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ECONOMIC GEOLOGY OF
AUSTRALIA AND
PAPUA NEW GUINEA

3. PETROLEUM

ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA

3. PETROLEUM

Edited by

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Editor-in-Chief

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FOREWORD

For four out of the six generations of European occupation, Australia has had a strong and varied mining industry ranging in economic importance from great to very great.

Twice before, in 1953 and 1965, on the occasions of the 5th Empire and 8th Commonwealth Mining and Metallurgical Congresses, the individual and company members of The Australasian Institute of Mining and Metallurgy, with the assistance of the Commonwealth and State Governments, made possible a compilation of the geology of the metallic deposits under the title "Geology of Australian Ore Deposits". The second edition was prefaced: . . . "It is the hope of the contributors that this volume will in about another ten years be replaced by a third edition".

Now this third edition has been achieved. Because the resources developed during the last decade have included major deposits of fuels and phosphate and because also some of the important metal developments have been in Papua New Guinea, this edition has been greatly expanded to cover all mineral deposits (except water) and includes Papua New Guinea. It has the title *Economic Geology of Australia and Papua New Guinea* and appears in four volumes—*Metals*, *Coal*, *Petroleum*, and *Industrial Minerals and Rocks*. It has been made possible by the cooperation of individual and company members of The Institute, Government geological departments, and the petroleum and coal industries.

In the realm of *metals* it was in the late 1940s that systematic company exploration and government regional mapping started a sustained effort to explore for a wide range of metals (other than gold) which were being used in increasing quantities worldwide. By 1965 some very important discoveries—notably major lead-zinc and copper orebodies at Mount Isa, Weipa bauxite and the Hamersley iron ore province—had been made, and a very much better geological understanding of the known deposits had been achieved. These discoveries focussed world attention on Australia, and led to a tremendous intensification of the exploratory effort which yielded such major prizes as the Bougainville porphyry copper, the Western Australia nickel province, the Northern Territory uranium province, Groote Eylandt manganese, and additional major bauxite.

Coal has been mined in Australia for over 170 years, and it has been known for a long time that the continent has large resources of black and brown coal. Reserves were kept in line with demand without much difficulty until the late 1940s. From then to the late 1950s coal exploration was increased to keep pace with increasing domestic usage, and was increased further, and with notable success, from the early 1960s to the present to take advantage of the greatly increased export opportunities.

Exploration for *petroleum* was in a minor key before 1953. A significant oil flow at Rough Range in 1953 greatly stimulated exploration, and eventually Australia's first commercial oil field was discovered in 1961 in the Surat Basin. This was sufficient to maintain exploratory momentum until the Barrow Island and Bass Strait oil discoveries were made, and large gas reserves found in several areas.

The development of *industrial minerals* has had a strong upward trend paralleling the progressive industrialization of Australia. The highlight of recent years was the discovery of major phosphate deposits in the Georgina Basin in north-west Queensland.

This third edition has had the benefit of the services as Editor-in-Chief of a geologist of long and wide experience of metal exploration and other aspects of geology, C. L. Knight, formerly of Conzinc Riotinto. R. B. Leslie, H. J. Evans and C. L. Knight edited the *Petroleum* volume, D. M. Traves and D. King the *Coal* volume, and C. L. Knight the *Metals* and the *Industrial Minerals and Rocks* volumes.

The Honorary Editor of The Institute, J. T. Woodcock, acted as consultant in the design of the printing format.

The committee and The Institute are especially indebted to these members and to their companies for this editorial and financial assistance. The committee and The Institute also wish to offer thanks to the very many individual contributors who are of course the authors of this publication.

M. MAWBY

Chairman of Committee

June 1975

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PREFACE

The aim of this publication is to record the present state of geological knowledge of the occurrence of *metallic ores, coal, petroleum and industrial minerals and rocks* in Australia and Papua New Guinea. One of its purposes is to provide a basis of fact on which future exploration can be built.

The titles *Economic Geology of Australia and Papua New Guinea—1. Metals etc.* were chosen as the simplest ones which would convey the scope of the contents to the reader. There is no volume on underground water, which is probably the most important of all minerals; some other organization may one day fill this gap.

Mineral deposits of all kinds are a product of their regional environment; therefore I felt that the publication must include accounts of the geology of all relevant regional geological elements (*basins, geosynclines etc.*) as well as geological accounts of the deposits therein. It eventuated that no regional geological element could be classified as irrelevant, because all contained, or might contain, some mineral or another. Therefore the reader will find in one or other of the four volumes accounts of all the regional geological elements—most of the Precambrian and more disturbed Phanerozoic in the *Metals* volume, and most of the less disturbed Phanerozoic in the *Petroleum* volume.

In Australia and Papua New Guinea the regional mapping has been done very largely by government geological surveys, and the exploration largely by companies. Consequently almost all the papers in this publication are the reportings of the results of substantial expenditure by governments or companies. Company authors contributed an overall 55 per cent of the publication—68 per cent of the *Metals* volume, 51 per cent of the *Coal*, 73 per cent of the *Petroleum* and 5 per cent of the *Industrial Minerals and Rocks*; the remainder, except for two or three, were by government or semi-government authors. We are indeed grateful to the organizations for allowing their work to be reported herein.

The first step in the production of the publication was taken in March 1972 when Sir Maurice Mawby, as chairman of the committee, approached the Ministers and heads of the government departments, the heads of mining and exploration companies, and the professors of geology at the universities, for their cooperation. The second step was an invitation by myself, as editor-in-chief, to the directors or chief geologists of government geological departments, and to the heads of a number of company exploration departments, plus a few individuals, to become editorial panel members to help in the assembling and first editing of the papers; the names and affiliations of the petroleum panel members are listed after this preface.

The editor(s) of each volume, in collaboration with the editor-in-chief, then drew up a list of papers and organization-authors, allotted a length to each paper commensurate with the importance of the topic, and drew up notes for the guidance of authors. Invitations were then sent out to the organizations (or in some cases to individuals) to write the papers. The majority of the manuscripts were received some time in 1973, but some did not arrive until late 1974. In general the information is dated at about the end of 1973.

Dr. N. H. Fisher, then Director of the Bureau of Mineral Resources, had the entire publication checked for violations of the Australian Code of Stratigraphic Nomenclature; we are very grateful for this.

In his foreword, Sir Maurice Mawby has thanked the organizations, editors, editorial panel members and authors. I wholeheartedly endorse his remarks, and add my thanks to the committee, and particularly to Sir Maurice Mawby, who has played such a vital part in enlisting the help of all.

For assistance and encouragement in the production of this *Petroleum* volume, The Institute is especially grateful to the Australian Petroleum Exploration Association (APEA) and to the Petroleum Exploration Society of Australia (PESA). Special acknowledgement is made in respect to the use in this volume of certain material which has been published previously in issues of the APEA Journal.

C. L. KNIGHT
Editor-in-Chief
1975

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CONTENTS

Foreword	<i>M. Mawby</i>	v
Preface	<i>C. L. Knight</i>	vii
 PART I GENERAL PAPERS		
Petroleum volume—Introduction	<i>Editors</i>	2
History of oil search in Australia and Papua New Guinea	<i>E. A. Rudd and R. C. Sprigg</i>	4
Petroleum exploration and development statistics	<i>Bureau of Mineral Resources</i>	12
Geochemical character of crude oils from Australia and Papua New Guinea	<i>T. G. Powell and D. M. McKirdy</i>	18
 PART II SOUTHERN COASTAL REGION		
Southern Coastal Region—introduction	<i>R. B. Leslie</i>	33
Gippsland Basin, on-shore	<i>J. A. R. Colman</i>	34
Gippsland Basin, off-shore	<i>W. F. Threlfall, B. R. Brown and B. R. Griffith</i>	41
Bass Basin, some aspects of the petroleum geology	<i>B. R. Brown</i>	67
Otway Basin	<i>D. W. Ellenor</i>	82
Murray Basin and associated infrabasins	<i>R. C. N. Thornton</i>	91
St. Vincents Basin	<i>Editors</i>	94
Pirie-Torrens Basin	<i>I. J. Townsend</i>	95
Eucla Basin	<i>D. C. Lowry</i>	95
Great Australian Bight Basin, South Australia	<i>R. Pattinson, G. Watkins and D. van den Abeele</i>	98
 PART III WESTERN COASTAL REGION		
Western Coastal Region—introduction	<i>R. B. Leslie</i>	107
Perth Basin	<i>D. K. Jones</i>	109
Carnarvon Basin	<i>B. M. Thomas and D. N. Smith</i>	126
Dampier Sub-basin, Carnarvon Basin	<i>D. E. Powell</i>	155
 PART IV NORTH-WESTERN REGION		
North-western Region—introduction	<i>R. B. Leslie</i>	169
Canning Basin, on-shore	<i>E. L. Horstman, D. A. Lyons, S. A. Nott and D. S. Broad</i>	170
Canning Basin, off-shore	<i>B. J. Warris</i>	185
Beagle Sub-basin	<i>J. W. Halse</i>	188
Browse Basin	<i>A. Crostella</i>	194
Bonaparte Gulf Basin—south-eastern part	<i>R. A. Laws and R. S. Brown</i>	200
Arafura Sea area	<i>B. Balke and D. Burt</i>	209
 PART V CENTRAL INTRACRATONIC REGION		
Central Intracratonic Region—introduction	<i>R. B. Leslie</i>	215
Amadeus Basin	<i>T. R. Pearson and D. D. Benbow</i>	216
Ngalia Basin	<i>A. T. Wells</i>	226

x CONTENTS

Georgina Basin	<i>K. G. Smith</i>	231
Wiso Basin	<i>E. N. Milligan</i>	237
Daly River Basin	<i>J. E. Lau</i>	239
Ord Basin	<i>P. J. Jones</i>	242
Officer Basin	<i>G. W. Krieg, M. J. Jackson and W. J. E. van de Graaff</i>	247
Arrowie Basin	<i>I. J. Townsend</i>	253
Bancannia "Trough"	<i>C. S. Bembrick</i>	254
Gulf St. Vincent region	<i>W. J. Stuart and A. T. von Sanden</i>	258

PART VI GREAT ARTESIAN BASIN REGION

Great Artesian Basin Region—introduction	<i>R. B. Leslie</i>	265
Surat Basin	<i>R. J. Allen</i>	266
Mimosa Syncline area (Surat Basin and underlying Bowen Basin) petroleum fields	<i>W. L. Benstead</i>	273
Roma Shelf petroleum fields	<i>R. D. Groves</i>	280
Coonamble Embayment	<i>C. S. Bembrick</i>	303
Eromanga Basin	<i>R. R. Vine</i>	306
Adavale Basin	<i>G. Auchincloss</i>	309
Galilee Basin	<i>R. R. Vine</i>	316
Cooper Basin gas and oil fields	<i>D. G. Battersby</i>	321
Frome Embayment	<i>B. E. Milton</i>	369
Arckaringa Basin	<i>B. E. Milton</i>	369
Pedirka Basin	<i>B. C. Youngs</i>	372
Carpentaria Basin	<i>H. F. Douth</i>	374

PART VII EASTERN REGION

Eastern Region—introduction	<i>R. B. Leslie</i>	383
Hodgkinson Basin	<i>C. F. J. Swarbrick</i>	384
Palaeozoic basins of the Townsville hinterland	<i>C. F. J. Swarbrick</i>	387
Drummond Basin	<i>R. W. Day</i>	392
Yarrol Basin	<i>P. R. Murphy</i>	395
Darling Depression	<i>C. S. Bembrick</i>	398
Tamworth Synclinorial Zone	<i>C. S. Bembrick</i>	401
Bowen Basin	<i>R. J. Paten and G. P. McDonagh</i>	403
Esk Trough	<i>L. C. Cranfield and H. Schwarzbock</i>	420
Gympie Basin	<i>R. G. Rollason</i>	423
Sydney Basin	<i>C. S. Bembrick and A. D. Lonergan</i>	426
Tasmania Basin—Parmeener Supergroup	<i>M. J. Clarke, N. Farmer and A. B. Gulline</i>	438
Laura Basin	<i>R. W. Day</i>	443
Styx Basin	<i>W. L. Benstead</i>	446
Maryborough Basin	<i>P. L. Ellis</i>	447
Nambour Basin	<i>L. C. Cranfield and H. Schwarzbock</i>	450
Ipswich Basin	<i>L. C. Cranfield and H. Schwarzbock</i>	452
Clarence-Moreton Basin	<i>W. L. Benstead</i>	454
Lorne Basin	<i>C. S. Bembrick</i>	457
Halifax Basin	<i>C. F. J. Swarbrick</i>	458
Hillsborough Basin	<i>A. R. G. Gray</i>	460
Capricorn Basin	<i>E. K. Ericson</i>	464

PART VIII PAPUA NEW GUINEA REGION

Papua New Guinea Region—introduction	<i>R. B. Leslie</i>	477
Papuan Basin—on-shore	<i>M. F. Ridd</i>	478
Papuan Basin—off-shore (Gulf Basin)	<i>R. A. Wise</i>	494
North New Guinea Basin	<i>R. B. Grund</i>	499
Cape Vogel Basin	<i>R. S. Bickel</i>	506

PART IX OIL SHALE

Oil shale—introduction	<i>R. B. Leslie</i>	517
Oil shale deposits of the north Eromanga Basin	<i>Staff of Pacminex Pty Ltd</i>	517
Oil shale in Queensland	<i>C. F. J. Swarbrick</i>	519
Oil shale in Tasmania	<i>M. J. Clarke, N. Farmer and A. B. Gulline</i>	524

INDEX

Index of wells, fields and prospects, stratigraphic units, and tectonic and structural elements	<i>C. L. Knight and H. H. Knight</i>	527
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PART I

GENERAL PAPERS

INTRODUCTION

by EDITORS

The search for petroleum in Australia began in 1892 and for the next fifty years continued intermittently on a relatively low scale with little encouragement.

The pace of exploration increased following the discovery of oil at Rough Range in 1953 and a surge of activity during the 1960s resulted in significant discoveries of both oil and natural gas.

Some success has continued into the early 1970s, particularly in regard to natural gas, but exploration is now declining.

Substantial reserves of gas have been established and the current indigenous oil production meets a significant portion of present demand but the longer term situation in regard to oil is uncertain.

Exploration for petroleum in Papua New Guinea has been extensive but unrewarding in respect to oil. Several significant gas discoveries have been made but none of these are developed as yet.

* * *

In this volume the occurrence of petroleum in and around Australia and Papua New Guinea is discussed within a series of papers which describe the geology of most of the Phanerozoic sedimentary basins in the region.

Several general papers on the history of petroleum exploration, the geochemical characterization of crude oils and various exploration statistical data relating to Australia and Papua New Guinea provide additional detail and three papers dealing with oil shale occurrence are also included.

In all, some ninety basins, sub-basins and infra-basins are described and more than one hundred commercial discoveries or significant showings of hydrocarbons are discussed. Several of the basins have little petroleum potential but have been included for completeness. An attempt has been made to apportion the size of papers according to the importance of petroleum occurrence and the extent of past exploration effort within the particular basin.

The various basins are grouped under seven broad subdivisions based upon geographic loca-

tion, age of sediments, basin type, proximity and inter-relationship. Regional subdivisions are shown in Fig. 1, and are discussed further in the separate introductions to Parts 2 to 8 of this volume.

The map appearing as Fig. 2 in the paper by Rudd and Sprigg in Part 1 of this volume shows in simplified outline the main sedimentary basins in Australia and Papua New Guinea. For greater detail the reader is referred to the *Tectonic Map of Australia and New Guinea* published in 1971 by the Geological Society of Australia. The basin outlines from the latter map are incorporated in the *Metallogenic Map of Australia and Papua New Guinea* published by the Bureau of Mineral Resources in 1972; a copy of the map is included in the Map Supplement to the Metals volume of this publication.

Following an initial approach to various exploration companies, government departments, and individuals, authors were selected having particular regard to their present or past involvement in exploration activities in the specific areas.

A broad outline was supplied to authors suggesting discussion of the following topics: (1) introduction giving overall picture of the basin; (2) review of exploration history; (3) previous literature; (4) tectonic framework; (5) stratigraphy; (6) structure; (7) significant hydrocarbon occurrence; (8) future prospects.

Authors were asked to supply manuscripts by the end of 1972, but as frequently occurs in projects such as this, many of the papers were not received until six months after that date and the last arrived late in 1974. A variation therefore exists in the cutoff date for exploratory information given in the various papers. The date of receipt of the paper from the author is given as a footnote on the first page of each paper.

The major contribution by the release of exploration data and provision of staff time and materials by the various companies and government departments is gratefully acknowledged.

Finally, the editors wish to express sincere appreciation to the panel members and particularly to the individual authors for their co-operation in the preparation of this volume.

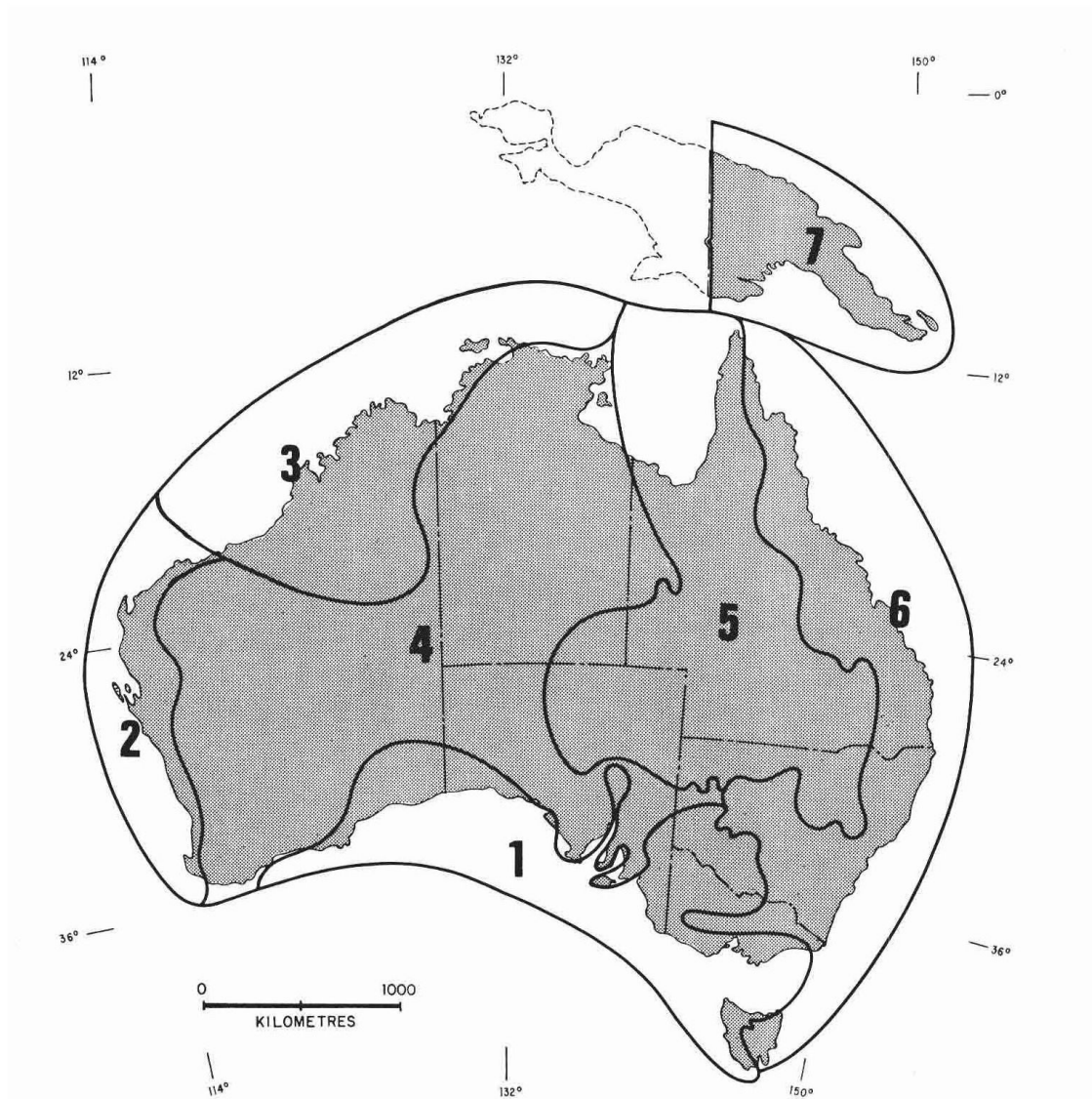


FIG. 1—Regional subdivisions of basin groupings: 1. Southern Coastal Region, 2. Western Coastal Region, 3. North-western Region, 4. Central Intracratonic Region, 5. Great Artesian Basin Region, 6. Eastern Region, 7. Papua New Guinea Region.

HISTORY OF OIL SEARCH IN AUSTRALIA AND PAPUA NEW GUINEA

by E. A. RUDD and R. C. SPRIGG

INTRODUCTION

It is now over twenty years since Rough Range No. 1A well was drilled late in 1953 in the north-west of Western Australia at a locality remote from any recorded indications of hydrocarbons. This well which received the modest reward by the Commonwealth Government as Australia's first discovery well marked a turning point in the search for petroleum in Australia.

Until that event the prevailing opinion was that "Australia is too old for oil" and this, added to the expression that "there is no oil south of the equator", had created a pessimistic attitude towards exploration in Australia by the oil industry. There were other significant features which had discouraged exploration.

Now that the discoveries which have been made seem obvious in hindsight it is worthwhile recalling those factors which delayed exploration and kept Australia dependent on imported petroleum for so many years.

There were no known seepages of oil in Australia, and the few known indications of hydrocarbons which had been encountered in drilling for water had proved disappointing.

Probably the most significant aspect was the absence on the Australian continent of marine Tertiary basins and since by far the greater part of the world's production came from the Tertiary this incentive was lacking.

The Mesozoic basins which were known were largely made up of freshwater sediments and the fact that several thousand water bores had been drilled into the Great Artesian and other basins without convincing discoveries of hydrocarbons was at best discouraging.

A factor which made exploration unattractive was the lack of knowledge of the geology below the surface of vast areas. Australia has low relief, with most of the continent at low elevation above sea level so that there are few areas in which deep dissection reveals sedimentary sections and structures to any depth or extent. Added to this is the unusual depth of weathering so that outcrops which do occur are disguised by alteration, and in many areas there is extensive sand cover. Seismic surveys which are essential to exploration under these conditions were not available until just prior to the Rough Range dis-

covery. The same comment could be made about the availability of up-to-date rotary drilling equipment and the technical competence and engineering services necessary for test wells.

The history of the development of an indigenous petroleum industry in Australia can therefore be divided into pre- and post- Rough Range, i.e. pre-1953 and post-1953. That is not to suggest that useful effort was not made prior to 1953, but it is now possible to realize that the early effort had little chance of success having due regard to the limited petroleum potential of continental Australia. It mattered little that people could stand on the Ninety Mile Beach of Gippsland and look out to sea with thought of Lakes Entrance oil in mind because the technology of off-shore drilling was still to be developed.

THE EARLY INDICATIONS—PRE-1953 (FIG. 1)

There had accumulated in the folklore of Australia a series of reports of indications of hydrocarbons sparsely spread across and around the continent.

It was always difficult to establish the authenticity of these indications because oil from drilling ropes and equipment frequently found its way into boreholes; drillers have always been noted for practical jokes and natural gas is an ubiquitous substance.

However it was generally accepted that there were significant indications of hydrocarbons at several Australian localities. It is worthwhile to review these briefly so that their relationship with later discoveries can be appreciated.

Oil in the form of crude bitumen was first recorded in Australia by members of the crew of H.M.S. *Beagle* at the mouth of the Victoria River in Northern Territory in 1839. Traces of bitumen in the vesicles of Cambrian basalts were subsequently reported on the Ord River Basin of Western Australia.

Across the continent, along much of the southern coast from the Great Australian Bight to western Victoria and Tasmania, the American sealers and whalers early in the nineteenth century collected stranded bitumen along the coast. This pitch-like material was used for the caulking of vessels. In 1869 Brough Smith of the Victorian



FIG. 1—Known hydrocarbon traces prior to 1953.

Department of Mines reported officially on the widespread occurrence of this material along the coast in his treatise entitled "The Goldfield and Mineral Districts of Victoria", and this coastal bitumen has since been the cause of much controversy with opinions ranging from an origin in the vicinity of South America to local seepage on the Australian Continental Shelf.

It was the discovery of a bitumen-like leathery deposit in lakes near Salt Creek in the south-east of South Australia that finally led to the drilling of the country's first oil exploration well. The material, "Coorongite", was actually the dried-up, wind-accumulated remains of a unicelled alga called *Botriococcus brauni* that still flowers in great profusion on reservoirs and other lakes in Australia in favourable seasons. The material burned with a smokey, oily flame and led to the

belief that there were oil seeps in this area. This 1892 well was the first of a number in the general area, all of which were shallow and did not encounter any authenticated traces of oil. The exploration led to many rumours of oil discovery "covered up" by foreigners, and the stories persist even to this day. There is no substance in them.

The first significant hydrocarbon discovery was of natural gas encountered in an artesian bore in 1900 at Roma in Queensland. Difficulties were experienced in bringing the gas into production, particularly because of its association with artesian pressure waters. It was not until 1906 that the first gas from the Roma well lit the town for ten nights before the flow failed. Thereafter attempts to exploit the Roma gas brought repeated disappointments until the Associated Group discovered the Pickanjinie Field and

others near Roma from 1960 onwards. However, this was not until after the Roma Oil Corporation in 1927 had struck wet natural gas at the rate of 17 thousand m³ per day. About 140 thousand litres of condensate were recovered before the flow failed in 1932.

In 1919 a well sinker on Gogo Station in the West Kimberley Division of Western Australia reported traces of oil which were confirmed by the government geologist. This started a long period of exploration drilling in this area which has continued until the present time without commercial success.

There had been test wells drilled in the East Gippsland area of Victoria prior to 1924 but in that year a water well at Lakes Entrance found traces of oil and gas and some 54 wells were subsequently drilled in the locality and delineated an area of approximately eight square miles within which oil occurred. The wells were shallow and oil with water was pumped from a sand with an average depth of 370 m. In 1942 the Commonwealth and Victorian Governments participated in the sinking of a circular shaft 4 m in diameter with a 7 m diameter work chamber at the bottom from which near horizontal drainage holes were drilled into the oil sand. The project was abandoned in 1951. A total of some 1 820 thousand litres of low quality crude oil was produced from the Gippsland Basin before the off-shore discoveries were made.

Between the two world wars pioneering and sporadic drilling operations were carried out by individuals, companies and Governments in a number of areas throughout Australia and particularly near Roma and in the Great Artesian Basin of Queensland; in the Hunter Valley and the Sydney Basin of New South Wales; at Lakes Entrance and the Gippsland Basin of Victoria; in the southeast of South Australia and in the Kimberleys of Western Australia. There was also activity in Papua and the Mandated Territory of New Guinea.

With the exception of the work by Oil Search Ltd. in Australia and with its partners D'Arcy Exploration Co. and Vacuum Oil Company in New Guinea the operations were comparatively slight and without economic success.

Despite the lack of success in this early period it should be noted that it was a time when information began to accumulate and a number of the people who later participated in the successful outcome of petroleum exploration in Australia became involved in the search for hydrocarbons. It was a case of "the longest journey always starts with the first step".

In 1946 Australian Motorists Petrol Co., later AMPOL, became interested in petroleum exploration.

Subsequently AMPOL joined with the Standard of California and the Texas Co. in 1952 to form the West Australian Petroleum Pty. Ltd. and WAPET has had a long association with the search in Australia.

The site chosen for the first test was at Rough Range near the Northwest Cape—a geographical feature unknown to most Australians at that time although it was one of the first areas sighted by early explorers. To this remote locality had to be shipped and unloaded without any existing facilities all the paraphernalia necessary to drill a modern petroleum test well—the first such modern rotary well drilled in Australia. Judged in hindsight it was an extremely bold venture and as it turned out for Australia an extremely fortunate one.

On 4th December 1953 it was announced that "a high grade crude oil flowed at a rate of 20 barrels (3·2 m³) per hour for 25 hours on a $\frac{1}{4}$ inch choke—the first commercial quantities of oil ever found on the Australian continent." There followed 27 wells in the Rough Range and Cape Range areas, all of which proved disappointing. Finally even the Rough Range discovery pool proved too small to be commercial. The discovery well was deepened eventually to 4500 m, meeting only traces of oil and gas until finally the well was abandoned. However, despite this setback, oil exploration in Australia had received its greatest stimulus, and as a result many new Australian companies were formed and moved into exploration along with an increasing number of international companies.

Not only had oil been discovered but Rough Range No. 1A made the point that surface indications of petroleum were not necessary to justify further exploration.

LATER DEVELOPMENTS—POST 1953

(FIGS. 2 AND 3)

In 1954 Australian Associated Oilfields struck gas at the rate of 35 thousand m³ per day in the Hospital Hill Bore near Roma, Queensland, and a new phase of exploration commenced in that area. At the same time the Woodside Company, operating the Gippsland Basin, recorded oil and gas shows in eastern Victoria and extended the interest in that area also. However, it was in 1956 that the Australasian Petroleum Company had a natural gas blow out at Kuru No. 1 in Papua. Three years later, in 1959, Island Exploration and Australasian Petroleum struck gas with an open flow potential of 3·05 million m³ per day at Barikewa No. 1 in Papua, and later in the same year Australasian Petroleum struck 85 thousand m³ of gas and 1 600 barrels (254 m³) of oil per day in Puri No. 1 in Papua.

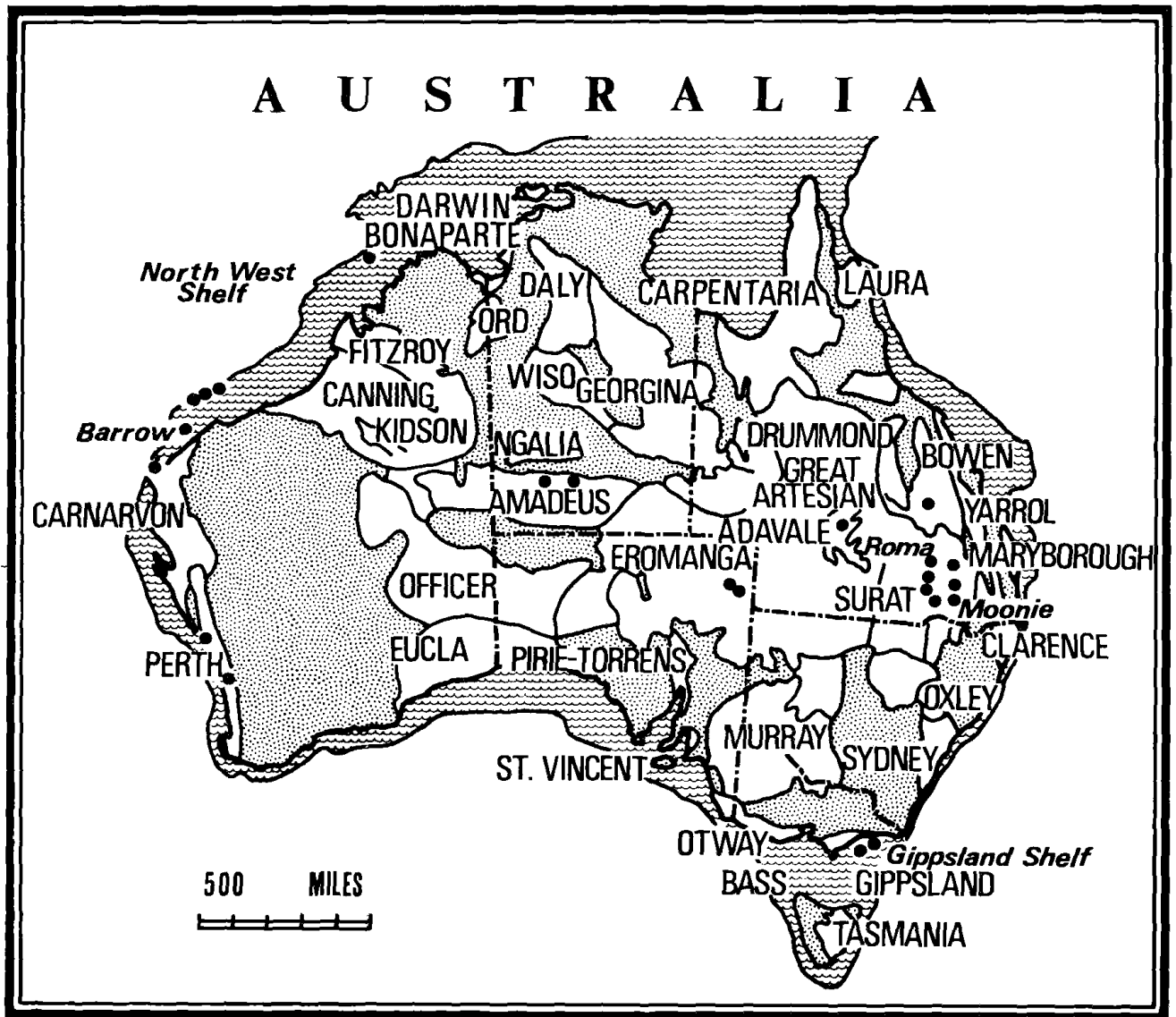


Fig. 2—Known occurrences of hydrocarbon in 1974.

Excitement continued in 1959 when Oil Search encountered a flow of 1.2 million m^3 of gas per day at Bwata No. 1 in Papua. These accumulations were never declared commercial. Thereafter interest moved back to Australia when Frome-Broken Hill then made a 113 thousand m^3 per day gas plus condensate discovery at Port Campbell in Victoria in the Tertiary-Mesozoic Otway Basin, but the flow declined rapidly to 57 thousand m^3 per day.

In 1960 the Associated Group made a series of discoveries in the general Roma district with the first significant flow of condensate gas from the Pickanjinie Well, and a new field developed. Soon after, Oil Search struck gas at the rate of 1.02 million m^3 per day in Iehi No. 1 in Papua, and the continent seemed set for exciting new commercial developments.

After the initial impetus given to petroleum exploration in Australia by the Rough Range discovery the fact that no commercial oil field had been developed there or elsewhere by 1960 seemed to suggest that the pessimists who had retreated one step in 1953, might be right when they inferred that while there might be wells there would not be fields.

The discoveries in the Surat Basin by Union-Kern-AOG late in 1960 and early in 1961 came at an appropriate time when exploration interest was beginning to decrease. The Cabawin No. 1 well near Tara in south-east Queensland, Union-Kern-AOG's first well, encountered high pressure gas and a flow of 60-100 barrels (9 to 16 m^3) of oil per day but it was the Moonie No. 1 well which flowed 1 765 barrels (281 m^3) per day of high gravity oil (44.5 A.P.I.) which led to Australia's first commercial oil field.