COOPER BASIN
SOUTH AUSTRALIA
Petroleum Exploration Data Package 11

EXPLORATION OPPORTUNITIES
BLOCKS CO2001-A to F
January 2001
Cooper Basin exploration opportunities — Blocks CO2001-A to F

Compiled by
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Petroleum Group

January 2001

Petroleum Exploration Data Package 11
Cover photos from left to right:
Moomba at sunset, Cooper Basin. (Courtesy of Santos; photo 043360)
Aerial view across longitudinal sand dunes, Cooper Basin. (Photo 043783)
Drilling rig in the Cooper Basin, South Australia. (Courtesy of Santos; photo 038700)

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Cooper Basin exploration opportunities
Blocks CO2001-A to F

EXECUTIVE SUMMARY

Six blocks are being offered in Australia’s largest onshore oil and gas province (Cooper Basin) for petroleum exploration licences ((P)ELs) on the basis of cash (plus work program) bidding (Table 1, Fig. 1). The blocks range in size from 1 to 7.8 km² (250–1940 acres). Bidding closes at 4.00 p.m. on Thursday 2 August 2001 and the winning bids will be announced in September 2001.

Due to the small size of the areas, reliance solely on competitive work program bidding is difficult to administer. Winning bidders will therefore be selected on the basis of a combination of cash and work program bidding. Bids in excess of one well in the five-year licence term will not be taken into consideration in the selection process.

Table 1. Summary of areas on offer in 2001 for the Cooper Basin, SA.

<table>
<thead>
<tr>
<th>Block</th>
<th>Area (km²)</th>
<th>Oil or gas discovery</th>
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</thead>
<tbody>
<tr>
<td>CO2001-A</td>
<td>3.9</td>
<td>adjacent Jack Lake gas field</td>
</tr>
<tr>
<td>CO2001-B</td>
<td>7.8</td>
<td>Lycium oil discovery</td>
</tr>
<tr>
<td>CO2001-C</td>
<td>1.0</td>
<td>adjacent Kujani gas field</td>
</tr>
<tr>
<td>CO2001-D</td>
<td>2.3</td>
<td>adjacent Nungaroo oil field</td>
</tr>
<tr>
<td>CO2001-E</td>
<td>1.2</td>
<td>adjacent Limestone Creek oil field</td>
</tr>
<tr>
<td>CO2001-F</td>
<td>5.4</td>
<td>adjacent Naroonowie oil field</td>
</tr>
</tbody>
</table>

Blocks CO2001-A, C, E and F lie on the flanks of producing fields, but are not known to contain defined prospects. Block CO2001-B includes potential updip from the Lycium oil discovery, and CO2001-D to the west of Nungaroo contains a seismically defined prospect.

Cooper Basin gas supplies markets in the cities of Adelaide, Sydney, Brisbane and Melbourne via an extensive pipeline network. Gas was discovered in 1963 and 153 gas fields had been discovered in the South Australian part of the basin at 1 January 2000. Santos estimate remaining reserves as 2280 bcf of sales gas and 284 bcf of ethane. The first Cooper Basin oil was discovered in Tirrawarra 1 in 1970, and in 1978 economic quantities of oil were also discovered in the overlying Eromanga Basin (Strzelecki 3). The Cooper Basin Liquids Project (1980–1984) was initiated to market the newly discovered oil and existing gas liquids. A liquids pipeline links Moomba to a processing plant and storage and export loading facilities at Port Bonython. Santos estimate remaining liquids reserves as $3.8 x 10^6 kL (24.1 mmbbl) of oil, $5.3 x 10^6 kL (33.3 mmbbl) of condensate and $8.0 x 10^6 kL (50.4 mmbbl) of liquefied petroleum gas (LPG).

Opening up the Cooper Basin has attracted national and international interest. A phased acreage release program commenced around February 1999 when all of the exploration tenements held by the Santos joint venture since 1954 expired without right of renewal. As a result, a total of 27 new petroleum exploration licences will be offered to the winning bidders. Total committed expenditure over the next five years is $266 million with a minimum of 194 exploration wells to be drilled. Native title negotiations are progressing for applicants and an agreement for Round 1 applicants is imminent.

A future Cooper Basin acreage release is awaiting a decision on blocks to be released in the Coongie Lakes area. This will be made following completion of a consultative process on issues relating to access to this environmentally important area.

Applications may be made for any or all of the six areas. In the event that more than one area is offered to an applicant for licence, there is no obligation for the applicant to accept any or all of the offers. It should be noted that there are no criteria limiting the number of (P)ELs which may be offered to one applicant (although in considering Competition Policy Principles it would require
major work program benefits to offer more than three to the one applicant). No preference will be given to the successful bidders for adjacent CO98, 99 or 2000 blocks in the assessment processes.

Applicants should submit a cash bid, which states the value of such a bid and include payment of a deposit by cheque for 10% of such a bid. This deposit will be refunded to all unsuccessful bidders, but will be retained for the winning bidders. The winning bidder will be required to lodge the remaining 90% of the cash bid immediately prior to grant of the (P)EL (which cannot occur until the right to negotiate process has been concluded with any native title parties).

Comments, inquiries and applications for exploration licences may be addressed to:
Director, Petroleum Group Phone National (08) 8463 3204
Office of Minerals and Energy Resources International +61 8 8463 3204
Primary Industries and Resources South Australia Fax National (08) 8463 3229
Level 7, 101 Grenfell Street International +61 8 8463 3229
Adelaide SA 5000 Web site www.petroleum.pir.sa.gov.au
AUSTRALIA Email pirsa.petroleum@saugov.sa.gov.au

The envelope containing your application(s) must be marked ‘CONFIDENTIAL — (P)EL APPLICATION’. Successful bids will be announced in late August 2001.

The closing date for CO2001-A to F applications is 4.00 p.m. on Thursday 2 August 2001.
Petroleum tenements in the Cooper Basin, SA, showing release blocks CO2001-A to F.
GEOLOGICAL SETTING

Eromanga Basin

The Eromanga Basin covers one million square kilometres (250 million acres) of central-eastern Australia and contains the multi-aquifer system of the Great Artesian Basin. It unconformably overlies the Cooper and Warburton Basins. Eromanga Basin stratigraphy can be divided into three sequences — lower non-marine, marine and upper non-marine (Fig. 2). Exploration is concentrated on the productive lower non-marine sequence.

The lowermost unit of the Eromanga Basin is the Poolowanna Formation, which consists of interbedded siltstone, sandstone and coal, deposited in high-sinuosity fluvial and floodplain environments. Poolowanna Formation intertongues with and is overlain by low-sinuosity fluvial deposits of the Hutton and Algebuckina Sandstones. Basinward lateral equivalents of the Algebuckina Sandstone are Hutton Sandstone, Birkhead Formation, Adori Sandstone, Westbourne Formation, Namur Sandstone and Murta Formation. The Hutton, Adori and Namur Sandstones are similar in lithology and facies to the Algebuckina but with an additional volcaniclastic component in minor amounts.

The Birkhead Formation consists of interbedded siltstone, coal and sandstone. Westbourne Formation consists of interbedded siltstone and sandstone of Late Jurassic age. Murta Formation and McKinlay Member overlie and intertongue with the Namur Sandstone and consist of thinly interbedded siltstone, shale and sandstone deposited in a large lake which extended throughout the Cooper Basin region. The McKinlay Member is a lacustrine shoreface facies.

Cadna-owie Formation records the transition into open marine conditions during the Early Cretaceous and consists of interbedded sandstone, siltstone and claystone with minor carbonate. The fluvio-deltaic Wyandra Sandstone Member is developed at the top of the Cadna-owie Formation. The contact between sandstones of the upper Cadna-owie Formation (Wyandra Sandstone Member) and overlying marine shales of the Bulldog Shale or Wallumbilla Formation approximates a prominent seismic reflector, the C horizon, which is mappable across the entire Eromanga Basin. Formations of the Early Cretaceous are of secondary interest to petroleum exploration in the area and are not discussed in detail. The marine succession is overlain by the rapidly deposited upper non-marine sequence (Winton Formation) which consists of coal, floodplain and low-sinuosity channel deposits.

A period of erosion and deep weathering in the Late Cretaceous caused by a switch in drainage from the Cooper region to the Ceduna Depocentre on the rifted southern margin of the continent was followed by deposition of the non-marine Cainozoic Lake Eyre Basin. The modern landscape was formed during the Pliocene to Quaternary.

Cooper Basin

The intracratonic Cooper Basin represents a Late Carboniferous to Triassic depositional episode. It lies unconformably over early Palaeozoic sediments of the Warburton Basin and is overlain disconformably by the Eromanga Basin (Fig. 3). Three major troughs (Patchawarra, Nappamerri and Tenappera) are separated by structural ridges (Gidgealpa–Merrimelia–Innamincka (GMI) and Murteree) associated with the reactivation of northwest-directed thrust faults in the underlying Warburton Basin. These troughs contain up to 2500 m of Permo-Carboniferous to Triassic sedimentary fill overlain by as much as 1300 m of Jurassic to Tertiary cover.

The Late Carboniferous to Early Permian formations of the Cooper Basin comprise, in ascending order, the Merrimelia Formation and Tirrawarra Sandstone — a glaciofluvial system deposited on glacially sculpted flat lying to deformed Warburton Basin sediments, volcanics and intrusives. The Tirrawarra Sandstone represents low-sinuosity fluvial to proglacial outwash deposits overlain by peat swamp, floodplain and high-sinuosity fluvial facies of the Patchawarra Formation.

Two lacustrine siltstone units (Murteree and Roseneath Shales) with intervening fluvio-deltaic sediments (Epsilon and Daralingie Formations) were deposited during a phase of continued
Fig. 2 Geological summary of the Eromanga Basin.
subsidence. Early Permian uplift led to erosion of the Daralingie Formation and underlying units from basement highs.

Floodplain, peat swamp and high-sinuosity fluvial facies of the Late Permian Toolachee Formation were deposited on the Daralingie unconformity surface and are overlain conformably by Late Permian to Early Triassic Arrabury Formation. The uppermost coal, approximating the top Permian, is mapped as the P seismic horizon (Fig. 4). The Arrabury Formation comprises floodplain and channel facies of the Callamurra, Paning and Wimma Sandstone Members, which are overlain by the Early Triassic Tinchoo Formation.

In the northern Patchawarra Trough, the Cooper Basin is locally overlain by the Middle to Late Triassic Cuddapan Formation. Deposition in the region was terminated at the end of the Early Triassic with slight but widespread deformation, regional tilt and erosion.

![Geological summary of the Cooper Basin](image)

**Fig. 3** Geological summary of the Cooper Basin.
Fig. 4 Top Permian, 'P' seismic horizon.
**Warburton Basin**

The Cooper Basin is unconformably underlain by sediments and volcanics of the eastern Warburton Basin (Fig. 5). Warburton Basin sediments range from Cambrian to Ordovician; Devonian sediments have not been intersected in the Cooper Basin region of South Australia. The eastern Warburton Basin is essentially a fold belt deformed during the Late Devonian to Carboniferous Alice Springs Orogeny, intruded by mid-Carboniferous granitoids and subsequently buried to depths ranging from 1300 m to almost 4000 m.

The eastern Warburton Basin contains a basal suite of acid-intermediate volcanics, tuff and agglomerate (Mooracoochie Volcanics), overlain by dolomitised shelfal limestone historically assigned to the basal Kalladeina Formation. A Middle to Late Cambrian carbonate shelf developed in the Coongie–Cuttapirie area, with a slope to the east. Several depositional sequences have been identified in the Kalladeina Formation typically with deep-water shales overlain progressively by shallow-water carbonate and clastic deposits. The Pando and Inamincka Formations continue this trend to shallow-water depths as part of a deltaic complex with an extensive marine shelf sand. Black shale of the Dullingari Group with rare graptolites was deposited in the deep-water Larapintine Sea which extended through the Warburton and Amadeus Basins to the Canning Basin.

Middle to Late Ordovician shale and siltstone constitute the last preserved deposits of the eastern Warburton Basin. Early to Middle Carboniferous granitic intrusives (Big Lake Suite) beneath the Nappamerri and Wooloo Troughs were responsible for localised silicification and contact metamorphism of Cambrian country rock. The unconformity at the top of the Warburton Basin is mapped as the Z seismic horizon. A weathered zone up to 150 m thick has altered Warburton Basin strata and the granites in particular, immediately beneath the Cooper Basin unconformity.

Structural style superimposed by compressional deformation during the Alice Springs Orogeny follows arcuate northeasterly trends imposed by northwest-directed thrust faults. Wrench fault zones have been mapped seismically in the Titan–Charo–Yanta area on the northwest flank of the Patchawarra Trough. Complex folding and faulting occur in some parts of the basin, but in many regions the early Palaeozoic is almost flat lying.

**PETROLEUM GEOLOGY**

**Reservoirs**

**Eromanga Basin**

Principal reservoirs are good to excellent reservoir quality Hutton and Namur Sandstones (porosities up to 25%, permeability up to 2500 mD). Oil is also reservoired in fair to excellent quality sandstones in the Poolowanna and Birkhead Formations, McKinlay Member and Murta Formation. The Algebuckina Sandstone is a major artesian aquifer. The Cadna-owie Formation (Wyandra Sandstone Member) forms a significant oil reservoir in Queensland, however economic hydrocarbons have yet to be discovered in this unit within South Australia.

**Cooper Basin**

Multi-zone high-sinuosity fluval sandstones form poor to good quality reservoirs. The main gas reservoirs occur primarily within the Patchawarra Formation (porosities up to 23.8%, average 10.5% and permeability up to 2500 mD) and Toolachee Formation (porosities up to 25.3%, average 12.4% and permeability up to 1995 mD). Shoreface and delta distributary sands of the Epsilon and Daralingie Formations are also important reservoirs. Oil is produced principally from low-sinuosity fluval sands within the Tirrawarra Sandstone (porosities up to 18.8%, average 11.1% and permeability up to 329 mD). Towards the margin of the Cooper Basin, oil is also produced from the Patchawarra Formation and from fluval channel sands in the Merrimelia Formation in Malgoona Field.

The Callamurra Member of the Arrabury Formation is conventionally regarded as a regional seal but nevertheless contains economic oil and gas reservoirs in some areas and is a leaky seal in
<table>
<thead>
<tr>
<th>AGE</th>
<th>ROCK UNIT</th>
<th>LITHOLOGY</th>
<th>STRATIGRAPHIC SEQUENCES</th>
<th>COMMENTS</th>
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<tr>
<td></td>
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<td>DULLINGARI MOVEMENT.</td>
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<td>EXTENSIVE DELTAIC INTERBEDDED SILTSTONE AND RIPPLED GLAUCONITIC SANDSTONE. BASALT FLOWS. ACритarchs, bryozoa, conodonts.</td>
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<td>Bioturbated glauconitic, 'hot' sandstone, gas in Moolalla 1</td>
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<td>INCREASING GLAUCONITIC SILICLASTICS, DECREASING CARBONATE.</td>
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<td>EXTENSIVE OOD, NUAA, ONCOLITE GRAINSTONE IN SHELF TO RED BED TRANSITION. TRILLOBITES, CONODONTS.</td>
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<td>Extensive deltaic and rippled glauconitic sandstone. Basalt flows.</td>
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<td>MOOTWINGEE MOVEMENT: Separation of Arrowie and eastern Warburton Basin depositional systems.</td>
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<td>Subaerial exposure, karst.</td>
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<td></td>
<td></td>
<td>Potentially significant petroleum reservoir; Gidgealpa-1 recovered heavily gas cut salt water from this dolomitised, fractured unit.</td>
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<td>Carbonate disconformably overlies volcanics.</td>
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<td>KANGAROIDIAN MOVEMENTS</td>
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<td></td>
<td></td>
<td>Carbonate disconformably overlies volcanics.</td>
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<td>Oil in Sturt 6</td>
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<td></td>
<td></td>
<td>Volcaniclastics - tuff, ignimbrite, sand and silt. Agglomerate with Cambrian fossil fragments.</td>
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<td>PROTEROZOIC</td>
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**Fig. 5** Geological summary of the eastern Warburton Basin.
others. Low-sinuosity fluvial sandstones of the Paning and Wimma Sandstone Members form economic oil and gas reservoirs and high-sinuosity fluvial sandstone of the Tinchoo Formation reservoir oil. As yet, there have been no economic oil or gas fields discovered in the Cuddapan Formation in South Australia.

**Warburton Basin**
Fractures in brittle siltstones (e.g. Dullingari Group in Lycosa 1) are capable of trapping commercial oil and gas. Fracture patterns and their relation to pre-Cooper and post-Cooper Basin structure are being studied by Primary Industries and Resources South Australia (PIRSA) and the National Centre for Petroleum Geology and Geophysics.

Pando Formation sandstone has surprisingly high porosity (~10%) in view of its low stratigraphic position. It is glauconitic and zircon-rich and consequently has a high gamma ray response. Moolalla 1 gas is reservoired in this formation which extends from Pando in the west to Moomba in the northeast.

Basal and middle Kalladeina Formation dolomites represent shelf limestones exposed to meteoric diagenesis during marine lowstands. Although minor gas shows have been recorded, porosity prediction has proved elusive, the dolomites and associated karst breccias proving tight when drilled.

Sturt 6 oil was produced from weathered tuff which forms an extensive unit beneath the southwest Cooper Basin. The tuff, together with underlying agglomerate and lava, comprises the Mooracoochie Volcanics. Both the oil and gas originated from Permian source rocks.

**Source rocks**
Both Cooper and Eromanga Basin mature source rocks have actively contributed to oil accumulations in the region. Each oil accumulation needs to be considered on its merits with respect to the extent of ‘mixing’ from Permian and Mesozoic sources.

**Eromanga Basin**
Oil originated either in the Eromanga or the Cooper Basin or a mixture of both. Although it is recognised that Birkhead and Murta Formation sources exist, there is still considerable debate as to their extent and relative contribution.

Potential source rocks of Jurassic and Early Cretaceous age contain Type II to Type III organic matter and have been shown to have maturities within the ‘oil window’ (onset of oil generation between vitrinite reflectance 0.65–0.7%). Significant suppression of measured vitrinite reflectance (Ro) has been detected in some Eromanga Basin source rocks using the FAMM technique. Average total organic carbon and pyrolysis yields are slightly lower for Eromanga source rocks compared to Permian source rocks. However, the Birkhead Formation (mid-Jurassic) contains the most hydrogen-rich organic matter and has an average total organic carbon content of 2.5% and S2 pyrolysis yield of 10.8 kg/tonne. The Poolowanna Formation shows fair to good source richness; the Westbourne Formation exhibits mainly fair source richness.

Hydrocarbon extracts of Jurassic potential source rocks are paraffinic and waxy and similar to those from Permian sediments. This lack of distinction probably reflects only minor changes in organic facies and/or maturation histories or alternatively, reflects oil staining/contamination of Eromanga source rocks by migrating Permian hydrocarbons.

Oils in Cretaceous reservoirs are often geochemically distinct from those in Jurassic reservoirs. They are typically light (45° API gravity), non-waxy, low sulphur, paraffinic crudes although waxy oils do occur. In Dullingari Field, Murta Formation oils are thought to be locally sourced from Early Cretaceous source rocks.

The marine Cretaceous sequence contains good potential source rocks, however it is considered immature for hydrocarbon generation. Clearly, more work needs to be done in order to distinguish local Eromanga Basin sourcing.
Cooper Basin

Permian coal measures and shales are the principal hydrocarbon source rocks in the region and are dominated by Type III kerogens derived from higher plant assemblages. Oils and condensates are typically medium to light (30–60° API) and paraffinic, with low to high wax contents. Most Permian oils in Permian reservoirs contain significant dissolved gas and show no evidence of water washing. Gas composition is closely related to maturity/depth with drier gas occurring towards basin depocentres although there is strong geological control on hydrocarbon composition.

The Patchawarra Trough contains the bulk of the oil and wet gas reserves consistent with local source rocks being in the ‘oil window’ while the hot Nappamerri Trough (40–50°C/km), underlain in part by granite, is overmature and contains mainly dry gas.

Permian source rocks have average total organic carbon and S2 pyrolysis yields of 3.9% and 6.9 kg/tonne, respectively (excluding coals). Locally, the Toolachee Formation is the richest source unit. The Patchawarra Formation is considered the other major source unit, especially the lower shales and coals. The lacustrine Murteree and Roseneath Shales have little source potential.

Together, the petrographic and geochemical evidence support coals and associated dispersed organic matter as the effective source rocks capable of generating gas and minor oil, albeit in low yields. At maturity levels between 0.7–0.95% Ro, initial generation from the richer facies has led to partial filling of reservoirs with wet gas and oil. There is a sharp onset of significant hydrocarbon accumulation when the source reaches a maturity of 0.95% Ro.

Thin, laterally discontinuous coals represent the best source rocks of the upper Nappamerri Group whilst shales tend to be organically lean. The lower Nappamerri Group is coal-poor, contains kerogen that tends to be oxidised and any source rocks are humic rich and gas prone.

Warburton Basin

Source rock quality of samples, principally from the Kalladeina Formation, is poor to fair. With the exception of anomalously low-maturity indices from Kalladeina 1, the succession below 3000 m is late-mature to post-mature for oil. Organic matter is mainly Type II kerogen derived from marine algal/bacterial precursors.

Seals and plays

Where the regional seal is thin or absent multiple oil and gas pools are stacked in coaxial Permian to Mesozoic structures and may occur from as low as the Patchawarra Formation to as high as the Murta Formation (Fig. 6). Locally, Permian oil has migrated into Warburton Basin reservoirs on the basin margin and gas has migrated into fractured Ordovician reservoirs fringing the Allunga Trough.

Fig. 6 Schematic section showing typical petroleum traps in the Warburton, Cooper and Eromanga Basins.
Eromanga Basin
Trapping mechanisms are dominantly structural (anticlines with four-way dip closure or drapes over pre-existing highs) with a stratigraphic component (e.g. Hutton–Birkhead transition, Poolowanna facies, McKinlay Member and Murta Formation). Eromanga structures in South Australia are rarely filled to spill with oil — net oil columns are relatively thin compared to the height under closure (due to poor sealing characteristics). Seals consist of intraformational siltstones and shales of the Poolowanna, Birkhead and Murta Formations — no economic hydrocarbons have been discovered in South Australia above the Murta Formation. Where these units are absent, potential seals include Bulldog Shale and Wallumbilla Formation.

Cooper Basin
Anticlinal and faulted anticlinal traps have been relied on as proven exploration targets but potential remains high for discoveries in stratigraphic and sub-unconformity traps, especially where the Permian sediments are truncated by the overlying Eromanga Basin succession. Economic oil and gas are reservoired in the Nappamerri Group, paradoxically regarded as a regional seal to the Cooper Basin. Intraformational shale and coal form local seals in the major reservoir units. Beneath the Daralingie unconformity are two important Early Permian regional seals — Roseneath Shale is the top seal of the Epsilon Formation and the Murteree Shale seals the Patchawarrra Formation.

Warburton Basin
Cooper Basin reservoirs, source rocks and seals have been juxtaposed against elevated ridges of Warburton Basin rock by faulting or by original deposition. These ridges are potential lateral seals but may also be reservoirs. Ridges are composed of sandstone, shale, carbonate and volcanic units, which are fresh to severely altered by weathering and diagenesis (but not metamorphism). Dips vary from horizontal to vertical, and units range from massive to slightly to pervasively fractured, with weak to strong faulting and folding. Their competence as lateral seals is dependent upon a combination of lithologic and structural factors.

Potential traps in the Warburton Basin include large hanging wall anticlines associated with northeasterly trending thrust faults and upthrown fault blocks on wrench fault zones.

A thick impermeable weathered profile on the top Warburton unconformity surface forms a semi-regional seal and is distinguished on logs by its low uniform resistivity.

Undiscovered potential
Introduction
The Cooper Basin is a mature petroleum province, however potential remains high for discoveries in stratigraphic and sub-unconformity traps, which have received increasing interest in the past five years. Pinchout plays along the margins of the Cooper Basin have been tested with commercial success. Three-dimensional seismic will have a critical role to play in delineating more subtle traps in the future. Remaining South Australian Cooper–Eromanga reserves are shown in Table 2.

Table 2. SA Cooper Basin reserve summary, 1.1.2000 (source Santos).

<table>
<thead>
<tr>
<th>Energy minerals</th>
<th>Reserves</th>
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<tr>
<td>Sales gas</td>
<td>2396 bcf</td>
</tr>
<tr>
<td>Ethane</td>
<td>299 bcf</td>
</tr>
<tr>
<td>LPG</td>
<td>50.4 mmbbl</td>
</tr>
<tr>
<td>Condensate</td>
<td>33.3 mmbbl</td>
</tr>
<tr>
<td>Oil</td>
<td>24.1 mmbbl</td>
</tr>
</tbody>
</table>
Undiscovered reserves of hydrocarbons have also been estimated by PIRSA, the Bureau of Resource Sciences and Stratigraphic Research International to predict the undiscovered potential of the Cooper and Eromanga Basins. Results are summarised in Table 3. For more detail, refer to *The petroleum geology of South Australia – Vol. 4: Cooper Basin*.

**Cooper Basin gas**

The present discovered recoverable raw gas reserves (at 1.1.2000) of the basin are $235 \times 10^9$ m$^3$ (8.3 tcf) comprising $136 \times 10^9$ m$^3$ (4.8 tcf) of produced gas and $100 \times 10^9$ m$^3$ (3.5 tcf) of gas yet to be produced from known discoveries. The average recovery factor for gas fields is 64%. There have been 123 Cooper Basin gas fields discovered in South Australia to 1.1.2000.

**Cooper–Eromanga oil**

The present recoverable oil reserves (at 1.1.2000) of the basin are $20.7 \times 10^6$ kL (130 mmstb) comprising $17 \times 10^6$ kL (107 mmstb) of produced oil and $3.7 \times 10^6$ kL (23 mmstb) of oil yet to be produced from known discoveries. The combined average primary and secondary recovery factor for oil fields is 21%. More than 80% of the oil reserves are contained in the Tirrawarra Field. There have been a total of 25 Cooper oil fields discovered in South Australia up to 1.1.2000. In the overlying Eromanga Basin, there have been 33 oil fields discovered from 293 wildcats (to 1.1.93).

**Results**

Potential (undiscovered) resources should not be compared to traditional proved, probable and possible reserves in known discoveries. Undiscovered resources are calculated to give a quantitative indication of the potential of the basin, and require considerable exploration to establish their existence. The results of methods considered to be reasonably reliable are summarised in Table 3.

Some of the potential attributed to the Cooper Basin may have already been discovered in the Eromanga Basin. The current discovered recoverable oil reserves of the Eromanga Basin in the Cooper Basin region are $14.5 \times 10^3$ kL (92.5 mmstb).

**Table 3. Comparison of undiscovered recoverable petroleum resources in the Cooper Basin.**

<table>
<thead>
<tr>
<th>Method</th>
<th>Gas $10^9$ m$^3$ (tcf)</th>
<th>Average estimate</th>
<th>High estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin analogue</td>
<td>108 (3.8)</td>
<td>192 (6.8)</td>
<td>277 (9.8)</td>
</tr>
<tr>
<td>APRAS* (average)</td>
<td>39 (1.4)</td>
<td>181 (6.4)</td>
<td>546 (19.4)</td>
</tr>
<tr>
<td>Pareto</td>
<td>41 (1.5)</td>
<td>60 (2.1)</td>
<td>83 (3.0)</td>
</tr>
<tr>
<td>Basin plays</td>
<td>0 (0)</td>
<td>25 (0.9)</td>
<td>215 (7.7)</td>
</tr>
<tr>
<td>Lognormal</td>
<td>7 (0.3)</td>
<td>12 (0.4)</td>
<td>19 (0.7)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil $10^6$ kL (mmstb)</th>
<th>Low estimate</th>
<th>Average estimate</th>
<th>High estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin analogue</td>
<td>14.8 (93.8)</td>
<td>20.2 (128.2)</td>
<td>25.6 (162.6)</td>
</tr>
<tr>
<td>Basin plays</td>
<td>0 (0)</td>
<td>13.7 (87)</td>
<td>41.5 (264)</td>
</tr>
<tr>
<td>Pareto</td>
<td>2.0 (12.9)</td>
<td>5.4 (34.3)</td>
<td>20.3 (127.6)</td>
</tr>
<tr>
<td>Lognormal</td>
<td>0.3 (2.0)</td>
<td>1.6 (10.0)</td>
<td>4.3 (27)</td>
</tr>
<tr>
<td>APRAS* (average)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4.3 (27.2)</td>
</tr>
</tbody>
</table>

* analytical petroleum resource appraisal system
A total of 5238 km of pipeline have been laid to gas markets in South Australia, New South Wales and Victoria and to the liquids load out facility at Port Bonython. Key pipelines are listed in Table 4 and shown in Figure 1.

**Table 4. Cooper Basin pipeline licences, February 1999.**

<table>
<thead>
<tr>
<th>PL</th>
<th>Pipeline name</th>
<th>Operator</th>
<th>Product</th>
<th>Length (km)</th>
<th>Pipe diam. (mm)</th>
<th>MAOP* (kpa)</th>
<th>Construction period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moomba–Adelaide plus 12 laterals</td>
<td>Epic Energy</td>
<td>sales gas</td>
<td>1065 total</td>
<td>560 various</td>
<td>7300</td>
<td>1968–69, 1969–90</td>
</tr>
<tr>
<td>2</td>
<td>Moomba – Port Bonython liquids line</td>
<td>Epic Energy</td>
<td>liquids</td>
<td>659</td>
<td>356</td>
<td>10380</td>
<td>1982</td>
</tr>
<tr>
<td>5</td>
<td>South West Queensland</td>
<td>Santos</td>
<td>sales gas</td>
<td>92</td>
<td>400</td>
<td>10000</td>
<td>1991–92</td>
</tr>
<tr>
<td>7</td>
<td>Moomba–Sydney plus loop line</td>
<td>East Australian Pipelines</td>
<td>sales gas</td>
<td>101, 10</td>
<td>864, 660</td>
<td>6200</td>
<td>1976, 1984</td>
</tr>
<tr>
<td>8</td>
<td>Moomba–Sydney ethane line</td>
<td>East Australian Pipelines</td>
<td>ethane</td>
<td>101</td>
<td>219</td>
<td>15300</td>
<td>1996</td>
</tr>
<tr>
<td>9</td>
<td>Stokes–Mettika</td>
<td>Santos</td>
<td>raw gas</td>
<td>3.5</td>
<td>323.9</td>
<td>11400</td>
<td>1996</td>
</tr>
<tr>
<td>10</td>
<td>Moomba interconnection</td>
<td>Boral Energy</td>
<td>sales gas</td>
<td>0.087</td>
<td>250</td>
<td>9665</td>
<td>1998</td>
</tr>
</tbody>
</table>

* maximum allowable operating pressure

There were 94 online gas fields with 495 connected gas wells (378 online), and 29 online oil fields with 124 producing oil wells in the South Australian Cooper Basin at 1.11.99.

A combined total of 162 PJ of sales gas was sold in 1999 to Epic Energy and AGL. The estimated average daily production in 1998 from the Cooper and Eromanga Basins was: sales gas, 14.2 x 10^8 m³ (0.5 bcf); crude oil and condensate, 3816 kL (21 400 bbl); and LPG, 986 tonnes (11 500 bbl).

Gas emerges at the wellhead at pressures up to 25000 kPa and temperatures up to 120°C. Gas from individual wells passes via field gathering systems (flowlines) to satellite stations which separate gas, free water and condensate. Evaporation ponds are used for water disposal. The essentially water-free gas and condensate pass to the Moomba treatment plant through trunklines. Crude oil is transported by either pipeline or truck to the Moomba plant. Currently, nine oil and eleven gas satellites are in operation in the Cooper and Eromanga Basins. Approximately 1010 km of trunklines and 1135 km of flowlines have been laid to date in the region.

At the Moomba plant free condensate and water are initially removed from the raw gas at the slug catchers. The gas then proceeds to the Benfield unit to ensure that no greater than 3% by volume of CO₂ remains in the sales gas stream. The gas is dehydrated at molecular sieves before it proceeds to the liquid recovery plant where 100% of the remaining condensate, 98% of the LPG (C₃ and C₄) and 75% of the ethane are removed, leaving sales gas for Adelaide and Sydney with a heating value <37.5 megajoules per cubic metre. The plant has been designed to process 25.4 x 10⁶ m³ (902 mmcft) of raw gas and 6000 kL (42 000 bbl) of condensate and crude oil per day. Condensate, LPG, crude and some ethane are transported as a ‘cocktail’ via a pipeline to Port Bonython where they are separated and marketed.

The feedstock delivered to Port Bonython is first sampled, filtered and metered to determine flow rates and composition. It is then pumped through a series of fractionating towers to separate ethane (which is used as fuel gas for the plant), propane, butane, light naphtha, intermediate naphtha,
heavy naphtha, and reduced crude. Once cooled to ambient temperatures, the naphtha and reduced crude fractions are pumped to the blending section where they are mixed in precise ratios. The resulting two products, ‘naphtha’ and ‘crude oil’ are sent to storage tanks to await shipping.

One destination for Cooper–Eromanga crude oil and condensate is the refinery at Port Stanvac, which supplies petroleum products mainly for the South Australian market. The refinery commenced operations in 1963 and the adjacent lubricating oil refinery began operations in 1976. The refinery does not have sufficient capacity to produce all the State’s requirements for motor spirit, and some must be imported from interstate. The main refinery products from Port Stanvac are LPG, solvents, motor gasoline, jet fuel, kerosene, diesel, lube oil base stocks for Australian and overseas markets, fuel oil and bitumen.

Other facilities

The northern part of South Australia is sparsely populated and relatively undeveloped due to its remoteness and harsh climate. The main primary industry in the region is cattle which are run on large pastoral leases. Eco-tourism is a growing industry in the region. The township of Innamincka is located 65 km from Moomba and offers a hotel, general store and light aircraft airstrip. The Birdsville and Strzelecki Tracks are unsealed, but provide access for heavy vehicle transport in the region.

Accommodation and support facilities are located at Moomba, a fly-in fly-out camp operated by the Cooper Basin Joint Venture. Access to these facilities requires the agreement of Santos. The Moomba Camp can accommodate 450 people, with an additional 150 beds mothballed. A full range of support services is available at Moomba including logging, wireline, fraccing, cementing, transport, fuel supply, aviation and emergency services. The sealed airstrip is 1720 m long and able to accept medium-sized jets.

Groundwater, extracted from the Great Artesian Basin aquifer system, is critical for petroleum operations in the region. There are two major aquifers, the lower occurs within the Algebuckina Sandstone and Cadna-owie Formation and provides hot (up to 100°C) good quality (total dissolved salts 1000 mg/L) artesian water. The upper aquifer comprises the Winton and Mackunda Formations which produce poorer quality water.

Oil and gas markets

A free market was introduced in 1988 for all oil and condensate produced in Australia. There is no restriction on imports or exports of crude oil or refined petroleum products. A similar regime has applied since 1991 for LPG. Markets for crude oil and condensate exist in South Australia and Australia and low-sulphur light crude oils find a ready domestic and overseas market.

Ex-field natural gas prices in South Australia are freely negotiated between buyer and seller. Ex-Moomba plant natural gas prices from the Cooper Basin (Fig. 7) are currently in the order of A$2.50 per gigajoule (~1 mcf). As a consequence of the gas reform process in Australia, regulatory

Fig. 7 Comparison of Australian and US gas prices.
policy impediments to the free trade in gas are being removed, rights of access to gas transmission and reticulation pipelines have been provided, and direct negotiations between consumers and producers facilitated. The issue of access to upstream facilities is also currently being reviewed.

Existing contracts with the South Australian and Queensland Cooper Basin Producers supply the State’s needs in full until 2004, and partial needs to 2013 and those of New South Wales until 2006. The Australian Gas Association predicts that gas will be the fastest growing energy source in Australia to 2030, with an annual growth of 3% predicted. Natural gas currently supplies around 18% of Australia’s primary energy needs, and the Australian Gas Association predict this will increase to 28% by 2030. Their study of future Australian gas supplies and demand forecasts that gas reserves in southern and eastern Australia will be insufficient to supply market demand within a decade (Fig. 8).

![Graph showing gas supply and demand, eastern Australia](image)

**Fig. 8 Gas supply and demand, eastern Australia (Australian Gas Association).**

### EXPLORATION ACCESS

#### Environmental management

PIRSA Petroleum Group acts as a one-stop shop for explorers in obtaining any necessary environmental approvals on the occasions when they are required from other government agencies. Approvals to conduct field operations etc. are first submitted to PIRSA, which arranges distribution to the other relevant government agencies for comment and then issues the necessary approvals. Petroleum Group staff are available to assist licensees prepare the necessary paperwork.

PIRSA Petroleum Group has introduced an objective based co-regulatory approach to the regulation of the upstream petroleum industry to reduce compliance costs and deliver better environmental outcomes. As this is a move away from prescriptive regulation and the pre-existing ‘command and control’ regime a change in both culture and method are required. There will still be inspection of field operations, including audits by PIRSA authorised officers.

The legislation governing onshore petroleum exploration and production in South Australia was reviewed through an extensive process of industry and public stakeholder consultation commencing in 1996 which led to the proclamation of the new *Petroleum Act 2000* and the promulgation of Petroleum Regulation 2000 on the 25 September 2000.

The main drivers behind the need for this new Act were:

- Changing attitudes and expectations of the community at large in particular to environmental issues. These changing expectations called for legislation which can adequately address environmental and heritage issues more openly and transparently than the previous Act.
- Competition policy reform facing the industry required exposing the industry to greater competition, e.g. smaller blocks, shorter licence terms and access to prospective areas to more licensees.
A need for regulations to be more receptive to changing and improving technology by focusing on the achievement of objectives rather than prescribing what needs to be done. To address these issues the new Act was developed through embracing six key principles of certainty, openness, transparency, flexibility, practicality and efficiency. In applying these principles the Act achieves:

- a more effective means for allocating and managing the rights to explore for and develop petroleum and other natural resources so as to facilitate competition
- greater security of title of petroleum rights through improved registration procedures and greater flexibility in the types of licences that can be granted
- a regulatory regime designed to more effectively and efficiently set and achieve environmental and public safety protection objectives
- effective public consultation processes for the establishment of environmental objectives
- a more effective means for ensuring that security of production and supply of natural gas is maintained at a prudent level
- effective public reporting to provide all stakeholders with sufficient information on industry performance and government decision-making
- a flexible regulatory approach which allows the selection of the most appropriate level of regulatory intervention and enforcement in order to ensure compliance with the regulatory objectives.

**National parks and reserves**

There are a number of protected areas which have been created to conserve examples of vegetation and landforms in the region (Fig. 9). There are seven categories of South Australian reserve and conditions of access vary, based upon classification, the activity proposed and its likely impact on the environment. Access for petroleum exploration and production is allowed in all parks in the Cooper Basin region and in all regional reserves in the State. Access issues into the Coongie Lakes Control Zone are currently under review.

Block CO2001-C lies within the Strzelecki Regional Reserve (Fig. 9). The Innamincka Regional Reserve, which covers much of the productive area of the Cooper Basin, was created under amendments in 1987 to the *National Parks and Wildlife Act 1972* specifically for the purpose of conservation while at the same time permitting the utilisation of the petroleum and other resources of the reserve.

Mineral and petroleum exploration licence applications for areas within regional reserves are processed by PIRSA but are referred to the Minister for Environment and Heritage for comment. Exploration work programs are also discussed with Department for Environment and Heritage as a matter of policy. In the case of production tenements, approval must also be given by the Minister for Environment and Heritage. Production licence applications are referred to the Minister for Transport and Urban Planning for advice on the environmental significance of operations. In all other respects exploration and production is carried out under the provisions of the Petroleum Act and Regulations.

The Cooper Creek, including Coongie Lakes, has been identified as a wetland of international significance under the Ramsar Convention which was established in 1971 to conserve significant wetland habitats (Fig. 9). The Coopers Creek floodplain is also included in the Register of the National Estate.

**European heritage**

A number of sites of European heritage significance, such as historic buildings and structures and geological monuments, occur in the region. These are indicated on environmental sensitivity maps held by PIRSA. The majority of the sites are small and easily avoided by exploration activities.
Fig. 9 Protected areas in the Cooper Basin
**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 procedures involve consulting with the relevant Aboriginal organisation and maintaining a watch for sites, objects or remains during activities. Generally the sites are no larger than a few hundred square metres and are easily avoided. Since the inception of the *Aboriginal Heritage Act 1988*, there have been no conflicts between Aboriginal heritage sites and exploration or production activities in South Australia. 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.

**Native title**

The Commonwealth *Native Title Act 1993* was passed by Federal Parliament on 22 December 1993. This Act provides statutory recognition and protection for the concept of native title as recognised by the High Court in the case of *Mabo v. The State of Queensland* (1992). This Act was substantially amended in 1998. Amongst other things, these amendments inserted provisions for reaching indigenous land use agreements, provided more detailed provisions for dealing with Acts which might affect native title, and provided a new test to be applied in the registration of claims for native title.

The term native title refers to those rights held by indigenous inhabitants of Australia at and since the time of European settlement that are recognised by the common law — it differs from conventional land title. There must be a sufficient and relevant connection to the land in question, continuous since settlement (1836 in South Australia). The nature of native title rights vary from group to group according to laws and customs, and 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.

Since the passage of the amendments to the Native Title Act in 1998, all applications in respect of native title under that Act are made as claims in the Federal Court (any claims made under the South Australian legislation (see below) are made in the Environment Resources and Development Court). The Federal Court refers claims for native title to the National Native Title Tribunal for registration. If the application passes the test which now must be applied before registration, the details of the claim are entered on the register kept by the Tribunal (the Register of Native Title Claims). Registration is a pre-requisite for getting most of the rights conferred on claimants under the Native Title Act, including the ‘right to negotiate’.

The National Native Title Tribunal also keeps the National Native Title Register which comprises a record of all determinations made by the Tribunal, Federal Court, High Court, other Courts or Tribunals and recognised State and Territory arbitral bodies.

The Native Title Act allowed for States to pass their own legislation in a number of areas. South Australia did so in 1994–95. This legislative package validated certain Acts which occurred before 1994, allowed the State Environment Resources and Development and Supreme Courts to hear native title related issues (including determinations under the State right to negotiate schemes) and set up alternative State right to negotiate schemes under the *Mining Act 1971* and the *Land Acquisition Act 1969*. A right to negotiate scheme was later enacted as part of the *Opal Mining Act 1995*. No State right to negotiate process was enacted for petroleum at that stage.

In so far as there is an impact on native title, the issuing of petroleum tenements in this State continues to be governed by the federal right to negotiate procedure. In response to industry concerns, 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.

Following passage of the Commonwealth Native Title Amendment Act in 1998, there are now a number of options available under the new federal legislation to develop alternate State procedures to handle native title matters. The South Australian Government has initiated a number of
legislative responses to these amendments. The State Government is undertaking extensive consultation with all relevant organisations as well as the Federal Government, to establish a right to negotiate process in the Petroleum Act similar to that previously implemented in the Mining Act. Under the State scheme, responsibility for negotiations lies with the licensee.

The right to negotiate process under the Native Title Act was initiated with regard to the successful applications from Round 1 of the Cooper Basin acreage release. In principal agreement has recently been reached between these parties, including agreement on compensation between the claimants, licence applicants and Government. Detailed drafting of agreement is currently in progress. A total of four native title claimants were involved and 11 new petroleum exploration licences will be offered to six joint venturers when the agreement is finalised, signed and registered (possibly in February 2001). This agreement can then be used as a precedent by new explorers to speed subsequent negotiations if so desired. Native title claims relating to the Cooper Basin are show in Figure 10.

**AVAILABLE DATA**

Open file well and seismic data available for Blocks CO2001-A to F are listed in Tables 5 and 6. Time structure maps and seismic sections for Blocks CO2001-B and C are shown in Figures 11–14. A free promotional CD has been compiled for the acreage release and includes:

- relevant well completion reports (pdf format)
- selected digital well logs
- *Petroleum geology of South Australia, vol. 4: Cooper Basin* (pdf format)
- well location data (Excel spreadsheet)
- shot point data.

**Table 5. Exploration wells drilled in or adjacent to Blocks CO2001-A to F.**

<table>
<thead>
<tr>
<th>Block</th>
<th>Well</th>
<th>Status</th>
<th>Spud</th>
<th>Rig release</th>
<th>Total depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2001-A</td>
<td>Aratna 1</td>
<td>plugged and suspended</td>
<td>06.04.1998</td>
<td>28.04.1998</td>
<td>3018</td>
</tr>
<tr>
<td></td>
<td>Jack Lake 1</td>
<td>suspended</td>
<td>19.02.1982</td>
<td>18.04.1982</td>
<td>3144</td>
</tr>
<tr>
<td></td>
<td>Jack Lake 2</td>
<td>abandoned</td>
<td>05.09.1987</td>
<td>08.10.1987</td>
<td>3200</td>
</tr>
<tr>
<td></td>
<td>Jack Lake 3*</td>
<td>suspended</td>
<td>17.11.1999</td>
<td>06.12.1999</td>
<td>3099</td>
</tr>
<tr>
<td>CO2001-B</td>
<td>Lycium 1**</td>
<td>abandoned</td>
<td>22.08.1989</td>
<td>05.09.1989</td>
<td>2250</td>
</tr>
<tr>
<td>CO2001-C</td>
<td>Kujani 1</td>
<td>suspended</td>
<td>29.04.1988</td>
<td>14.05.1988</td>
<td>2124</td>
</tr>
<tr>
<td></td>
<td>Kujani 2</td>
<td>abandoned</td>
<td>08.10.1992</td>
<td>21.10.1992</td>
<td>2180</td>
</tr>
<tr>
<td></td>
<td>Ulandi 4</td>
<td>abandoned</td>
<td>27.10.1991</td>
<td>03.11.1991</td>
<td>1317</td>
</tr>
<tr>
<td>CO2001-E</td>
<td>Limestone Creek 2</td>
<td>suspended</td>
<td>20.08.1984</td>
<td>04.09.1984</td>
<td>1579</td>
</tr>
<tr>
<td></td>
<td>Limestone Creek 7</td>
<td>suspended</td>
<td>24.07.1987</td>
<td>29.07.1987</td>
<td>1304</td>
</tr>
<tr>
<td></td>
<td>Limestone Creek 8</td>
<td>suspended</td>
<td>24.02.1988</td>
<td>04.03.1988</td>
<td>1306</td>
</tr>
<tr>
<td></td>
<td>Narcoonowie 3</td>
<td>suspended</td>
<td>03.08.1984</td>
<td>18.08.1984</td>
<td>1650</td>
</tr>
<tr>
<td></td>
<td>Narcoonowie 4</td>
<td>suspended</td>
<td>10.10.1991</td>
<td>24.10.1991</td>
<td>1659</td>
</tr>
</tbody>
</table>

* confidential
** drilled within block
Registered Native Title claims
Current January 2001
- SC97/003 (Wangkangurru/Yarluyandi People)
- SC97/004 (Edward Landers Dieri People)
- SC98/001 (Yandruwandha/Yawarrawarri People)
- SC99/001 (Adnyamathanha People)

Petroleum tenements
- Acreage release block (Bids close 2nd August 2001)
- Petroleum Exploration Licence Application (PELA)

Cooper Basin - South Australia
NATIVE TITLE CLAIMS

Fig. 10  Native Title Claims, Cooper Basin region
Table 6. Seismic data recorded in Blocks CO2001-A to F (all 2D).

<table>
<thead>
<tr>
<th>Survey</th>
<th>No. of lines</th>
<th>Line km</th>
<th>Survey</th>
<th>No. of lines</th>
<th>Line km</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2001-A (7 surveys, 14 lines, 22 km)</td>
<td></td>
<td></td>
<td>CO2001-B (4 surveys, 9 lines, 21 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67 CP01</td>
<td>1</td>
<td>2.2</td>
<td>68 CP01</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>69 CP04</td>
<td>1</td>
<td>2.9</td>
<td>83 CP21</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>71 CP04</td>
<td>1</td>
<td>1.6</td>
<td>87 CP11</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>76 CP01</td>
<td>2</td>
<td>1.6</td>
<td>88 CP01</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>83 CP31</td>
<td>3</td>
<td>4.7</td>
<td>92 CP09</td>
<td>2</td>
<td>0.7</td>
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<tr>
<td>89 CP01</td>
<td>2</td>
<td>1.5</td>
<td>96 CP01</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>97 CP01</td>
<td>4</td>
<td>7.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2001-C (5 surveys, 7 lines, 4 km)</td>
<td></td>
<td></td>
<td>CO2001-D (7 surveys, 10 lines, 7 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67 CP01</td>
<td>1</td>
<td>0.4</td>
<td>69 CP01</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>76 CP01</td>
<td>1</td>
<td>0.4</td>
<td>82 CP42</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>87 CP11</td>
<td>2</td>
<td>1.8</td>
<td>83 CP21</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>92 CP11</td>
<td>2</td>
<td>0.8</td>
<td>85 CP21</td>
<td>3</td>
<td>3.2</td>
</tr>
<tr>
<td>94 CP21</td>
<td>1</td>
<td>0.7</td>
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Fig. 11 Top V horizon (Patchawarra Formation) time structure map, CO2001-B.
Fig. 12 Seismic section 87-APP (Lycium structure), CO2001-B.
Fig. 13 Top C horizon (Cadna-owie Formation) time structure map, CO2001-D.
Fig. 14 Seismic section 85- XSX (Nungaroo structure), CO2001- D.
APPLICATION PROCEDURES

Required information
An application for an exploration licence ((P)EL) should include the information listed below and be prepared using the pro forma included herein. It must also be accompanied by a plan of the application area and the prescribed fee (currently A$2362 per licence application, but scheduled to be subjected to a consumer price index adjustment on 1 July 2001).

An application can be made by one or more individuals, one or more companies or a combination of both. Where a foreign company makes an application, that company must be registered under the provisions of the Australian Corporations Law. Information on registration requirements can be supplied on request.

Technical qualifications and experience
The applicant must submit with the application a summary of their technical qualifications and experience (or their consultants/agents) 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 resources available to the applicant is to be supplied to demonstrate ability to fulfil the work program. Such evidence can be in the form of the latest annual report or a verifiable statement from an independent accountant, auditor or financial institution for each applicant company. If other known financial and exploration commitments over the next five years are such as to subsequently impact on the applicants ability to carry out the program set out in the application, attention must be drawn to this fact and the implications briefly described.

Cash bid
Applicants should submit a cash bid, which states the value of such a bid, and include payment of a deposit by cheque for 10% of such a bid (made out to Primary Industries and Resources South Australia). This deposit will be refunded to all unsuccessful bidders, but will be retained for the winning bidders. The winning bidder will be required to lodge the remaining 90% of the cash bid immediately prior to grant of the (P)EL (which cannot occur until the right to negotiate process has been concluded with any native title parties).

Work program
It is also a requirement that a work program be submitted, including a statement of exploratory operations the applicant proposes to carry out in the first five-year term. It is most important to note that due to the small size of all CO2001 blocks on offer, the Minister for Minerals and Energy considers that extensive work programs are not justified in order to efficiently and effectively evaluate these blocks. Therefore in selecting the successful bidder, consideration of the applicants’ work program will be limited to seismic and one well in the first five years. For blocks CO2001-B and D it is expected that the well would be guaranteed. This is not the case for the remaining blocks.

Special conditions
The licences will be offered under the Petroleum Act 2000 with the right of renewal for a further five-year term at the end of the initial five-year term, with a non-negotiable relinquishment of 50% at renewal.

Award criteria
Bids will be assessed taking account of the criteria listed below. All these criteria are used when selecting the winning bid. It is important to note that the timing of well drilling may be taken into account. As stated above, proposals to drill more than one well in each block will not be taken into...
account in the bid assessment process. The bidder with the highest cash bid will be successful. The most important criteria for assessment of CO2001 work programs are:

- amount of cash bid
- adequacy of financial resources and technical expertise available to the applicant
- applicant’s past performance in fulfilling work program commitments elsewhere in South Australia
- for blocks CO2001-B and D, whether any proposed well is guaranteed.

The timing of drilling will be taken into account if cash bids are equal. In addition to the above criteria, where bids are similar, the benefits of the introduction of new explorers into the area (including intention with regard to establishing an office in South Australia) may be taken into account.

It should be noted that there are no criteria limiting the number of (P)ELs which may be offered to one applicant providing the applicant has adequate financial resources to complete all programs. In the case of ‘cascading bids’ (i.e. multiple or hybrid bids for an area by one applicant or joint venture) only the highest of the bids will be considered.

**Notification of assessment**

The bid of the successful applicant will be published. Other applicants will be notified of the reasons for their application being unsuccessful.

**Contact information**

Comments, inquiries and applications for exploration licences may be addressed to:

| Director, Petroleum Group | Phone     | National     | (08) 8463 3204 |
| Office of Minerals and Energy Resources | Fax       | National     | (08) 8463 3229 |
| Primary Industries and Resources South Australia | Web site  | www.petroleum.pir.sa.gov.au |
| Level 7, 101 Grenfell Street | Email     | pirsa.petroleum@saugov.sa.gov.au |

The envelope containing your application(s) must be marked ‘CONFIDENTIAL — (P)EL APPLICATION’. Successful bids will be announced in late August 2001.

**The closing date for CO2001-A to F applications is 4.00 p.m. on Thursday 2 August 2001.**
APPLICATION FOR AN EXPLORATION LICENCE

Petroleum Act 2000 (Section 65)

DESCRIPTION OF AREA
Please indicate block(s) under application. Note each block is offered as a separate licence and the application fee is currently A$ 2362* per licence application. Details in support of the application and the application fee of $....................... are attached (see checklist).

* Note that the fee is scheduled to be subjected to a consumer price index adjustment on 1 July 2001. Contact PIRSA for the amended fee prior to submitting your application.

<table>
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<tr>
<th>Block</th>
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<th>Approximate area (km²)</th>
<th>Approximate area (acres)</th>
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<td>CO2001-F</td>
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</table>

PROPOSED WORK PROGRAM

Well (specify whether Year 1, 2, 3, 4 or 5) .....................

Guaranteed well* □ Non-guaranteed well □

Any other work proposed (note this will not be taken into account in selecting the successful bid)

..............................................................................................................................................................................
..............................................................................................................................................................................

Cash bid amount** $………………….. Deposit (10% of cash bid)$…………………..

* Applicable to Blocks CO2001-B and D
** Note 10% of this amount is to be lodged with the application. The remaining 90% to be of the cash bid to be lodged immediately prior to grant of the (P)EL.

..............................................................................................................................................................................
..............................................................................................................................................................................

Signature of applicants(s). Where application is made by a consortium including a company(s), the application must be made under the company(s) seal.

Dated this ...................................... day of ...................................... 2001

Closing date 4.00 p.m. on Thursday 2 August 2001.
Send applications marked ‘Confidential – contains (P)EL application’ to:

Director, Petroleum Group Phone: National (08) 8463 3204
Office of Minerals and Energy Resources International +61 8 8463 3204
Primary Industries and Resources South Australia Fax: National (08) 8463 329
Level 7, 101 Grenfell Street International +61 8 8463 3229
Adelaide SA 5000
AUSTRALIA
APPLICATION CHECKLIST

The following information must be included in the licence application:

- complete the attached pro forma (use of this form is strongly recommended)
- application must be signed or executed by the applicant
- if applicant is a foreign company, the company must be registered as a foreign company under the provisions of the Australian Corporations Law
- include one copy of a plan of the application area
- include a summary of the technical qualifications of the applicant (or consultants/agents of the applicant)
- include evidence of the financial position of the applicant to demonstrate ability to fulfil the proposed work program (i.e. the latest annual report or a verifiable statement from an independent accountant/auditor/financial institution)
- using the pro forma include a statement as to the amount of cash bid plus a cheque for 10% of the amount made out to Primary Industries and Resources South Australia
- using the pro forma include a work program statement of exploratory operations the applicant proposes to carry out in each year of the initial five-year term of the licence
- include the prescribed fee for each licence applied for (currently A$2362, but scheduled to change 1 July 2001), made payable to Primary Industries and Resources South Australia — it is recommended that you check the current fee with PIRSA prior to sending in your application
- ensure the envelope(s) containing your application(s) is marked ‘CONFIDENTIAL – (P)EL APPLICATION’.