



Distribution of Petroleum Resources in Australia

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**Australia: State of the Environment
Technical Paper Series (Land Resources)**



Environment Australia, part of the Department of the Environment

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Cataloguing-in-publication data:

Radke, S. et al.

Distribution of petroleum resources in Australia / S. Radke et al.

17 p. 29.7 x 21 cm. – (State of the environment technical paper series
(Land resources))

Bibliography: p. 11

ISBN 0 642 25282 3

1. Petroleum reserves—Australia. I. Radke, Sandra. II. Australia.
Dept. of the Environment. III. Series

553.28'0994—dc21

For bibliographic purposes, this document may be cited as:

Radke, S., Passlow, V., De Nardi, R. & le Poidivin, S. 1997 *Distribution of petroleum resources in Australia*, Australia: State of the Environment Technical Paper Series (Land Resources), Department of the Environment, Canberra.

For additional copies of this document or for further information, please contact the Community Information Unit of the Department of the Environment, GPO Box 787, Canberra ACT 2601. Phone, toll free, 1800 803 772, Facsimile 02 6274 1970

This book was printed in Australia on Australian-made, 100% recycled paper (Tudor RP).



Central Queensland University Publishing Unit

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Preface

Australia: State of the Environment 1996 (the first ever independent and comprehensive assessment of the state of Australia's environment) was presented to the Commonwealth Environment Minister in 1996. This landmark report, which draws upon the expertise of a broad section of the Australian scientific and technical community, was prepared by seven expert reference groups working under the broad direction of an independent State of the Environment Advisory Council. While preparing the report, the former Department of the Environment Sport and Territories, on behalf of the reference groups commissioned a number of specialist technical papers. These have been refereed and are now being published as the State of the Environment Technical Paper Series. Reflecting the theme chapters of the report, the papers relate to human settlements, biodiversity, the atmosphere, land resources, inland waters, estuaries and the sea, and natural and cultural heritage. The topics covered range from air and water quality to sea grasses and historic shipwrecks.

Acknowledgments

The authors would like to thank Chris Parvey and the Australian Geological Survey Organisation (AGSO) for providing sedimentary basin coverage from AGSO's PetroInfo Database.

Abstract

Hydrocarbon occurrences have been reported in Australia since early settlement. However, significant commercial discoveries have only been made in the last 30 years. Factors controlling the production of petroleum are varied and may be classified as geological, regulatory, environmental, cultural and economic. Known resources can be classified according to status. These resources are mapped according to three criteria: petroleum type, production status and commercial status. Data are from several databases managed by the Bureau of Resource Sciences (BRS) and the Australian Geological Survey Organisation (AGSO).

1 Introduction

This paper supplements the map of petroleum occurrences in Australia which was prepared by the Bureau of Resource Sciences (BRS) for the 1996 State of the Environment Report. Alternative and more detailed spatial distributions are provided and an overview of the factors that contribute to the discovery of petroleum resources in Australia is presented, as is the methodology used in producing the spatial distribution maps.

2 Historical summary of petroleum exploration and development

Hydrocarbon occurrences have been reported in Australia since early settlement when whalers and sealers noticed seeps along the southern beaches of Victoria and South Australia (McGregor 1993). The first written record of oil discovery in Australia was noted in November 1839 by Lt. John Stokes, surveyor on the *Beagle*, while sailing along the Australia's northwest coast. At that time, petroleum was not an important commodity, being used initially for caulking and as a substitute for whale oil.

Developments in America in the late 1880s increased demand and initiated the search for oil. The first recorded well to search specifically for oil in Australia was sunk near the Coorong in South Australia in 1886 (APEA 1988), but success was not forthcoming until 1900 when gas was struck in a well drilled near Roma, Queensland.

It was not until after the Second World War, however, that the scale of exploration increased significantly in Australia. In 1946 the Australian Government established the Bureau of Mineral Resources (BMR),

now known as the Australian Geological Survey Organisation, to survey the continent and collect geoscientific data. This initiative laid the groundwork for systematic assessment of petroleum and mineral resources.

Following some initial mapping efforts by the BMR, Ampol and Caltex combined to form West Australian Petroleum (WAPET) and commenced exploration at Rough Range on the Exmouth Peninsula. Within three months of drilling in 1953, WAPET struck oil at 1100 metres. This first discovery turned out to be small and uneconomic but it was significant for reversing the common belief that Australia did not possess oil resources. Since then, WAPET has grown into a consortium of partners, comprising Mobil Limited, Chevron Asiatic Limited, Chevron Oil Australia Pty Ltd, Chevron Oil Company of Australia, Shell Development (Australia) Pty Ltd, Texaco Oil Development Company and Western Mining Corporation Limited, with extensive interests in the Carnarvon Basin, including the Barrow Island field, and interests also in the Perth Basin.

In 1957 the State and Commonwealth Governments introduced the *Petroleum Search Subsidy Act (PSSA)* which was directly aimed at encouraging petroleum exploration and increasing Australia's self sufficiency in petroleum resources. Under the *PSSA*, companies were subsidised up to 50% of the cost of exploration. In return, valuable exploration data were provided to government and are maintained as a public domain information resource. These data have been extensively used in research and exploration. The *PSSA* operated until 1974.

By the 1960s exploration was being conducted at Lakes Entrance in Gippsland, the Great Artesian Basin of central Australia, the Otway Basin of Victoria, the Roma district of Queensland, the Great

Australian Bight and Otway Basin of South Australia and prospective areas of the Northern Territory. Significant successes in the 1960s commenced with the Moonie oil field in Queensland and the larger Moomba gas field in South Australia, initiating production in the Surat and Cooper basins. In 1965 and 1966 sufficient gas was discovered by Esso/Broken Hill Proprietary (BHP) in the Barracouta and Marlin fields of Bass Strait to supply Victoria for many decades. In 1968 the Snapper field and soon after the Kingfish oil field (the largest to be found yet) were discovered and others followed in quick succession. Australia changed from a country relying on imports to one with better than 70% self-sufficiency.

In the 1970s large gas and condensate discoveries were made on the offshore North West Shelf. More recently, significant oil discoveries have been made in the offshore Bonaparte Basin in the Timor Sea.

Bass Strait resources are now in significant decline and the focus is on offshore West Australia and the Timor Sea, including the Zone of Cooperation with Indonesia. In recent years, this trend has been driven in the Carnarvon Basin by production of crude oil from Wanaea, Cossack and Griffin area fields, full production at Wandoo and condensate production at Goodwyn. Upcoming crude oil developments at Laminaria and Corallina, in waters administered by the Northern Territory, and by Elang and Kakatua in the Zone Of Cooperation A (ZOCA) will sustain the trend, offsetting new developments at West Tuna and Bream B in Bass Strait. The significant condensate resource at Bayu/Undan in ZOCA has also been proposed for early development.

3 Factors controlling the distribution of petroleum production

3.1 Geological

A geological setting favourable to petroleum generation and accumulation is fundamental to the distribution of petroleum production. Hydrocarbon accumulation requires an organic-rich source rock, a porous reservoir rock, a seal of non-porous rock bounding the reservoir and a trap (a feature that causes migrating fluids to accumulate within the reservoir). In addition, the right combination of heat, pressure and time is necessary to 'cook' the organic

material in the source rock 'kitchen' and generate hydrocarbons. The most prospective geological settings are found in the Mesozoic and Tertiary sedimentary basins of Australia, particularly in offshore areas.

3.2 Regulatory

In Australia, all petroleum is the property of the Crown and ownership of land does not carry with it any rights to explore for, or produce minerals or petroleum from that land. Offshore the Crown's position is expressed in terms of sovereignty and sovereign rights rather than ownership. Consequently, both onshore and offshore interests in petroleum require a special grant from the Crown made pursuant to the petroleum legislation relevant to the jurisdiction.

Four categories of jurisdiction currently exist in Australia: onshore, coastal waters, offshore (excluding the Zone of Cooperation) and the offshore Zone of Cooperation between Australia and Indonesia. Onshore legislation is administered by the relevant State or Territory and covers all land inland from the low-water mark including all bays and harbours adjacent to that State or Territory. Coastal waters extend outwards from the low-water mark to 3 nautical miles (4.8 km) beyond the territorial sea baseline and are also under State/Territory jurisdiction. Offshore exploration and development beyond the coastal waters are conducted under the *Petroleum (Submerged Lands) Act 1967 (P(SL)A)* which is jointly administered by the Commonwealth and the relevant State or Territory. In the Timor Sea, a Zone of Cooperation has been delineated with regard to petroleum operations after a treaty was signed in 1989 between the Australian and Indonesian governments. Legislation relevant to this area is distinct from the *P(SL)A* and is administered by a Ministerial Council for the Indonesia–Australia Zone of Cooperation, consisting of relevant Ministers in Australia and Indonesia.

Offshore exploration acreage is released each year by the Commonwealth and State/Territory Governments. In the past releases have usually been made twice a year, although in some years only one release is made. Availability of acreage in onshore Australia and in coastal waters varies with the relevant legislation. Leases are granted for specified renewable tenures, depending on the activity (exploration or development) and the relevant

legislative guidelines. In general, renewal of tenure carries an obligation to reduce the size of the area under permit, as exploration efforts should, theoretically, better define the potential area.

3.3 Environmental and cultural

Petroleum exploration and production activities are undertaken subject to the provisions of government legislation which provide for the protection of the environment. Special provisions may need to be made to protect environmentally sensitive areas, areas of high conservation value or areas of commercial or recreational value such as coral reefs and atolls, breeding grounds and nesting colonies.

There are Commonwealth legislative provisions for the protection of historic shipwrecks and sites of scientific or cultural value, including sites of significance to both European and Aboriginal cultures. These provisions apply also to onshore exploration and development. Under the *P(SL)A* companies must also have an approved oil spill contingency plan prior to commencement of any drilling operations.

Environmental and other land use regulations and policies primarily affect petroleum exploration and development by restricting access to exploration acreage. This constrains full assessment of petroleum resources, the ability to attract investment and, ultimately, the ability to maximise the use of Australia's identified resources. While onshore areas have been most affected to date, a number of conservation sites exist in marine areas. Where exploration and development is not prohibited, environmental and land use regulations and policies affect how work is conducted and usually add costs to petroleum operations, thus having an economic impact.

3.4 Economic

Economic factors that have the greatest impact on hydrocarbon exploration and development include crude oil pricing, government taxation and market access. Proximity to the infrastructure and facilities of developed fields also plays a part as do technical requirements, for example the cost of deep water

versus shallow water development or compliance with environmental best practice.

4 Status of petroleum resources

The following classifications, used by the BRS in this report, indicate the status of petroleum resources in Australia to date. Due to the various factors controlling petroleum production and development, particularly economic factors, the status of a resource will change with time.

4.1 Past producer

Resources in areas of past production are depleted to the extent that future production is highly unlikely. Few areas fall into this category and include the Talisman field in the Carnarvon Basin, together with a number of small fields in the Bowen, Perth, Gippsland, Canning and Surat basins.

4.2 Producer

Oil and gas production currently occurs in all States except New South Wales and Tasmania. Major production areas include the Gippsland (Bass Strait), Cooper/Eromanga, Bowen/Surat, Carnarvon, and Bonaparte (North West Shelf, Timor Sea) basins. This category also includes 'shut-in' fields that have previously produced but, due to changing economic factors, have had operations suspended until a more favourable economic climate exists; production at these shut-in areas may be resumed at any time or may remain suspended for years.

4.3 Potential producer

Areas of potential production include discovered sub-economic accumulations that have not yet produced petroleum. Further development in these areas is either planned or reasonably likely with favourable changes in economic factors. Production in these areas may be commenced at any time.

4.4 Other discoveries

Petroleum discoveries which are uneconomic and unlikely to be productive in the foreseeable future are classified as other discoveries.

5 Undiscovered resources

Undiscovered petroleum resources are typically rated in terms of probability. As the assessment of these probabilities is very dependent on existing knowledge of the area being considered, it is useful to categorise each area of exploration activity as either mature, underdeveloped or frontier.

Mature areas in Australia include the Gippsland Basin in Bass Strait, which has been actively and successfully explored for over 25 years, and a small portion of the Carnarvon Basin in offshore Western Australia. Underexplored provinces are areas where there are small to moderate proven petroleum reserves, but insufficient exploration data exist to fully assess the resource potential of the area. Such underexplored areas include the offshore Bonaparte, Otway and Perth basins, and the onshore Amadeus, Cooper, Eromanga, Surat, Perth and Otway basins. Most of Australia's offshore areas are frontier areas where very few or no wells have been drilled and there is a lack of data which could be used in accurately assessing their potential. These areas, however, may be considered prospective because they have favourable geological settings.

Forecasts of the potential areas, sizes and numbers of undiscovered resources are carried out by the BRS each year using statistical methodology. The results of this work are reported in the BRS annual publication *Oil and gas resources of Australia*.

Based on recent forecasts (1995), the most prospective areas containing undiscovered oil, in ranked order, are the Carnarvon and Bonaparte basins, basins offshore from north-east Queensland, and the Gippsland, Browse, Perth, Otway and Eromanga basins. The presence of significant undiscovered oil offshore in the Browse, Perth and Otway basins and offshore from north-east Queensland is unproved and must be regarded as speculative.

Gas discoveries are most likely in the Carnarvon, Browse, Bonaparte, Otway and Gippsland basins. The Perth and Cooper basins and the basins offshore from north-east Queensland have less potential.

6 Distribution of petroleum resources in Australia

Maps showing the spatial distribution of petroleum occurrences were prepared by the BRS using data from BRS and AGSO databases. The maps were produced by displaying petroleum well locations using Environmental Systems Research Institute, Inc. (ESRI) ArcView II software. Wells in areas of discovered petroleum resources were extracted from the Petroleum Exploration Data Index (PEDIN) database and characterised according to the type of petroleum resource and the production status of the field as listed in the Australian Petroleum Accumulations (APA) database.

Using the same set of data, three **views** were developed to present and analyse the data in different ways: **petroleum type**, **production status** and **commercial status**.

The data are shown in the three maps in the appendices to this paper.

Appendix A

Petroleum accumulations in Australia classified by petroleum type.

Appendix B

Petroleum accumulations in Australia by production status.

Appendix C

Petroleum accumulations in Australia by commercial status.

The following sections (6.2, 6.2 and 6.3) describe the construction of these maps.

6.1 Petroleum type

The primary aim here is to show the distribution of petroleum occurrences by the type of petroleum resource that has been discovered or produced. Three ArcView *themes* were created for:

- oil occurrences
- gas occurrences
- oil/gas occurrences.

Each of these themes can be displayed separately or together in various combinations. In Appendix A all three themes are illustrated. The themes are differentiated by colour. In this case the maps use the traditional red for gas and green for oil; blue is used for oil/gas occurrences.

Each well in these themes is given a *classification* according to the status of the hydrocarbon field to which it belongs allowing more detailed characterisation of the occurrences to be displayed:

Past producer: resource depleted by previous production

Producer: currently producing or shut-in field

Potential producer: discovered resource which may produce in the future

Other discoveries: petroleum occurrences that are uneconomic and are unlikely to be economic in the foreseeable future.

These four classifications are differentiated in the maps by the consistent use of symbols across all three themes with the symbol taking the colour of the relevant theme.

6.2 Production status

Appendix B shows the map produced. The primary aim is to show the distribution of petroleum occurrences by the production status of the field. Essentially this reverses the structuring of the data from the petroleum type view shown in Appendix A, as indicated below. Four ArcView *themes* were thus created for:

- past producer (resource depleted by previous production)
- producer (currently producing or 'shut-in' field)
- potential producer (discovered resource which may produce in the future)
- other discoveries (petroleum occurrences that are uneconomic and are unlikely to be economic in the foreseeable future).

Each of the above themes can be displayed separately or together in various combinations. In this report all four themes are illustrated. The themes are differentiated by symbols.

Each well in the above themes is given a *classification* according to the type of petroleum resource that has been discovered or produced, allowing more detailed characterisation of the occurrences to be displayed:

Oil occurrences

Gas occurrences

Oil/gas occurrences.

As in section 6.1, the classifications are differentiated by colour: the traditional red for gas, green for oil and blue for oil/gas occurrences. This colour scheme is the same across all four themes with the colour taking the symbol of the relevant theme.

6.3 Commercial status

Appendix C shows the map produced. This map was used for preparing a simplified small scale map that appears in the State of Environment Report (DEST 1996).

The primary aim is to show the distribution of commercial versus non-commercial petroleum occurrences. This view is essentially a compression of the production status view in that it consolidates several of the production status classifications into two ArcView *themes*:

- commercial (producer)
- non-commercial (past producer, potential producer, and other discoveries).

Each of the above themes can be displayed separately or together. In Appendix C these themes are illustrated and differentiated by symbols.

Each well in the above themes is given a *classification* according to the type of petroleum resource that has been discovered or produced allowing more detailed characterisation of the occurrences to be displayed:

Oil occurrences

Gas occurrences

Oil/gas occurrences.

Classifications are differentiated by colour, in this case the traditional red for gas, green for oil and blue for oil/gas occurrences. These colours are the same across both themes.

6.4 Limitations

Although wells shown on each map are given symbols according to the *overall* status of their field, in reality not all wells in a given field are producing wells. The availability and/or reliability of these data on a well-by-well basis is uneven. Furthermore the usefulness of differentiating wells on this basis at small scale is limited, and fields themselves are not usually resolved. The data do, however, show the general pattern of petroleum resource occurrences in Australia.

7 Database sources

The sources of information used in preparing the spatial distributions for the State of the Environment Report include the following databases managed by the BRS and the AGSO:

Petroleum Exploration Data Index (PEDIN)

PEDIN is an Oracle relational database containing basic data on petroleum drilling and geophysical activity in Australia. Data are entered daily from scouting information collected by the BRS and from company exploration reports submitted to the Commonwealth under *PSSA* and *P(SL)A* legislation. Open file data from PEDIN is available on a cost recovery basis and is used by government and petroleum industry clients. PEDIN is jointly managed by the BRS and the AGSO.

Spatial data in the form of latitude and longitude coordinates were obtained from PEDIN to plot well locations in the State of the Environment Report.

Australian Petroleum Accumulations (APA) database

APA is an Oracle relational database that is linked to PEDIN via both the hydrocarbon field name and the discovery well for the field. APA contains summary information on hydrocarbon fields in Australia including trap types, reservoir units and area of closure. The APA database is updated on a regional (basin) basis and supports a series of BRS APA publications. APA is wholly managed by the BRS.

Hydrocarbon field data such as the field name, basin, commercial status (*commstatus*), and hydrocarbon type (*fluidtype*) were used in preparing the spatial coverages of petroleum occurrences for the State of the Environment Report.

Reserves database

The Reserves database is an Oracle database that holds reserves and production data on hydrocarbon accumulations in Australia. The database is managed and used by the BRS for resource assessment studies and, while summary compilations of these data are publicly reported, the individual company records are confidential.

The reserves database was used to verify and/or assign the commercial status and hydrocarbon types for the various accumulations in the APA database.

PetroInfo

Major sedimentary basin outlines shown in all three maps were obtained from AGSO's PetroInfo geographic information system. PetroInfo is designed to display a range of regional petroleum exploration data including sedimentary basins, depth to basement, well locations, faults and geologic structure, seismic lines and paleoenvironment data.

The sedimentary basins data is based on work by Parvey and others (1994). The data are stored as an ArcInfo coverage.

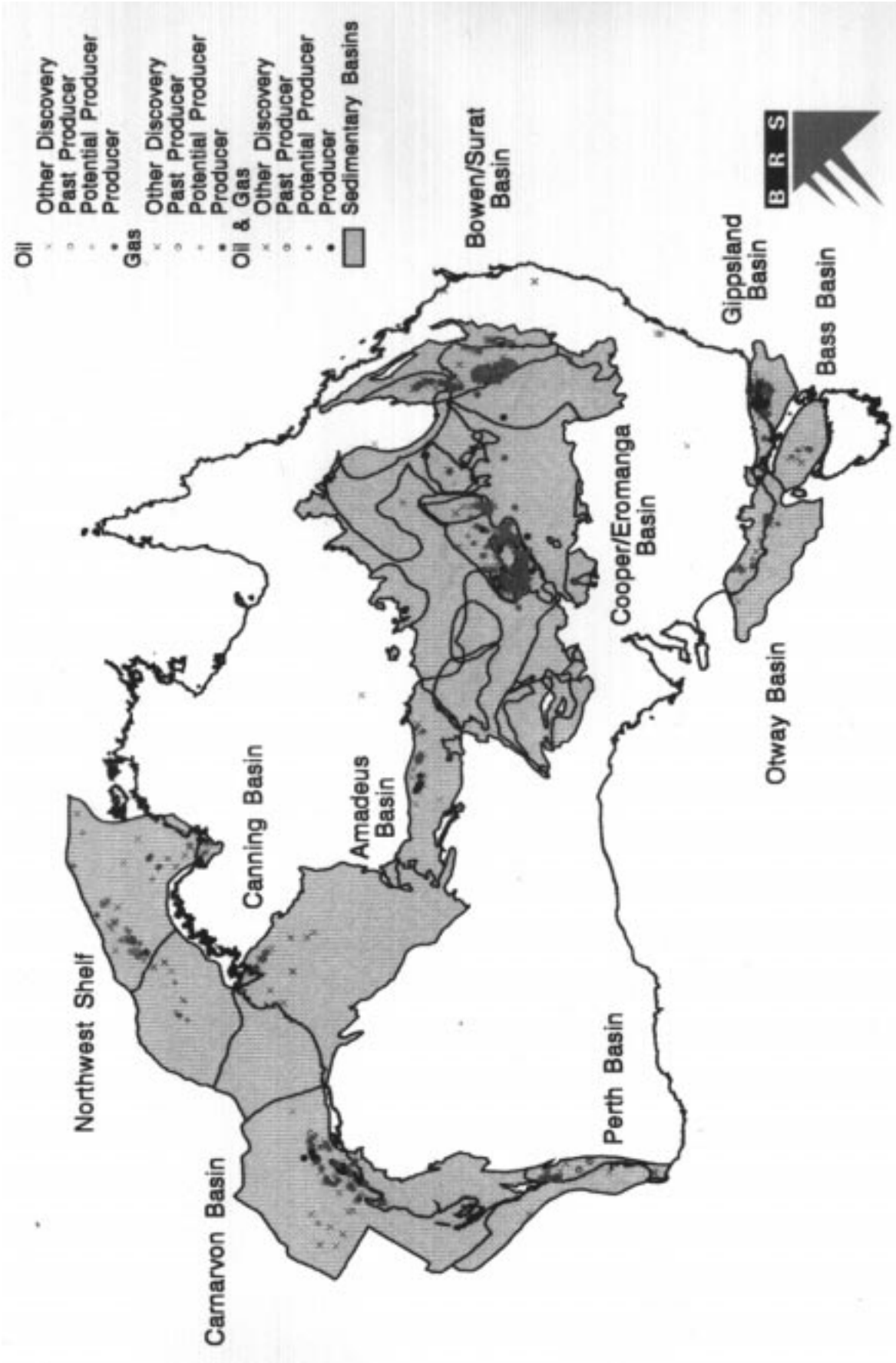
The maps provided here were produced from the above datasets in November 1996. As the principal datasets (PEDIN, APA, Reserves) are continually updated and maintained by BRS, future updates of the maps can be produced as required.

7.1 Further information

For further information on petroleum resources contact the Director, Petroleum Resources Branch, Bureau of Resource Sciences, PO Box E11, Queen Victoria Terrace, Parkes, ACT 2601.

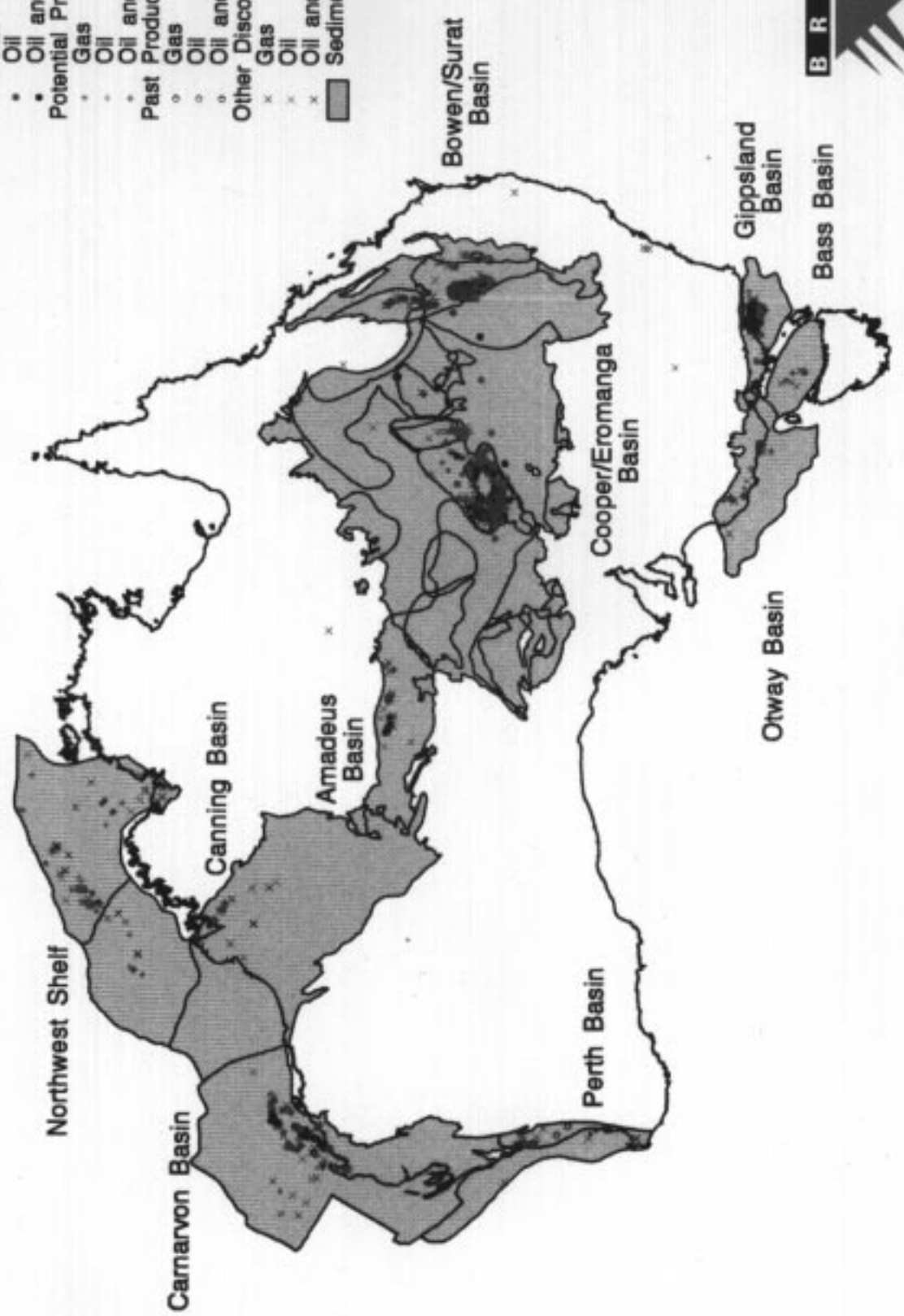
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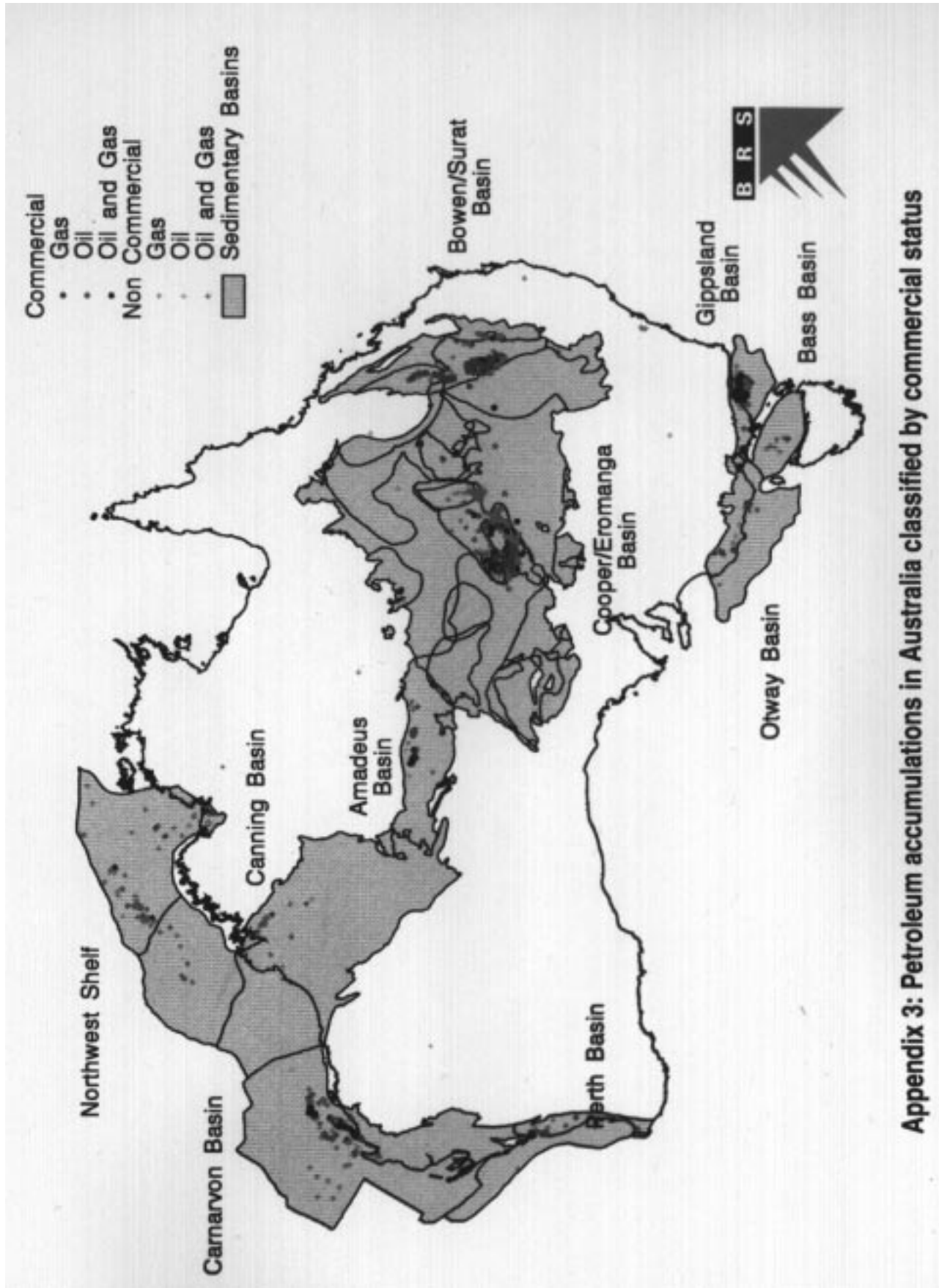


Appendix 1: Petroleum accumulations in Australia classified by petroleum type

- Producer
 - Gas
 - Oil
 - Oil and Gas
- Potential Producer
 - Gas
 - Oil
 - Oil and Gas
- Past Producer
 - Gas
 - Oil
 - Oil and Gas
- Other Discovery
 - x Gas
 - x Oil
 - x Oil and Gas
- Sedimentary Basins
 -



Appendix 2: Petroleum accumulations in Australia classified by production status



Appendix 3: Petroleum accumulations in Australia classified by commercial status