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Petroleum Exploration in Australia
(October, 1964)

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Within the land areas of Australia and Papua-New Guinea the twenty-seven sedimentary basins cover 1,480,000 square miles of the total area of 3,159,000 square miles. The individual basins range in area from 4,000 to 510,000 square miles (Fig. 1), and contain marine and continental sedimentary rocks ranging in maximum thickness from 1,000 to about 50,000 feet and including rocks of all ages from Proterozoic to Pliocene.

At present, 100 tenement holders have an aggregate tenement area of 2,600,000 square miles, including off-shore areas. Tenement areas range from 4 acres to 142,000 square miles. One joint-venture group holds a total of 336,480 square miles.

Many of these large areas were granted when there was very little interest in Australian oil exploration and an absence of any general belief in the probability of finding commercial oil.

Since then several discoveries of oil and gas and a number of impressive shows of oil have established the presence of hydrocarbons in many parts of Australia and have given rise to a steady increase in the number of companies engaged in oil exploration.

Basic regional exploration is still only partly complete and very little detailed investigation has been undertaken. The regional outcrop geology has been established in the new Guinea, Papua, Laura, Bowen, Maryborough, Ipswich-Clarence, Sydney, Otway, St. Vincent, Carnarvon, Canning (including Fitzroy), Bonaparte, and Georgina Basins. Reconnaissance aeromagnetic surveys (flight lines at two-mile spacing) cover three-quarters of the Carpentaria Basin, most of the Bowen Basin and Surat Basin, two-thirds of the Great

Artesian Basin, one-third of the Ipswich-Clarence Basin, two-thirds of the Murray Basin, the whole of the Gippsland Basin, the whole of the Perth and Carnarvon Basins, one-half of the Canning Basin, the whole of the Bonaparte Basin, one-tenth of the Georgina and Amadeus Basins and about one-quarter of the Papua Basin. Reconnaissance gravity surveys (1 station per 100 square miles) cover about one-third of the Papua Basin, one-fifth of the Carpentaria Basin, one-sixth of the Maryborough Basin, two-fifths of the Bowen Basin, one-third of the Surat Basin, one-half of the rest of the Great Artesian Basin, one-fifth of the Sydney Basin, the whole of the Gippsland Basin, half of the Murray Basin, half of the St. Vincent Basin, the whole of the Perth Basin, four-fifths of the Carnarvon Basin, two-thirds of the Fitzroy Basin and three-quarters of the rest of the Canning Basin, half of the Bonaparte Basin, two-fifths of the Georgina Basin and all of the Amadeus Basin. Detailed gravity surveys (1 station per 10 square miles) have been completed only in the north-western part of the Canning Basin, the north-western part of the Carnarvon Basin and the northern and southern parts of the Perth Basin.

Regional seismic surveys and some detailed surveys have been started in the Papua, Bowen, Surat, Maryborough, Great Artesian, Sydney, Gippsland, Otway, St. Vincent, Perth, Carnarvon, Canning and Bonaparte Basins. A few reconnaissance seismic traverses have been run in the Carpentaria, Murray, Officer, Amadeus and Georgina Basins.

Stratigraphic drilling has begun in the Papua, Carpentaria, Laura, Bowen, Surat, Great Artesian, Maryborough, Ipswich-Clarence, Sydney, Gippsland, Otway, Murray, St. Vincent, Torrens, Eucla, Perth, Carnarvon, Canning and Bonaparte Basins but only about 3,000,000 feet has been drilled in all (about 2 feet per square mile of the area of the sedimentary basins).

Expenditure on exploration is a useful guide to the level of activity. Since 1900 about £133 million has been spent in the whole of Australia and Papua-New Guinea - £35 million in Papua-New Guinea; £44 million in Queensland; £7 million in New South Wales; £9 million in Victoria; £11 million in South Australia; £25 million in Western Australia, and £3 million in Northern Territory. Expenditure on oil exploration since 1957 is shown in Table 1.

TABLE 1

Australian Expenditure on Oil Search.

	Expenditure (£ Million)			
Calendar Year	Company (Nett)	Subsidy	Govt. - Cwlth. and State *	Total
1957	7.3	-	0.5	7.8
1958	5.5	0.1	0.6	6.2
1959	5.9	0.6	0.7	7.1
1960	6.2	1.0	0.8	8.0
1961	6.5	1.2	1.1	8.8
1962	12.5	3.0	2.3	17.8
1963	14.6	5.2	2.5	22.3
1964*	13.0	5.0	2.5	20.5

* Estimated

GOVERNMENT ASSISTANCE

The role of Government in oil exploration has been to provide technical and financial assistance. On the technical side, the Bureau of Mineral Resources, Geology and Geophysics carries out geological and geophysical surveys and drilling to obtain regional data on the sedimentary basins, and undertakes laboratory investigations. The State Mines Departments control tenements and also carry out field surveys and laboratory investigations. The Division of National Mapping provides aerial photographs, photomaps and base maps to form the basis for geological and geophysical surveys.

In addition to taxation concessions to oil exploration companies and their shareholders, since 1957 the Commonwealth Government has been subsidizing exploration for oil; £15,219,000 had been paid in subsidies for drilling, geophysical surveys and bore-hole logging to September, 1964. In October, 1961, the Petroleum Search Subsidy Act 1959 was amended to include test drilling under subsidy, to provide for payment of subsidy for drilling on a footage basis and to extend the period of operation of the Act to June 1964. In June 1964, the Act was amended to extend its operation to June 1967. £5,000,000 has been appropriated for subsidy payments in the year 1964-65.

The Subsidy Acts have been designed to increase the total amount of exploration, to encourage companies to enter the field and to ensure that subsidised exploration is adequately planned, carried out and reported upon and that the results are generally available within a short time. All of these aims are being achieved. Although discoveries of petroleum are the most significant immediate results of this policy, the very great improvement in the quality of the exploration work being carried out and its permanent documentation may in the long term prove more important as regards the success of the exploration effort on a national scale.

The Bureau of Mineral Resources which supervises the technical aspects of the Subsidy Act, insists on a certain minimum standard in operations; in most cases this is ahead of standards previously applied in Australia and is in line with overseas exploration practice. For example, before 1958 very few bores were adequately logged and tested; the Bureau's insistence on logging and testing has led to the introduction of several logging units that formerly were not available in Australia. The logging and testing programmes of many companies

still leave much room for improvement particularly for use in quantitative work on the logs, but it is expected that the current improvement will continue until Australian exploration is up to the best overseas standards.

In order to make the results of subsidised operations available, agreements have specified that the data be made available (and/or published) twelve months after the completion of field work; agreements made under the amended Act reduced this period to six months. Where published reports do not contain all the available data (for reasons of space or other expediency) this data is available for examination at Bureau offices in Canberra and Melbourne, and copies are available from approved copying firms.

A Sedimentary Basins Study Group has been established within the Bureau of Mineral Resources to collect all available data on the sedimentary basins, to collate and compile this data and to publish review maps and reports. The data obtained in subsidised operations will provide a basis on which work can begin but it is hoped to enlist the co-operation of State Mines Departments and of exploration companies to ensure that most of the data that have been obtained may be used. Much data that normally are not included in reports such as detailed outcrop sections, basic gravity data, details of experimental seismic work and copies of seismic records will be sought.

A Core and Cuttings Laboratory has been established in Canberra, where representative cores and cuttings from all subsidised bores and as many others as can be obtained are available for examination. Facilities are provided for visiting geologists to examine the material.

STATUS OF EXPLORATION

One oil field has been established, at Moonie, Queensland and oil discoveries have been made at Richmond, near

Roma, Queensland, at Alton (50 miles west of Moonie), at Conloi (100 miles north of Moonie) and at Barrow Island, Western Australia. Gas wells have been found at Kuru, Bwata, Barikewa and Iehi in Papua, at Pickanjinnie, Bony Creek, Blyth Creek, Yanalah, Richmond, Snake Creek (all near Roma) and Rolleston, Arcturus and Gilmore in Queensland, at Mereenie (150 miles west of Alice Springs, N.T.), Gidgealpa, S.A., and Yardarino and Barrow, W.A. Good oil shows that did not lead to production were found at Rough Range, Meda and Yardarino (W.A.), Cabawin, Wunger, Sunnybank and Lake Galilee (Queensland), Puri (Papua) and Port Campbell (Victoria). These discoveries establish that petroleum is present in many of Australia's sedimentary basins and suggest that commercial fields will be found in many places.

Domestic risk capital is more readily available than hithertofore for well-organized exploration companies, and many experienced overseas companies are for the first time taking part in or examining the possibility of taking part in exploration for oil in Australia. These overseas groups bring not only funds but also equipment and experienced personnel to the task.

As the amount of information on the sedimentary basins increases so in almost every case do the general and in some instances the particular prospects for the discovery of commercial petroleum.

The main problem is still the establishment of the regional geology of the basins in precise and reliable terms so that regional structure, isopachs and lithofacies can be determined and the geological history established. From this the history of movement of hydrocarbons may be indicated and the more prospective areas of the basin selected for detailed exploration.

Aeromagnetic surveys are being used to establish the structural form of the basins and detailed gravity is being used to indicate areas of structural anomaly for seismic investigation.

Most drilling to date has consisted of only one bore on any one anticline. In some such structures detailed seismic survey has indicated a significant variation of sequence on the flanks, because of unconformities or deposition over an established and/or growing fold.

In some areas where the surface is underlain by dense or cavernous limestone, volcanic rock or laterite, it has been found difficult and/or costly to obtain seismic reflections using standard techniques. These areas may call for the use of a different technique such as the "Thumper" or "Vibroseis". Vibroseis has been used in W.A. with satisfactory results in limestone and lateritic terrain.

The information obtained from drilling could be improved to provide more data of potential significance, for example sonic logs to help in interpretation of seismic records (or velocity surveys where sonic logging is not available); pressure-temperature information from all tests regardless of the nature of the formation fluid (from this the hydrodynamic characters of each sand can be determined and these may indicate areas where prospects of petroleum accumulation are good); water analyses from formation tests; more porosity and permeability determinations on cores; more cores from permeable formations; more stratigraphic control of lithofacies; logging of organic content and of carbonate content of cuttings.

The Papua Basin which for years was the area of most intensive exploration in the Australian region is at present being less actively explored.

The prospects of the basin have been enhanced by the discovery of wet gas in the Miocene and of dry and wet gas in the Cretaceous. The unconformity between the Mesozoic and the Tertiary and the thrust fault established at Puri introduce

problems in exploration but neither the Cretaceous nor the Miocene has been explored completely. The Omati Basin has sedimentary peculiarities that have not been explained and much more exploration is justified in this area.

Following the entry of several experienced American companies into the State, Queensland has been the locale of greatest exploration activity for several years. Marine Permian sediments containing oil and gas have been found in the Surat Basin and oil and gas discoveries have been made in the overlying Mesozoic. So far the subsurface extensions of the Lower Palaeozoic of the Georgina Basin have not been determined. The Mornington Island bores restricted the prospective area of the Carpentaria Basin but examination of the Gulf is continuing.

The discovery of oil and gas at several places in the Bowen Basin and its southward extension has increased the prospects of this basin considerably; the search is now for areas of adequate sand development in or in contact with the Permian marine source rocks. A number of structural drilling targets have been defined. It is evident that the Bowen Basin is a structural basin including only the western part of the original basin of sedimentation.

The emphasis within the Great Artesian Basin has been on the exploration of the pre-Mesozoic rocks; very little attention has been given to the salt-water sands within the marine Cretaceous although these must be rated as definitely prospective. The discovery of Lower Palaeozoic marine sediments at Mootwingee on the margin of the Great Artesian Basin was followed by the discovery of marine Ordovician at Putamurdie and marine Cambrian at Gidgealpa. Gas has been discovered in the Permian at Gidgealpa and oil shows have been reported in the Permian and Cambrian there. Data on the structure of the basin and of pre-Mesozoic basins underlying it are gradually being obtained. The discovery in bores of red-bed sequences below

the Mesozoic has reduced the prospects of the Pre-Mesozoic basins in the east-central area of the basin. The age of these sequences is not well established. Marine Devonian was found in the Adavale Basin and has led to the discovery of gas at Gilmore.

The Wreck Island bore on the western margin of the northern off-shore extension of the Maryborough Basin revealed marine Tertiary sediments overlying basement. This discovery is being followed up by seismic and aeromagnetic surveys of the off-shore area.

In the Sydney Basin, marine fossils have been found in the Narrabeen; several wells have been drilled but none has made a discovery and only three have been drilled completely through the Permian.

A shallow stratigraphic bore at Wentworth (N.S.W.) revealed Permian sediments underlying the Tertiary in the Murray Basin, and several subsequent bores have given information about this basin which is generally shallow but may have some relatively small prospective areas.

In the Gippsland Basin, marine Cretaceous sediments were found by re-examination by the Geological Survey of Victoria of material from the Hollands Landing bore. Several wells have been drilled into the Mesozoic and a show of wet gas obtained in one of them. Aeromagnetic and seismic surveys have indicated the extension offshore of the Gippsland and Otway Basin and have found a new basin - the Bass Basin between Tasmania and Victoria in Bass Strait. Off-shore drilling is expected to start in the Gippsland area late in 1964.

Significant shows of wet gas and condensate have been found in the Otway Basin. Flaxmans Hill No. 1 Well, struck wet gas but on test it produced insufficient quantities for development. The problem is now to locate areas of adequate sand development in contact with the source beds. Submarine seepages of heavy crude have been located off the coast of

south-eastern South Australia. Apart from their adding to the positive indications of petroleum in the basin these seepages are also important as they suggest that, whatever its origin this petroleum is migrating through the Tertiary and may, in favourable locations, form pools in the permeable Tertiary sands.

Little new work has been done lately on the St. Vincent and Torrens Basins.

The stratigraphic bores at Eyre and Gambanga in the Eucla Basin revealed shallow basement: although this confirms the thinness of the prospective sediments in these areas it does not effectively change the prospects of this basin which have always been regarded as low and related to the possibility of a thicker prospective sequence seawards.

The occurrence of marine Triassic sediments and traces of oil in the Permian in stratigraphic bore B.M.R. 10A, Beagle Ridge, and the confirmation of the presence of basement rocks in the Beagle Ridge has provided additional prospective sediments to those already known in the Perth Basin and afforded evidence of large structural relief in the basement. The Beagle Ridge and its flanks would appear to be one of the more important prospective areas in the basin. Deep stratigraphic bores have been drilled in the central area of the Perth Basin at Eneabba and Woolmulla, some gas shows were struck. At Yardarino (40 miles south-east of Geraldton) gas production was discovered in the Permian together with a good show of oil.

In the Carnarvon Basin, additional seismic work south of Rough Range area produced a structural drilling target, drilled at Whaleback 1. Traces of petroleum were reported from the Jurassic. The first deep well into the Palaeozoic, Quail No. 1, has been drilled, but proved dry. B.M.R. stratigraphic bores have shown traces of petroleum in both the Sakmarian Lyons Group and the Artinskian Byro Group and marine sediments and permeable sands in both. Barrow No. 1, on Barrow Island in the northern off-shore extension of the Carnarvon Basin

found gas and oil in the Jurassic.

The Canning Basin is now known to include the deep Fitzroy Basin and at least two basins in the south. The deep basin may be repeated at the east margin of the Canning Basin beyond a structurally high saddle at the south-eastern end of the Fitzroy Basin. This deep basin may continue southward to join with the western end of the Amadeus Basin and the north-western extension of the Officer Basin. The hinge areas on either side of these deep basins and the basement ridges between the shallower basins offer attractive areas for exploration, since Lower Palaeozoic sediments of good permeability have been proved on the Broome Ridge and marine shales in the Samphire Marsh bore. The occurrence of salt intrusions at Frome Rocks No. 1 bore and at Woolnough Hills suggests that salt-dome structure may be found in the Palaeozoic with or without expression in the Mesozoic. Although the pre-Permian has been the main exploration target, oil shows have been obtained in the Permian and it remains a prospect in areas where contemporaneous structures are intact.

The Spirit Hill bore revealed good source rocks in the Carboniferous of the Bonaparte Basin. Bonaparte No. 1 well drilled a thick sequence of Palaeozoic shale with only traces of petroleum and some porous sands.

A regional gravity traverse suggested a moderately deep Palaeozoic basin in the area east of Newcastle Waters in the Barkly Basin, and geological and seismic surveys near Camooweal have established the contemporaneity of the Camooweal Dolomite and the petroliferous Middle Cambrian. B.M.R. is undertaking stratigraphic drilling in this area.

Regional surveys of the Georgina Basin have indicated a marine sequence, dominantely carbonate, of moderate thickness and some structural relief. Sediment appears mainly to be of shelf type but the palaeogeography of the basin of deposition

has not been established; it is evident, however, that it was different from the present structural basins.

It has also been established that the Amadeus Basin, is a structural basin with sediments mainly of shelf type, dominantly terrigenous. It is suggested that the Georgina and Amadeus Basins are the structural remnants of a single large basin of deposition in which the Amadeus Basin represents the proximal shelf, the Georgina Basin the distal shelf or rim, and the Precambrian gneiss of the Harts Range area the location of the deep basin. The Precambrian gneiss shows strong evidence of deep burial and north-south compression at a stage much later than the high-grade metamorphism. The main problem in these two basins is to determine their structural and sedimentational histories so that possible migration directions of petroleum in relation to the development of structures may be assessed. Slight shows of gas and oil were found in the first two wells drilled and a good show of oil was found by B.M.R. in a shallow bore drilled to investigate phosphate. Mereenie No. 1 well discovered large flows of gas in the Ordovician sandstones but had to be plugged. East Mereenie 1 confirmed this discovery.

The net result to date is that there have been some encouraging discoveries, which have led to the development of one oilfield which started producing early in 1964. But there has also been over the past few years, a very significant improvement in the quality as well as the amount of exploration work done and this has resulted in a very large increase in the understanding of the geology of the sedimentary basins. This in turn has increased the prospect of finding petroleum to the point where it is now generally accepted that petroleum will be found in commercial quantities in many of the basins.