons in these bores would have been of great use in the work that must be done in Queensland before success can be deserved or won. Some of this information has been preserved and has been used by the Geological Survey Department in the preparation of underground maps of the artesian basins, but it is by no means so complete as might have been possible.

I sincerely hope that the work which I have indicated to be necessary will be embarked upon and a greater area will be methodically prospected than is the case at present, and that success will attend these efforts to find oil for Australia.

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