

Otway Basin Exploration Opportunity



May 1996

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OTWAY BASIN, SOUTH AUSTRALIA

DATA REPORT

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MINES and ENERGY
SOUTH AUSTRALIA



**OTWAY BASIN
EXPLORATION OPPORTUNITY
BLOCKS OT96-A and OT96-B**

by

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Petroleum Division

MAY 1996

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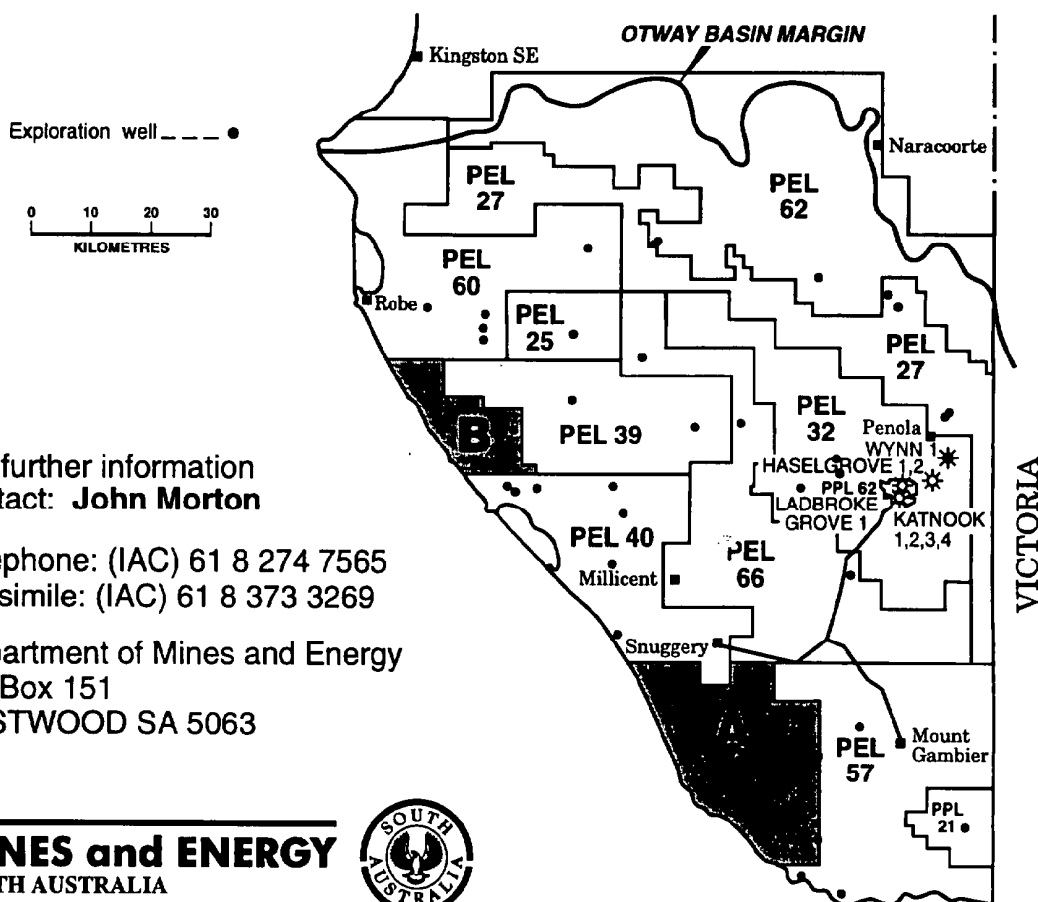
Cover photo: Vibroseis trucks in PEL 32 - Otway Basin, South Australia (Courtesy: Bob Laws, MESA)

OTWAY BASIN – SOUTH AUSTRALIA CALL FOR APPLICATIONS

Petroleum Exploration
Licence applications
are invited for
the two areas
OT96 A and B
in South-East
South Australia.



Applications close on 27 September 1996.



EXECUTIVE SUMMARY

Two areas (OT96-A and B) located in the South Australian sector of the onshore Otway Basin, are available for application as Petroleum Exploration Licences (PELs). The approximate area of each block and seismic coverage is as follows:

Block	Area	Area	Seismic (pre 1980)		Seismic (post 1980)	
	(km ²)	(acres)	(line km)	(line miles)	(line km)	(line miles)
OT96-A	255	62 600	54	34	164	102
OT96-B	677	167 290	182	113	329	204

The Otway Basin is one of a series of basins which originated with the rifting and final pull-apart of the Australia-Antarctica landmass, initiated during the Early Cretaceous. The oil and gas productive Gippsland Basin is the best known of these basins as it contains several giant oil and gas fields.

Commercial gas was discovered in the onshore Otway Basin in South Australia at Katnook in 1987. Sufficient reserves were proved by follow-up drilling to enable the signing of contracts and construction of a pipeline to supply local markets in 1991. Oil has been recovered from two wells in Victoria (Lindon 1 and Windermere 1) and three in SA – Caroline 1, Sawpit 1 and Wynn 1. Wynn 1 flowed oil at 120 BOPD, the first well in the basin to flow oil to surface. In the eastern Otway Basin in Victoria two large discoveries were made in the offshore in 1993, estimated to contain approximately 1 000 BCF of gas in place.

There are a number of undrilled prospects and leads within the area, the largest of which is the Benara Prospect in OT96-A, with a potential reserve of approximately 190 mmbbls of recoverable oil.

KEY DATA

Age of sediments	- Early to Late Cretaceous.
Thickness of sediments	- Up to : 8 km (Area A), 4 km (Area B)
Depth to target zones	- 1 600 to 2 650 m.
Basin type	- Rift.
Depositional setting	- Fluvial-lacustrine-deltaic.
Regional structure	- Early half grabens, late growth faulting.
Source rocks	- Casterton and Laira Formation shales, Eumeralla Formation coals and shales (Areas B). Eumeralla Formation coals and shales (Area A).
Reservoirs	- Fluvial and deltaic sandstones.
Traps	- Faulted anticlines
Depth to oil/gas window	- 1 300 to 3 800 m
Expected hydrocarbons	- Oil in flank areas, gas with some liquids potential in deeper areas.
Number of wells (Area A)	- Three (Lake Bonney 1, Burrungule 1 and Kentgrove 1).
Number of wells (Area B)	- One (St Clair 1)
Seismic coverage (Area A)	218 line km (164 line km post 1980)
Seismic coverage (Area B)	511 line km (329 line km post 1980)

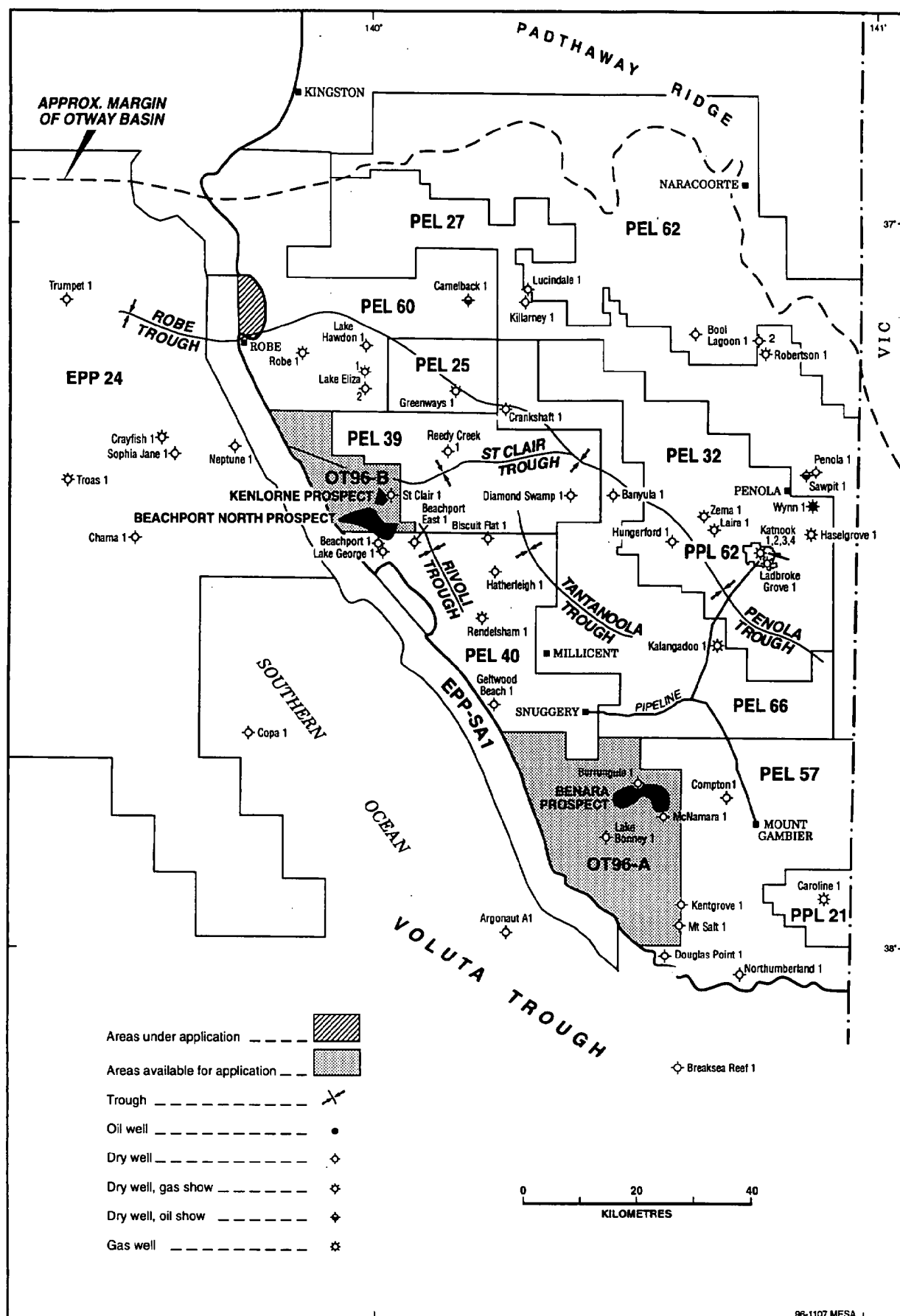


Fig. 1 Petroleum exploration licences and wells, Otway Basin SA

APPLICATIONS FOR EXPLORATION LICENCES

Applications may be made for either or both of the areas OT96-A and B and applicants are encouraged to apply for both areas of interest. In the event that more than one area is offered for license to the applicant, (on the basis of the most competitive work program), the applicant is not obliged to accept any or all of the offers.

Enquires and applications for a Petroleum Exploration Licences over either or both areas may be addressed to:

Mr R A Laws
Director, Petroleum Division
MESA
191 Greenhill Road
PARKSIDE SA 5063

PO Box 151
EASTWOOD SA 5063

Before August 1996

Telephone:	National	(08) 274 7680
	International	*61 8 274 7680
Facsimile:	National	(08) 373 3269
	International	*61 8 373 3269

From August 1996

Telephone:	National	(08) 8274 7680
	International	*61 8 8274 7680
Facsimile:	National	(08) 8373 3269
	International	*61 8 8373 3269

** Dial appropriate International Access Code*

Applications should be accompanied by a proposed 5 year work program, a map of the application area, a \$2000 application fee, and details of the technical and financial resources of the applicant.

Guidelines for making an application are included in Appendix 2 and an application form is included in Appendix 3.

**The closing date for applications is
4 pm on 27 September 1996.**

INTRODUCTION

The Otway Basin is part of the Australian Southern Rift System (Figs. 1, 2), formed along Australia's southern margin during a period of rifting and continental breakup which separated Australia and Antarctica. The northern margin of the basin extends up to 50 miles (80 kilometres) inland whilst the southern margin is poorly defined and lies in the region of the continental slope some 160 kilometres offshore. Approximately 70 percent of the basin is offshore. The basin straddles the South Australian/Victorian State border.

Seismic studies have shown that the structural evolution of the Otway Basin is analogous to basins such as the Tucano-Reconcauo Basin of Brazil and the Gabon and Cabinda Basins of the west coast of Africa. Each of these basins have been found to contain at least one giant oil field.

EXPLORATION HISTORY

The first oil well drilled in the Otway Basin was in 1866 at Alfred Flat. The explorers were convinced of the presence of oil in the subsurface on the basis of bitumen strandings frequently found on the coastline and oily algal scums floating on nearby lagoons. Robe 1 was drilled in 1915 on a palaeo-dune, but it is believed the well did not penetrate the most prospective reservoir section (Crayfish Subgroup) although gas shows were encountered in the Eumeralla Formation. Lake Eliza 1, drilled in 1969, also encountered gas shows in the Otway group. The first offshore well was drilled in 1967 and over the period 1967 to 1975 Esso and Shell drilled six wells offshore, in the South Australian sector of the basin. Although hydrocarbon shows were encountered, no discoveries were made. Failure is attributed to the then poor quality of seismic data and to a poor understanding of the stratigraphic relationships which together led to all of these wells being invalid tests (either drilled off structure or the main objective not penetrated).

The first commercial production of hydrocarbons was established with the drilling of North Paaratte No. 1, an onshore well located near Port Campbell in Victoria, in 1979. Gas is currently being produced from the Late Cretaceous Waarre Sandstone through this well. Lindon No. 1, drilled in 1983, recovered a heavily biodegraded oil within the Tertiary Pebble Point Formation but commercial production could not be achieved. In 1987, Windermere No. 1 recovered oil from sands within the Early Cretaceous Eumeralla Formation (Fig. 3).

In 1987, Katnook 1 (Fig. 1), an onshore well in the South Australian portion of the basin, flowed gas at rates up to 9 MMCFD during production testing of a sand at the base of the Eumeralla Formation. A follow-up well, Katnook 2, drilled in 1989, flowed gas at rates of over 16 MMCFD during production testing of the Pretty Hill Sandstone. The field is now on commercial production. Another field (Ladbroke Grove) was discovered near to the Katnook field in 1989. Since the early 1990s, advances in seismic acquisition have greatly improved seismic resolution of deep structures in the troughs, and this has been reflected in an improvement in the success ratio, which is now about 1 in 3.

Recent discoveries have included a small but significant volume of oil recovered from Sawpit 1 (1992) and in early 1993 gas was recovered on RFT in Troas 1, an offshore well in South Australia. In 1994 Haselgrove 1 discovered a commercial gas field near the Katnook Field, and Wynn 1, in PEL 32, flowed oil to surface at 120 BOPD. This well has finally dispelled the previous perception that the Otway Basin is gas prone, and there is now the likelihood of a significant oil discovery in the near future. Drilling activity onshore is expected to be at a record level in 1996, with 8 firm wells planned and a strong possibility of additional drilling.

TECTONIC HISTORY OF THE OTWAY BASIN

Rifting (Tithonian-Barremian)

Initiation of the Mesozoic Otway Basin began in the Late Jurassic with thermal doming. During the Tithonian to Berriasian, the Casterton Formation was deposited, comprising mainly carbonaceous shale with minor feldspathic sandstone, siltstone and basalt. It is a difficult unit to correlate seismically, and shows as an enigmatic subparallel band of reflectors up to 1 500 m thick above basement. It is best seen on the northern margins of the basin and is presumed to occur in the deepest parts of the troughs. The Casterton Formation is interpreted to have been deposited immediately prior to rifting in relatively deep lakes, probably related to initial fracturing. Extrusion of volcanics within this formation occurred via early faults and fractures within Palaeozoic basement.

Rapid escalation of rifting activity occurred in the Berriasian, with the development of many half graben along the length of the Otway Basin, which are mostly infilled by the Crayfish Group (Fig. 3). Crayfish Group deposition was strongly controlled by tectonic uplift and subsidence during this rifting stage. Up to 5 800 m of fluvial and lacustrine clastics and coals were deposited in a 20 million year period. Contemporaneous rift volcanism provided abundant volcanogenic debris.

Sediment influxes occurring in simple extensional basins commonly depict rugged topography on the upthrown fault block with significant alluvial fan systems. In the Crayfish Group, however, there are no thick alluvial fan deposits and axial drainage dominated over transverse drainage within the Robe and Penola Troughs (Fig. 2). The overall depositional setting is one with relatively low relief on the upthrown block, accompanied by high subsidence rates. Although the surface expression of the faults is minimal, they exercised significant control on three-dimensional facies distribution. Maximum subsidence and hence maximum sediment thickness occur adjacent to the main faults.

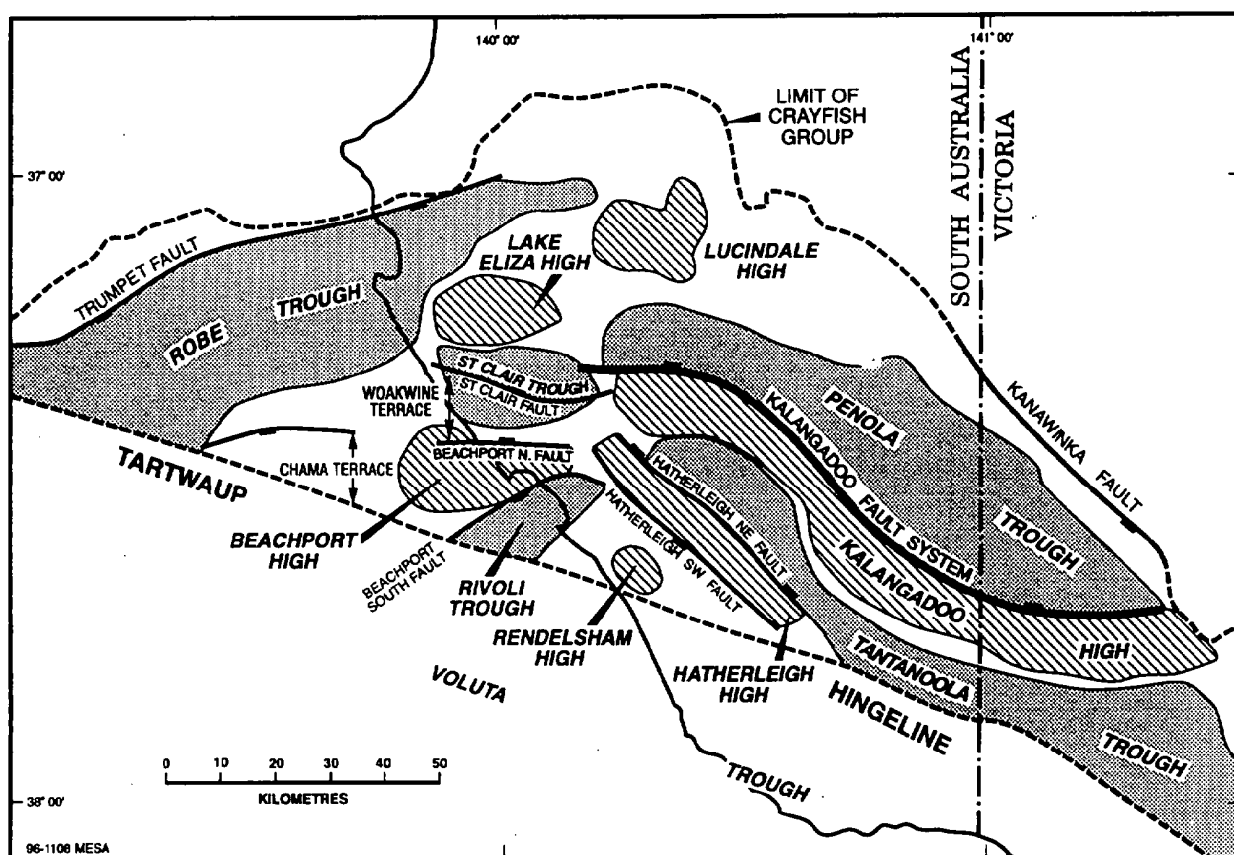


Fig. 2. Structural elements of the Otway Basin

Knowledge of basement structure and rift features is limited to shallower areas of the basin due to limited penetration by drilling and resolution of seismic. Major half graben vary in orientation from east-northeast-west-southwest in the Robe Trough to southeast-northwest in the Penola Trough. The orientation of the main troughs and the relationship between them has led to a wide range of tectonic models to explain the observed rift system which have varied in extension direction from northwest-southeast to northeast-southwest. Sandbox modelling and mapping have shown that a north-south rift extension direction is the most likely for the Tithonian-Barremian rifting event.

The end of this intensive rift phase occurred in the Barremian, fault-related tilting, folding and uplift resulted in extensive erosion of the Crayfish Group.

Sag and rifting (Aptian-Albian)

A second major rifting phase developed in the Aptian, resulting in deposition of Eumeralla Formation flood-basin sediments (siltstone, mudstone and minor sandstone and coal seams). Onshore, Eumeralla Formation deposition was mildly controlled by faulting, but the rapid facies changes and thickness variations occurring in the underlying Crayfish Group are not seen. The extension direction of this phase is more widely accepted as being northeast-southwest. Fault trends at top Eumeralla Formation level show a strong subparallel trend in the orthogonal northwest-southeast direction. The sedimentary depocentre, and hence main rift activity, moved southwards at this time.

It is interpreted that the earlier rifting phase failed in the Robe Trough and most of the current onshore areas in the Barremian. The overlying Eumeralla Formation blankets earlier troughs and basement highs, and thickens rapidly southwards of the Tartwaup Hingeline into the Voluta Trough rift axis. Little drilling and seismic evidence is available on the main Eumeralla Formation syn-rift sequence south of this hingeline.

Fission track analysis indicates a major cooling event leading to regional uplift and significant erosion at the end of the Albian. This corresponds to continental break-up at 95 Ma and the onset of sea floor spreading.

Slow sea floor spreading (Cenomanian-Eocene)

Continental separation between the Australian and Antarctic plates began at the start of the Cenomanian. This marks a change from a Late Jurassic-Early Cretaceous intracontinental rift system to a Late Cretaceous-Tertiary passive margin. A slow spreading rate, continued until the Middle Eocene (~45 Ma). This extension and associated subsidence resulted in extensive marginal marine to deltaic deposition south of the Tartwaup Hingeline. Up to 5 000 m of Late Cretaceous Sherbrook Group sediments, overlain by up to 1 500 m of Tertiary sediments, have been mapped offshore. Structuring was predominantly down-to-basin listric syndepositional faulting in contrast to previous rifting styles.

A bypass margin existed north of the Tartwaup Hingeline, with thin Sherbrook and Wangerrip Group deposition, as most sediment was transported further south and deposited onto the continental margin. Localised depocentres evolved over the Tithonian-Barremian troughs due to sediment compaction, leading to variations in Sherbrook Group thickness over the bypass margin.

Thermochronological analysis indicated that the western Otway Basin underwent episodes of uplift and erosion throughout the Late Cretaceous and Tertiary, due to inferred tectonic readjustments in response to plate reorganisations and changing stress fields. Rifting of the Tasman Sea during the Campanian (82 Ma) and Eocene (52 Ma); was the primary cause of stress field change, applying a right lateral stress regime.

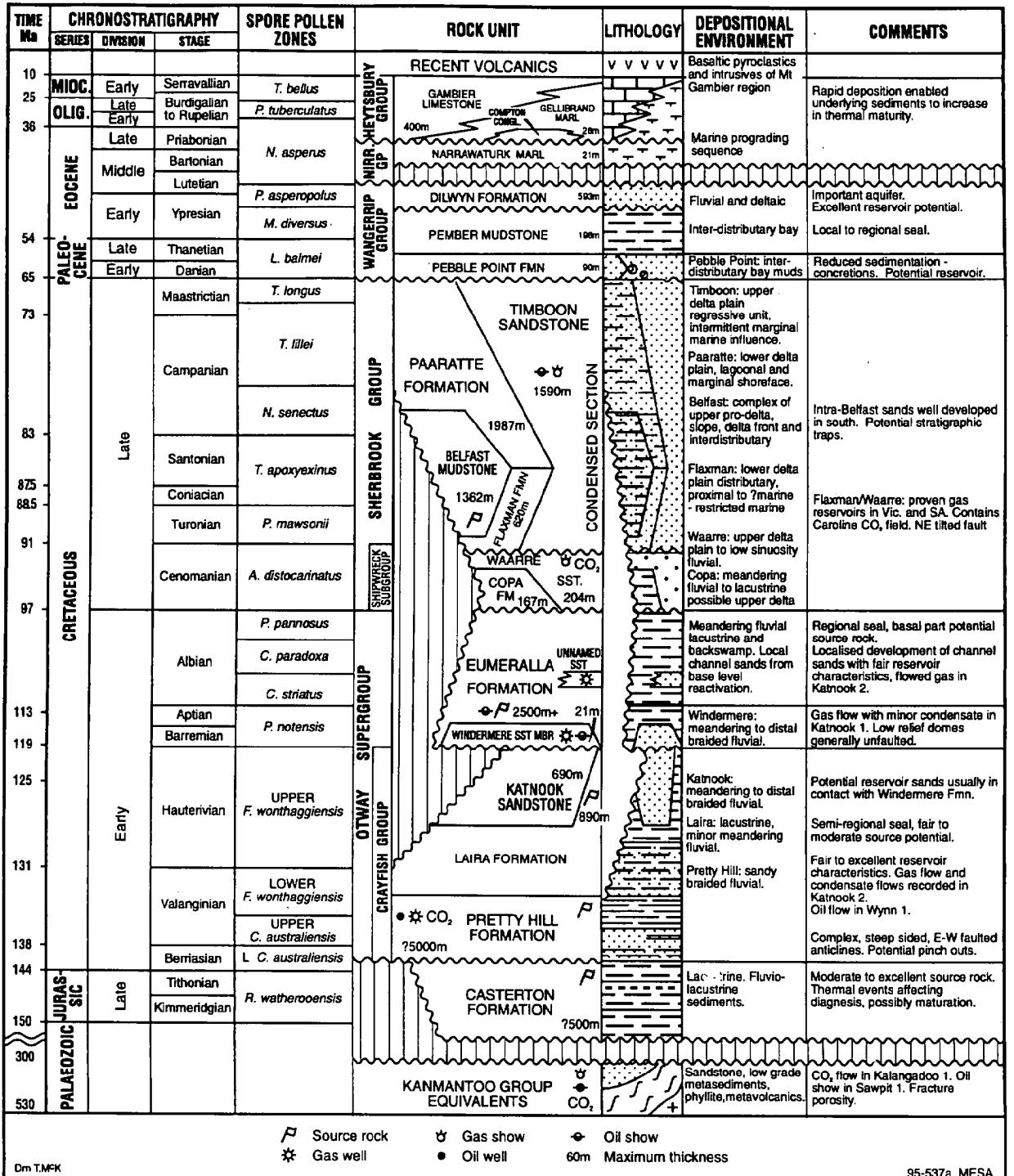


Fig. 3 Geological summary of the Otway Basin in SA

Fast sea floor spreading (Eocene-Recent)

A rapid increase in continental spreading rate occurred in the Middle Eocene, around 42 Ma, to reach the current half rate of ~110 mm/year. Continuing thermal subsidence and starvation of clastic input led to deposition of predominantly marine carbonates. At least 670 m of Nirranda and Heytesbury Groups sediment occur in the southeast offshore Otway Basin in South Australia (Fig. 3).

Throughout the Tertiary, the shelf edge prograded southwards. Changes in sea level during this period have resulted in spectacular channel cutting and filling.

Wrenching and compression (Miocene-Recent)

Analysis of fault and anticline patterns throughout the Otway Basin indicates an east-west orientated dextral wrench system for this period. This has caused northeast-southwest anticlinal uplift in some areas, and significant inversion along many existing faults. The influence of this event on structures and fault planes is very important in hydrocarbon exploration.

The cause of this change in stress regime has been related to collision on the northern and eastern margin of the Australian plate. Continuity of this stress field to the present day is validated by the persistence of significant earthquake activity, particularly in the Beachport High area, the site of the most intense structural inversion mapped in the South Australian portion of the basin.

Volcanism (Pliocene-Recent)

The most recent phase of tectonic activity involved extrusion of several episodes of volcanics. In Victoria, extensive basaltic and ash volcanics were extruded during the Pliocene-Pleistocene (the Older Volcanics). Two more recent events (the Newer Volcanics) in South Australia and Victoria have been dated as Pleistocene and Holocene. This tectonic phase represents a significant risk to petroleum exploration by introducing magmatic CO₂ into the sedimentary sequence, to the detriment of hydrocarbon entrapment.

For a complete and detailed summary of the geology of the Otway Basin, the reader is referred to Morton and Drexel (1995).

PRODUCTION FACILITIES AND GAS MARKET

Following the discovery of gas at Katnook in 1987, negotiations between the partners of PEL 32 and PASA led to the signing of a contract in 1990 for the supply of 22.5 PJ of sales gas from the Katnook and Ladbroke Grove fields over 15 years. Gas production commenced in February 1991. The main pipeline supplies natural gas to Mount Gambier and the Apcel paper mill at Snuggery and is owned by Tenneco Gas. The natural gas replaced the use of LPG at Apcel and tempered LPG at Mount Gambier. A smaller pipeline supplies gas to the SAFRIES Pty Ltd potato chip factory south of Penola. Condensate recovered from Katnook is stored at the plant and transported (by truck) to the Adelaide refinery at Port Stanvac.

Further discoveries of gas (even if small) would find a market within the South-East. Discovery of 200 to 250 BCF of gas would justify construction of a pipeline to Adelaide.

ENVIRONMENT

Natural environment

Climate

The South-East has mild dry summers and cold wet winters. Rainfall ranges from 500 to 850 mm. In the winter months, large areas are waterlogged or temporarily inundated due to the combination of high rainfall, high watertable and flat topography. Consequently, onshore activities are generally restricted to the summer and autumn months of December through to April in most years. It is possible to prepare drillsites in advance during the drier months to allow drilling year round.

Offshore, the progression of low pressure systems from late autumn to late spring-early summer makes seismic recording and drilling difficult due to rough seas.

Landforms

The area is dominated by a suite of landforms which reflect the Pleistocene marine transgressions and regressions. The coastline is characterised by active dunes and extensive coast-parallel lagoons with sandy beaches and low cliffs. Inland, a series of stabilised dune ridges which rise 20-50 m above the surrounding plain dominate the landscape. The ridges are separated by interdune plains, which are seasonally inundated during the winter and spring, preventing seismic operations and limiting drilling to higher ground.

The South-East is largely underlain by limestone and there are numerous karst landforms such as sinkholes and caves which, whilst not preventing drilling or seismic, need to be taken into account in planning an activity. There are also a number of extinct volcanoes in the vicinity of Mount Gambier; the largest, Mount Burr, rises 239 m above sea level.

Groundwater

The South-East is characterised by a near-surface unconfined aquifer, the Gambier Limestone. This is the main source of water for the region's population and is used for both drinking and irrigation. The aquifer is spectacularly exposed in the extinct volcanic cone of Mount Gambier, from which the city draws its water. The aquifer is recharged by winter rainfall and water often rises to within a metre of the surface. This is a problem for drilling-mud sumps which will pollute the aquifer unless they are lined and the contents disposed of in an approved manner.

Native vegetation

Over 90% of the surface area of the Otway Basin has been cleared of native vegetation, and the patches and corridors which remain are important as habitats for native animals and plants. Due to the importance of the vegetation, clearance should be avoided wherever possible. In many cases it is possible to make use of existing tracks and fencelines. If clearance is necessary then techniques which minimise the impact on the vegetation must be used. The best method of clearing a path for seismic recording is to hydro-axe the vegetation to create a suitable surface for vehicles. Hydro-axing also reduces the impact on vegetation to a level such that lines are generally indistinguishable from the surrounding vegetation within five years.

National Parks

There are 28 National Parks within the South Australian portion of the Otway Basin which have been created to conserve the best examples of vegetation and landforms in the area. Access is permitted to 13 of these. To date, access has not been necessary as their small size makes it possible to work around them. Within area OT96-A, the Canunda National Park (Fig. 4) represents the largest park where access for exploration is denied. However, this park is restricted to a thin coastal strip characterised by steep and extensive dunes adjacent to Lake Bonney. The conditions of access, should it be required, would vary from park to park, based on the activity proposed and the impact it is likely to have on the environment.

Cultural environment

Aboriginal heritage

In South Australia it is an offence to disturb or destroy Aboriginal sites, objects or remains. Standard procedures for determining the presence of Aboriginal heritage prior to the commencement of activities have been determined. These involve consulting with the relevant Aboriginal organisation and maintaining a watch for sites, objects or remains during activities. The sites are generally no larger than a few hundred square metres and are easily avoided. Since the inception of the Aboriginal Heritage Act in 1988, there have been no conflicts between Aboriginal heritage sites and exploration or production activities.

Commonwealth Native Title Act 1993

The *Native Title Act 1993* was passed by Federal Parliament on 22 December 1993. The lengthy and complex Act provides statutory recognition and protection for the concept of native title as recognised by the High Court in the case of Mabo v Queensland in 1992. Native title means rights held by indigenous inhabitants of Australia at and since the time of European settlement - it differs from conventional titles. The nature of native title rights vary from group to group according to laws and customs, however there must be a sufficient and relevant connection to the land in question, continuous since 1836 in South Australia. Native title may include the right to camp or travel across land, rights to hunt, fish, gather food and take materials (timber, bark, ochre etc.) from the land. Applications by Aboriginal claimants are recorded in the Register of Native Title Claims. The National Native Title Tribunal (NNTT) makes determinations on applications under the Act. A National Native Title Register comprising a record of all approved determinations made by the NNTT, Federal Court, High Court, other Courts or Tribunals and recognised State/Territory arbitral bodies.

The Premier of South Australia declared in April 1994 that SA would enact State legislation to ensure that State laws were consistent with the Commonwealth's Racial Discrimination Act and as far as appropriate, the Native Title Act, while retaining the option to challenge the Native Title Act in whole or in part to make it more workable and less complex. Late in 1994, a package of four Native Title Bills was introduced into the House of Assembly and were all passed.

Following passage of the Commonwealth Native Title Act, petroleum exploration and production licences continue to be issued over South Australian land over which Native Title Rights have been extinguished on the advice of the Crown Solicitor (leasehold and freehold land which comprises the vast majority of the State). In 1995 a 'safety net' clause was introduced into the Petroleum Act which gives a licensee first right to any licence which may be terminated due to no fault of the licensee.

The Commonwealth Government is currently reviewing the Native Title Act. It is likely that administrative procedures under the Act will be simplified.

Licence holders are encouraged to develop a dialogue with regard to Aboriginal Heritage and related matters, with Aboriginal people having associations with their licence area.

Environmental regulation

A number of environmental issues are pertinent to petroleum exploration and production in the Otway Basin, all of which can be resolved by proper operational planning.

The Department has produced *Environmental sensitivity maps* which indicate areas where particular care is required for specific exploration or production practices, and areas which in some cases should be avoided. They are available upon request from MESA.

In order to ensure that activities are undertaken in a manner which minimises environmental impacts, a number of documents are required before approval to commence operations is given.

Onshore, a *Declaration of Environmental Factors* (DEF) is required prior to commencement of activities. This is the licensee's assessment of the environmental impact of an activity. In addition to the DEF, a *Code of Environmental Practice* (CEP) is also required by regulation. This document describes the procedures that the proponent will adopt during the planning, assessment, field management, auditing and monitoring phases of an operation.

MESA has also produced model *Codes of Environmental Practice* for both exploration and production, which provide guidance to licensees on environmental issues that need to be taken into consideration in project planning and undertaking exploration activities. These codes are currently being revised in a move towards an outcomes based approach, however in the interim they provide a good basis from which to start.

Access to agricultural land is negotiated with the landowner. Any access disputes can be resolved on appeal to the Minister for Mines and Energy. The most common issues are vehicle and plant hygiene to ensure that weeds and disease are not spread, fire, crop damage, and repair of any damaged fencing or gates. There are standard techniques for managing such issues and relationships between the petroleum industry and landowners in the South-East of South Australia have generally been excellent.

Although a number of documents are required, the approval process is not onerous. MESA is able to assist licensees by providing examples of the documentation and advising on their scope. To date there have been no significant concerns raised by licensees with respect to requirements to minimise the environmental impacts of their operations.

KEY REFERENCES

- Hill, A.J. 1996. Petroleum exploration and development in South Australia (11th edition). *South Australia. Department of Mines and Energy. Report Book*, 96/13.
- Morton, J.G.G. and Drexel, J.F. 1995. The Petroleum Geology of South Australia Series: *1. Otway Basin*. MESA publication, (280pp).

PROSPECTIVITY OF AREA OT96-A

The OT96-A area comprises 677 km² of the northern Voluta Trough. Seismic coverage is poor, with only 218 line km of seismic in total. The 164 km of recent vintage (post 1980), is mostly line ends of surveys in the adjacent PEL 40 to the north. Seismic quality is generally poor, even for the recent vintage lines, due to the cavernous Gambier Limestone, which absorbs most of the seismic energy. Since the early 1990s, there have been significant advances in acquisition and reprocessing to improve resolution. Three wells have been drilled in the area. Canunda National Park occupies the coastal strip of the area; no exploration access is permitted to this park.

Plays in the Early Cretaceous Crayfish Group are too deep to be economically drilled, but plays may exist in the lower Sherbrook Group (Shipwreck Subgroup) sediments.

Reservoirs and seals

Due to limited data in this area, and for this play generally in the South Australian portion of the basin, there is some risk associated with reservoir and seal distribution, and in reservoir quality. Potential reservoirs include the sands of the Copa Formation, Waarre Sandstone and Flaxman Formation. Seals are either intraformational or the Belfast Mudstone provides a regional seal in at least in the southern part of the area. To the north the Belfast Mudstone becomes thin or absent, and the Paaratte and Flaxman Formations may become difficult to distinguish (e.g. Burrungule 1); seals will be only intraformational in those cases. Alternatively, to the north the potential reservoirs of the Waarre Sandstone and sands of the Flaxman Formation may change facies to shale (e.g. Compton 1). Data on reservoir quality is limited, but data from the Caroline field indicate porosities of 10 to 20 %. Data from the Victorian portion of the Basin indicate very good reservoir quality may be found in the Waarre Sandstone.

Source and migration

The main source will be coals of the basal Eumeralla Formation, which maturity modelling has indicated is early mature for oil in the northern part of OT96-A but where substantial thickness of Sherbrook Group sediments are present (in the southern part of the area), the lower part of the Formation is in the peak oil generation zone. Migration would rely on fault pathways to charge Shipwreck Subgroup reservoirs. The ability for the Eumeralla to source oil is well documented; oil from Caroline 1 and Breaksea Reef 1 in South Australia, and from several wells in Victoria have been shown to originate from the Eumeralla. Gas in Troas 1 has also been sourced from the Eumeralla Formation. The Belfast Mudstone lacks sufficient maturity over most of the area to generate hydrocarbons.

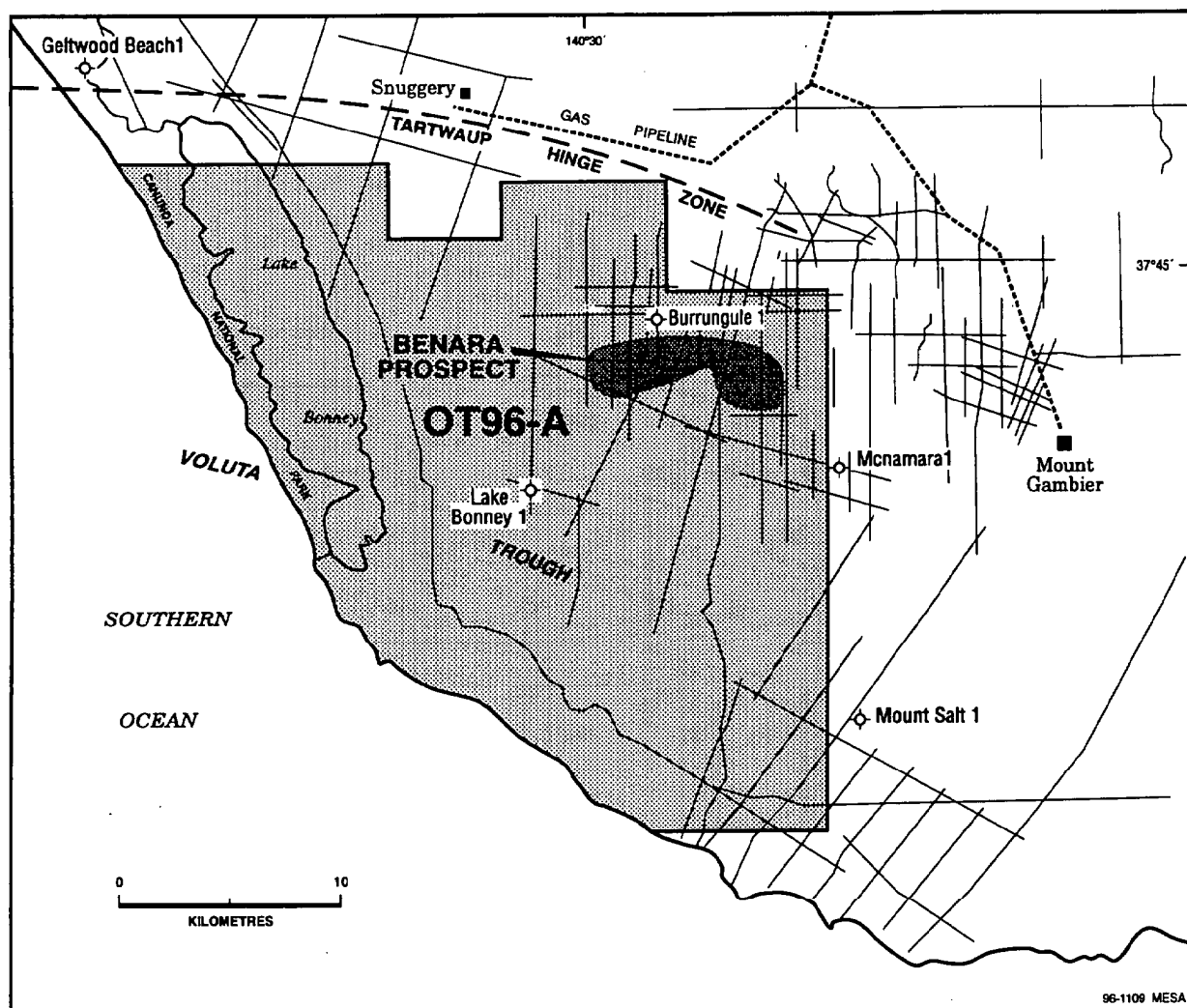


Fig. 4 OT96-A modern seismic coverage

BENARA PROSPECT

POTENTIAL RESERVES

Oil: 190 MMSTB Recoverable oil

Gas: 670 BCF Recoverable gas.

STRUCTURE: Horst block.

RISK: Medium. Requires more seismic.

SEAL: Befast Mudstone.

RISK: Low to Medium. Fault may not seal.

RESERVOIR:

Copa, Waarre and or Flaxman sands.

RISK: Low.

SOURCE: Eumeralla Formation.

RISK: Medium. Early mature for oil.

MAXIMUM AREA OF CLOSURE:

2000 hectares (4942 acres)

VERTICAL CLOSURE:

325 metres (1066 feet)

DEPTH TO TARGET:

1820 metres (5970 feet)

DEPTH TO BASEMENT:

Not identified on seismic

POROSITY: 14%

H.C. SATURATION: 65%

NET TO GROSS RATIO:

0.86

$1/B_g = 200$

GAS RECOVERY FACTOR: 70%

$1/B_o = 0.90$

OIL RECOVERY FACTOR: 25%

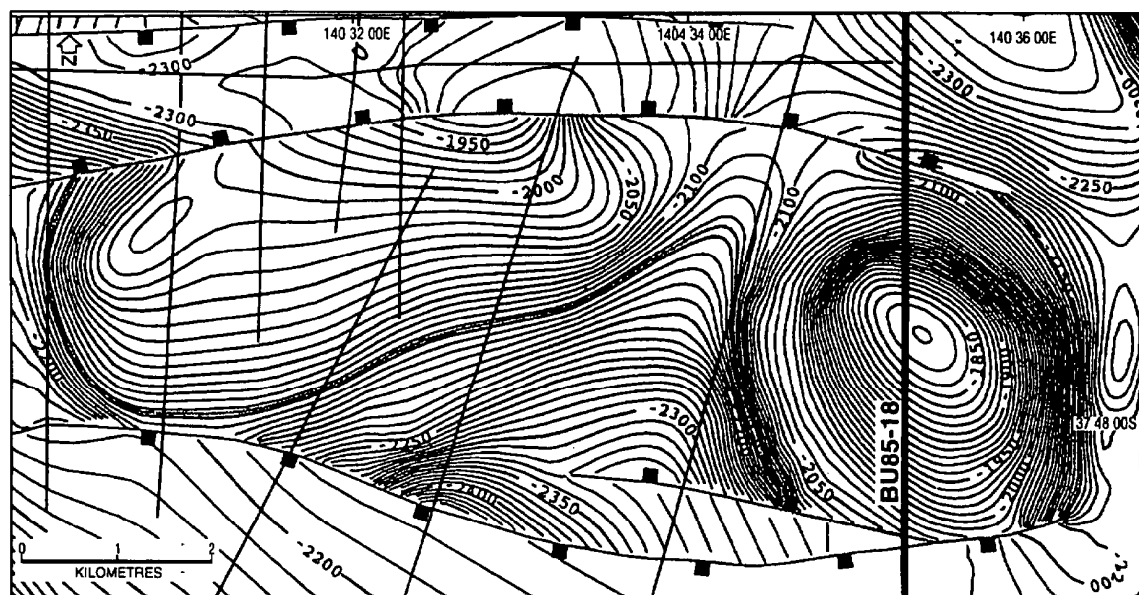
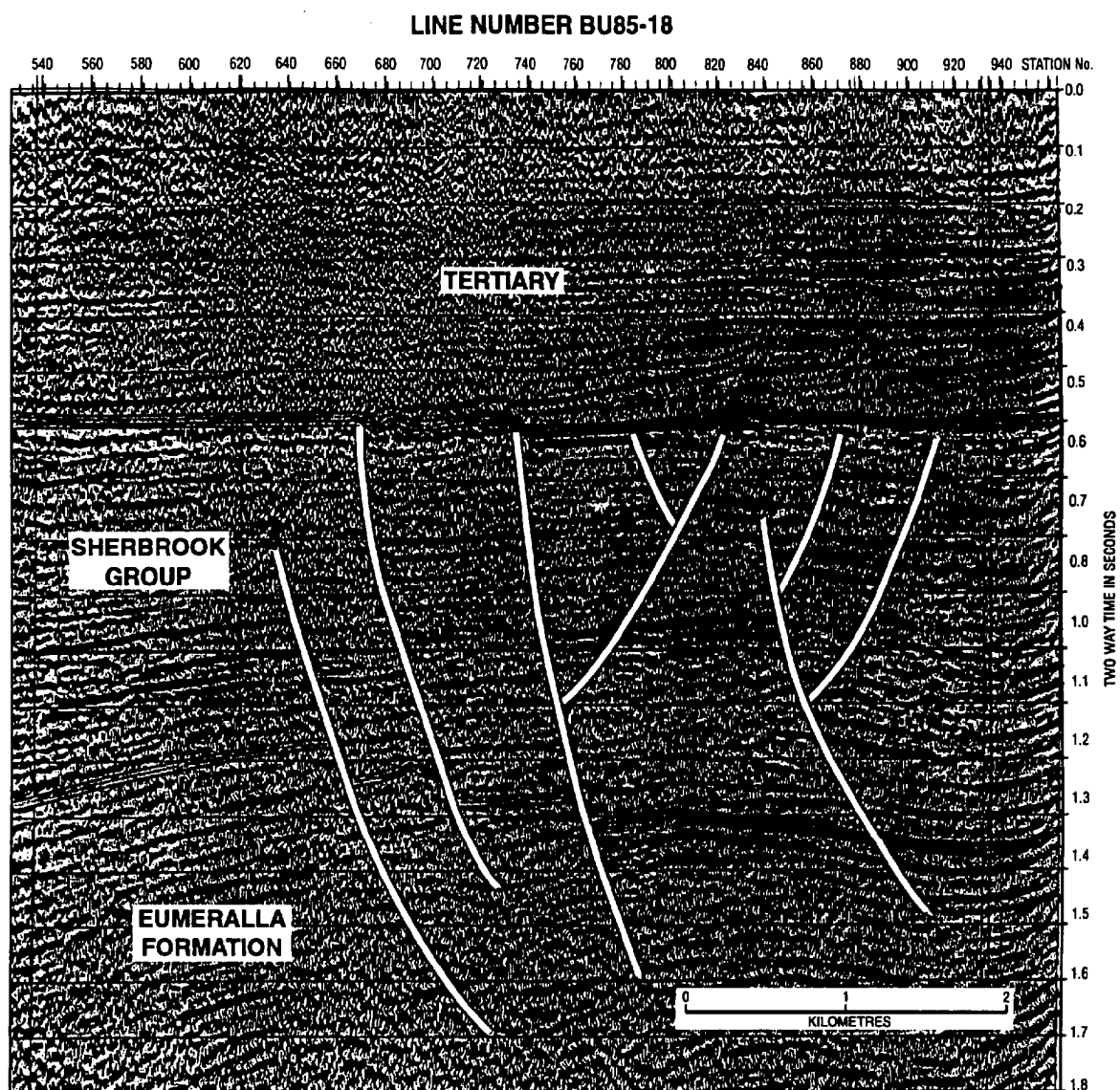


Fig. 5 Benara Prospect

PROSPECTIVITY OF AREA OT96-B

The OT96-B area comprises 255 km² of the western St Clair Trough. Seismic coverage is fair in the eastern part of the area but is absent due in the west due to difficulties in acquisition in coastal lake areas. In all there are 218 km of seismic coverage, of which 164 km are of recent vintage. There is one well in the area, St Clair 1, which was dry.

Plays exist mainly in the Crayfish Group sediments, in fault dependent anticlines. Pinchout plays may exist close to the Beachport High, in the southern part of the area.

Reservoir and seals

Reservoirs will be sands of the Crayfish Group and the Windermere Sandstone Member, with the Eumeralla and Laira Formations as seal, as were found in St Clair 1. There is some risk associated with the Laira Formation seal continuity, as the Laira Formation appears to change facies in the St Clair Trough to sand. Reservoir quality appears to be good to excellent in St Clair 1. As in the Otway Basin generally, fault leakage may be a problem, but the Beachport High area has undergone recent strong compressional tectonics which may help seal faults in the area.

Source and migration

Source will be either local, from the underlying Pretty Hill and Casterton Formations, or lateral, from the Eumeralla Formation offshore to the west (believed to be the source for the offshore Troas gas discovery). The results of St Clair 1 indicate that the local source may be poor, due to a lack of source facies in the lower Pretty Hill Formation. Local sealing faults may impede migration to the north or south, but charge for prospects is possible parallel to the major fault trends from offshore mature Eumeralla Formation source to the west.

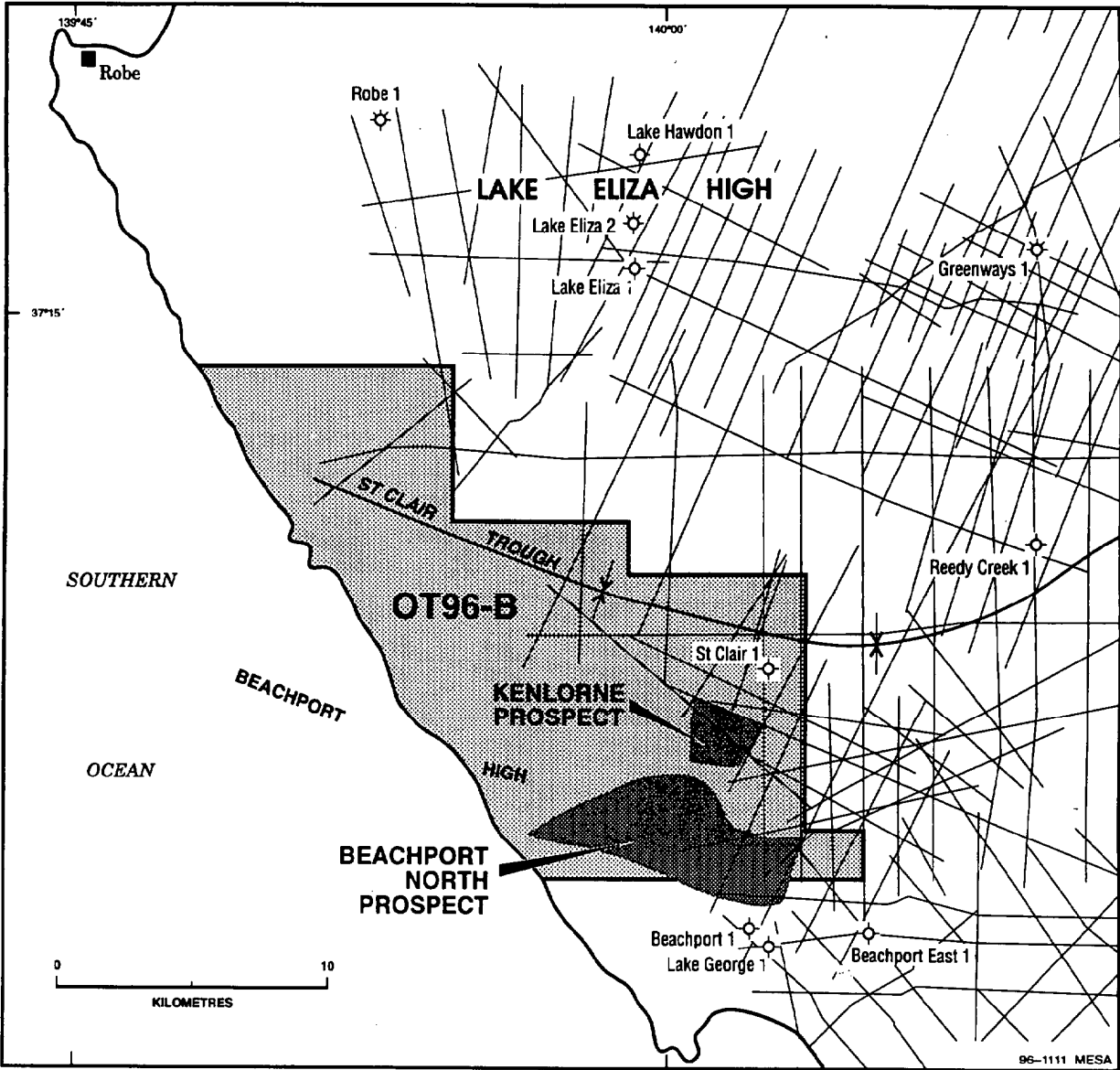


Fig. 6 OT96-B modern seismic coverage

KENLORNE PROSPECT

POTENTIAL RESERVES

Oil: 16 MMSTB Recoverable oil.

Gas: 50 BCF Recoverable gas.

STRUCTURE: Horst block.

RISK: Medium. Requires more seismic.

SEAL: Eumeralla Formation.

RISK: Low to Medium. Fault may not seal.

RESERVOIR: Crayfish Group sands.

RISK: Low.

SOURCE: Intra Pretty Hill shales and Casterton Formation.

RISK: High. Fair-moderate source quality and potential

MAXIMUM AREA OF CLOSURE:

757 hectares (1 871 acres)

VERTICAL CLOSURE:

90 metres (295 feet)

DEPTH TO TARGET:

1 600 metres (5 250 feet)

DEPTH TO BASEMENT:

2 400 metres (7 875 feet)

POROSITY: 15%

H.C. SATURATION: 65%

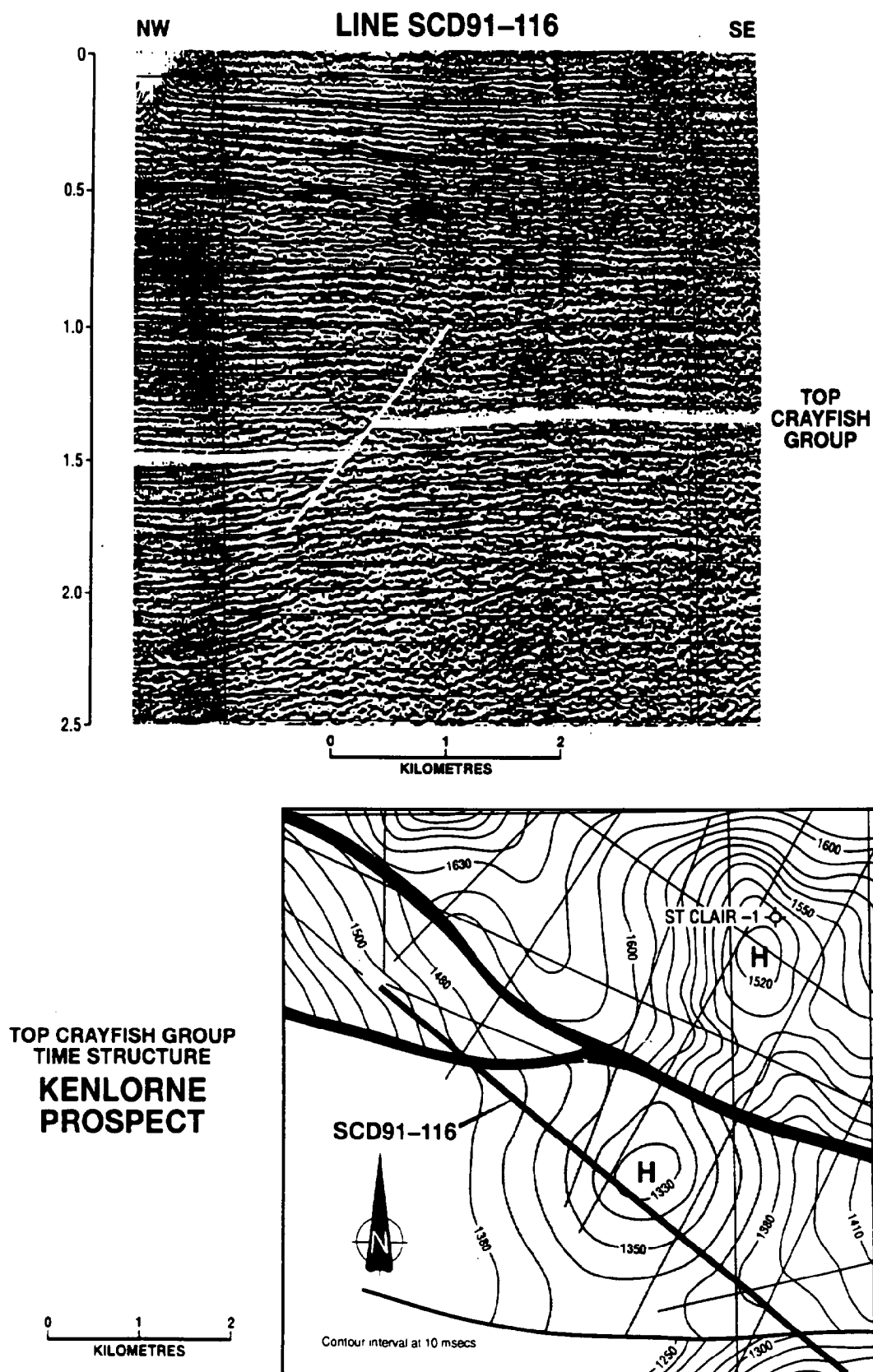
NET TO GROSS RATIO: 0.50

$1/B_g = 180$

GAS RECOVERY FACTOR: 70%

$1/B_o = 0.90$

OIL RECOVERY FACTOR: 25%



96-0023 MESA

Fig. 7 Kenlorne Prospect

BEACHPORT NORTH PROSPECT

POTENTIAL RESERVES

Oil: 137 MMSTB Recoverable oil.

Gas: 431 BCF Recoverable gas.

STRUCTURE: Pinchout against basement high	RISK: Medium. Requires more seismic
SEAL: Eumeralla Fm	RISK: Low
RESERVOIR: Crayfish Group sands	RISK: Low.
SOURCE: Intra Pretty Hill shales and Casterton Formation.	RISK: Low. Fair-moderate source quality and potential
MAXIMUM AREA OF CLOSURE:	2292 hectares (5664 acres)
VERTICAL CLOSURE:	300 metres (984 feet)
DEPTH TO TARGET:	1450 metres (4757 feet)
DEPTH TO BASEMENT:	1500 metres (4920 feet) at crestal location 3500 metres (11 480 feet) on northern flank
POROSITY: 15%	H.C. SATURATION: 65%
NET TO GROSS RATIO:	0.50
$1/B_g = 180$	GAS RECOVERY FACTOR: 70%
$1/B_o = 0.90$	OIL RECOVERY FACTOR: 25%

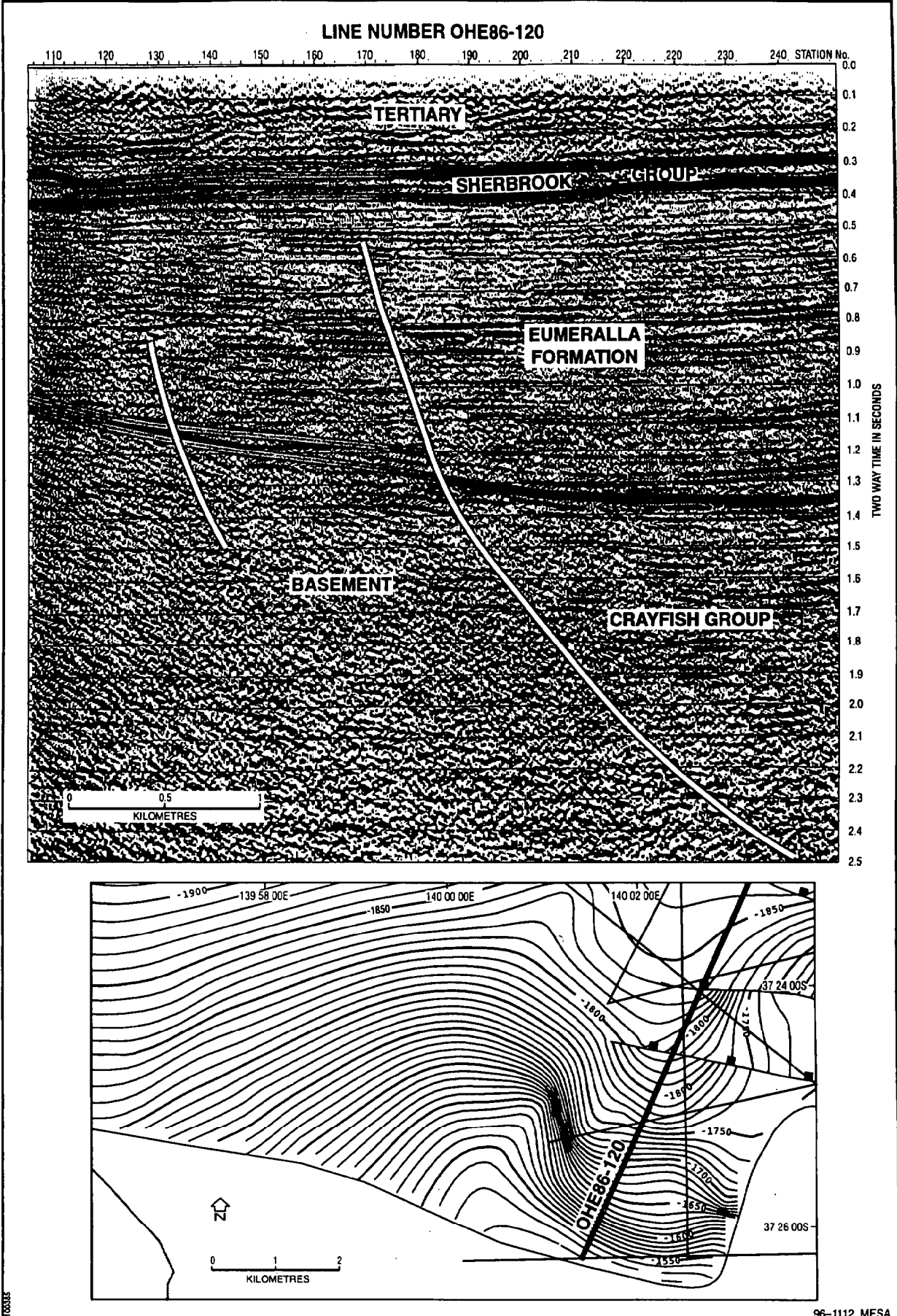


Fig. 8 Beachport North Prospect

APPENDIX 1

DATA AVAILABILITY

Definition of basic data from onshore South Australia tenements

Under the terms of the Petroleum Regulations, 1989, basic exploration data relating to petroleum search activities in onshore tenements becomes open file and available for public purchase upon:

- The surrender or expiry of those tenements.
- Where an exploration licence (PEL) is in force, basic well data may be made available to the public after the expiration of two years from the rig release date and, for geophysical surveys, two years after the completion of field acquisition.
- Where a production licence (PPL) is in force, basic well data may be made available to the public after the expiration of five years from the rig release date and for geophysical surveys, five years after the completion of field acquisition.
- While a production licence is in force, production data from each completion may be made available to the public after the expiration of three months from the end of the relevant six month period (ie. ending 30 June and 31 December each year).

Basic data include:

Gravity/Magnetic Surveys – all data other than potential field qualitative and quantitative interpretation maps and reports.

Seismic Surveys – all data other than:

- seismic picks, correlations and stratigraphic units on sections,
- time/depth contour maps,
- interpretation reports.

Vertical Seismic Profiling and Well Check Shot Data – all data other than qualitative or quantitative maps and reports using proprietary techniques.

Lithological Data and Formation Tops – all data other than core analysis studies carried out by oil company research units utilising proprietary techniques.

Palaeontological Data – all data other than conclusions drawn from the species lists and range charts.

Source Rock Data – all laboratory and contractor data.

Special Core Analyses – all data other than relative permeability data, capillary pressure test data and water flood test results derived by oil company research units utilising proprietary techniques. All contractor derived data and results are defined as basic data.

Regional Geological Data – all data other than:

- regional basin-wide geological and palaeoenvironment maps,
- regional formation structure and isopach maps.

Reservoir Engineering Data – all contractor derived data and results are defined as basic data.

Reserve Data – company derived estimates are not considered basic data.

Basic Well Drilling Data – all data from this source are defined as basic data.

Wireline Log Data – all data other than oil company log interpretations utilising proprietary techniques.

Fluid Analyses – all laboratory and contractor data.

Samples – core and cuttings are defined as basic data.

Well Completion Reports – regardless of the above, all data supplied in well completion reports is regarded as basic data.

Note: These provisions are currently under review.

Data available from MESA

PEPS-SA

MESA have developed PEPS-SA (Petroleum Exploration and Production System-South Australia), a comprehensive database of SA petroleum exploration and production data. PEPS-SA is being continually developed and is now available for purchase. PEPS-SA is available in a variety of formats including PC-based data packages or hardcopy.

PEPS-SA comprises eight key data sets – wells, geophysics, geology, engineering, production, statistics, tenements and addresses – each of which is subdivided into modules:

Wells: Well and petrophysical log data. Basic well data for all wells is included.

Geology: Cores and cuttings, core photographs, formation tops, palynology and source rock analyses. Results from analyses post-dating the well completion report and recent revisions to stratigraphy are included.

Geophysics: Seismic survey and seismic line data.

Engineering: Abandonment, casing and perforation details and drill stem, liquid evaluation and well tests.

Production is separated into gas, oil and CO₂ recorded on a monthly basis for each completion.

Statistics provides a quick reference to annual statistics on petroleum exploration and production (expenditure, sales, annual LPG/condensate production per field etc).

Tenements: exploration, production and pipeline licence summaries.

Customers may purchase the entire data set or only modules of interest. Data may be selected for specific areas or for all of SA. Purchase includes quarterly updates for a full year. A brochure and demonstration disk on PEPS-SA is available free of charge.

Contact Alan Sansome: fax (08) 373 3269
email: asansome@msgate.mesa.sa.gov.au

Seismic Database

A comprehensive index of all seismic lines recorded in the State has been prepared on a survey by survey basis. This index is stored in PEPS-SA and a manual system. It includes survey summary data, shotpoint ranges and line lengths.

Contact Rob Langley (08) 274 7683.

A digital seismic shotpoint database covering SA and adjacent waters to 40° S latitude has been compiled and data is available in various formats on 9-track tape or diskette. Hardcopy maps can be prepared for any area at any scale.

Contact Peter Dunn, telephone (08)274 7544, facsimile (08) 272 7597.

Aeromagnetic Database

A digital database of aeromagnetic survey boundaries has been compiled and gives the location of all airborne surveys over SA and adjacent waters.

Contact Nick Dunstan (08) 274 7637.

Petroleum Tenements

An A4 size petroleum tenement map, including a listing of tenement, holder(s) and interests, expiry date and area, is prepared quarterly and is

free on request. A 1:2 000 000 scale tenement map is available quarterly.

Contact Mario Collela (08) 274 7552.

All tenements granted, surrendered or cancelled are published in the SA Government Gazette issued weekly from the State Information Centre, 25 Grenfell St, Adelaide. These notices are also widely publicised in the business, investment and resources sectors of the local and international press, as well as by circulation to listed exploration companies, stockbrokers, etc.

Consolidated Data Sets

A program has now commenced to consolidate open file basic and interpreted data into coherent data sets. A range of attribute databases have been prepared (e.g. wireline log data, basic well information, seismic survey data, formation tops etc.). Geographical databases have been created such as the seismic shotpoint and seismic horizon interpretation databases. Image processing has also been used to enhance seismic horizon databases. Datasets are available for the Eromanga Basin (1992) and in progress for the Cooper, Warburton, Simpson and Pedirka Basins.

Contact Dave Cockshell (08) 274 7671.

Digital Geological Maps of SA

SA_Geology provides an accurate, detailed and up-to-date overview of the State's geology.

Covering the entire State, the dataset portrays outcrop geology, derived from 1:250 000 mapping, but generalised into over 80 individual units.

Contact Dr Tony Belperio (08) 274 7615.

Accessing Data

MESA holds the largest collection of SA geoscientific literature, mining and exploration data, dating from the 1850s. The data comprises open file company exploration reports (including well completion and seismic survey reports), MESA open file report books, geophysical data including seismic sections, magnetic tapes and petrophysical logs, Government publications, geoscientific maps, plans, publications and more.

Most publications may be borrowed by means of inter-library loan. Unpublished data which has been microfilmed are also available on inter-library loan (in microfiche only). Unpublished data are held on microfiche, however viewing of hardcopy at MESA can be organised by prior arrangement.

Contact Greg Drew (08) 274 7732.

Purchasing Data

The MESA Document Storage Centre is responsible for storing and copying all unpublished material. Copies may be ordered in paper, microfiche, transparency or digital media. The centre strives to complete standard orders within two days.

Contact Peter Dunne, telephone (08) 274 7549 or mobile 015 972248, facsimile (08) 272 7597.

Core Library

Confidential and open file drillhole samples obtained from Departmental and company petroleum, stratigraphic and mineral exploration are stored at the MESA Core Library. The Core Library is located 2 km from head office at 23 Conyngham St, Glenside. Viewing facilities are fully enclosed. All open file samples are available for inspection and sampling is permitted. Forty-eight hours notice is required to reserve sample space and allow time for layout of sample trays. There is **no charge** levied to inspect or sample core and cuttings at this facility.

Contact Brian Logan, telephone (08) 379 9574, facsimile (08) 338 1925.

Petroleum Geology of South Australia

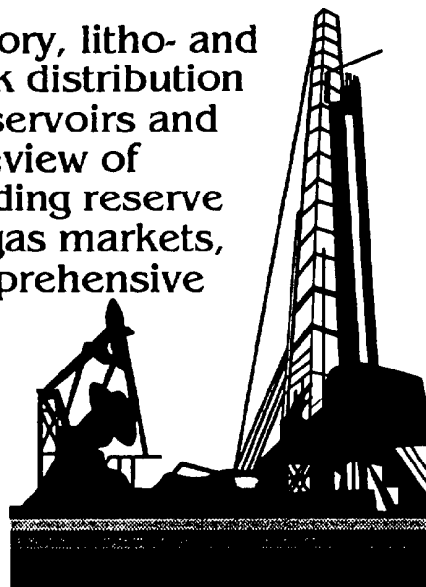
Volume 1: OTWAY BASIN

A new comprehensive summary and interpretation of the petroleum geology of the Otway Basin in South Australia.

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Structural and tectonic history, litho- and biostratigraphy, source rock distribution and maturity modelling, reservoirs and seals, trap development, review of previous discoveries (including reserve estimates), infrastructure, gas markets, environmental issues, comprehensive reference list



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SOUTH AUSTRALIA



Contact:

John Morton

Mines and Energy, South Australia

Ph: (08) 274 7565 Fax: (08) 373 3269

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- Comprehensive report on mapping project with structural and tectonic history interpretation. Comprises 20 pages, plus 25 figs and 11 enclosures including many of the maps described below. Price \$200.00.
- Coloured contour maps of 5 horizons and 4 isopachs at 1:250 000 and 1:100 000 (north and south sheets) scales covering onshore and offshore SA. Includes time and depth datatypes.
 Horizons: Topographic Elevations/Bathymetry
 Top Sherbrook Group
 Top Eumeralla Formation
 Top Crayfish Group
 Top Basement
 Isopachs: Cainozoic
 Sherbrook Group
 Eumeralla Formation
 Crayfish Group
 Price: \$700 per sheet set (of 9) per datatype or \$100 per map sheet.
- Colour filled contour maps of 5 horizons and 4 isopachs (as above) at 1:250 000 scale. Includes time, depth and velocity datatypes.
 Price: \$700 per sheet set (of 9) per datatype.
- Isometric displays of 5 horizons (depth only) at approximately 1:250 000.
 Price: \$500 per set or \$100 per plan.
- Image displays of 5 horizons and 4 isopachs (depth only) at 1:250 000; coloured and greyscaled versions.
 Price: \$1,000 per set or \$150 per image.
- Interpreted coloured seismic sections over 47 wells (onshore and offshore) (drafted at A3 size).
 Price \$500 per set or \$20 per well section.
- Customised coloured contour maps, isometric displays and images of above datasets. Price: POA.

Digital:

- Digitised seismic section interpretation (500 lines).
 Price: \$4 850 for all lines or \$15 per line.
- Grid files of time, depth and velocity datasets of 5 horizons and 4 isopachs (Petroseis grid files (including fault files) or ER Mapper gridfiles).
 Price: \$5 000 per dataset (includes 5 horizons and 4 isopachs) or \$1 000 per grid file.

Contact:

Dave Cockshell
 MESA
 PO Box 151, EASTWOOD 5063
 Ph: (08) 274 7671
 Fax: (08) 373 3269.

APPENDIX 2

ONSHORE PETROLEUM ACT GUIDELINES

Introduction

Petroleum exploration and development in South Australia are administered under the Petroleum Act, 1940 (onshore) and the Petroleum (Submerged Lands) Acts, 1967 of the Commonwealth and 1982 of the State (offshore). Vacant onshore areas are continuously available for licence applications, whereas offshore permits are open to application only after gazettal of areas by the Commonwealth and State Governments.

PETROLEUM ACT, 1940 GUIDELINES

Note: The area to which this Act applies covers all of onshore South Australia exclusive of Commonwealth Lands; it extends south to the State Territorial Sea Baseline and includes the waters of Spencer and St Vincent Gulfs.

ONSHORE PETROLEUM EXPLORATION		Petroleum Act Reference
Title of Tenement	Petroleum Exploration Licence (P.E.L.).	
Who Can Apply	An individual, a body corporate (i.e. a company) or an unincorporated association of persons and bodies corporate (i.e. a joint venture involving several persons and/or companies).	6(1)
	Where application is made on behalf of a company, the application must be made under the company seal.	41(b)&(c)
When Application Can be Made	Initial Licence - At any time over any area not already under licence.	6(1a)
	Renewal of Licence - not less than 3 months before existing licence is due to expire.	18(5b)
Maximum Area	26 000 sq. km.	15(1)
Application Fee	For initial application - \$2000	7(2)
	For each renewal - \$1000	7(2)
Bond (to ensure compliance with licence conditions)	\$15 000 minimum. Amount required is specified in letter of offer. Bond may be in the form of cash, cheque or bank guarantee.	13(1)
Term of Licence	Initial Term - 5 years.	15(2)
	Each Renewal (to a maximum of 3) - 5 years.	15(2)
Annual Rental Payable	Initial 5 Year licence term - 24 c/sq.km. First Renewal (2nd 5 Year licence term) -	18c(a)

	36 c/sq. km.	18c(b)
	Second Renewal (3rd 5 Year licence term) - 48 c/sq. km.	18c(c)
	Third & Final Renewal (4th 5 Year licence term) - 60 c/sq. km.	18c(d)
Minimum Work Commitments	As negotiated with applicant after application (which must contain a proposed 5 year work program) has been received.	
Minimum Expenditure Commitments	Initial 5 Year licence term - first two years - \$16 per sq. km. per year - last three years - \$24 per sq. km. per year.	17(1)(a) 17(1)(b)
	First Renewal (2nd 5 Year licence term) - \$100 per sq. km. per year.	18a(1)(a)
	Second Renewal (3rd 5 Year licence term) - \$125 per sq. km. per year.	18a(1)(b)
	Third & Final Renewal (4th 5 Year licence term) - \$150 per sq. km. per year.	18a(1)(c)
Area to be Relinquished on each Renewal	25% of original licence area. This is in addition to any areas voluntarily surrendered during each 5 Year licence term.	18(2)
Fee for Minister's Consent to Dealings in Licence	\$1000 per transaction (document).	42(3)
Fee for Inspection of Register	\$100	Reg.13(2)
Fee for Copy or Extract from Register	\$1 per page	Reg.13(4)
Method of Application	Letter of application addressed to the Chief Executive Officer, Department of Mines and Energy (there is no prescribed form).	7(1)
	Attached to the application should be:	
	(1) full names and addresses of the party/ parties making the application, including (where applicable) the percentage interests of the various parties	
	(2) two copies of a map and description of the area being applied for	7(3)
	(3) a table showing the work intended to be carried out, and the estimated cost of	

that work, during each year of the five year licence term.

7(3a)

(Expenditure estimates should satisfy the minimum expenditure commitments set out in Sections 17 and 18).

(4) particulars of the technical qualifications and expertise available to the applicant party/parties (e.g. qualifications and experience of employees, consultants retained etc.).

7(4)

(5) particulars of the financial resources available to the applicant party/parties to carry out the proposed terms and conditions of the licence.

7(4)

(In the case of a company application, this is generally supplied in the form of a copy of the company's most recent Annual Report).

(6) the \$1000 application fee.

7(2)

Where the application is made on behalf of a company, the application must be made under the company seal.

41(b)&(c)

Penalty for Non-Payment of Annual Rental Fees

All fees are payable in advance. If fees are not paid by the due date, a fine of 10% is imposed and in addition, interest accrues at the rate of 6% per annum. If any fee is in arrears for 3 months or more, the licence may be cancelled.

83(1)&(2)

Licence Variations

Only on application by the licensee, the Minister may at any time during the term of the licence, vary or revoke a condition of the licence or attach new conditions to the licence.

17(3)

Environmental Conditions

These will be outlined in the letter of offer attached to the licence.

Surrenders (Partial or Whole of Licence)

The Act requires the licensee to:

- (1) apply to the Minister for permission to surrender
- (2) give three months notice in writing
- (3) pay all outstanding fees
- (4) pay all outstanding monies and wages to workmen and employees.

38(1)

38(1)(a)

38(1)(b)

38(1)(c)

Surrenders are only permitted if the licensee has fulfilled all the terms and conditions of the licence up to and

	including the year in which the application to surrender is lodged.	38(2a)
	Licensees are required to lodge all outstanding data on their licences and carry out the cleanup and rehabilitation of their licence areas (where necessary) as a condition of surrender.	
	Surrenders are effective from the end of the appropriate year of the term of the licence (unless specified otherwise).	38(2b)
Required Notice for Approval to Undertake Work in Licence Area	Three months notice is required to arrange necessary clearances with other Government Agencies. This is carried out by DME on the licensee's behalf.	
Required Notice of Entry to Landholders	No risk of damage to land or improvements thereon - 14 days.	51(1)
	Risk of damage to land or improvements thereon - 28 days.	51(1)
Gazettals	Gazettals occur on:	
	(1) Grant of Licence	6(2)
	(2) Surrender of Licence	
	(3) Cancellation of Licence	71(1)
Suspension and Cancellation	The Act provides for suspension and/or cancellation for failure to comply with licence conditions.	87a(1)

APPENDIX 3

LICENCE APPLICATION FORM AND PROCEDURES

Application

Although there is no form set by regulation, an application for a Petroleum Exploration Licence (PEL) may be lodged in accordance with the attached PRO FORMA, and should be accompanied by two copies of a plan of the application area and accompanied by the prescribed fee (which is currently A\$2 000 for each licence applied for).

An application for a PEL can be lodged at any time over any area of the State not currently under a PEL or a Petroleum Production Licence (PPL) unless applications for the area have been specifically invited and a closing date nominated for receipt of applications.

An application can be made by an individual(s) or a company(s) or a combination of an individual(s) or a company(s). When a foreign company makes an application, the foreign company must be registered as a foreign company under the provisions of the Australian Corporations Law. Information on registration requirements can be supplied on request.

Technical Qualifications/Experience

The applicant must submit with the application a summary of the technical qualifications of the applicant (or consultants/agents of the applicant) to satisfy requirements that the applicant is capable of satisfying compliance with the Petroleum Act and the terms and conditions of the licence.

Financial Position

Evidence of the financial position of the applicant is to be supplied to demonstrate ability to fulfil the proposed work program. Such evidence can be in the form of the latest annual report or a verifiable statement from an independent accountant/auditor/ financial institution. If financial resources are not available for the full five year program, the applicant will have to provide evidence that there are financial resources available for at

least the first licence year program prior to the grant of the licence.

Work Program

The applicant must submit with the application a statement of exploratory operations the applicant proposes to carry out in each year of the five year term of the licence, including an estimate of exploration expenditure to be incurred in each year of the licence.

A minimum exploratory expenditure for each of the first two years of the licence is sixteen dollars per km² per year, and twenty four dollars per km² for each of the remaining three years.

Competing Applications

Where there are competing applications and where the financial and technical criteria are satisfied, the successful applicant would normally be the applicant who has offered the most effective work program. The number and timing of wells would be the most critical element in determining the most effective work program, with seismic and other work generally being a secondary issue.

Where competing bids are within reasonable proximity in total scope, preference would generally be given to the applicant who has the most effective work program in the early years of the licence.

Once a licence has been granted, a licensee is obliged to carry out the work program stipulated in the year the licence is in. Any failure to fulfil the work program for that year may, if a genuine 'force majeure' case is not proved, may result in cancellation of the licence. Variation of licence conditions are possible, however this would only generally be done where extraordinary cause exists, especially for a licence issued for which there were competing bids.

MINES and ENERGY
SOUTH AUSTRALIA



PRO FORMA

OTWAY BASIN ACREAGE RELEASE

APPLICATION FOR PETROLEUM EXPLORATION LICENCE

PETROLEUM ACT, 1940 (SECTION 7)

To the Chief Executive Officer, Department of Mines and Energy

I/We,

.....

.....

hereby make application for the grant of a petroleum exploration licence in respect of the area described hereunder:

DESCRIPTION OF AREA

Block		Approximate area	
		km ²	Acres
OT 96-A	<input type="checkbox"/>	255	62 600
OT 96-B	<input type="checkbox"/>	677	167 290

Please indicate Block under application. Note each Block is offered as a separate licence and the application fee is currently A\$2 000 per licence.

Details in support of the application (see guideline) and the application fee of \$..... are attached.

Dated this day of 19.....

.....

.....

Signature of applicants(s)*

* Note: Where application is made by a consortium including a company(s), the application must be made under the company(s) seal