

HISTORY OF PETROLEUM EXPLORATION AND DEVELOPMENT

B.J. O'Neil*

Chapter 3

INTRODUCTION

This chapter concentrates on the South Australian portion of the GAB, which contains the Eromanga Basin. Significant developments, some of which had important implications for petroleum exploration and development locally, occurred in the Northern Territory, New South Wales and Queensland and were important in promoting exploration in the South Australian sector of the GAB or in providing direct supporting evidence of the existence of oil or natural gas. For example, the first discovery of natural gas in the GAB was made during water drilling at Roma in Queensland in 1900 and oil was subsequently noted in the Longreach, Queensland town water bore in 1925. Drilling at Mount Arrowsmith in New South Wales on the northeastern edge of the Frome Embayment established the presence of Middle Cambrian sediments in 1965–66 and these correlated with Middle Cambrian sequences in the Flinders Ranges thus indicating that the sedimentation continued across the Frome Embayment. More recently the Jackson (1981) and Inland (1995) discoveries in the Queensland sector of the Eromanga Basin confirmed that the petroleum resources of the basin had a longer term commercially viable future. Likewise, oil and gas discoveries in the South Australian sector of the Cooper Basin stimulated further exploration within and beyond South Australia.^{†1}

A record of the technical advances, changes in engineering or drilling procedures and practices, and revised geological theories or exploration or development concepts have been outlined in several publications.² This chapter refers in passing to some of the political factors at the national and State levels that impacted upon, and had implications for, the success or otherwise of the petroleum search in the Eromanga Basin. For example, the petrol rationing introduced by the Federal Government as a wartime measure in July 1940 was maintained long after the emergency of World War II and was not lifted until February 1950. Rationing highlighted Australia's dependence on overseas fuel supplies and made the necessity to identify local oil deposits increasingly obvious. Later still, the importance of the State's energy needs in the 1970s, emphasised particularly by the oil shortages and world oil prices rises in 1973–74, led the State Government through the Department of Mines to facilitate the exploration, discovery and production of oil and gas. As well, the Department contributed to the State's economy by achieving a resolution of the gas price and supply issues when the Government put arrangements in place to secure energy resources and attract development opportunities. Global factors, such as dramatic events on the world scene and fluctuating oil prices, also affected exploration and production in the region.³

The initial search for oil and gas in South Australia was generally undertaken by individuals or small syndicates and was largely confined to the populated areas or the coastal regions of the South-East. This work was generally neither systematic nor overly scientific in nature. But after World War II larger companies became involved and regional geological investigations focused attention on major sedimentary basins, including the GAB, the Gambier Embayment and the Murray Basin. Nevertheless, large parts of the State were condemned on little or no evidence, such as the prejudice against South Australia's geological potential as an oil and gas province.

The Federal Government began to take an increasing interest in the oil search as a national responsibility. The Commonwealth Oil Advisory Committee (1936–40), which included South Australia's Director of Mines Dr Keith Ward among its members, facilitated geological surveys and drilling operations through subsidies and hiring equipment for committed, modern explorers. Such assistance encouraged higher standards of exploration and reporting, so that companies began to employ more geologists with appropriate skills to focus on the technical aspects of oil exploration.

During the search for oil in South Australia the link between private company endeavours and the Government as facilitator has been notable although the official line — that it was most unlikely that there would be oil in payable quantities in the State — was maintained in the Department of Mines until the evidence proved incontrovertible.⁴ The work of professional geologists in private companies and the Department did much to dispel the doubts but the turnaround in thinking was a long time coming. To be fair, the scepticism about South Australia's commercial oil prospects was based on the scientific observations, interpretations and conventional beliefs of the day. The results of investigations up to the 1940s by the Department, by private prospectors and by companies appeared to justify the negative and cautious terms — 'the least improbable area', 'the prospects are least unfavourable' — about the possibilities for oil. There were no geological indications of commercial deposits of petroleum and time and effort were not to be wasted on a seemingly futile search.

A catalyst for change was the transition of South Australia's economy to an increasingly industrialised one. Sir Thomas Playford (Premier, 1938–65) keenly encouraged secondary industries to the State. One of his continuous themes was the

* MESA

† References are contained in the endnotes at the end of this chapter

need for South Australia to have independent, reliable sources of energy. At first coal was considered to be sufficient but the potential for uranium to supply an atomic energy reactor was established in the immediate post-war period through the Radium Hill Project, the contract for which brought the State into the international energy resource market. But it was the possibility of oil and gas in the State which suggested an alternative to coal.

Playford's view on the need for South Australia to be independent in its energy resources was illustrated by his efforts to have an oil refinery established in Adelaide. During 1958 the Government negotiated with two overseas oil companies through their joint company, the Standard Vacuum Refinery Company (Australia), to build an oil refinery but the construction of Port Stanvac, ~15 km south of Adelaide, did not begin until 1961. The first crude oil was processed at Port Stanvac in March 1963. That and other petroleum products — its major product was fuel — are processed there for the local markets, principally Adelaide and the metropolitan area.

New ideas and concepts, new investigative and explorative techniques, and new strategies in the local oil and gas search were to pay dividends in the 1960s. In harmony with the Playford Government's desires, the Department of Mines was placed in a sound position to promote oil and gas exploration and development. Playford's encouragement and involvement in petroleum exploration and development was unparalleled for a political figure: 'Few other statesmen would risk accompanying geoscientists into little explored country at the earliest stage of petroleum search in order to observe new exploration methods'.⁵ Playford was keen to learn: he always explained this was 'all to the benefit of South Australia'. He comprehended technicalities and detail, helped by a good memory, and he had a high level of understanding. With the exception of 1963 when severe flooding prevented a trip, his annual holidays from 1960 to 1964 included field trips to the northeast region usually in the company of Minister of Mines Sir Lyell McEwin, Director of Mines Tom Barnes, Deputy Director Lee Parkin, Charles Easley (Delhi's Resident Manager) and the Department's Petroleum Geologist, Heli Wopfner. On the 1960 trip the Premier's inspection party visited the Department's seismic survey operations in the northeast and across the recently reconnoitred route from the

Birdsville Track to Oodnadatta and inspected seismic and drilling operations, investigated potential seismic traverses and examined the surface geology of the area.

Such support reflected the great change in attitudes towards the region. To 1954 petroleum exploration in the South Australian sector of the GAB in essence comprised exploratory and stratigraphic drilling based on basic surface mapping, a few limited gravity and magnetic surveys and cursory seismic traverses. The remoteness of the area hindered exploration and the failure of the many artesian drillholes to provide any sign of oil and only some 'shows' of gas suggested that the Eromanga Basin was not a hydrocarbon prospective area.

Drilling in the GAB had been predominantly for water supplies. Therefore most of the drilling stopped short of penetrating the deep, pre-Jurassic strata. Information that was useful for petroleum exploration in the Eromanga Basin in South Australia was first obtained with the drilling of the Patchawarra Bore (total depth (TD) 1664 m) in search of water, on Innamincka Station 55 km north of Innamincka. Completed in September 1914, the drillhole reached the Early Cretaceous Allaru Mudstone but was abandoned before fully penetrating the Cretaceous succession. Water and gas flowed from the Late Cretaceous Winton Formation.

In 1924 Deputy Government Geologist Dr Lockhart Jack carried out surface mapping of northeastern South Australia while investigating additional underground water supplies.⁶ He mapped a fold structure and noted the presence of gentle folds in the Cordillo Downs area. The outcropping Tertiary anticlines, a tantalising piece of evidence, were long overlooked until subsequent mapping in the area in the mid-1950s indicated their significance and relationship to petroleum potential. It was then realised that in targeting artesian water the drilling had concentrated on water courses lying along synclines. Pastoralists searching for water had focused on the watercourses and major river channels where the feed was best. There were an estimated 6000 water drillholes in the GAB by 1958.⁷ Thus specific petroleum targets or structures, such as the Cordillo or Innamincka Domes, had not been subjected to groundwater or stratigraphic drilling.

The Federal Government in the 1930s had attempted to provide for uniform legislation over oil-bearing land and partly in response to this and partly because of McEwin's own desire to establish local oil supplies, the South Australian Parliament revised the legislation over petroleum. Early in his term as Minister of Mines (from 8 August 1939) McEwin concluded that the oil search had to be encouraged despite the Department's lack of faith in the oil search. McEwin was prepared to legislate: the *Mining (Petroleum) Bill* was introduced into Parliament in October 1940 and it passed through both Houses comfortably. It provided for extensive grants of land to companies searching for oil as its basic aim was to increase substantially the area available for oil exploration, prospecting and development while at the same time providing for more secure tenure than companies had previously been given. The *Mining (Prospecting for Oil)*



Simpson Desert party (after crossing near Warrina Siding), July 1960. From left: kneeling, Lee Parkin (Deputy Director of Mines) and Jack Whitford (Engineering and Water Supply Department (EWS)); standing, John Rattus (Mines Department), Warren Bonython (explorer, in profile), Jack Clark (News), Lawson Glossop (Advertiser), Charles Easley (Delhi), Tom Barnes (Director of Mines), EWS worker (not with party), Premier Playford, EWS worker (not with party) and Laurie Steel (EWS). (Courtesy of Heli Wopfner; Photo 42140.)

Act 1928 had limited the area for oil prospecting to a maximum of 65 km² for each permit holder, either directly or indirectly, for up to two years and required permit holders each year to either spend at least £1000 or to drill at least 305 m. The new Act provided for exploration, prospecting and production by way of: an oil exploration licence (OEL) for areas not less than 2590 km² or more than 25 900 km² for two years, with the right of renewal; an oil prospecting licence (OPL) for areas between 21 and 518 km² for up to four years; and an oil mining licence for areas between 10 and 259 km² for up to 21 years. The legislation also asserted the Crown prerogative over petroleum, even where a previous alienation of land had provided for private ownership rights. In addition, a royalty of 10% of the selling value of any crude oil produced from the licence area was payable to the State.

South Australia's geology and geography necessitated generous concessions to attract explorers and developers and ahead of anywhere else in Australia the new legislation made available huge areas of the State to encourage companies to explore for oil. Only by issuing licences on very favourable terms could the State Government attract large companies and overseas interests to invest in oil and natural gas exploration. The *Mining (Petroleum) Act 1940* came into effect on 31 July 1941 but its impact on petroleum searches was thwarted by World War II. Although some exploration was undertaken it was only after the war that the Act's effectiveness became apparent when several companies were attracted to explore in the State. The Act stimulated some company interest but practical results did not follow immediately.

EXPLORING THE FROME EMBAYMENT

The Eromanga Basin forms part of the GAB, which first attracted serious attention during World War II. The remoteness of the GAB and its lack of signs of oil seeps made it seem an unlikely source of oil and gas. Besides, the costs of exploration and development in those early days were prohibitive for such a distant and unpromising area.

Some in the private sector remained hopeful of finding oil and gas and one company decision of direct importance to the State was Zinc Corporation Ltd's exploratory work in the Frome Embayment.⁸ Zinc Corporation, which operated mines and a mill at Broken Hill, wanted to find commercial supplies of natural gas to substitute for the imported fuel oil which had to be brought from Adelaide. The outbreak of World War II accentuated the chronic fuel shortages, particularly of coal, facing South Australia and the Zinc Corporation took steps to secure its own independent fuel supply. In 1940 the company commissioned J.P. De Verteuil to report on the petroleum potential of northeast South Australia and adjoining States. He reported negatively on the geological aspects of discovering petroleum in the region.⁹ However, small quantities of natural gas had been reported from several widely separated artesian water bores in the Frome Embayment. The company's plan for a geological examination of the area included examining the regional geology, studying the water drillhole logs, undertaking a gravity and magnetometer survey and testing using modern drilling equipment.

Few outcrops were known to exist in the area and the regional geological study was limited to the flanks of the

embayment and studying the available drillhole logs. A reported gas blow-out in a drillhole on the Joulmie anticline about 130 km northwest of Broken Hill aroused the Zinc Corporation's interest in the possibility of oil and gas in the embayment as did some other water drillholes allegedly showing definite signs of gas. But the earlier drillhole logs were unreliable as they consisted largely of the remarks of drillers and others who did not possess the relevant geological training or experience and who were mainly interested in finding artesian water supplies.

When the discovery of an oil substance in the vicinity of Lake Frome was reported in State Parliament on 5 November 1941, the Department of Mines was criticised for its negative attitude on the oil issue. But even the evidence from this find was not encouraging. South Australia's potential for oil discoveries continued to be officially and privately disparaged, which was surprising given that the Government was committed to the search for oil. The Department then lacked the expertise to investigate oil properly: for example, no petroleum geologists were employed and there was no-one with any specific oilfield experience.

The introduction of specialists and advisers with expertise in new exploration techniques, such as improved drilling standards and equipment (stratigraphic drilling and percussion drilling replacing cable tool drilling), geophysics (seismic, gravity and aeromagnetic surveys) and theoretical constructs for investigating structures rather than deposits (as the oil search demanded), was critical to the search after World War II. Evidence of the new approach was seen in the efforts of the Zinc Corporation, in conjunction with the Bureau of Mineral Resources (BMR), in the Frome Embayment from 1946.

W.S. Robinson of the Zinc Corporation is attributed as a catalyst for action in the post-World War II period with the support of key staff including A.J. Keast and Maurie Mawby. Mawby's confidential report in 1944 drew attention to the gas detected in artesian water bores in the Frome Embayment and this was followed by a report by N. Osborne in the next year which reasoned that oil in the region was a remote prospect but that the likelihood of there being natural gas justified exploratory drilling.¹⁰ The first OEL granted under the *Mining (Petroleum) Act 1940* was east of Lake Frome to the New South Wales border and covered an area of 10 360 km² in the southern part of the GAB in the area known as the 'Frome Basin' (Frome Embayment). OEL 1 was granted to Keast on behalf of Zinc Corporation in April 1945. The company then requested the State Government to increase its mapping activities in the area and at Leigh Creek.¹¹ Some artesian water bores north and east of Lake Frome indicated gas: for example, the Quinyambie New Homestead Bore, completed in 1945, revealed gas at the southern margin of the GAB near the South Australia – New South Wales border.

OEL 1 was surrendered in April 1946 and OEL 2 was granted over the same and an additional area to Keast on behalf of Zinc Corporation at the same time. OEL 2 (18 518 km²) extended further west and north than the original licence and was taken up on 1 April 1946 for a term of two years. The company then commenced geological surveying in the Frome Embayment. At the request of the State Government the Federal Government, through the BMR, provided a magnetic and gravity survey crew to obtain readings in the area from November 1946 until mid-1947.

These were the first magnetic and gravity surveys carried out in the Eromanga Basin area of South Australia and the BMR also conducted a detailed gravity survey over the Joulmie anticline in western New South Wales (Fig. 3.1). The Federal geophysical party was provided to Zinc Corporation without cost in an effort to encourage the further exploration of Australia's natural resources. The BMR played a critical role in developing structured programs of geological surveying for petroleum, even though there was resistance from most of the States to the BMR encroaching on what was considered to be States' rights.

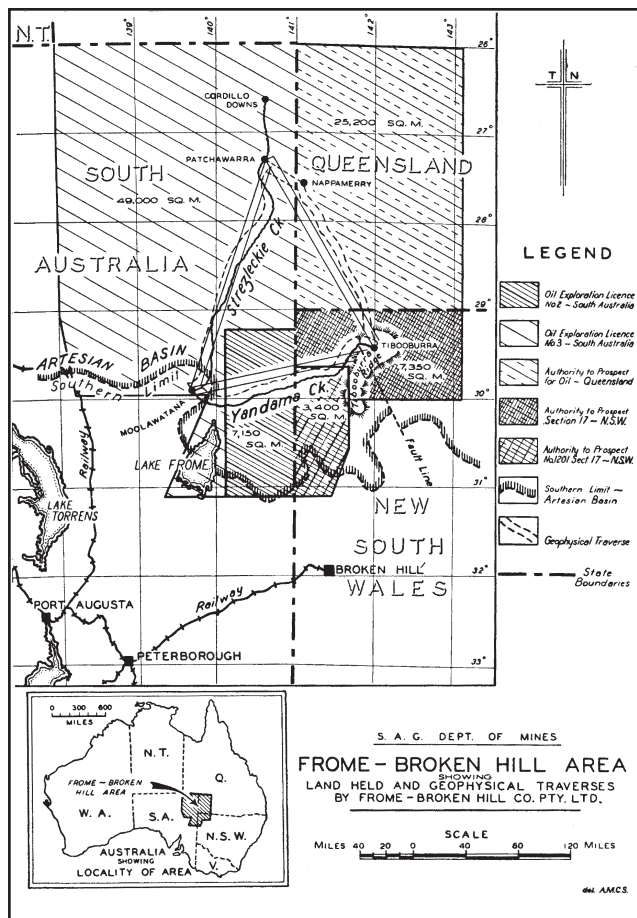


Fig. 3.1 The areas held by Frome-Broken Hill in South Australia (OELs 2 and 3) and interstate and its geophysical traverses, as at 30.11.47. (Mining Review No. 87.)

In January 1947 Mawby on behalf of the Australian Mining and Smelting Co. Ltd (an associate of Zinc Corporation) was granted OEL 3 for two years over 126 910 km² of the northeast corner of South Australia, covering the area of the now known Cooper and Eromanga Basins petroleum discoveries. During that year two gravity and magnetic survey crews working for Zinc Corporation under the direction of a geophysicist in New York, B. Sauv , undertook a regional reconnaissance survey over a large triangular area from near Tibooburra in New South Wales to the Patchawarra Bore and 'Moolawatana' in South Australia.¹² This survey traversed 38 200 km² of the Frome Embayment between the Flinders and the Barrier Ranges and 240 km northwards into the southern GAB area of OELs 2 and 3. The aim of the survey was to locate areas in the Frome Embayment and the GAB with structural features which could trap natural gas and/or oil. Two parallel widely spaced gravity-magnetic lines, 8 km apart, traversed the area

east-west and north-south from May to November 1947 after surveying work which had commenced in September 1946. The Federal Government commenced the work but the BMR personnel were withdrawn in June 1947. The stations on each side of the triangle were located 3.2 km apart though some along the South Australia - New South Wales border from Hawker's Gate to New Quinyambie Station were 1.6 km apart. The gravity anomaly immediately south of the Patchawarra Bore (Patchawarra Maximum) was considered unique in that it was not reflected as a magnetic minimum in the magnetic data in the area and it was considered worthy of further exploration. As a result, it was recommended that a seismograph party be brought to the region for two months to shoot refraction profiles along this anomaly to determine the thickness of the sedimentary section.¹³ The area of the outcropping Innamincka Dome (a gravity high, 80 km long by 24 km wide) was included in the survey. Another high was detected at Cordillo where a large anticlinorium was subsequently exposed. The southern Frome Embayment was considered unsuitable for petroleum exploration due to the lack of a thick sedimentary section.

In December 1947 Mawby wrote a personal letter to the Director of Mines, Ben Dickinson, to explain part of his interest in the region:

Mr. W.S. Robinson has on several occasions spoken of extending our present gas areas 'from Tarcoola to the Western edge of our present Licences and North to Alice Springs'. He has, however, stated that 'I don't profess to be a geologist, geophysicist, or any other type of expert, but I'll bet there is as good a chance for the location of the 'marine series' of sedimentaries there as there is anywhere else in Australia'.

Please treat this as confidential but I feel that it is up to me to reply to his very general statement or hunch. I know the general structure over this area from David's maps and also those of Lockhart Jack in your departmental Bulletins, but I was wondering whether you could have someone in your Department draw up some sections east-west and north-south to illustrate the present conception of the structure underlying this area. No detail is necessary but just a general idea so that I may enlarge on the subject when I meet him early in January.

Please do not take this seriously but anything you could do would be appreciated.¹⁴



Visiting geologist Dr Frank Reeves' party at Balcanoona during the 1948 inspection for Cambrian sediments and petroleum prospects in the Lake Frome area: Reg Sprigg and Frank Reeves (second and third left) and Ben Dickinson (second right). (Photo 2887)

In the same month OELs 2 and 3 were transferred to the Frome-Broken Hill Co. Pty Ltd (an equal partnership of Zinc Corporation, Vacuum Oil Co. Pty Ltd and D'Arcy Exploration Co. Ltd – a subsidiary of the Anglo-Iranian Oil Co. Ltd) which was formed in that September so that Zinc Corporation could introduce international expertise and assistance to the petroleum search. Frome-Broken Hill's interests also extended to Queensland, Western Australia, Victoria and the Northern Territory. In January 1948 Frank Reeves, Frome-Broken Hill's consultant geologist, Dr E. Lehner, Anglo-Iranian Oil's consultant geologist, and H.J. Evans of Frome Broken-Hill were joined by Reg Sprigg and Ben Dickinson of the Mines Department on the company's field reconnaissance of parts of the Cambrian basins in the Flinders Ranges.¹⁵ The consultants were impressed by the Cambrian limestone of the region, as limestone was known to be an oil source in other parts of the world. They also considered it important to determine the existence or otherwise of Cambrian rocks underlying the Frome Embayment so as to establish the margins of the Cambrian basin. Reeves wanted an examination made of 'bedrock outcrops' in the Frome Embayment to assist in determining the possibility of oil or gas sources in the GAB. Dickinson explained that the Department was unable to assist Frome-Broken Hill undertake that work then. In subsequent correspondence Reeves stated that more attention should be given to the oil prospects of the lower Palaeozoic in central Australia but after examining information and reports supplied to him by the Department he concluded that the only area of Cambrian offering oil prospects would be the Cretaceous-covered areas south and east of the Barkly Tableland, Queensland, if the Cambrian did exist there.

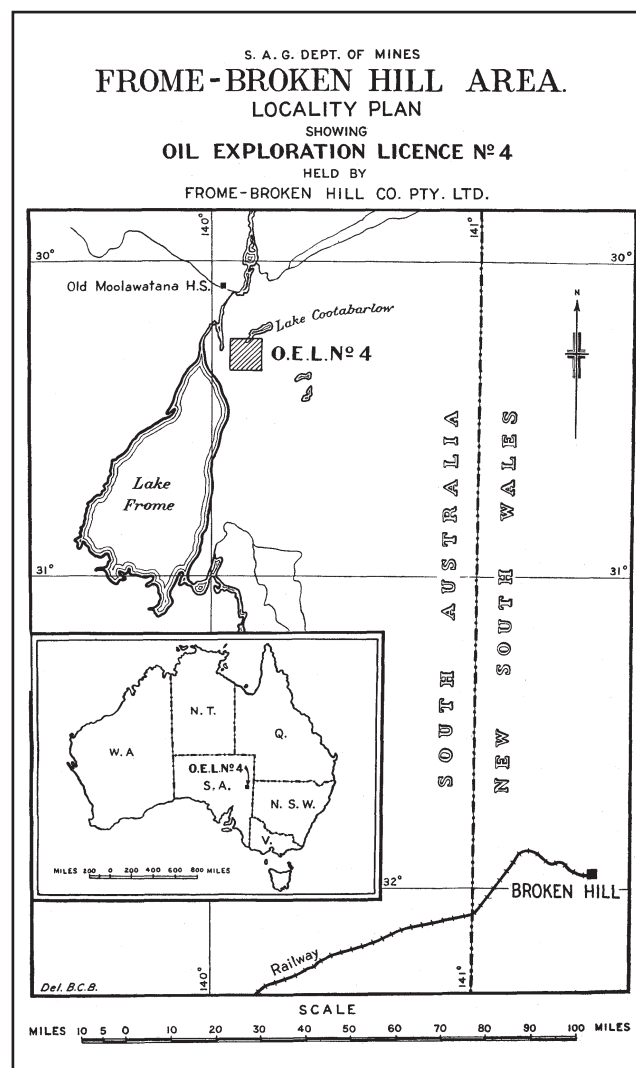
OEL 3 was reissued to Frome-Broken Hill in June 1948 by which time the results of the previous exploration program had been studied by Standard Vacuum's geologists and geophysicists in New York.¹⁶ Frome-Broken Hill then applied for an OPL (Fig. 3.2). In November 1948 OPL 4 covering 130 km² northeast of Lake Frome and near Lake Cootabarlow in the northern Frome Embayment was granted to the company to drill through the sedimentary section to basement (estimated at ~1430 m). The aims were to identify the stratigraphic sequence of the rocks, to test their suitability for oil storage and possible gas accumulations in that part of the GAB.

Zinc Corporation imported a Sullivan 300A rotary rig with a nominal 915 m (actual 1067 m) depth capacity to drill its stratigraphic drillholes. However, the first hole drilled, by a Zinc Corporation subsidiary Enterprise Exploration Ltd, was for a Zinc Corporation – State Government joint venture which had a primary objective of finding artesian water and a secondary objective of penetrating the Jurassic sands to test the potential for oil and gas.¹⁷ The State Government contributed £10 245 as a portion of the cost.¹⁸ In June 1948 a planned 1220 m drillhole was commenced at Kopperamanna on the Birdsville Track, to replace the 914 m drillhole completed between 1906 and 1908 about 1 km from the new site. Drilling was abandoned at 992 m due to the loss of tools. The drilling of a deviated hole from January 1949 from 875 m enabled the drillhole to be completed as an artesian bore but the search for oil and gas-bearing strata was abandoned in March.

Fig. 3.2 Locality map of OPL 4 (erroneously labelled OEL 4) held by Frome-Broken Hill, the first OPL for the Eromanga Basin. (Mining Review No. 88.)

Kopperamanna was the first of six drillholes sunk by Enterprise Exploration for natural gas in the GAB. Enterprise Exploration's stratigraphic drilling in OPL 4 commenced in 1949 and resulted in the Cootabarlow 1 (TD 437 m), Cootabarlow 2 (TD 492 m) and Cootabarlow 3 (two flagons of gas contained methane) water drillholes. Drilling was completed in November 1949 and OPL 4 was surrendered immediately.¹⁹ The drill logs and samples sent to the Department showed no indications of oil or commercial quantities of gas and the company could not justify further work in either OPL 4 or the area generally. Other drillholes by Enterprise Exploration were Tilcha 2 (TD 717 m) and Lakeside Bore 1 (TD 328 m).²⁰

Although its partners in Frome-Broken Hill withdrew from the area, Zinc Corporation continued the work as it wanted to test the GAB thoroughly. Standard Vacuum geologists recommended the company continue drilling near Lake Cootabarlow. They also stressed that magnetic and gravity surveys would not determine the type of structures being searched for and that refraction seismic surveys were needed to delineate the structure in detail. However, the BMR's seismic team was fully occupied until mid-1951. The Zinc Corporation's imported drilling rig was offered for sale in April 1951: its six bores had detected methane and artesian water but the geological and geophysical data generated did not reveal reservoirs or structures to encourage the company to keep drilling. The company then surrendered the licence.



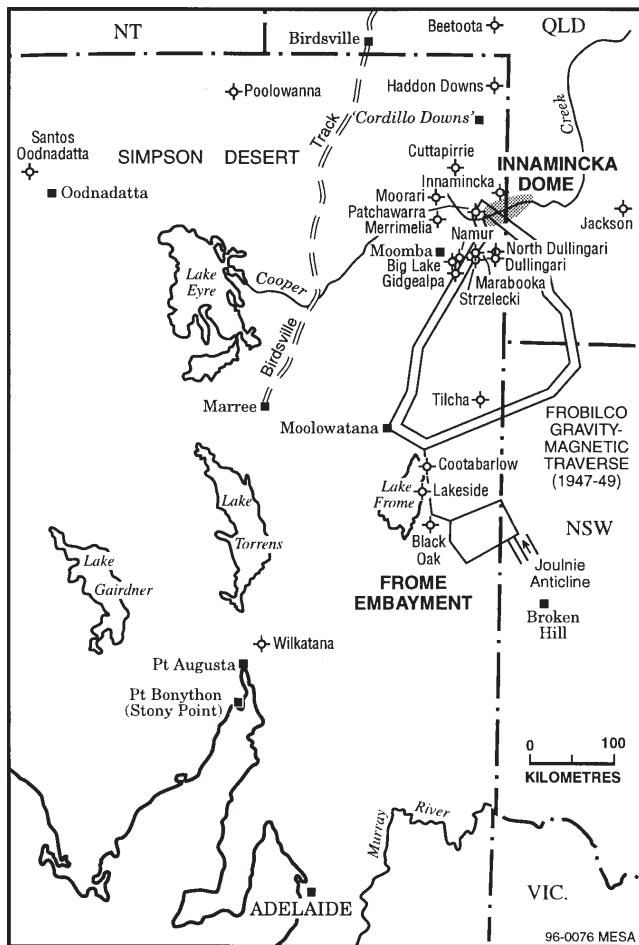


Fig. 3.3 Map of areas and some of the key locations and drillholes referred to in the text.

By 1951 the Lake Frome area was considered to have been investigated thoroughly and the geological structure determined (Fig. 3.3). Though dry gas had been reported in several drillholes in the Frome Embayment in association with water, the prospects of finding commercial oil were rated low and no shows of oil had been noted from drillholes or seeps in the region.²¹ Following the discovery of oil at Rough Range in Western Australia in early November 1953, in December Australian Mining and Smelting was granted OEL 6 over the Frome Embayment and northeastern South Australia for two years from January 1954. The area of ~145 230 km² covered the earlier OELs 2 and 3. After re-examining the previous geophysical and geological results Australian Mining and Smelting abandoned OEL 6 in December 1954 'for lack of surface structure'.²²

We know that most of the artesian bores in this area yield inflammable gas at the same horizon as the artesian water is encountered and several bores drilled by our subsidiary, Enterprise Exploration Co. Pty. Ltd., in this area some years ago proved the continuance of this gaseous horizon further south than was originally believed. Our hopes were that the geophysical examination may disclose the presence of a domal structure capable of acting as a gas reservoir but evidently this hope is too optimistic.²³

The interpretation provided by Standard Vacuum's Chief Geophysicist, Dr M.M. Slotnick, confirmed the previous

assessment: the Frome Embayment was considered very shallow with thin Cambrian sediments overlying base level Precambrian rocks.

SANTOS AND PARTNERS: EARLY TRIALS AND TRIBULATIONS

With the passage of time the importance of Australia having a domestic supply of oil and gas became even more critical than it had been prior to and during World War II. Between 1946 and 1953 petroleum exploration in the Murray Basin of the Upper South-East and in the GAB amounted to about 18 months geological survey work and 28 months of geophysical work, and drilling in the Frome Embayment area. The sparse post-war geological, geophysical and drilling exploration indicated that the GAB contained a well-developed series of folds and domes. The incentive offered by Rough Range and then the formation of Geosurveys and Santos in 1954 were important stimulants to petroleum exploration locally and brought a revised approach to exploration thinking. The Suez crisis, which peaked in January 1957, added to the national importance of the oil search. However, during that year only 20 holes were drilled for oil in Australia. But it was the oil and gas discoveries elsewhere in Australia that sustained interest in, and hopes for, the local search.

The cause of oil exploration within South Australia was taken up by a new company in March 1954 when Santos Ltd — from the acronym for South Australian Northern Territory Oil Search — was incorporated. The idea to found Santos came through a meeting of like-minds. John Bonython and Robert Bristowe, whose acquaintance stretched back to their schooldays, carried with them personal observations about the possibility for oil in South Australia. Bonython had not forgotten the view expressed by a grand-uncle that oil would be found in the GAB, if at all, in Australia. Bristowe had flown over this terrain on trips to and from Darwin and he found it interesting that the country was similar to the oil-bearing regions he had observed when flying between Persia (Iran) and Moscow in his role as a King's Messenger. Bristowe's layman's view of the existence of oil is, of course, far too simplistic: the surface cover above concealed the oil below. Nevertheless, as is often the case, the interpretation of the likelihood of oil based on geographical features had a practical consequence. Bristowe and Bonython pooled their ideas in 1954, studied relevant literature in the Public Library and turned to the University of Adelaide for further advice. Martin Glaessner of the Geology Department referred them to Reg Sprigg in the Department of Mines.

Sprigg's open-mindedness about the possibility of oil in South Australia had already led him into serious conflict with his Director, Ben Dickinson. In 1952 he had tried to persuade Dickinson to allow him to undertake an assessment of the petroleum prospects of the GAB but the Director refused. Sprigg's earlier interest in oil and in Frome-Broken Hill's investigations had been stimulated further through his work with a Russian hydrogeologist in the Department:

[Ivan Chebotarev] was very interested in taking a basin like the GAB and trying to characterise the geochemistry of the waters and things like this. I got him to think about geothermal gradients, which I was interested in ... We were working over all the old records of bores and things

and he just happened to say to me one day, 'You know, in Russia we would be very interested in some of these waters, petroleum-wise. We reckon we can tell whether there has been oil ... or whether the oils are migrating.' ... he never got it down in writing but he got [over] a lot of parallel [ideas] ... But he used to say, 'If I was looking for oil in this State, I would be looking at the northeast corner. That is where you should be looking.'²⁴

The request for information from Bonython and Bristowe was the catalyst for Sprigg to resign from the Department in late February 1954 when he set up his own exploration company, Geosurveys of Australia Pty Ltd. Geosurveys was registered less than a week before Santos was incorporated. They were not the only companies interested in 'the good oil': five OELs were issued in 1954 compared with the same number in the previous 14 years and more than half the State was held under licence.

Sprigg's resignation was an unexpected outcome of the Department's earlier intransigence on the oil question. The State ultimately benefited. Geosurveys and Santos aspired to acquire all of the northeast they could for the long-term. In March 1954 Robert Bristowe was granted OEL 7 for two years, an area of 312 095 km², and in September 1954 this was transferred to Santos. The licence initially adjoined OEL 6 but when Australian Mining and Smelting surrendered OEL 6 in December 1954 Santos applied successfully to have the area included in OEL 7. Sprigg recalled: 'It was a funny business ... we badly wanted the northeast corner. [Mawby] rang me on a Friday afternoon and said, 'We are giving it up. I promised to let you know. It is all yours if you want it.'²⁵ The area then totalled 507 397 km².

Santos and Geosurveys first became involved in an investigation of minor oil showings in artesian water bores at

Wilkatana, north of Port Augusta. While Santos intended to concentrate on the Wilkatana area, Sprigg's interests lay elsewhere. In the short-term Sprigg went along with Santos, and with Bonython and Bristowe he visited Wilkatana where they noted spots of oil on a water bore. Santos was then floated as a public company on the Stock Exchange and first trading began in February 1955.²⁶

The stand of the Department against the possibility of finding substantial deposits of oil and gas in South Australia made it a reluctant partner in the initial searches. Director Dickinson 'didn't have much faith in finding natural gas' and continued to restrict Sprigg's efforts in pushing the Department towards petroleum exploration.²⁷ Given Dickinson's scepticism about the petroleum potential, the eventual discovery of oil and gas in commercial quantities came as a surprise. His capitulation had perhaps begun when Frome-Broken Hill began exploring the Frome Embayment and asked the Department for advice: 'That is when I felt that we should become involved in geophysical work. It was the best we could do in that sense'.²⁸

Although opposed to the likelihood of oil and gas, Dickinson finally oversaw the introduction of geophysical techniques and the move to seismic work. By the mid-1950s the Department of Mines contributed more actively to the local efforts. During his trip to London for the Queen's coronation in 1953, Premier Playford saw seismic crews in operation in America and the success that had been obtained through seismic exploration work. He decided that South Australia should run its own seismic surveys, rather than rely on the services of the BMR, then the only seismic operation in Australia. There were no contract crews in Australia and this further stimulated Playford to approve the purchase of the expensive equipment plus the capital expenditure for the camping equipment.

Soon after commencing seismic activities in 1955 the Department expanded its role in geophysics and implemented important regional geological mapping, aerial photograph and geophysical survey programs, which provided great assistance to oil exploration companies over the long term. But it took some time to build up this expertise. The Department was contracted to conduct seismic surveys in the Wilkatana region for Santos in 1955, but commercial success did not follow from the exploratory drilling of 24 holes which recovered oil but not in economic quantities. However, the drilling at Wilkatana in 1955 attracted much interest especially from Premier Playford and Minister McEwin, who were enthusiastic about resource development. This then required a shift in thinking by key personnel in the Department: if the Premier wanted oil found then there would have to be a very good excuse for it not to be!

The visit of the world-renowned American petroleum geologist Dr A.I. Levorsen (of Tulsa, Oklahoma) to Australia early in 1957 at the invitation of John Bonython proved vital in promoting further petroleum searches in the country. He investigated the Santos holdings at Wilkatana, in the western GAB and other Cambrian areas. Levorsen was not overly impressed by Wilkatana and reputedly remarked that the area had potential for 'Fords and Chevies' but that the 'Cadillacs and champagne' were further north.²⁹ He recommended that Santos increase its holdings and focus its attention to the northeast, even extending into southwestern Queensland. His

OIL! ★ OIL!

PUBLIC LECTURE

SANTOS

Operations at Wilkatana and Throughout Australia

Port Augusta Town Hall

Thursday, 6th December, 1955

SPEAKERS :
Messrs J. Bonython and R. C. Sprigg

COLOUR MOVIE FILMS

You are Especially Invited. Admission Free.

6 -12 - 1955

Stimulating public interest in the good oil.

positive and public support for the likelihood of oil in that huge region where Santos had been reluctant to explore, despite Sprigg's suggestions to do so, provided fresh impetus to the oil search.

In addition, Levorsen suggested that the Federal and State Governments encourage the petroleum industry by offering subsidies for exploration and by implementing geophysical surveys.³⁰ He urged the Federal Government to subsidise stratigraphic drilling in any approved Australian basin area on a £ for £ basis. While South Australia had encouraged the search for oil through its legislation and an earlier bonus scheme (despite the Department's doubts), acting on Levorsen's recommendation the Federal Government introduced the Petroleum Search Subsidy Scheme through its *Petroleum Search Subsidy Act 1957* under which stratigraphic drilling by private companies in some sedimentary basins was subsidised to the tune of £500 000 initially and then £1 million from 1959, when a second Act allowed for subsidies for geophysical work. The Federal Government also provided taxation concessions for investors in oil search companies and for the companies themselves.

Not only did Levorsen contribute his geological expertise to the search, but he also showed his business acumen by introducing Santos to the Delhi-Taylor Oil Corporation (later Delhi International) of Dallas, Texas. The nature of the oil search, the size of the State and the limited geological knowledge about oil fully taxed Santos. Levorsen realised that Santos lacked the resources and finance to explore properly and he saw the need for Santos to obtain the financial backing and petroleum industry expertise that an American oil company could provide. When Delhi agreed to join Santos in the search for oil, the arrangement was for Delhi to be the operator of the geophysical and geological work, to drill two deep drillholes, one in South Australia and one in Queensland, and to acquire a 50% interest in a geological, seismic and drilling program and spend at least £2 million over the ensuing four years. Delhi was obliged to open an office in Adelaide. Delhi-Santos, as the combination became, then pursued the search, always more in hope than with definitive results for much of the next decade.

The partnership also looked for extra financial assistance: Frome-Broken Hill's earlier lack of success in South Australia had not deterred its hopes for oil and the company joined Delhi-Santos as an equal partner in 1959 before the spudding of the first drillhole in the Cooper Basin. This method of a licensee 'farming-out' areas to others prepared to 'farmin' to a joint arrangement was legislated for by amendments to the Mining (Petroleum) Act 1940 in 1958, which also allowed the creation of a checkerboard system through which the licence areas could be divided into areas of 2435 km² apiece so that other companies could join in the search. The time for working the new blocks was extended from one to five years. Frome-Broken Hill's farmin agreement was a temporary one under which it was to pay for the drilling of three drillholes in South Australia and Queensland to earn a third interest in OELs 6 and 7.

Geosurveys made gravity observations in the Oodnadatta area on the western margin of the GAB in 1955.

The company undertook reconnaissance gravity and magnetic surveys between Birdsville and Marree and north of Cordillo Downs for Santos in June and July 1956. This was northwest of the area of ~38 850 km² surveyed by Frome-Broken Hill in 1947-48. In 1956 a Geosurveys' geologist, Heli Wopfner, mapped some large structures near Oodnadatta and Jack's observations of 1924 were again recalled. Sprigg had continued to ponder the possibilities that might lie further north of Wilkatana and he sent Wopfner and Rudi Brunnschweiler, another of Geosurveys' overseas recruits, to investigate outcropping anticlines in the GAB. During a ground and air reconnaissance survey in the northeast in March and April 1957, Wopfner mapped fold deformations in the GAB in the Cordillo Downs to Innamincka area, similar to the anticlinal structures noted by Jack in 1924.

Likely surface structures were now evident and the aerial mapping by Wopfner and Brunnschweiler produced the first structure contour map of any part of the GAB, and added several other anticlinal structures to the one noted by Jack. The clandestine nature of the operation was necessary because of Santos's reluctance to follow Sprigg's desire to check the area. The anticlinal structures identified and the basic stratigraphic subdivision of the Jurassic-Cretaceous sediment succession in the western GAB were encouraging signs for further oil exploration. Wopfner identified and mapped the major structures from Innamincka to Morney in Queensland within two weeks of the Cordillo Downs exercise commencing.

After the drilling of Santos Oodnadatta 1 in the western GAB, 16 km north-northwest of Oodnadatta, (spudded May 1957, completed August, TD 403 m with six shows of oil being detected between 60 and 284 m), a reconnaissance seismic survey north of Oodnadatta by the BMR late in 1957 confirmed the existence of the structures identified by Wopfner. The BMR seismic survey between Cordillo Downs and Oodnadatta was the first such survey in the western GAB: geophysical surveys prior to this had been gravity and magnetometer only. Santos extended the Frome-Broken Hill 1947 triangular traverse and completed the Marree-Birdsville section and linked up with its Cordillo Downs Station survey line. As well, on behalf of Santos, Geosurveys drilled five shallow stratigraphic petroleum holes 13 km northeast of Haddon Downs in the Cordillo Downs area between October 1957 and January 1958. The deepest reached 458 m but only water was detected.

A departmental seismic operation in the Innamincka area and into southwest Queensland was undertaken from August 1958 to May 1959. This was on a recharge basis with Delhi reimbursing the Department. Premier Playford had acceded to Delhi's request to improve and expand the seismic equipment and operations prior to this survey and 'the Government seismic survey team was then regarded as equal to the best anywhere'.³¹ In 1958 Geosurveys purchased seismic equipment to undertake contract work for Delhi. Meanwhile, the Department supplied the technical staff, seismic equipment, caravans and two drills while Geosurveys provided non-technical services, carrying facilities including double-decker buses, a drill and other equipment. The preliminary investigations

conducted by the Department were in largely unknown areas and thus placed it at the forefront of exploration. In these sand covered areas geophysical techniques, such as general reconnaissance seismic surveys, could reveal indications of the geological structures below the surface in general over large areas.



General view of the Innamincka camp in 1958. (Photo 10229)

The extensive seismic surveys by the Department and surface mapping of the Innamincka Dome further aroused Delhi's interest and in December 1958 the company sent four geologists and geophysicists to inspect the anticlinal structures that Wopfner had investigated at Innamincka. It was then that Delhi-Taylor agreed to become Santos's partner. A drill site was selected at Innamincka after Sprigg and Wopfner led an inspection party along the Strzelecki Creek in 1958.

At the end of March 1959 the National 130 rig which had drilled Rough Range 1 was used by the Delta Drilling Co. to drill Innamincka 1. This was not only the first drillhole in the Cooper region but it was also the first to penetrate the full Eromanga Basin sequence in the Moomba area and the first recognition of the Permian Cooper Basin as it discovered a coaly Permian sequence containing gas shows below the Eromanga Basin. Wopfner, then representing Santos there, countersigned the daily reports and sent coded information to John Bonython to inform him independently of the progress.³² Playford and McEwin visited the site several times, for the pegging ceremony in February and in July and August.

The experienced Departmental palaeontologist, Dr Nell Ludbrook, was called upon in the great oil search thus demonstrating the practical applications of palaeontology. She described the excitement of the times with the drilling of this wildcat oil drillhole:

We knew the Artesian Basin very well. We knew that we went through all these Cretaceous shales and mudstones and aquicludes and then we reached a water-bearing sandstone (which was considered to be of Jurassic age) called the Blythesdale Sandstone. Innamincka was located on an anticlinal, a domal, structure. Theoretically oil rises: if you put a drillhole down at the top of the dome you should hit the oil that is in the top ... But not long before, Wapet had drilled Rough Range 1 and they did hit oil at the top of the Rough Range anticline and they took out all that was there ... we drilled Innamincka and thought that we would strike oil at the top. We didn't

strike anything and we went through the clays and mudstones and shales. We struck the sandstone and hit the water, we had water but no oil, and so they decided to drill on.

The only person in the Department who had any connection with drilling for oil was me and I was only connected through the micropalaeontology and so all cores from this drillhole used to come into my room ... and some of them were 4-inch diameter cores, so my room was always full of boxes of core. I used to tell them where they were in the drill ... Delhi thought this was marvellous. I could say to them, 'Well, you haven't hit bedrock yet, just drill on and see what's below.'³³

Innamincka 1, 35 km northeast of Innamincka, was completed in November 1959 after reaching a depth of 3852 m in moderately dipping Ordovician beds. It revealed thin Permian sediments beneath a thin Mesozoic sequence and confirmed the presence of folded but unmetamorphosed middle Palaeozoic and Triassic sediments and Ordovician strata. Oil and gas prospectivity was suggested by the hydrocarbon shows in the sediments of the Permian basin below the GAB: during the eight months of drilling, 35 cores were taken and 10 drillstem tests (DSTs) were run which provided evidence of some gas with water in the Permian, Hutton Sandstone, Mooga (Namur) Sandstone and the Transition beds (Cadna-owie Formation). The water in the Mesozoic and the hydrocarbon prospectivity of the Permo-Triassic sequence encouraged further exploration.

In 1960 the Department participated in drilling Betoota 1 in Queensland although the operation was beyond the State border. That drillhole went through the same sequence as at Innamincka but on the flank of a structure and it ran into a conglomerate so the drillhole was stopped. Frome-Broken Hill withdrew from the farmout arrangement with Delhi-Santos after Betoota 1 was drilled.

THE BREAKTHROUGH AND INTO THE 1960s

Discoveries of oil and gas further afield — at Moonie (1961) and Alton and Conloi (1964) in Queensland, at Mereenie in Northern Territory (1964), at Barrow Island, Western Australia (1965) and offshore Victoria in the Bass Strait (1965) — continued to encourage speculators, investors and companies around the country. The general mineral boom of the 1960s brought many overseas and Australian companies, including Santos, Delhi, Western Mining, Alliance, Geosurveys, Bridge Oil, French Petroleum and Total, onto the petroleum scene. For example, caught up in the excitement of it all, Reg Sprigg became involved in company formation and promotion: with others he had launched the oil and gas exploration company Beach Petroleum in 1960 and later held licences in the Northern Territory sector of the Eromanga Basin. In 1962 Hubert Harvey (a Santos director since 1957) arranged for Total Exploration, a subsidiary of the French Petroleum Company (Australia) Pty Ltd to inject £800 000 into Delhi-Santos by purchasing one million shares. More foreign and interstate capital came to the fore after the discovery of gas at Gidgealpa: Burmah Oil, for example, joined in the search in 1965. The Government readily acknowledged that foreign capital and

imported technology and expertise were necessary if oil and gas were to be discovered.

Reflecting the growth of new technologies and exploration strategies in the industry, a Seismic Geophysics Section was formed in the Department of Mines in October 1960 to focus on 'soft rocks' for petroleum exploration. Departmental geophysicists worked in the vicinity of Birdsville in the GAB from July to November 1960. In this period work was carried out at Durham Downs and Innamincka Dome for Delhi (with the company contributing minimal financial support). Senior Geophysicist Ken Seedsman went to the United States of America, Central America, France, West Germany and Libya from February to October 1961 to study new seismic methods and techniques. Meanwhile the field party was sent to continue seismic shooting from Birdsville to Marree at the end of May. The local search received further encouragement with the news in December 1961 of the discovery and commercial potential of the Moonie oilfield in Queensland: Australia's first production of oil in commercial quantities began there in 1964.³⁴

During those exciting evolutionary years the Department had a secure market for its services but the financial situation developed to the stage where the Department could not justify the expense of undertaking work which contract seismic crews could have been doing at that stage of exploration. In addition, the expense of replacing the Department's aging equipment was not justified and gradually its seismic crews were reduced until the reconnaissance work was left for contractors operating on behalf of exploration companies. From 1960 the geophysical, aeromagnetic and gravity surveys became better organised and more systematic. The use of foreign seismic contractors, such as Namco, United Geophysical and GSI, continued a trend that Frome-Broken Hill had adopted 25 years before. French Petroleum's extensive reflection and refraction seismic surveys across the Simpson Desert began in 1963. International and government seismic teams then began to work their way through the Eromanga Basin in all directions.

Much of the Department's seismic surveying, partly on contract for oil exploration companies and partly reconnaissance and semi-detailed work for the Geological Survey, was in the State's north and northeast areas where the results were important in identifying the Gidgealpa-Merrimelia-Innamincka (GMI) Ridge, with the consequential discovery of natural gas in the Cooper Basin. After 1964-65 the large-scale operations were cut back although seismic work on a reconnaissance basis continued until 1968. Thereafter the Department was involved in actual seismic field work in a more limited fashion but maintained oversight of company activities and continued its strong interest in geophysical interpretive work.

Palaeontological work in the Department also contributed greatly to petroleum exploration. Nell Ludbrook's well-respected studies on the subsurface of the sedimentary basins, including the GAB, were directed primarily towards petroleum and groundwater exploration.³⁵ During 1962-63 she spent three months in the United States of America, England and Europe studying the investigative techniques used by oil companies and a range of methods relating to palaeontological problems in sedimentary basins. Coupled with the palaeontological work was the establishment of a

palynological laboratory which enabled the Department to correlate samples of strata obtained from the petroleum drilling across regions.

The importance of controlling an orderly petroleum search was emphasised in January 1962 with the formation of the Petroleum Exploration Section in the Department. The Section recorded the data obtained by private drilling, ensured that aquifers were protected (so that subsurface waters of different salinities did not mix), supervised the maintenance of drillhole sites (especially so that they were cleaned properly and restored after drilling) and, primarily, retained the information for public distribution under the Petroleum Search Subsidies Act which required publication of the information after six months. The early release of information enabled the exchange of ideas, which encouraged more petroleum exploration. The Departmental geologists continued to inspect drillhole site operations and analyse the preliminary data, such as cutting samples, cores and wireline logs.

Drilling at Innamincka was followed by more seismic work and the drilling of Dullingari 1 in the Strzelecki Desert, 65 km south of Innamincka, in 1962. Dullingari 1 was the first drillhole in the Moomba area of the Eromanga Basin to be sited using seismic survey results. Seismic surveys were recorded in 1958, 1960 and 1961. The drillhole penetrated thick Eromanga and Cooper Basin sequences, more than 610 m of Permo-Triassic sediment, including some excellent source rocks, and showed unmetamorphosed sediments unconformably underlying the Permian strata. Gas shows were encountered in the Permian but mechanical problems with the testing equipment meant that the reservoirs were not evaluated. Drillholes in South Australia (Pandieburra 1 and Putamurdie 1) and Queensland (Orientos 1 and Naryilco 1) added to the geological knowledge of the area and justified further exploration. Although these drillholes were plugged and abandoned as dry holes, they revealed sediments with petroleum potential and they were all 'on structure'. Delhi-Santos Pandieburra 1 (TD 2211 m, one DST showed traces of gas) was drilled between March and June 1963 and Delhi-Santos Putamurdie 1 (TD 1953 m) was drilled from July 1963: they were located on the Birdsville Track Ridge area of the Eromanga Basin, northwest of Moomba.

For a long time Oodnadatta 1 remained the most important stratigraphic drillhole in relation to detecting hydrocarbon indications in the Eromanga Basin sequence in the western part of the GAB as limited exploration took place there in the 1960s. In March 1963 A.P. Newall jnr took out OEL 31, 12 430 km² on the western perimeter of the basin. No field exploration work was conducted in this area but a photo-geological study was made by the licensee prior to surrendering the licence in February 1964. In February 1965 the North Australian Petroleum Co. Ltd took out OEL 34, 47 860 km² covering the most western part of the basin, including the Stuart Range - Woomera and Lake Phillipson areas, and planned to tie seismic lines to aeromagnetic data compiled for OELs 20 and 21. The licence was cancelled in March 1968 as the licensee had not conducted any exploration. On behalf of the State Government the Department of Mines drilled Cootanoorina 1 from April to June 1967 (TD 948 m). This was in OELs 20 and 21 and was the first stratigraphic test drillhole in the Arckaringa Basin. The drillhole was south of Oodnadatta (and 7.5 km south-southwest of Mount Toondina) and was drilled to test pre-Permian strata and

Permian sediments below the Mesozoic cover. Although drilling was terminated due to the limitations of the drilling equipment, significant reservoir sandstones with traces of hydrocarbons demonstrated the exploration potential of the Arckaringa Basin.

Aeromagnetic, gravity and refraction seismic surveys conducted in the Cooper Basin area between 1960 and 1964 helped to define the structural trend which includes the Merrimelia anticline. The GMI Ridge was first identified on seismic lines shot west of Innamincka by the Department in August 1962 and follow-up work by Delhi-Santos delineated and extended the structure. Heli Wopfner related the flavour of the times:

In 1963 Santos-Delhi was joined by the French Petroleum Co. who took up a huge farmout area over the Simpson Desert ... they started to do seismic across the Simpson Desert ... So the experience of French people who a few years before had discovered the giant oilfield in Hassi el Massoud in northern Algeria had a profound influence on the thinking of Santos, also probably on Delhi.

At that stage we were looking for Hassi el Massoud-type structures, Palaeozoic-type oil and Palaeozoic structures below the Mesozoic and late Palaeozoic of the GAB. We were joking about it, saying that it was quite logical because 'There is sand in the Sahara, there is oil in the Sahara; there is sand in the Simpson Desert, therefore there must be oil in the Simpson Desert.'³⁶

Delhi-Santos's first off-structure drillhole on the eastern flank of the GMI Ridge, Gidgealpa 1 (TD 3997 m), penetrated a thick Permian section with several sands with good reservoir properties. A fossiliferous Cambrian carbonate sequence with porous zones containing gas-cut salt water was tested. The drilling focused on the early Palaeozoic sediments and the Permian section, which contained gas shows, was so badly washed out and caved that it could not be tested. Although the logs showed excellent porosity in the Permian sands, Santos was reluctant to proceed. The issue had to be forced at the highest level and the State Government insisted that the Permian sands be tested at any cost or another drillhole be drilled on the same structure. The Department intervened and Wopfner played a pivotal role in enforcing the drilling of Gidgealpa 2 as he wrote to Tom Barnes in November 1963:

The question of the usefulness of Gidgealpa No. 2 Drillhole hinges on the attitude of the Permian sediments across the Gidgealpa structure. Santos Ltd's view that the Permian thins out to nearly nothing across the structure is opposed by Delhi's interpretation of only moderate thinning. In order to obtain a completely objective picture of the behaviour of the Permian strata across Gidgealpa anticline, I urgently suggest a re-evaluation of the seismic data by the Senior Geophysicist (Seismic) [Ken Seedsman]. Without an independent opinion, I feel we are unable to grasp the full situation presently under discussion.³⁷

As a consequence of the reassessment, the Department insisted on drilling Gidgealpa 2 in December 1963.

Gidgealpa 2 was drilled on structure and DSTs in the Permian sands indicated a flow of 56.6 m³ of gas per day. The drillhole produced 328 x 10³ m³ of gas and 6.7 kL of condensate per day on completion. Five developmental

drillholes were then drilled to test the extent of the field, which was determined at 18 km in length by 6.5 km in width. Delhi-Santos's primary objective had been oil and gas was a secondary consideration. In the circumstances, Delhi-Santos sought to utilise the gas discovery. This testing of commercial quantities of gas from the Permian was the first petroleum discovery in the Cooper Basin and led to further drilling which in each case penetrated the Eromanga sequence.



Heli Wopfner cutting core from the Gidgealpa 2 drill hole watched by Hoot Gibson, an American geologist with Delhi. (Photo 20031)

The discovery of Permian gas at Gidgealpa had the greatest importance for exploration and development of the region and indicated that the local efforts were not in vain. But one consequence of this discovery, and that of oil at Tirrawarra in 1970, meant that in keeping with the geological theories of the day, the Eromanga Basin continued to be considered unprospective for oil and gas and the explorers concentrated on the Cooper Basin instead. The long-held pessimism about the prospectivity of the Eromanga Basin seemed well substantiated. In the late 1940s and early 1950s the standard assessment was that the Mesozoic sequences of the GAB would not contain oil or gas accumulations. Even the small, encouraging signs from the exploration efforts from the mid-1950s did not dispel the notion. The conventional scientific assessment was that hydrocarbons in the Eromanga Basin could only have been flushed or had not generated oil. Some optimists persisted as each small piece of new evidence suggested that a commercial oil discovery might be possible. Given that most of the drilling was directed at the Permian sequences of the Cooper Basin, and therefore geologists did not sit on the drillhole until it had reached the Permian and that logging was not undertaken over the Eromanga Basin interval, the hydrocarbon potential of the Mesozoic sequences received scant attention. Such was the impact of the Gidgealpa discovery on the local oil and gas search that by the mid-1960s licences were held by oil and gas explorers for most of the State.

Assessing the potential of the Gidgealpa gas field occupied much of 1964, and the Moomba gas discoveries in 1966 further vindicated the Department and the believers in the industry. Four drillholes were completed on the Merrimelia structure in 1964 and 1965 and the first recorded sign of oil in Triassic sediments was made in Merrimelia 2 but a perceived lack of porosity and effective permeability was



Unable to conceal his delight at the optimistic developments at Gidgealpa, Premier Playford displays a beer bottle containing the first distillate from Gidgealpa 2 while the General Manager of Santos, John Klug, looks on approvingly at Adelaide Airport, 16 February 1964. (Courtesy of the Advertiser; Photo 42772)

considered to count against the possibility of Merrimelia containing commercial hydrocarbons. A non-commercial gas flow was made at Merrimelia 4.³⁸

The discoveries by Delhi–Santos of natural gas at Moomba 1, 30 km south of Gidgealpa, in March 1965 followed by Daralingie 1 in November 1967 and Toolachee 1 in March 1969 indicated considerable potential reserves of natural gas in the northeast. Mixed with these successes were the usual run of misses: Delhi–Santos Kalladeina 1 (TD 3762 m), drilled between July and September 1967 on the Birdsville Track, was abandoned as a dry hole.

Exploration recommenced in the Lake Frome area of the Eromanga Basin in 1968 when Delhi–Santos drilled three stratigraphic drillholes along the southern margin of the lake. Their first drillhole under this program was Lake Frome 3 (June–July 1968, TD 781 m) about half-way between Mount Frome and the southern point of Lake Frome, followed by Lake Frome 2 (July–August 1968, TD 772 m) and Lake Frome 1 (August 1968, TD 782 m) in reverse numerical order. The drillholes penetrated the Eromanga Basin sequence and part of the Arrowie Basin. Though the drillholes were dry and abandoned, the drilling confirmed that the pre-Mesozoic sediments in the Lake Frome area equated to the Cambrian section of the northern Flinders Ranges, thereby confirming the earlier correlation based on geological and geophysical data.

With the discovery of Moomba it was clear that South Australia had an energy resource that could be developed.³⁹ But the questions were how and in what form? The answers came in part from a trip that Barnes, Parkin, the new Premier, Frank Walsh, and new Minister of Mines, Stan Bevan, made to North America and Europe for almost three months in 1966 to examine pipeline developments. While on the trip the news reached them that the drilling at Moomba had struck gas and this confirmed the probability of a pipeline being constructed to carry the gas reserves of Gidgealpa and Moomba to Adelaide. Ultimately, the 0.56 m diameter pipeline over 750 km from Moomba to Adelaide was completed in July 1969 and was opened officially by Premier Steele Hall in Elizabeth in November. Adelaide was the second city in Australia (after Brisbane)

to be provided with clean, and cheap, natural gas through a pipeline.⁴⁰

The importance attached to the oil and gas search was reflected in the legislative developments of the period. The Mining (Petroleum) Act was amended in 1958 to increase the terms of exploration and prospecting licences to five years with the right of renewal. Then in 1967 the Act underwent a major revision and the subsequent *Petroleum Act 1968* redefined many of the terms to account for the modern developments and recent petroleum research. The power of the Minister to enforce exploration and production was strengthened, the OEL was renamed the petroleum exploration licence (PEL) and the OPL was replaced by a petroleum production licence (PPL): the area for a PEL was not to exceed 25 900 km² and a program of exploration had to be maintained. Upon each renewal of a PEL at least a quarter of the area was to be excised from the leased area. The terms of the PEL were designed to ensure that the licensees explored rigorously. The PPL, granted for 21 years with the right of renewal, imposed a royalty of 10% per annum of the value of the petroleum at the well-head. The Act included provisions for the conservation of resources, the prevention of operations contaminating water or petroleum formations, ‘the proper drilling and completion of drillholes, the suspension of drilling operations and the abandonment of drillholes’ and the disposal of waste products associated with the operation. Licences were stipulated for pipeline construction and operation. A Petroleum Advisory Committee was established to consider appeals and objections to the Minister’s decisions under the Act. As well, the Regulations under the Act were revised to establish new ground rules for the petroleum industry.

The 1968 Act appeared to continue to treat Delhi–Santos favourably: for example, a covenant in the legislation protected Santos’s OELs 20 and 21 from the new exploration requirements. OELs 20 and 21 were reissued in March 1969 but were not converted to PELs 5 and 6 (an area of 497 450 km²) until after 30 June 1969. At that time the licensees reduced their area by surrendering the offshore region of the western coast of Eyre Peninsula. PELs 5 and 6 were issued for a guaranteed 20 years without area relinquishments and with nominal exploration requirements and the right of renewal for a further 20 years.



Moomba natural gas processing plant, November 1969. (Photo 43830)

THE 1970s

Since World War II the spectacular mineral and energy successes had all seemed to lie outside South Australia, as if to confirm the perception of a State deficient in resources. After Gidgealpa and Moomba, the Department tried to counteract the perception of a lack of resources by pointing to the Cooper Basin as a known gas province with the possibility that there would be oil too. The Permian reservoirs in the Gidgealpa and Moomba Fields demonstrated the commercial natural gas viability of the region as evidenced by the opening of the Moomba–Adelaide natural gas pipeline in November 1969. The oil potential remained a tantalising possibility however.

The boom that permeated the Australian mining scene from the mid-1960s introduced several new exploration companies to the northeast of South Australia. Farmin arrangements with Delhi–Santos in 1969 and 1970 injected badly needed capital to the petroleum search. Companies participating in the Eromanga Basin province included Vamgas N.L., Alliance Petroleum Australia N.L., Crusader Oil N.L., Western Mining Corporation Pty Ltd, Pexa Oil N.L. and Bridge Oil N.L. Ten of the companies working in PELs 5 and 6 formed a consortium in 1975, the Cooper Basin Producers Unit (the Producers), a complex arrangement designed to secure the development of the Cooper Basin by unitising or pooling their gas reserves in order to produce gas more efficiently for supplying the Adelaide and Sydney markets.⁴¹

In 1970 more than 5000 km of seismic data was recorded and 20 exploration drillholes completed. The number of Cooper Basin gas discoveries increased with Packsaddle, Tirrawarra, Della, Merrimelia, Mudrangie and Strzelecki that year. The announcement by Bridge Oil in July 1970 of a gas flow from sand in the lower and middle Gidgealpa Formation and a light crude oil reservoir in the lower Gidgealpa Formation at its Tirrawarra 1 drillhole indicated that the continuing long search in the Cooper Basin was beginning to pay dividends. Although this first oil to flow to the surface in South Australia confirmed that oil in commercial quantities existed in the State, the extent of the deposit and how it might best be used remained to be proven.

After the Tirrawarra discovery a liquids pipeline to the coast became a serious consideration but flooding at Moomba during 1971 slowed the assessment and evaluation of the area. Tirrawarra set the scene for more exploration in the Cooper Basin with gas being discovered at Big Lake, Coonatie, Dullingari, Burke, Brumby and Kanowana in 1971 and 1972, as was oil and gas at Fly Lake and Moorari. In addition, the natural gas reserves were revised and upgraded in several instances such as Toolachee, Della and Tirrawarra. The future looked promising and there were hopes for interstate and overseas markets, a petrochemical plant, a natural gas pipeline grid, and even a national energy strategy.

The inability to secure a petrochemical plant despite strenuous efforts throughout the 1970s was also a disincentive to explorers discovering liquids-rich gas. The natural gas liquids discoveries in the early 1970s had encouraged the Producers to plan treatment facilities and the State Government promoted an ethane-based petrochemical plant as a viable option. Under the Unit Agreement, the Producers were required to investigate the processing of liquids including the storage and use of ethane as the feedstock for

manufacturing ethylene at a petrochemical plant. An environmental impact inquiry in 1973 led to Redcliff on the northern Spencer Gulf being selected as the site for a petrochemical complex for processing the ‘wet’ gas and liquids that would be available after dry gas had been produced for Sydney and Adelaide. Few local companies had the capacity to commit themselves to a project of the magnitude envisaged and so the State Government looked to overseas interests to establish the industry, either individually or as part of a consortium. In 1973 Dow Chemical informed the Government of its interest in developing a complex but the project depended on there being sufficient ‘proven and probable’ reserves of gas after meeting the market demands.

Meanwhile the first Federal Minister for Minerals and Energy (1972–75), Rex Connor, placed export controls on mineral and energy resources, in order to develop local reserves for later export, while seeking to maximise the prices of what was exported. South Australia’s interests were affected when the Federal Government banned the export of LPG in 1974 because Connor wanted it marketed locally. A result of the Federal Government’s policies for marketing indigenous oil and gas was the pronounced decline in exploration and development in the Cooper Basin: in 1973 one drillhole was drilled and none in 1974 and 1975. In April and May 1974 the Department of Mines drilled Oodnadatta Town Bore 2 as an artesian water bore (TD 439 m) and no signs of oil or gas were recorded. The Department had drilled Yardinna 1 (TD 156 m), 32 km northwest of Oodnadatta, late in 1970 but did not detect any signs of oil, gas or water. Few seismic surveys were conducted, the most notable being Western Mining’s in the Pedirka Basin after the company had farmed into the area in 1973.

The imposts of the Federal Government which precipitated a downturn in the petroleum industry from 1973 included the termination of the Petroleum Search Subsidy Scheme, the abolition of tax concessions to mining companies controlled by overseas interests, and a restriction on the involvement of foreign companies such as Aquitaine and Delhi by an insistence on at least 50% Australian equity in uranium, natural gas and coal projects. Such difficulties impaired Santos’s operations and introduced unwelcome delays to the development plans for the Cooper Basin.

Attention was again directed towards the Eromanga Basin in 1976 with the drilling of Namur 1, which discovered gas in the Jurassic Namur Sandstone. This was the first economic petroleum discovery in the South Australian sector of the Eromanga Basin and led to a change in thinking about the prospectivity of the basin. The next promising show was oil from sandstones of the Early–Middle Jurassic Poolowanna Formation at Poolowanna 1 in the central Simpson Desert of the western Eromanga Basin. Drilled by Delhi–Santos–Western Mining in 1977, this was the first oil flow from the Eromanga Basin.

The first discovery of commercial quantities of oil in the Eromanga Basin was Strzelecki 3, which was spudded in September 1978, when 382 kL of oil per day flowed from the Hutton Sandstone. This drillhole was intended to test the gas accumulation in sediments of Permian age, which had been detected in Strzelecki 1 in 1970, with a secondary Jurassic target. That is, the Cooper Basin was still considered the prime target. Strzelecki 3 really established the Eromanga Basin’s petroleum potential and encouraged more exploration

for Jurassic oil in the basin: late in 1978 drillholes were completed on the Mudlalee and Packsaddle structures but both were dry holes. Strzelecki 4, drilled in the same stratigraphic unit as Strzelecki 3 in 1981, flowed at 572 kL of oil per day, the largest oil flow recorded (to 1983) from a single sand unit on continental Australia.⁴² The Strzelecki Field came on stream in 1983.

As a result of the discoveries at Poolowanna, Strzelecki and Namur, the prospectivity of the region was upgraded. Changes in drilling practices and philosophies were key components in these Eromanga discoveries. The previous practice had been to drill through the Cretaceous and Jurassic sediments into the Gidgealpa Group of the Cooper Basin before testing. Several oil pools were located subsequently in the Mesozoic sedimentary sequence overlying the Permian hydrocarbon province of the Cooper Basin. Successful holes included Munkarie 1 and 2 (gas), Kirby 1 (gas), Wilpinnie 1 (gas), Toolachee 9 (gas), Dullingari North 1 (oil and gas), Beanbush 1 (gas), Cuttampirrie 1 (oil and gas), Merrimelia 6 (oil), Dilchee 2 (gas), Mudera 1 (gas), Kerna 1 and 2 (gas), Moorari 3 (oil) and Marabooka 1 and 2 (gas) which were new discoveries or extensions to existing fields.

Dullingari North 1 was the second discovery of oil in the Eromanga Basin and indicated that Strzelecki was not an isolated discovery. The drillhole, spudded in August 1979, was drilled to test the gas potential to the north of the Dullingari gas field where the first drillhole completed had been Dullingari 1 in 1962. That drillhole had penetrated shallow Eromanga oil and Permian gas but neither were recognised and it was completed as a water bore. The gas discovery drillhole, Dullingari 2, was not spudded until 1972 and was followed by gas appraisal drillholes Dullingari 3 and Dullingari 4, the latter also revealing some oil. Cuttampirrie 1 was also a very significant Eromanga oil discovery as it was drilled in the Patchawarra East Farmout Block 100 km northwest of the Strzelecki and Dullingari Fields and therefore extended the prospective area of the Eromanga Basin substantially.⁴³

The discovery of oil at Strzelecki 3 led to a reappraisal of the Merrimelia structure and a second stage of exploration began in July 1981 when Merrimelia 6 was drilled on the crest of the structure where the absence of Permian sediments had previously discouraged drilling. In the event 69 kL of oil per day were recorded from the top of the Namur Sandstone and 436 kL of oil per day were recorded from the Hutton Sandstone. This was the discovery drillhole for commercial quantities of oil in the Merrimelia Field.

Despite the innovative concept of the Producers Unit, some companies still seemed to be reluctant to be imaginative in their approach to exploration. The Department of Mines and Energy's Supervising Geologist (Fossil Fuels), Bevan Devine, encouraged an expanded horizon but this view sometimes had to be forced on the companies. Because the prospectivity was perceived to be in the Permian, the overlying Jurassic was thought to be unprospective and samples were taken at very long intervals, if they were taken at all. Even the potential of the Permian had been discovered as it was passed through. Samples started to be taken when the drill cut the Permian but the gas detector was not hooked up until just above the top of the Permian. This continued until the Namur discovery after which samples were taken at ten-foot intervals from the casing shoe (i.e. through the Jurassic and Cretaceous), the

gas detector was hooked up from the casing shoe and a well-site geologist was required to be on site throughout. Subsequent oil discoveries in the Jurassic changed the approach as it was realised that several oilfields had been missed and drilled through. There were several confrontations with the operator, Delhi, in implementing the change of policy on drilling but that view facilitated the discovery and production of oil from the Jurassic sector.

Thus by the late 1970s a broader perspective and imagination was being applied to the search in the Cooper Basin:

There was a recognition finally of the importance of the Mesozoic rocks as sources of oil. The irony is that the Mesozoic rocks were the initial targets for oil in Sprigg's days and the drilling of Innamincka 1 ... those structures that were drilled in those very early days were structures where the Mesozoic was only thinly or only poorly developed or even missing. The drills went straight through into the Palaeozoic rocks and the Palaeozoic rocks became the target. From the earliest time the Cambrian was always a target and eventually that oil turned up [with] gas in the Permian. The Mesozoic through all this time had been overlooked and it was because some escaping oil from some of the existing holes mystified people as to where it was coming from that the potential of oil in the Mesozoic emerged and a whole new era of exploration developed as a consequence ... In some ways it is a vindication of the original concept developed by Sprigg when he first got people interested in the whole area.⁴⁴

This renewed focus was in part a response to the Dunstan Government's desire to secure energy resources and the need to find extra reserves of natural gas to meet the State's energy requirements. Hence the Government funded some exploration in order to establish the gas reserves beyond 1987.

The continued efforts by the companies also demonstrated the investment that they had made by way of capital, time and effort. At times, however, their degree of commitment to developing the oil and gas potential was questioned as the State faced the prospect of its gas supplying the Australian Gas Light Co. in Sydney until 2006 while its own usage was probably limited to 1987. The time horizon of the Government and the Producers differed because from a commercial point of view the companies did not want to put money into gas exploration when they could not expect a return until after 1987. Consequently, the Government did not simply come to an arrangement with the Producers for them to carry out exploration with a subsidy or funding in return, or as a pre-payment, for gas. Instead the Department again became closely involved in locating and proving up commercial quantities of oil and gas.

As a result of the Producers' intransigence the Government arranged to explore independently of the Producers by an exploration program through the South Australian Petroleum Exploration Group (SAPEG) which was formed in the Department in 1976 and funded by a levy on gas consumers.⁴⁵ The Producers maintained some limited exploration work but the arrangement with SAPEG was designed to provide new sources of gas to ensure supplies for South Australia beyond 1987. SAPEG funded the exploration and drilling of drillholes according to its own program, which had to

be negotiated with the Producers because, under their PELs, they had the right to conduct exploration and held the rights to any oil and gas found.

SAPEG's future was uncertain as it was initially expected to operate to 1977 with the concept then being reviewed. Changing circumstances again opened a window of opportunity. In 1974 the Federal Government of Gough Whitlam had acquired 25% of Delhi's interests in all new fields discovered in the Cooper and Eromanga Basins after 1974 and 50% of its production interests in all fields discovered before 1974.⁴⁶ But the Federal Government under Malcolm Fraser decided to sell this holding.

After being made aware of the sole risk provisions of the joint operating agreements covering the arrangements amongst the Producers in each of the farmout blocks, South Australia's Minister of Mines and Energy Hugh Hudson realised that a new company provided a means of continuing the government-funded exploration without having the annual negotiation with the Producers. Instead the Minister could exercise the sole risk rights. Hudson initiated the idea of creating a company to acquire Delhi's interests, which was made possible because their location within PELs 5 and 6 therefore required the Minister's assent to any transfer. A limited liability company, the South Australian Oil and Gas Corporation (SAOG), was incorporated on 9 September 1977 after SAPEG was hived off from the Department. SAPEG's arrangements with the Producers were transferred to SAOG which was to undertake an independent major exploration program in PELs 5 and 6.

The creation of SAOG was the culmination, in effect, of the Department's long-standing direct involvement in PELs 5 and 6 through its seismic and drilling activity. Although its role then became one of monitoring and regulating the work there, some special projects were implemented to assist the Producers. In 1978–79 the Department formed an Eromanga Study Group to conduct special investigations to identify the potential hydrocarbon traps in the Cooper and Pedirka Basins. The Group re-assessed the basin stratigraphy, lithofacies distribution and the formation waters in the region. A soil–gas survey in the Strzelecki–Mudalee area was undertaken by the Department and the CSIRO Fuel Geoscience Unit using a new method of sampling and on-site chromatographic analysis. Late in 1979 Toodla 1 was commenced near Oodnadatta to clarify the basin margin stratigraphy.

In addition, a Petroleum Source Rock Studies Section was formed in the Department to generate information on the quality, thermal maturity and subsurface distribution of potential hydrocarbon rocks in sedimentary basins. Amdel provided laboratory facilities for source-rock analysis. The Department collaborated with the Geology Department at Wollongong University and the BMR in working on the organic geochemistry and petrography of carbonaceous sediments in the Pedirka Basin. More extensive thermally mature Permian sediments were identified in the five exploration drillholes in the basin. Likewise, new research on the Mesozoic shales, siltstones and coals in six exploration drillholes in the Eromanga Basin identified significant

concentrations of resinite and resinous vitrinite which were regarded as potential generators of gas and light oil at low levels of organic maturation. By now the Jurassic–Cretaceous sequences of the basin were regarded as containing excellent source rocks for oil.

THE MODERN ERA

In 1979 an agreement between Santos and Delhi gave Santos the sole responsibility for the development and production of the Cooper Basin gas and condensate fields while Delhi became the exploration operator. Delhi also took on the development and production role for the Eromanga oilfields. Then in 1981 CSR Ltd purchased the Australian petroleum interests of Delhi whose direct role in developing South Australia's petroleum resources was soon to end.

As notable as this was, several other milestones occurred in the early 1980s. The State's on-going search for energy supplies was rewarded when the Cooper Basin was proven to contain Australia's largest known onshore oil reserves. This ultimately facilitated a significant development, the \$1.5 billion Cooper Basin Liquids Project, which saw an expansion of facilities in the Cooper Basin. In 1981 the construction of the first stage of the Liquids Project, the production facilities at Port Bonython, began and the plant commenced operating in 1983; in February 1983 the first shipment of condensate received through the 659 km Moomba – Port Bonython liquids pipeline was shipped to the Geelong oil refinery in Victoria; in March 1983 the first shipment of Cooper Basin crude oil was sent from Port Bonython; and in June 1984 LPG production began, with the first loading for export to Japan coinciding with the official opening of the Project. These were more than just historically significant dates: they represented events of vital importance to the State's economy which have benefited the State greatly through the consequent stimulus to economic activity and from the royalties earned.

The new, small oil discoveries made during the late 1970s, together with the large amounts of condensate, 'wet' (liquid-rich) gas, which could be extracted from the supply of 'dry' gas to Sydney and Adelaide, made the Liquids Project feasible and took the place of the earlier schemes



Track-mounted drilling rigs were adopted for traversing sand dunes and negotiating the desert terrain. Being very manoeuvrable, they minimised surface damage and reduced the environmental impact of the petroleum search. (Photo 40401)

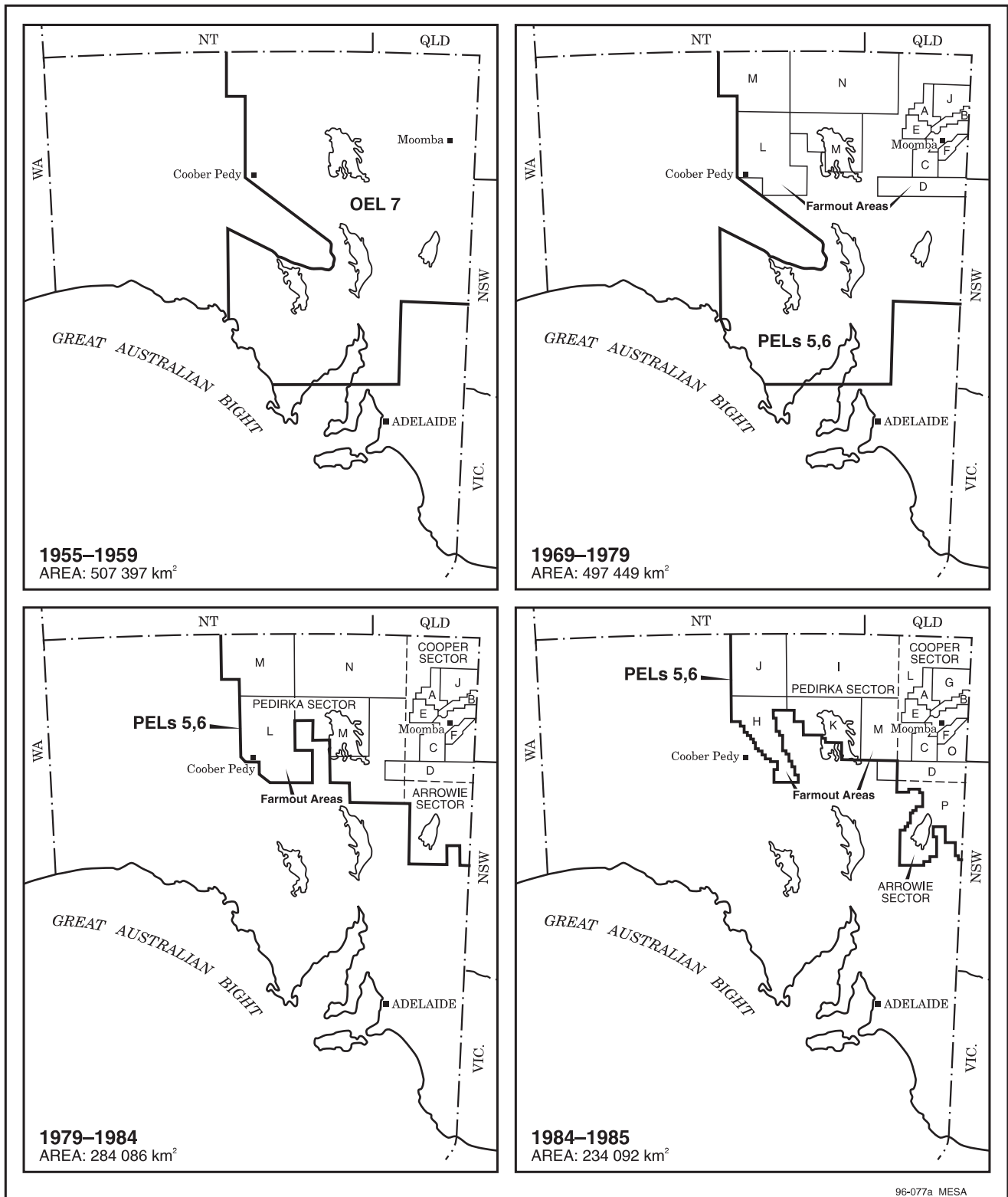
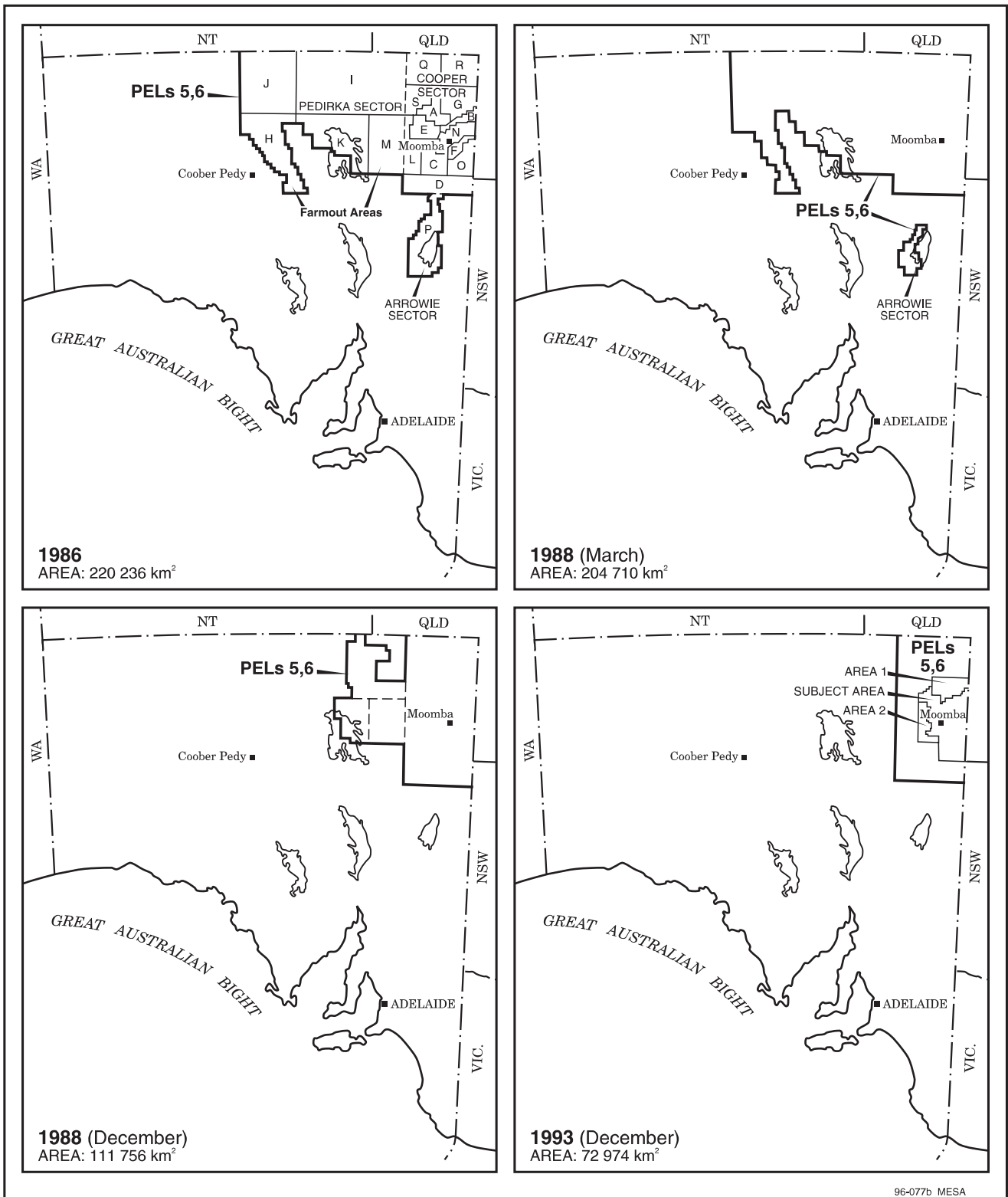


Fig. 3.4 Tracing the broad trend of the area acquisition and relinquishment history in the Eromanga Basin, South Australia from 1954–93. Note that the period 1959–69 is not shown: the area remained the same as for 1954–59 but OEL 7 was renamed OELs 20 and 21.

for the Redcliff petrochemical plant. The Indenture under the *Stony Point (Liquids Project) Ratification Act 1981* included a provision for the Producers to investigate ethane extraction, its underground storage and later processing in a petrochemical plant, which remained a tantalising possibility.

The Liquids Project required oil and gas reserves to be sustained and more oil and gas supplies to be proven and this

pressure meant that exploration for oil and gas in the Eromanga Basin was maintained through the mid-1980s and the development of the area was stimulated. Of the six oilfields in the initial stages of the Project, two (Strzelecki and Dullingari) produced oil from the Eromanga Basin and Merrimelia produced oil from both the Eromanga and Cooper Basins. The arrangement made between Santos and Delhi in 1979 enabled Santos to focus on the Project.



The Department in conjunction with the petroleum industry progressively introduced several codes of environmental practice for exploration and development work in PELs 5 and 6. The first code was adopted for seismic work in 1984 after negotiations between the Department and Delhi over a seismic survey in the Cooper Basin, which the company had commenced without formal approval late in 1983. At that time the visible effects of seismic lines were being criticised by environmentalists. The codes achieved spectacular results: since the mid-1980s the presence of seismic lines has been difficult to detect after a year or two, while signs of many

earlier lines are still quite obvious. The improvements resulted in part from the Department's insistence that Santos use rollers to make tracks in the gibber country. In 1983 Santos's Government Liaison Officer began managing the environmental aspects of the company's upstream activities in the Cooper Basin and an environmental group was then established by Santos. In October 1989 new regulations were introduced under the Petroleum Act and an environmental assessment and a code of environmental practice became a mandatory requirement before petroleum exploration and development operations could be approved.

The Tonkin Government (1979–82) in South Australia had raised the possibility of piping oil and gas from South-West Queensland to Port Bonython but the Bjelke-Petersen Government in Queensland rejected this proposition and instead took the perplexing decision to install a pipeline from Jackson to Moonie and thence to Brisbane. But the prospect for interstate linkages remained attractive. As for oil and gas, South Australia looked to expand its pipeline network both within the State (the Wasleys – Torrens Island pipeline loop was commissioned in September 1986 and the Port Pirie – Whyalla submarine pipeline came into operation in April 1989) and beyond its borders. In July 1991 a contract was signed for the ten-year supply of gas from Queensland via a pipeline from northwest of Jackson to Moomba for the treatment and recovery there and at Port Bonython of sales gas, LPG and condensate. This agreement represented one-third of the State's demand for gas then although production was not to commence officially until January 1994.

In 1979 the exploration rights granted to Delhi–Santos had been modified when the companies volunteered to halve the area covered by PELs 5 and 6 to 284 086 km² (Fig. 3.4). The area covered was then divided into the Cooper, Pedirka and Arrowie Sectors. The Cooper Sector is not subject to any relinquishment provisions until 1999 when the exploration rights to the whole Cooper Basin must be relinquished, without the right to renewal. The Pedirka and Arrowie Sectors were subject to relinquishment of 25% at five-year intervals commencing in February 1984. Under the 1984 conditions of renewal the area of PELs 5 and 6 was reduced to 231 948 km² and Delhi–Santos were required to drill 54 drillholes and acquire 4000 km of seismic in the Cooper Sector. In subsequent years additional voluntary minor relinquishments were made until February 1989 when the area of PELs 5 and 6 was halved again, to 111 756 km². Within a year the area was again reduced, to 73 202 km² and minor reductions followed. Throughout this period new PELs were issued to several companies in the areas relinquished.

In 1981 McKinlay 1 discovered oil on the Murteree Ridge, the first of many oilfields on the structure. In Queensland, meanwhile, Jackson 1 discovered oil: the Jackson oilfield has become the largest onshore oilfield in Australia. Kuncherinna 1 found traces of oil in the western Eromanga in 1982 and the first drillhole in a 'Rapid Oil Drilling' program, Narcoonowie 2, was cased and suspended as a potential oil producer. This program was designed to evaluate the potential of the Jurassic sediments in the southern parts of PELs 5 and 6. The Limestone Creek, Biala, Ulandi and Murteree oilfields were all discovered in 1984. Poolowanna 2 was plugged and abandoned in 1985 and the drilling of Oolarinna 1, Killumi 1, Glen Joyce 1 and Miandana 1 in the Poolowanna Trough region were all unsuccessful. Mount Hammersley 1 was drilled in 1987 and Dalmatia 1 in 1988 with the discovery of the Sturt, Taloola and Tantanna oilfields near the edge of the Cooper Basin.

Between 1977 and 1984 more than 350 petroleum drillholes were completed and many thousands of kilometres of seismic data was recorded for the Eromanga Basin

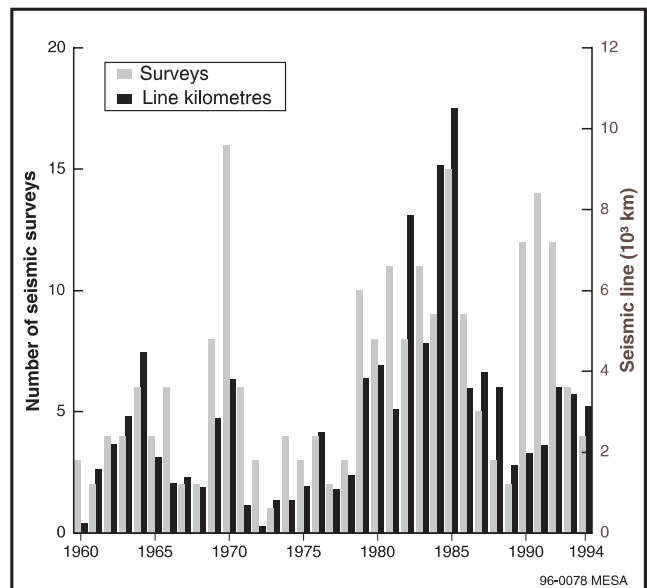


Fig. 3.5 Seismic surveys in the Eromanga and underlying basins, 1960–94.

(Fig. 3.5). In 1984 alone ~20 000 km of seismic data was recorded throughout the entire Eromanga Basin and 100 exploration drillholes completed. The exploration and development work continued over the next decade.

Eromanga Basin discoveries during the 1990s up to and including 1995 have been at a low level, reflecting an overall decrease in exploration drilling. The only Eromanga discovery in 1990 was Callabonna 1 when oil was recovered on a test of the Birkhead Formation. The drillhole was sited northwest of the Tirrawarra Field, near the Permian edge of the Cooper Basin. Keleary 1 was drilled in 1991 and discovered oil in the Early Triassic Tinchoo Formation (Cooper Basin) and the follow up appraisal drillhole, Keleary 2, drilled in 1994 discovered two new Eromanga Basin oil pools (Poolowanna Formation and Hutton Sandstone). No new Eromanga discoveries were made in 1992 but Crater 1 was drilled by Stirling Petroleum in PEL 55 in an area previously relinquished from PELs 5 and 6. This drillhole was located on the ridge of an interpreted astrobleme but failed to find hydrocarbons.

New discoveries in the Eromanga Basin in 1993–94 included: gas in the Early Cretaceous Murta Formation of Nappacongee East 1, 53 km east of Moomba, the first in this formation in South Australia; oil in Dirkala South 1, ~50 km south of Moomba; and oil in Mudlalee 3 in a trap on trend with the Strzelecki Field. The first drillhole with a horizontal section drilled in South Australia, Meranji 14H, was preceded by the pilot stratigraphic drillhole Meranji 14. Meranji 14H (TD 2310 m) was completed in 1993–94 ~30 km northwest of Moomba. The drillhole targeted the Namur Sandstone and the bottom 407 m was drilled as a horizontal section in the Namur Sandstone oil reservoir: the drillhole flowed 326 kL of oil per day. In 1995 Wilpinnie 3 on the flank of the Nappacongee structure discovered oil in the Namur Sandstone. The increase in exploration announced by Santos early in 1996 for the period from 1996 to 1998 is expected to generate an increase in Eromanga discoveries in the latter part of the 1990s.

THE SIMPSON AND PEDIRKA BASINS

The full extent of the Pedirka Basin, ~185 000 km² in the western GAB, is predominantly in the central north of South Australia and the southeast of the Northern Territory but a small area in southwest Queensland is also included. About one-fifth of the Pedirka Basin lies in South Australia. The Pedirka Basin is separated from the Cooper Basin by the Birdsville Track Ridge.⁴⁷ Exploration began in the area in 1959 after Delhi–Santos were granted OELs 20 and 21. In 1961 an aeromagnetic survey was flown by Aero-Service Corp. for Delhi–Santos. In March 1963 they farmed out the eastern Pedirka area to French Petroleum for whom the Compagnie General de Geophysique (CGG) undertook a seismic survey from March to July. Crossing the Simpson Desert, CGG generated the first subsurface data in this region from Dalhousie Springs to Birdsville. From August to November Wongela Geophysical Pty Ltd conducted a helicopter gravity survey near Dalhousie. United Geophysical Corporation ran the Kallakooah reflection seismic and gravity survey for French Petroleum from April to July 1964. CGG ran the Poolowanna seismic and gravity survey from December 1964 to April 1965 and from June to October 1965, and also the Emery seismic survey in February and March 1966. The French seismic surveys covered at least 2440 km and the geophysical work indicated that future exploration should examine older sediments, not just the Permian, and other prospective strata.



A track through the western Simpson Desert prepared by French Petroleum in 1963 when its farmin arrangement with Delhi–Santos began. (Photo 12955)

The early logistical problems of exploration in the Pedirka and Simpson Basins prevented much stratigraphic data from being recorded. Four of the six drillholes completed by French Petroleum in the basin were in South Australia. All six holes were dry but they were the first of several stratigraphic drillholes to penetrate the western Eromanga Basin sequence of the Simpson region. In 1963 French Petroleum drilled two stratigraphic drillholes, Witcherrie 1 (TD 1464 m) in October and November and Purni 1 (TD 1880 m) in December 1963 and January 1964. French Petroleum drilled Mount Crispe 1 (TD 1721 m) in April and May 1966 and Mokari 1 (TD 2386 m) in May and June 1966. These stratigraphic drillholes targeted the Permian but found no significant hydrocarbon shows. This earliest data of substance about the basin stratigraphy enabled a detailed geological cross-section to be prepared. French Petroleum considered that the Permian strata did not contain

good petroleum reservoirs. Its farmin area extended beyond the Pedirka and Simpson Basins and from September to October 1964 the company drilled Poonarunna 1 on the Warburton River, 65 km east of Lake Eyre North and west of the Birdsville Track. Drilling ceased at 1697 m as no significant shows were detected and the drillhole was completed as an artesian water bore. The company ceased work in the area in 1966.

A decade of activity began in 1969 during which five seismic surveys were conducted and one drillhole completed. In 1969 Delhi–Santos entered another farmout arrangement, this time with Vamgas N.L. for the far western area of the Simpson Basin. United Geophysical ran a seismic survey covering 320 km for Vamgas in 1970 and detected eastward thickening sediments between the eastern Pedirka Basin and the Eromanga Basin.



One of the earliest operations in Australia to use vibrators for seismic surveys was in the Simpson Desert in May 1974. (Photo 43831)

In 1973 Western Mining farmed in to the area held by Delhi–Santos–Vamgas – Total Exploration and undertook seismic work in the eastern Pedirka Basin. The Mudlankie seismic survey over 575 km was completed in October 1973, the Beal Hill survey over 250 km was conducted between April and June 1974, and the Lake Thomas survey of 450 km was completed in October 1974. During 1974 the Federal Government acquired a percentage of the working interest in the farmout area through its partial purchase of Delhi's interests.

Although the area was greatly underexplored, by 1975 sufficient work had been completed by the various companies and contractors for the Department of Mines to issue a small report to encourage more searches and to establish priorities for these.⁴⁸ The structures delineated and the potential reservoir formations were factors likely to attract more exploration.

Of the four drillholes to test the Eromanga Basin in 1977, Macumba 1 and Poolowanna 1 were drilled in the Simpson Desert. In October and November 1977 Delhi–Santos–Vamgas–SAOG – Western Mining drilled Macumba 1 (TD 2617 m) which was dry and abandoned. However, the discovery of oil in basal Jurassic and Triassic sediments at Poolowanna 1 represented the first flow of oil from the Eromanga Basin in South Australia. Poolowanna flowed some waxy crude to the surface but it is not a commercial

oilfield. It is now recognised as having produced oil from a separate older basin, the Simpson Basin. The large north-south structure, faulted on its western margin, was investigated by two appraisal drillholes but both failed to recover hydrocarbons. The structure lies within the newly created Simpson Desert Conservation Park with no access for exploration.

As a result of Poolowanna 1 more exploration was undertaken in the area in the 1980s. When Delhi-Santos's exploration rights were modified in 1979 the area covered by PELs 5 and 6 was halved and divided into the Cooper, Pedirka and Arrowie Sectors. The Pedirka and Arrowie Sectors were subject to relinquishment of 25% at five-year intervals commencing in February 1984. Under the new conditions Delhi-Santos were required to undertake a renewed drilling program and complete 18 drillholes and acquire 7100 km of seismic in these two sectors. This resulted in the first drilling in the Pedirka Basin since 1981. In the two years from 1984 the drillholes completed included Poolowanna 2, Oolarinna 1, Killumi 1, Glen Joyce 1 and Miandana 1, which were all plugged and abandoned. Fewer than 20 petroleum exploration drillholes have been completed in the Pedirka and Simpson Basins to date. Delhi-Santos completed three drillholes in 1985 and two in 1988. All of the seismic surveys conducted in the Pedirka and Simpson Basins have produced more than 24 700 km of seismic data. Data gathering and reprocessing has continued through to the present and the expectation of an oil or gas province in these basins remains.

CONCLUSION

The Cooper Basin and the overlying Eromanga Basin are geologically complex and the identification of potential oil and gas reservoirs and their hydrocarbon resources was protracted. One result with important repercussions for oil and gas exploration and development was that the initial success, notably at Gidgealpa, came from the Cooper Basin. Consequently, the dominant focus on the Cooper Basin diverted attention from the potential of the Eromanga Basin. This perception was only overturned through small and gradual steps.

The Eromanga Basin became an important target following the discovery of oil pools above the Cooper Basin gas discoveries. The Eromanga discoveries were generally made years after the deeper gas discoveries: some examples are Strzelecki, Merrimelia, Gidgealpa, Big Lake and Dullingari. Several follow-up exploration programs specifically targeting Eromanga Basin reservoirs were carried out. The delayed Eromanga exploration success points to further potential in even shallower pools such as the Cadna-owie Formation and the Coorikiana Sandstone. The Coorikiana Sandstone is a proven gas reservoir in several South Australian gas fields but recent seismic processing has shown that the structural configuration at this level can be independent of the older Eromanga-Cooper structure. The Cadna-owie Formation produces oil in the Eromanga Basin in Queensland and could be proven as a future reservoir in the South Australian area.

ENDNOTES

As well as providing a historical overview of petroleum exploration and development in the Eromanga Basin, this chapter is intended to encourage further research and documentation of the region's history. Specific primary sources have been used to assist in setting the scene in conjunction with the broader perspective derived from the secondary material. But the majority of the technical publications do not cite original source material: it is apparent that the information contained in some of the publications is either repetitive or erroneous (and in some cases, both). The specific references listed in the endnotes provide original sources and explanatory matter. However, the majority of the secondary sources examined during the preparation of this chapter are contained within the reference section for this volume as this material has been used in the compilation of other chapters.

¹Kapel (1966a) formally named the Cooper Basin. Mott (1952) defined the Eromanga Basin.

²Moore and Mount (1982), Gravestock *et al.* (1986), O'Neil (1989).

³See, e.g., Lewis (1983), O'Neil (1992, 1995), Sprigg (1983), Wopfner (1972, 1988).

⁴Ward (1944).

⁵Cooper (1992, p. 22).

⁶Jack (1925, 1930).

⁷Sprigg (1958).

⁸*This Age of Oil* (1960, pp. 79–81), DM 185/1945, Australian Archives (SA): A877/2; CL 22740.

⁹De Verteuil (1940).

¹⁰Mawby (1944), Osborne (1945).

¹¹DM 185/1945. (DM and DME indicate MESA dockets.)

¹²Sauvé (1947).

¹³Ivey (1948).

¹⁴DM 469/1947.

¹⁵Evans (1946).

¹⁶Kaufman and McPhail (1948).

¹⁷DM 469/1947.

¹⁸DM 265/1947.

¹⁹DM 776/1948.

²⁰Cootabarlow 1 provided a water supply for Cootabarlow 2. Tilcha 1, or the Tilcha Old Bore (TD 715 m), was sunk by the lessees of the Quinyambie Station (Ward, 1946) and probably completed in 1950. An attempt to plug and abandon was made in 1965 (DM 1324/1965). Black Oak Bore and Quinyambie Station New Homestead Bore (443 m) were drilled as part of the Enterprise Exploration artesian drillholes program (Ker, 1966). Tilcha 2 was completed by May 1950 on the northern side of Callabonna Creek on a pastoral property of S. Kidman and Co. east of Lake Callabonna. It finished in bedrock below the Blythesdale Group in Upper Jurassic strata (TD 717 m) and the company sent the Mines Department two bottles of gas and one of water for analysis by the Department of Chemistry; tests revealed the presence of methane (DM 398/1950). In 1950 Zinc Corporation completed Lakeside Bore 1 through the Blythesdale Group and stopping in sandstone bedrock on the east of Lake Frome; and Black Oak Bore, southeast of Lake Frome, through the Aptian Formation of the Lower Cretaceous strata (artesian but contained a minor show of

methane, TD 138 m). The Oil Bore Index records a 60% methane discovery at depth unknown for Lakeside Bore 1 (DM 1014/1949).

²¹DM 265/1947.

²²DM 265/1947.

²³DME SR 11/5/19.

²⁴Interview with Reg Sprigg by B.J. Cooper 19.9.83.

²⁵Interview with Reg Sprigg by B.J. Cooper 19.9.83. OELs 6 and 7 expired in February 1959 and were reissued as OELs 20 and 21 (~457 520 km²).

²⁶Gibbs (1988, p. 349).

²⁷Interview with Sir Ben Dickinson by B.J. O'Neil 24.1.90. See throughout Sprigg (1989, 1993) and also interviews with Reg Sprigg by B.J. Cooper 19.9.83 and by B.J. O'Neil 17.1.90.

²⁸Interview with Sir Ben Dickinson by B.J. O'Neil 24.1.90.

²⁹*Advertiser* 1.12.19, Gibbs pp. 350–351, Wilkinson (1988, p. 31).

³⁰Gibbs (1988, p. 374), Passmore (1994).

³¹Cooper (1992, p. 21).

³²Cooper (1992, p. 21).

³³Interview with Nell Ludbrook by B.J. O'Neil 7.12.89.

³⁴Wilkinson (1988, pp. 33, 152).

³⁵See, e.g., Ludbrook (1966).

³⁶Interview with Heli Wopfner by B.J. O'Neil 28.6.89.

³⁷DME SR 11/5/111.

³⁸In 1969 Alliance Petroleum Australia N.L. earned a 50% interest in the Merrimelia–Innamincka Block by a farmin agreement with the Delhi–Santos–Vamgas consortium. Alliance then drilled Merrimelia 5 which was completed as a gas producer in 1970. The overall results of drilling there were not encouraging.

³⁹Delhi Australia Petroleum Ltd changed the name of the dry claypans of Lake Moonba (Moonba meaning 'big noise' or 'thunder') to Lake Moomba for ease of pronunciation (Manning, 1990, p. 211).

⁴⁰Donovan and Kirkman (1986, p. 275), Young (1990, pp. 216–17).

⁴¹The Producers were Alliance Petroleum Australia, Basin Oil, Bridge Oil Developments, Bridge Oil, Crusader Resources, Delhi Petroleum, Reef Oil, Santos, Total Exploration Australia and Vamgas. The South Australian Oil and Gas Corporation later joined the Producers Unit. Delhi and Santos were the joint operators on behalf of the Producers but on 1 January 1979 Santos became the sole operator.

⁴²Jackson 1 in the Eromanga Basin in Queensland recorded a flow of 646 kL of oil per day but this was for the complete drilled section.

⁴³The first 3D survey in the Eromanga Basin was conducted by SAOG at the Cuttampirrie oil and gas field in 1981.

⁴⁴Interview with Bruce Webb by B.J. O'Neil 28.1.93.

⁴⁵Devine [1977], Young (1986).

⁴⁶In the areas of PELs 5 and 6 which had not been farmed out Vamgas derived a 20% share of Delhi's interests and the Federal Government had a 25% interest less the Vamgas-derived interest, but excluding fields discovered before 1974. In the non-farmout areas this arrangement meant in effect that the respective interests were Santos 50%, Delhi 30%, Vamgas 10% and the Federal Government 10%.

⁴⁷During its geological exploration of the Simpson Desert Geosurveys referred to the Permian sub-basin as part of a Simpson Desert Basin (Sprigg, 1962), which later became simply the Simpson Basin. The name Pedirka was adopted in 1965 (Canaple and Smith, 1965; see also Sprigg, 1963).

⁴⁸Youngs (1976).

