Department for Energy and Mining

South Australia
COOPER BASIN
Acreage Release
CO2019 A-E

BIDS CLOSE 4.00 pm ACDT
Friday 29 November 2019

www.energymining.sa.gov.au/petroleum

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

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South Australia
COOPER BASIN

Acreage Release Blocks CO2019 A-E

BIDS CLOSE 4.00 pm Australian Central Daylight Time, Friday 29 November 2019

THE OFFER

The Cooper Basin region is a competitive tender area and vacant acreage must be gazetted and offered for work program bidding. Vacant Cooper Basin acreage arising from recent acreage relinquishments has been divided into five new petroleum exploration licences (PELs) that cover parts of the Warburton, Cooper, Eromanga and Lake Eyre basins which are being offered by the South Australian Government on the basis of work program bidding (Figure 1). The release totals 13,582.3 square kilometres (km^2).

Block	Area (km^2)	Wells	2D Seismic (Line km)	3D Seismic (km^2)
CO2019-A	9892.9	3	2163.7	8.1
CO2019-B	2009.0	2	1147.6	124.9
CO2019-C	545.2	1	1180.8	259.9
CO2019-D	742.3	0	899.6	0.0
CO2019-E	392.9	5	687.0	14.4
	13,582.3	**11**	**6078.8**	**407.3**

Table 1 Summary of blocks and available data.

Eleven petroleum wells have been drilled in the CO2019 acreage release areas (Figure 2). A total of 6078.8 line kilometres of 2D and 407.3 km^2 of 3D seismic data have been acquired within the blocks (Figure 3). The blocks offer a diversity of play types and the opportunity to build a portfolio of prospects and leads across parts of the Warburton, Cooper, Eromanga and Lake Eyre basins.

Should any additional acreage be relinquished within areas in the vicinity of CO2019 Blocks up until four weeks prior to the close of bids, the Department for Energy and Mining's Energy Resource Division (DEM ERD) may include those additional areas within the adjacent block. Any additions to the Blocks will be advertised on DEM ERD's website, and promptly published in the South Australian Government Gazette prior to the close of bidding.

Applicants should also note:

- in the event that additional Parks or Reserves are proclaimed under the *National Parks and Wildlife Act 1972* prior to the grant of a PEL, and where such Parks or Reserves prohibit the exploration for and production of petroleum, then the area of any such Parks or Reserves shall be excised from the area to be granted as a PEL.
- the *Petroleum and Geothermal Energy Act 2000* (PGE Act) requires licence holders to prepare
  - an Environmental Impact Report (EIR) in consultation with all potentially affected people, enterprises and organisations as a precedent to co-regulatory consideration of activity approval. EIRs document potential impacts on the social, natural and economic environments (which includes public health), and outline the extent to which these impacts are likely and manageable;
  - a Statement of Environmental Objectives (SEO), informed by an EIR, that must state the environmental objectives to be achieved in carrying out the specified activities, as well as the assessment criteria and conditions that must be met to ensure the objectives have been achieved by the licensee; and

EROMANGA BASIN SUMMARY

Age	Early Jurassic – Late Cretaceous
Area in South Australia	360,000 km^2 (139,000 square miles)
Depth to target zones	1200–3000 m
Sedimentary thickness	Up to 3000 m
Hydrocarbon shows	Commercial discoveries of oil from almost every unit from the Poolowanna Formation to the base Cadna-owie Formation in the Cooper region; elsewhere shows in the Poolowanna Formation. Gas has been discovered in and produced from the Coorikiana Formation in the Cooper Region.
First commercial discovery	1976 gas (Namur 1) 1978 oil (Strzelecki 3)
Basin type	Intracratonic
Depositional setting	Productive non-marine sequence overlain by non-productive marine, marginal marine, and non-marine sediments.
Conventional reservoir types	Braided and meandering fluvial, shoreface and lacustrine turbidite sandstones.
Regional structure	Broad, four-way dip closed anticlinal trends in regional sag basin.
Seals	Lacustrine – floodplain shales and basin-wide volcanogenic sandstones.
Source rocks	Underlying Cooper Basin coals and siltstone; where mature Birkhead and Murta Formations siltstone and coal.
Onshore Cooper Basin petroleum wells (to December 2018)	704 (mostly in Cooper region)

- in the case of any specific areas which may have unique values or importance, area- and activity-specific EIRs and SEOs can manage local to regional social, natural environment and economic risks. Control zones can be specified to protect areas of unique values and importance. Area- and activity-specific SEOs may incorporate control zone(s) and will be informed with targeted consultation focused on potentially affected people, enterprises, organisations and co-regulators. This will ensure that relevant risks to unique values are managed to an acceptable level through appropriate design, location, construction and operation, including monitoring of any proposed activities.

COOPER BASIN SUMMARY

Age	Late Carboniferous – Middle Triassic
Area in South Australia	35,000 km^2 (13,510 square miles)
Depth to target zones	1250–3670 m
Sedimentary thickness	2500 km
Hydrocarbon shows	Widespread over 8 formations.
First commercial discovery	1963 gas (Gidgealpa 2)
Basin type	Intracratonic
Depositional setting	Non-marine
Conventional reservoir types	Fluvial, deltaic, shoreface sandstones.
Unconventional reservoir types	To be established but possibly shale and low permeability sandstones.
Regional structure	Faulted anticlines.
Seals	Lacustrine shale, coal.
Source rocks	Carbonaceous shale, thick (up to 30 m) coal.
Onshore Cooper Basin petroleum wells (to December 2018)	1846
Geothermal wells (to December 2018)	10

If a proposed activity regulated pursuant to the PGE Act cannot demonstrate compliance with the objectives for the protection of social, natural and economic environments, then approval for the activity will not be granted.

The value of contemporaneous, multiple land-use is a key factor in developing all EIRs and SEOs for upstream petroleum operations anywhere in the State, including the south east of South Australia.

In this regard – as stated above – defined control zones with special conditions to protect pre-existing land use and values are expected be a factor in EIRs and SEOs for regulated activities in the CO2019 areas.

LINKS

- CO2019 acreage release web page
- Information Sheet P1 Holders of petroleum and geothermal tenements in South Australia
- Previous onshore acreage releases
- The petroleum geology of South Australia, Volume 2 Eromanga Basin
- The petroleum geology of South Australia, Volume 4 Cooper Basin

Cooper and Eromanga basins, South Australia

NATIVE TITLE and PETROLEUM TENEMENTS with CO2019 A–E BLOCKS

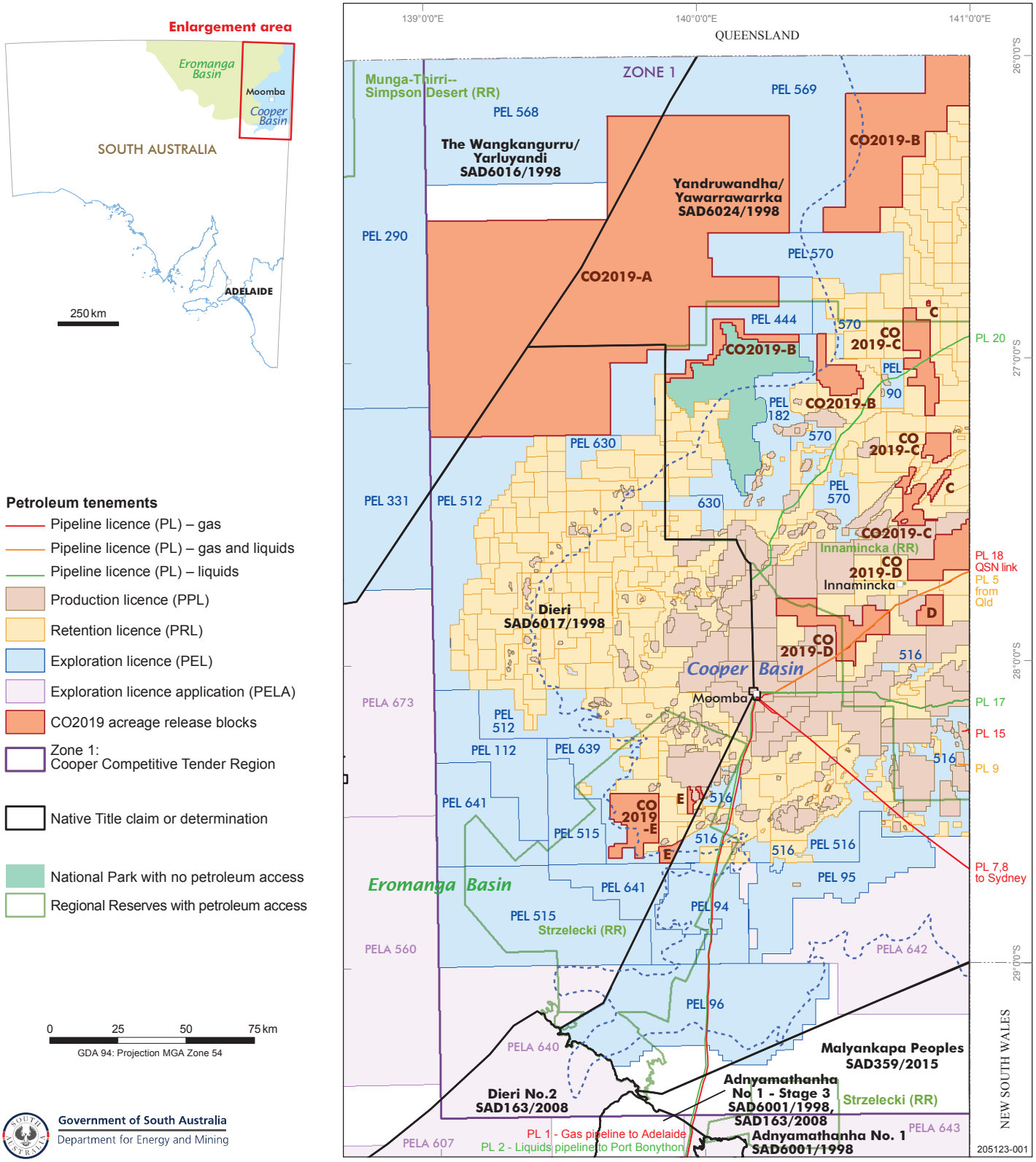

Figure 1 Petroleum licences.

Cooper and Eromanga basins, South Australia

PETROLEUM WELLS AND PROVEN OIL FAIRWAY

Petroleum wells

- Dry hole
- Dry hole with oil shows
- Gas shows
- Gas well
- Gas well with oil shows
- Oil and gas well
- Oil and gas shows
- Oil well
- Proposed or currently drilling

Geothermal wells

- Abandoned well
- Observation well
- Suspended well

Petroleum tenements

- Pipeline licence (PL) – gas
- Pipeline licence (PL) – gas and liquids
- Pipeline licence (PL) – liquids
- Production licence (PPL)
- Retention licence (PRL)
- Exploration licence (PEL)
- Exploration licence application (PELA)
- CO2019 acreage release blocks
- Proven oil fairway
- National Park with no petroleum access
- Regional Reserves with petroleum access

0 25 50 75 km

GDA 94: Projection MGA Zone 54

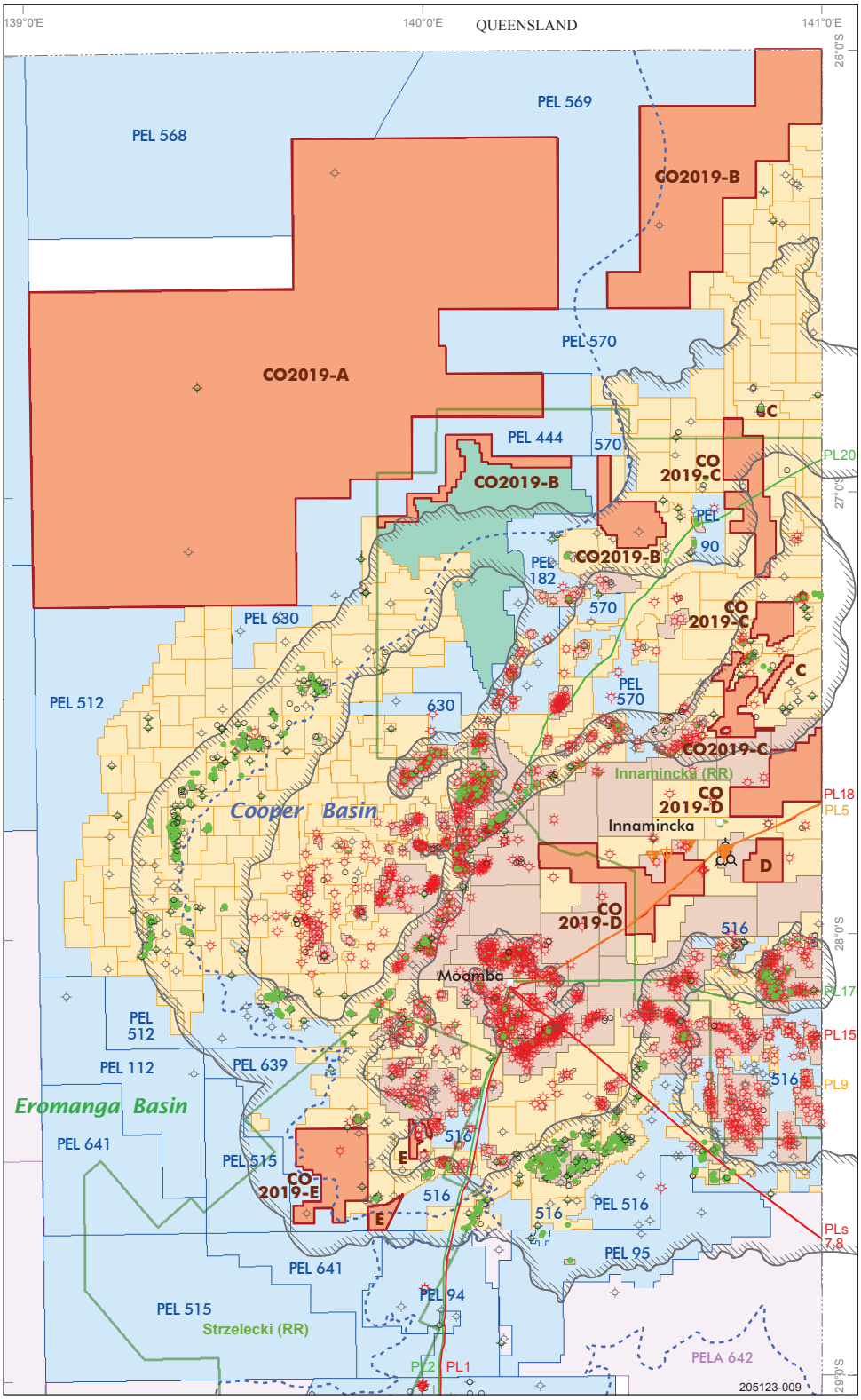

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Figure 2 Petroleum wells.

Cooper and Eromanga basins, South Australia
SEISMIC COVERAGE

Seismic

- 3D seismic survey areas
- Seismic lines

Petroleum tenements

- Pipeline licence (PL) – gas
- Pipeline licence (PL) – gas and liquids
- Pipeline licence (PL) – liquids
- Production licence (PPL)
- Retention licence (PRL)
- Exploration licence (PEL)
- Exploration licence application (PELA)
- CO2019 acreage release blocks

- National Park with no petroleum access
- Regional Reserves with petroleum access

0 25 50 75 km

GDA 94: Projection MGA Zone 54

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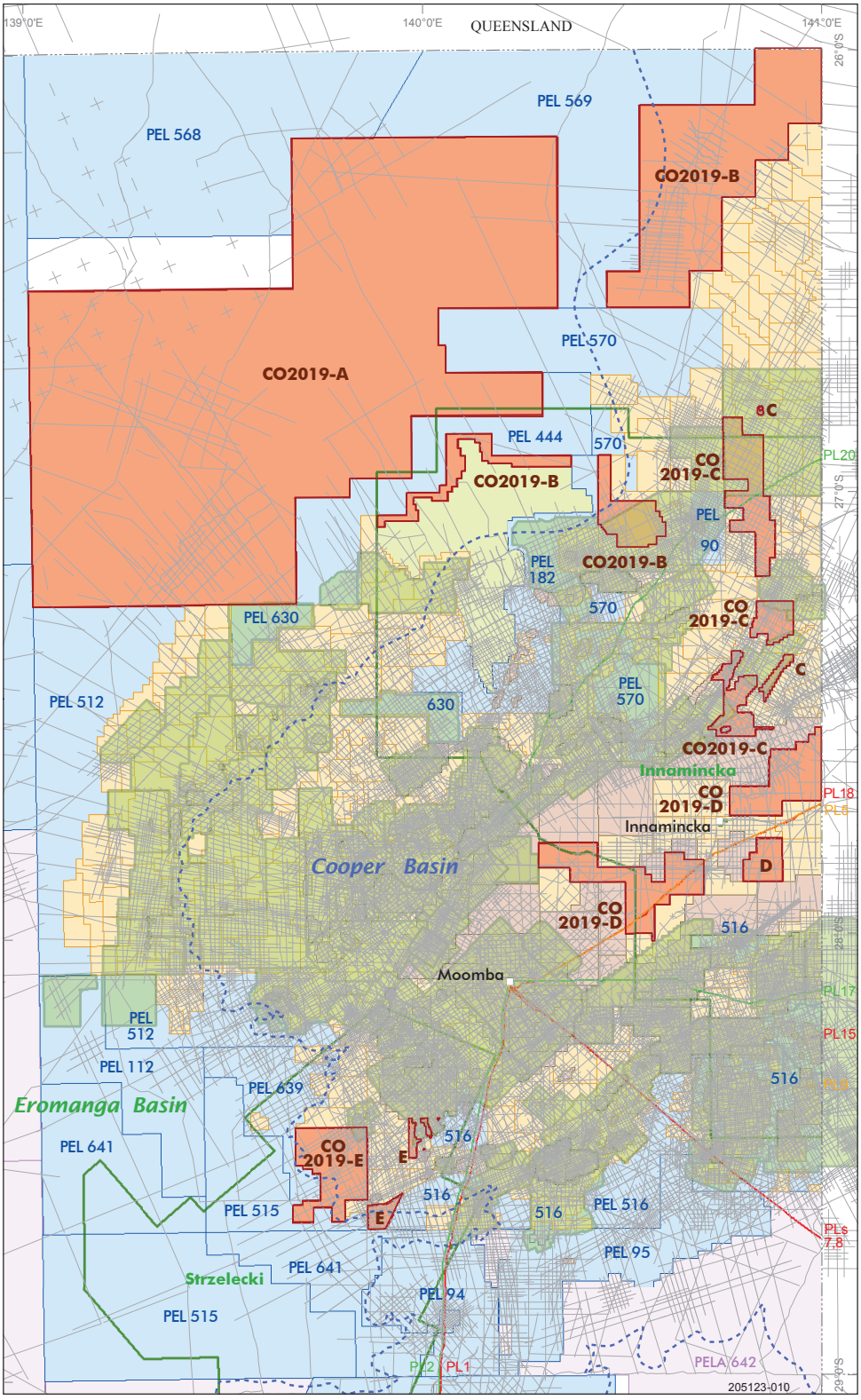


Figure 3 Seismic coverage.

INTRODUCTION

The Cooper Basin is a Permo-Carboniferous to Triassic intracratonic basin located 800 km north of Adelaide, extending into southwest Queensland (Gravestock et al. 1996). It is overlain by the prospective Early Jurassic to Late Cretaceous intracratonic Eromanga Basin which extends of much of central-eastern Australia (Cotton et al. 2006). The Cooper and Eromanga basins collectively contain up to 3700 m of predominantly non-marine fluvial, glaciofluvial, lacustrine and lacustrine deltaic deposits overlain by Early Cretaceous marine deposits and capped by non-marine Late Cretaceous and Cenozoic deposits (Figure 4). Targets in the Cooper and Eromanga basins are 1200–3700 m deep. The Cooper and Eromanga basins unconformably overlie Early Palaeozoic Warburton Basin marine carbonates and clastics – the original exploration target in the 1950s and 1960s. In the Nappamerri Trough, the Cooper Basin succession overlies Mid-Carboniferous Big Lake Suite granite which has been explored as a source of geothermal energy (Wyborn et al. 2004; Wyborn 2008).

The Cooper Basin and overlying Eromanga Basin comprise Australia's largest and most productive onshore hydrocarbon province, supplying major south-eastern Australian gas markets since 1969 and producing oil since 1982. The Cooper Basin Liquids Project (1980–84) was initiated to market the oil and gas liquids. A liquids pipeline links Moomba to a processing plant and storage and export loading facilities at Port Bonython.

Over 2500 exploration and development wells have been drilled and over 76,220 km 2D and 15,970 km^2 3D seismic recorded to end 2018. Estimated total cumulative product sales to end December 2018 are: 5.47 tcf of sales gas, 85.88 mmboe of condensate, 211.09 mmbbl of oil and 86.62 mmboe of LPG. Annual petroleum production and the value of sales since 1970 are shown in Figure 5. Oil production was declining until 2002 when a resurgence of drilling activity, modern 3D seismic data acquisition by new explorers generated new discoveries. Gas sales peaked in 1989 and have been declining since 1998, operators have focussed on developing existing gas fields with infill drilling and exploration of new conventional play trends

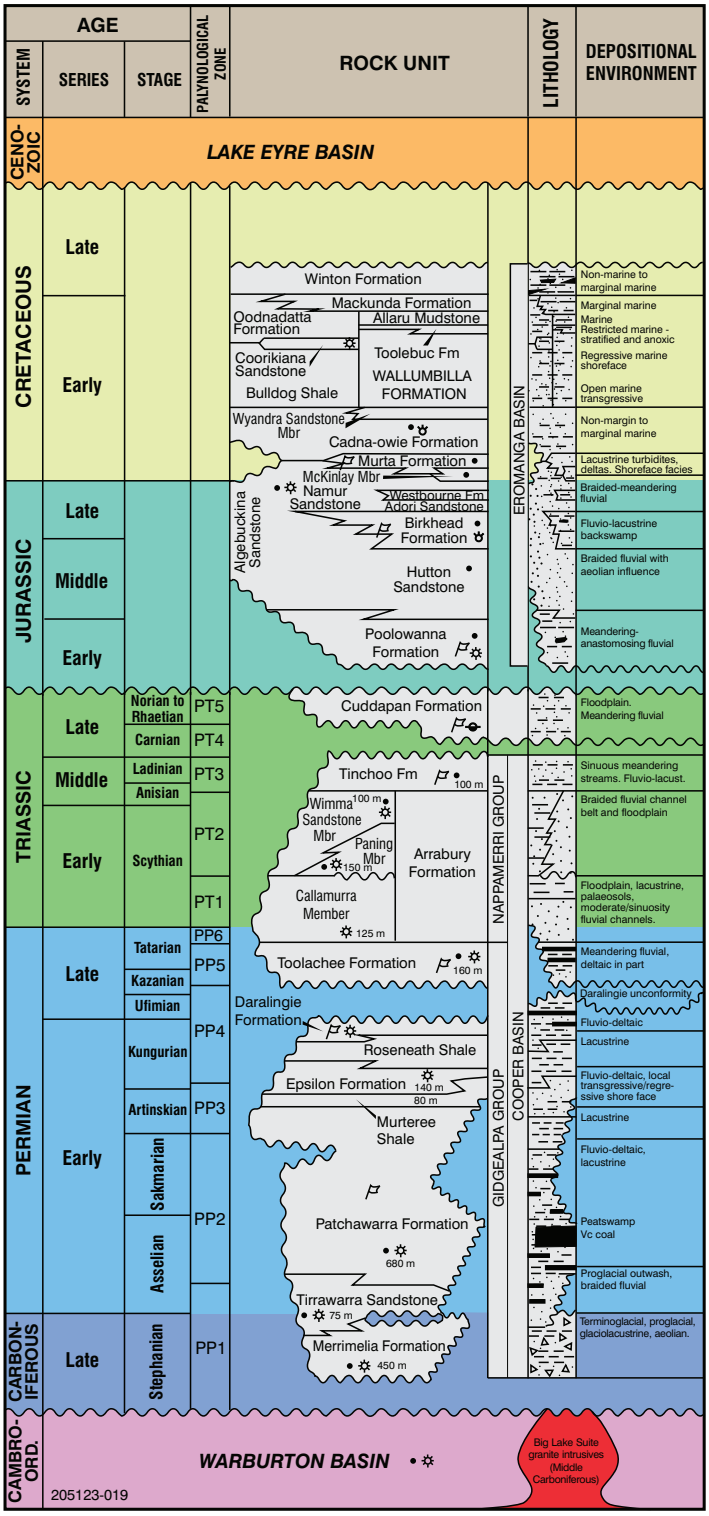


Figure 4 Cooper–Eromanga Basin stratigraphy.

in the Patchawarra Trough and resource plays such as deep coal and tight sandstone reservoirs.

Exploration drilling has produced a steady stream of discoveries since the discovery of gas in 1963 as indicated by the world class exploration success rates (Figure 6a). While drilling hiatuses correlate with oil price crashes (Figure 6b), the steep increases in the oil discovery success rate (Figure 6c) are linked to improved seismic acquisition and processing, more

3D seismic acquisition, testing new play types (e.g. the Jackson discovery in 1981 and the Strzelecki 3 oil discovery in 1978) and also to new companies entering the basin and reinvigorating exploration. The gas discovery success rate curve is rather steady.

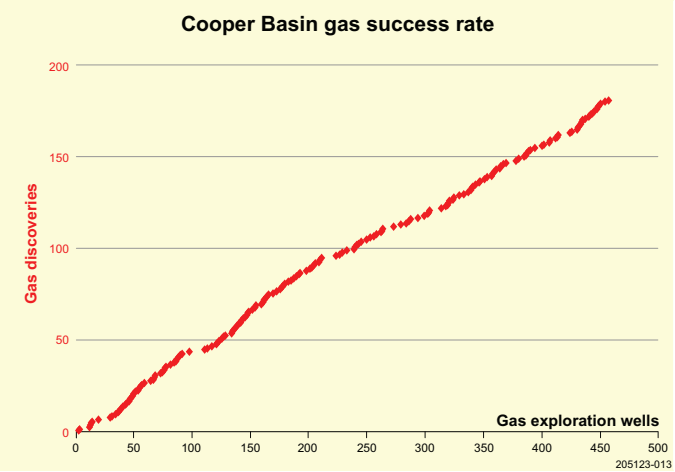
Oil production from the South Australian Cooper and Eromanga basins has increased approximately 12% year-on-year to 20,000 barrels per day over the term 2017 to 2018. Daily gas production from the South Australian Cooper and Eromanga basins remains consistent at approximately 250 tera-joules per day. In 2018, 55% of this gas flowed through the Moomba to Adelaide pipeline and 45% through the Moomba to Sydney pipeline. Furthermore, in 2018 the net flow of gas between South Australia and Queensland was directed towards Moomba.

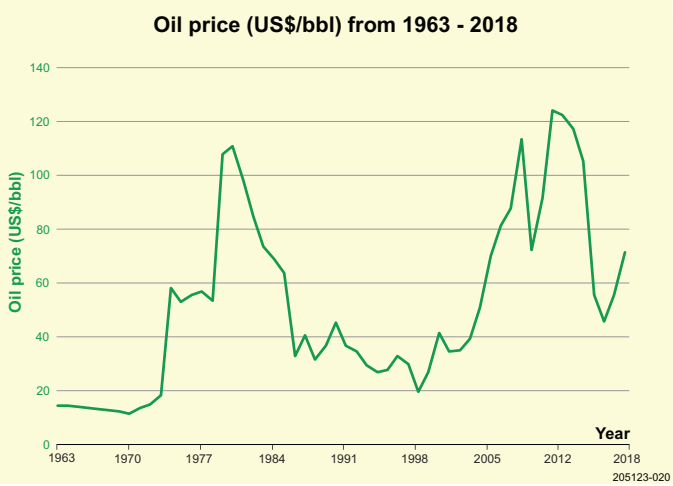
PETROLEUM GEOLOGY

The Cooper Basin unconformably overlies Warburton Basin strata, Carboniferous granitic intrusives and Proterozoic metamorphic basement. The unconformity is mapped as the Z seismic (basement) horizon (Figure 7). The intracratonic Cooper Basin represents a Late Carboniferous to Triassic depositional episode terminated at the end of the Middle Triassic with regional uplift and erosion. Three major troughs (Patchawarra, Nappamerri and Tenappera) are separated by ridges (Gidgealpa–Merrimelia–Innamincka (GMI) and Murteree) associated with the reactivation of NW-directed thrust faults in the underlying Warburton Basin (Figure 7). These troughs contain up to 2500 m of Permo-Carboniferous to Triassic sedimentary fill overlain by as much as 1300 m of Jurassic to Cenozoic strata.

Warburton Basin plays

The Cambro-Ordovician eastern Warburton Basin was the original oil and gas target in northeastern South Australia for Santos Limited in the 1950s. Early exploration drilling discovered economic gas in the overly Cooper Basin and the Warburton Basin came to be considered economic basement for many years. Most wells penetrate less than 40 m into Warburton Basin formations and seismic surveys





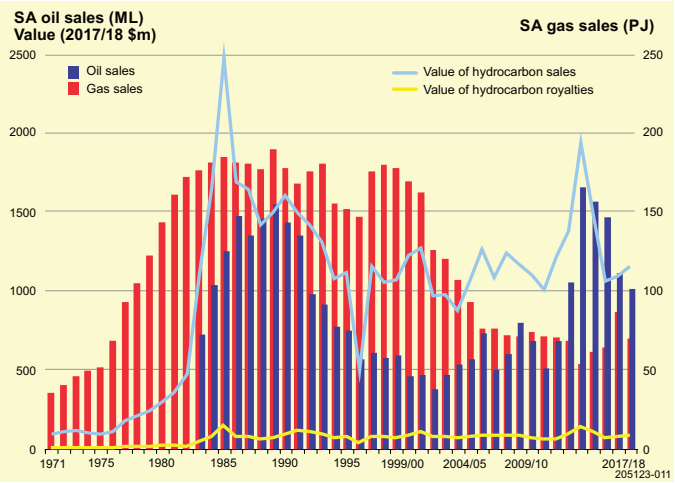


Figure 5 Annual Cooper–Eromanga Basin petroleum production and the value of sales since 1970.

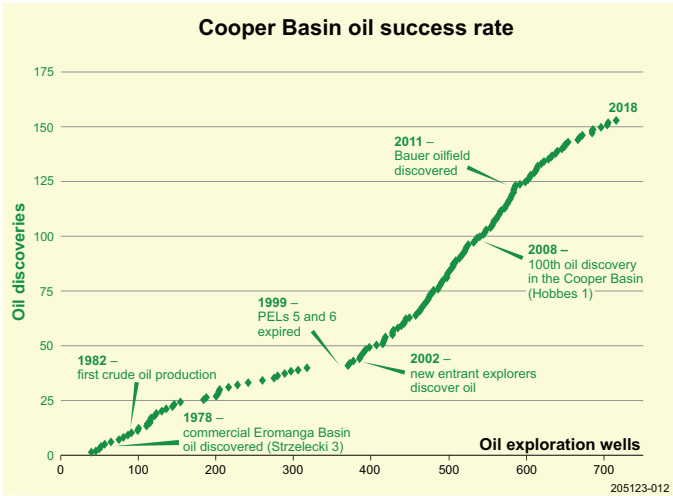


Figure 6 (a) Cooper Basin gas success rate. (b) Oil price (1963–2019). (c) Cooper Basin oil success rate.

focus on acquiring the best data through the Cooper Basin section so it remains lightly explored (Boucher 2001a).

However over 90 wells have recorded shows and economic hydrocarbons have been discovered and produced from fields including gas in Lycosa 1 and Moolalla 1, and oil in Sturt 6 and 7. Most recently, Senex reported in 2018 that results from Gemba 1 are encouraging for a potential new Dullingari Group play (https://www.senexenergy.com.au/wp-content/uploads/2018/12/2018.12.17-Gemba-1-gas-exploration-well.pdf). Hydrocarbons reservoired in Warburton Basin formations are most likely to have migrated from down dip Cooper Basin source rocks, although evidence exists for marine-sourced oil which is most likely Early Palaeozoic in origin.

Warburton Basin deposition commenced in a back arc rifted setting with igneous intrusives and extrusives, volcaniclastics and carbonates of the Early Cambrian Mooracoochie Volcanics. The volcanics are overlain by the Diamond Bog Dolomite, a potential reservoir, then over 1600 m of Kalladeina Formation mixed clastics and carbonates deposited on a shallow marine shelf which was subaerially exposed at times, with potential karst formation. In the mid to late Cambrian, a slope and moderately deep basin are interpreted east of the shelf (Figure 8). Shelfal Lower and Upper Kalladeina Formation and Coongie Limestone Member facies intertongue with over 770 m of deep water slope and basinal shales of the Lycosa Formation (Dullingari Group).

Roberts et al. 1990 focussed on Kalladeina Formation plays including Warburton-sourced oil trapped in ooilitic dolostone, vuggy dolomite and karstic limestone reservoirs. The Coongie Limestone Member has good reservoir properties. Source rocks remain poorly understood. Traps include palaeo-highs on the unconformity surface and structural traps.

The Kalladeina Formation is overlain by shallow marine Pando Formation bioturbated glauconitic sandstone, a proven reservoir, which intertongues with Narcoonowie Formation shelf carbonates and siliciclastics.

The Dullingari Group is overlain by over 1700 m of extensive deltaic deposits of the Early-Middle Ordovician Innamincka Formation red beds. Two basalts have been intersected in the Early Palaeozoic succession, the Jena Basalt and the extrusive Pondrinie Basalt.

An enigmatic 'altered zone' may form a seal to Warburton Basin and lower Cooper Basin reservoirs (Boucher 2001b) , Cooper Basin siltstones and shales above the unconformity may also seal Warburton reservoirs.

The eastern Warburton Basin was deformed along structural corridors such as the GMI Ridge and uplifted during the Carboniferous Alice Springs Orogeny and subsequently buried beneath the Cooper Basin. There is potential for structural traps updip from Permian source rocks, and also migration from Palaeozoic source rocks analogous to the Amadeus Basin, if sufficiently permeable reservoirs can be located.

For more information about the Warburton Basin: http://www.energymining.sa.gov.au/petroleum/prospectivity/warburton_basin

Cooper Basin

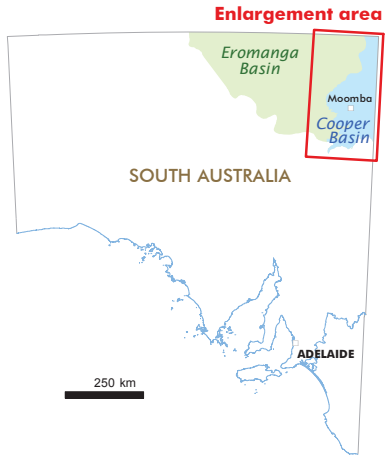
The Late Carboniferous to Late Permian succession consists of basal glaciofluvial clastics and proglacial outwash deposits, overlain by thick coal measures (peat swamp), floodplain, lacustrine and high sinuosity fluvial facies. Uplift and erosion at the end of the Early Permian resulted in a depositional break and Late Permian to Early Triassic fluvial and floodplain facies were deposited on the unconformity surface. Deposition in the region was terminated at the end of the Early Triassic with slight but widespread deformation, regional tilt and erosion. The top of the Permian succession is mapped as the P Seismic Horizon.

Eromanga Basin

The Jurassic–Cretaceous Eromanga Basin can be divided into three sedimentary packages — a lower non-marine package, a marine package, and an upper non-marine package. Exploration is concentrated on the productive lower non-marine sediments, which consist of basal high-sinuosity fluvial and floodplain deposits (Poolowanna Formation), overlain by extensive and thick low-sinuosity fluvial sandstones (Hutton and Namur sandstones). Two floodplain and lacustrine units (Birkhead and Westbourne formations) occur within this low sinuosity sandstone dominated package. The Namur is in turn overlain by extensive lacustrine and shoreface facies (Murta Formation), deposited in a large lake which extended throughout the Cooper Basin region. Eromanga Basin sandstone units are also part of the Great Artesian Basin and are significant aquifers in South Australia and Queensland.

Cooper and Eromanga basins, South Australia

TOP BASEMENT DEPTH IMAGE with STRUCTURAL ELEMENTS



CO2019 acreage release blocks

Zone 1:
Cooper Competitive Tender Region

Cooper Basin permian edge

Cooper Basin subcrop limit

Current tenements not shown

0 25 50 75 km

GDA 94: Projection MGA Zone 54

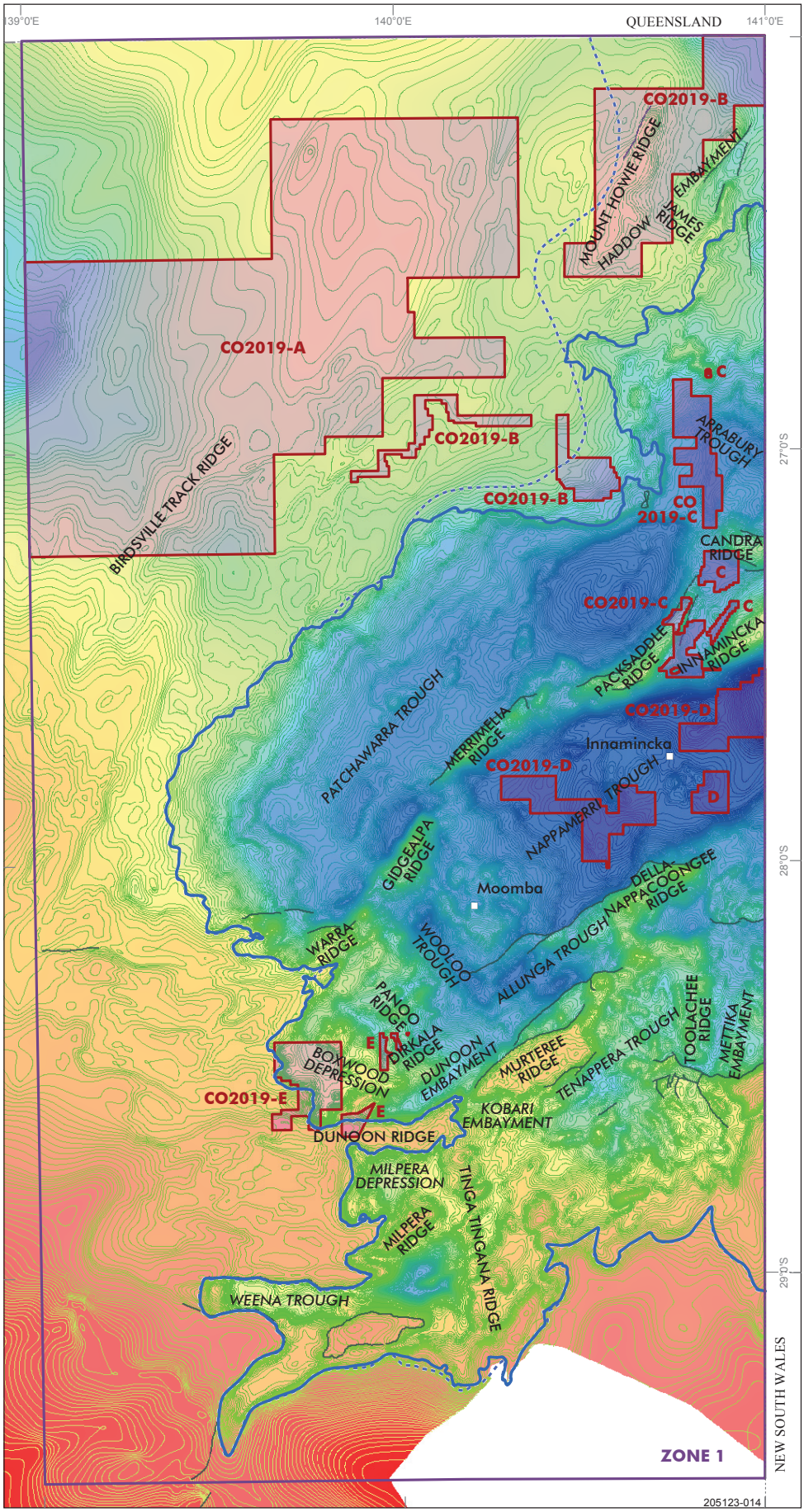


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Figure 7 Top Basement ('z' Horizon) depth structure map with structural elements.

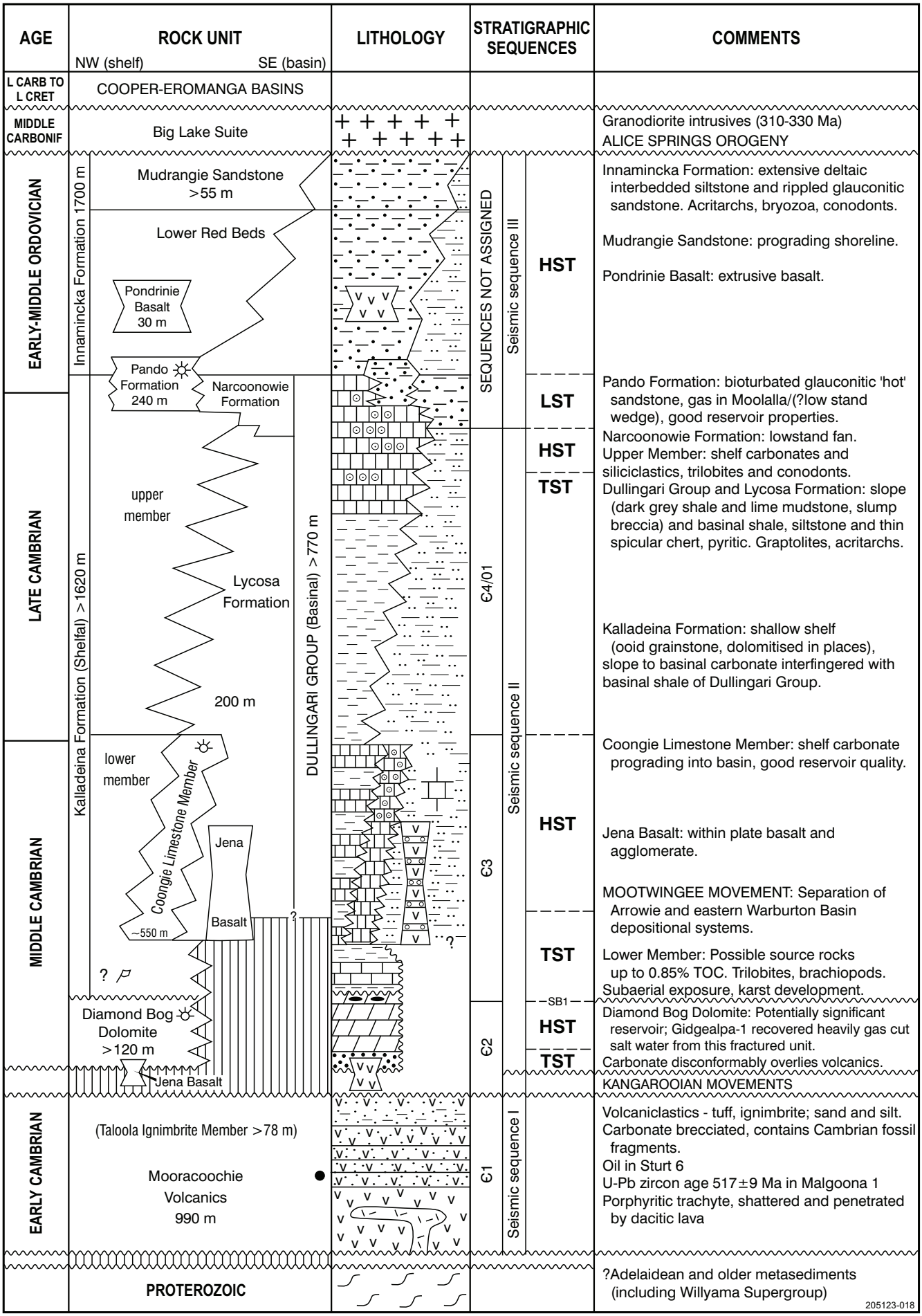


Figure 8 *Warburton Basin stratigraphy.*

The lower non-marine package is overlain by Early Cretaceous marine shales that form a regional seal, and are covered by Late Cretaceous Winton Formation non-marine deposits. The top Cadna-owie Formation (Early Cretaceous) is mapped as the C Seismic Horizon.

Lake Eyre Basin

Cenozoic fluvial to lacustrine deposits of the Lake Eyre Basin unconformably cover the Eromanga Basin. The unconformity at the top of the Eromanga Basin is often difficult to distinguish in wells and seismic. The modern desert, lake and river channel environments are part of the Lake Eyre drainage basin.

SOURCE ROCKS

Cooper Basin

Numerous producing oil and gas fields and significant gas and oil shows in wells in the Cooper Basin region indicate that sufficient mature source rocks are present and have generated hydrocarbons. Permian coal measures and shales have high Total Organic Carbon (TOC) content and represent the main hydrocarbon source for Cooper Basin oil and gas accumulations.

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 over mature and contains mainly dry gas.

Coal and carbonaceous shale of the Patchawarra Formation represent the principal source rocks of the Cooper Basin, both in source richness and quality, and overall thickness (Boreham and Hill 1998). Rock-Eval data indicates that Patchawarra Formation source rocks contain a mix of both Type II and Type III kerogen (Figure 9). Toolachee Formation coal and carbonaceous shale represent the second most important source rock unit of the Cooper Basin in terms of richness, quality and thickness. Rock-Eval data indicates that Toolachee Formation source rocks also contain a mix of both Type II and Type III kerogen (Figure 10). The total gas generative potential of the Cooper Basin source rocks has been estimated to be between 4027 tcf (minimum estimate) to 8055 tcf (maximum estimate) (Morton 1998).

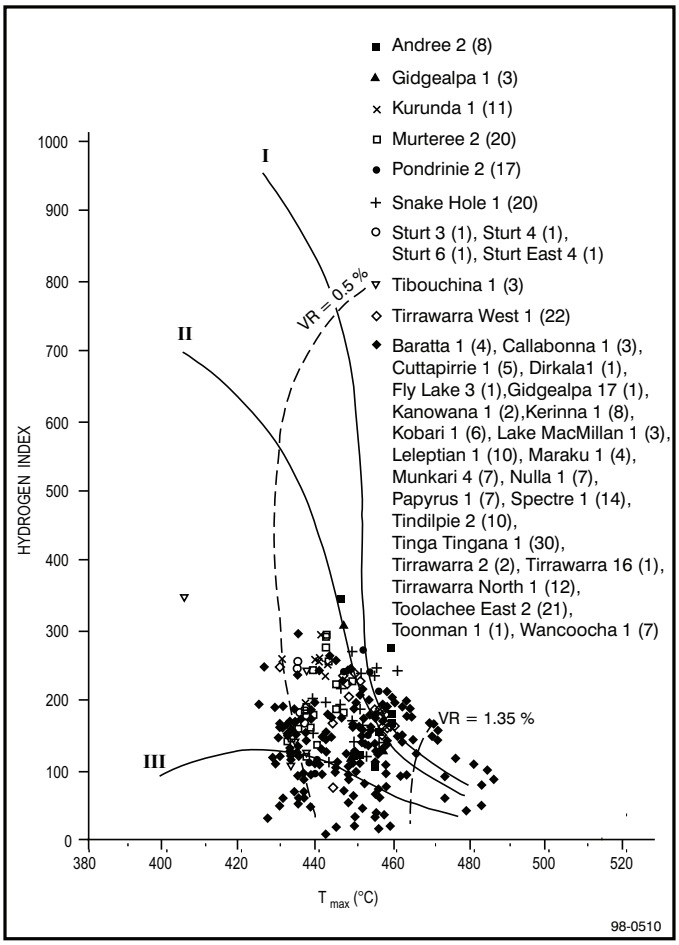


Figure 9 HI vs T_{max} plot, Patchawarra Formation.

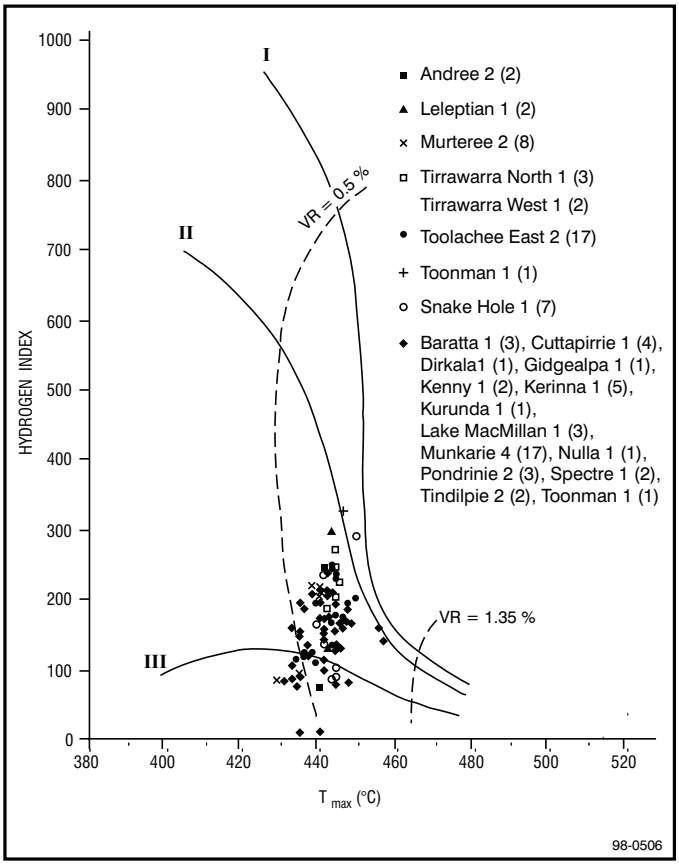


Figure 10 HI vs T_{max} plot, Toolachee Formation.

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.

Eromanga Basin

In the Eromanga Basin, the Poolowanna and Birkhead formations contain organic-rich shales that are oil-prone (Type II/III kerogen) and maturity ranges from 0.5–0.7% Ro. The Murta Formation is interpreted to have potential to generate light paraffinic crude oils, even at maturity levels as low as 0.50–0.55% Ro. It generally contains Type II/III kerogen, however the best Murta source facies contain telalginite and indicators of bacterial precursors occur.

The marine sediment package and upper non-marine sediment package are immature for hydrocarbon generation over much of the basin (<0.45% Ro).

Both Permian and Mesozoic source rocks have contributed to oil accumulations in the Eromanga Basin. Each Eromanga oil accumulation needs to be considered in terms of its access to potential source kitchens to assess the likelihood of Permian and/or Mesozoic sources (McKirdy et al. 2005; Kuske et al. 2015).

RESERVOIRS AND SEALS

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

The Callamurra Member of the Arrabury Formation is regarded as a regional seal, but nevertheless contains economic oil and gas reservoirs in some areas and is a leaky seal in others. Low sinuosity fluvial sandstones of the Paning and Wimma Sandstone members form economic oil and gas reservoirs and high-sinuosity fluvial Tinchoo Formation sandstones reservoir oil. As yet, there have been no economic oil or gas fields discovered in the Cuddapan Formation in South Australia.

Intraformational shale and coal form local seals in the major reservoir units. Beneath the Daralingie unconformity are two important Early Permian regional seals — the lacustrine Roseneath and Murteree shales. The Roseneath Shale is the top seal of the Epsilon Formation, and the Murteree Shale seals the Patchawarra Formation. A younger regional seal is provided by the Triassic Arrabury Formation. The shale gas potential of the Roseneath and Murteree shales was tested in the Nappamerri Trough with around 20 deep gas exploration wells drilled since 2010 by Beach Energy and the Santos JV.

The principal Eromanga Basin sandstone units form good to excellent reservoirs with Hutton and Namur low sinuosity fluvial sandstones recording porosities up to 25% and permeabilities 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 Wyandra Sandstone Member of the Cadna-owie Formation forms a significant oil reservoir in Queensland; however, the only significant accumulation in South Australia occurs in the Aldinga Oil Field. Seals consist of intra-formational diagenetic sandstones, siltstones and shales of the Poolowanna, Birkhead and Murta formations in the Cooper region.

TRAPS

Warburton Basin

The Warburton Basin was the original exploration target in the region in the 1950s but remains under-explored, despite having all the required ingredients of a valid hydrocarbon system: oil and gas shows and flows, reservoir, seal, traps and access to proven mature source rocks via down dip migration pathways from the Eromanga and Cooper basins (Sun and Gravestock 2001). Hallmann et al. (2006)

present evidence for small amounts of migrated Warburton Basin oil in Permian reservoirs.

In 1990, commercial quantities of gas were discovered in Lycosa 1 and Moolalla 1 and oil in Sturt 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. Overlying units such as Merrimelia Formation glaciolacustrine shale would form an effective seal.

Cooper Basin

Anticlinal and faulted anticlinal traps have been relied on as proven exploration targets for decades 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 also reservoired in the Nappamerri Group, paradoxically regarded as a regional seal to the Cooper Basin.

Structural growth during the Permian and Jurassic and differential compaction played an important role in trap formation and fill, as well as strongly affecting reservoir properties. Anticlinal, fault, sub-unconformity truncation, structure–stratigraphic (e.g. channel fairway facies draped on structural nose) and stratigraphic pinchout traps are also proven plays and have been targeted in the western Patchawarra Trough.

Eromanga Basin

Trapping mechanisms within the Eromanga Basin are dominantly structural (anticlines with four-way dip closure or drapes over pre-existing highs) with a stratigraphic component (e.g. Poolowanna Formation, Hutton–Birkhead transition, intra-Birkhead channel sands, McKinlay Member and Murta Formation). Birkhead channels ('hose on a nose') have been successfully targeted using modern 3D data along the western flank of the Cooper Basin. Explorers have achieved 43% success rate with a finding average 2.5 million barrels (mmbbl) recoverable oil. Bauer Oil field is a subtle anticline (pre-drill mean recoverable resource was estimated as 0.5 mmbbl) mapped using 3D data and drilled in 2011. In 2017 there were 26 wells in the field and the original, probable (2P) estimated ultimate recoverable reserve is estimated at 20 mmbbl. (Buick 2016).

Seals consist of intraformational siltstones within the Poolowanna, Birkhead and Murta formations. The Birkhead-Hutton petroleum system is the most productive in the Eromanga Basin.

Stacked oil pay in the McKinlay/Namur, Hutton and Birkhead occurs around the Cooper Basin region. The Eromanga Basin also contains rare gas accumulations, where Permian gas has migrated upwards along faults and been trapped higher in the section (e.g. Namur Gas Field).

EXPLORATION POTENTIAL

The number of oil discoveries in the South Australian part of the Cooper Basin reached 153 at the end of August 2018 (Figure 6c). Extensive areas on the flanks of the Cooper Basin and in the broader Eromanga Basin remain lightly explored with only sparse regional 2D lines and regional scale gravity and aeromagnetic surveys in places.

In the core Cooper Basin region oil and gas exploration has typically focused on four-way dip-closed anticlines. 3D seismic is an extremely useful tool for prospect delineation in the Eromanga Basin where vertical closures can be small, falling within the range of possible errors introduced by statics and lateral velocity variations. There is currently a 43% success rate for oil exploration wells drilled on 3D seismic in the Eromanga Basin. Stratigraphic plays are a proven play concept in Cooper Basin (e.g. the Brownlow Gas Field, Patchawarra Trough), and recent Eromanga Basin discoveries on the western flank of the Cooper Basin have a stratigraphic component.

The Warburton Basin remains underexplored.

Significant potential for gas in unconventional reservoirs remains in the Cooper Basin, in the form of shale gas, tight gas and coal seam gas. The most recent exploration has focused on deep coal targets in the Patchawarra Trough (Santos) and a shallower coal play in the southern Cooper Basin (Strike).

The US Geological Survey (USGS) has estimated that the entire Cooper Basin (South Australia and Queensland) has a risked mean recoverable shale gas resource of 29.8 trillion cubic feet of gas, 482 million barrels of oil and 80 million barrels of natural gas liquids. The USGS report *Assessment of continuous oil and gas resources of the Cooper Basin, Australia, 2016* can be downloaded via the following link https://pubs.usgs.gov/fs/2016/3050/fs20163050.pdf

DATA AND INFORMATION

A comprehensive summary of Cooper and Eromanga basin petroleum systems are available in The Petroleum Geology of South Australia series – Eromanga Basin Volume 2 (2nd edition) and Cooper Basin Volume 4 . These volumes include chapters on structural and tectonic history, litho- and biostratigraphy, source rocks and maturity, reservoirs, seals, trap development, discovered reserves, field reviews, undiscovered potential, and exploration history. These free publications can be downloaded via DEM's website.

Cooper and Eromanga basin data and reports can be downloaded from the ERD website including:

- Basin prospectivity reports – Eromanga Basin, Cooper Basin and Warburton Basin
- Petroleum and Geothermal Energy Act 2000
- Roadmap for Unconventional Gas Projects in South Australia (2012)
- Free Database PEPS South Australia – access to well logs and production data downloads
- A regional selection of Cooper Basin well logs as LAS files

The following reports and datasets can be accessed from a dedicated cloud storage link:

- Selected petroleum seismic 2D reports and 3D reports and data relevant to CO2019 A-E
- Selected petroleum well completion reports relevant to CO2019 A-E
- Selected SEG-Y 2D seismic line data – CO2019 A-E
- GIS shapefile dataset and ESRI ArcGIS project – CO2019 A-E
- Cooper Basin Grids
- Acreage release block tenement map – CO2019 A-E

Cooper Basin Prospectivity Study (Geoscience Australia 2016)
(Includes reports, metadata, presentations and Petroleum systems model that were developed as part of a collaborative study between Geoscience Australia, South Australia and Queensland)
http://www.ga.gov.au/about/projects/energy/onshore-energy-systems/cooper-basin-prospectivity-study

INFRASTRUCTURE AND TRANSPORT

Oil and gas production

A network of flowlines transports gas from individual wells to field gathering systems and then onwards to satellite stations that separate gas, water and condensate. Evaporation ponds are used for water disposal, with the gas and condensate reaching Santos' Moomba Gas Plant via trunklines. Crude oil is transported to the Moomba plant by pipeline or truck for processing and export. There are approximately 2000 producing oil and gas wells within the South Australian Cooper Basin.

Beach Energy and Senex Energy have an agreement for third-party gas and liquids to be processed at Moomba.

Processing and export

The Moomba Gas Plant and pipeline infrastructure is critical for processing and transporting gas to markets on Australia's east coast and is supported by substantial underground gas storage facilities. Raw gas and ethane are processed at the Moomba Gas Plant. Sales gas are exported to domestic (South Australia, Queensland, New South Wales) gas markets and is also available to the LNG plants in Queensland for export internationally. Ethane is exported to NSW via the Moomba to Sydney Ethane pipeline.

Natural gas liquids recovered at the Moomba plant are sent, together with stabilised crude oil and condensate, via a 659 km pipeline to Port Bonython for further processing. Products including naphtha, crude oil, propane and butane are available to domestic customers via the road tanker loading facilities and export customers via ship loading facilities.

Facilities

The township of Innamincka is located 65 km northeast of Moomba. It offers a hotel, general store, light-aircraft airstrip and is accessible by good quality roads.

Accommodation and support facilities are located at the Moomba Production Facility, operated by the Cooper Basin Joint Venture. Access is by arrangement with the operator (facilities are not open to the public). The full range of support services are located at the Moomba camp including

wireline logging, fracture stimulation, cementing, transport, fuel supply, aviation (sealed airstrip) and emergency services.

LAND USE AND ACCESS

Regulatory framework

In April 2016, the Australian Competition and Consumer Commission (ACCC) inquiry into Australia's east coast gas supply (http://www.accc.gov.au/regulated-infrastructure/energy/east-coast-gas-inquiry-2015) concluded that government(s) should consider adopting regulatory regimes to manage the risks of individual gas supply projects on a case by case basis rather than using blanket moratoria. South Australia's framework is recognised as efficiently and effectively deploying leading practices in this regard:

- The grant of a *Petroleum and Geothermal Energy Act 2000* (PGE Act) licence provides a unique entitlement to progress relevant petroleum, geothermal and gas storage projects and operations.
- Gaining approval for on-ground activities is a separate (case-by-case) step that follows the grant of a PGE Act licence. South Australia's regulatory framework involves robust stakeholder consultation, ensuring that the concerns of potentially affected people, enterprises and organisations are taken into account when decisions are made to approve (or otherwise) on-ground activities regulated under the PGE Act.
- Approval for on-ground operations will be only be gained (if gained) after South Australia's regulators are satisfied that:
  - All risks that will adversely affect other users of the land will be avoided; and
  - All concerns from potentially affected people (including land owners, enterprises, cultural heritage and native title groups, community groups, and other government departments) have been adequately addressed.
- In order for a licensee to undertake operations in accordance with the PGE Act, an Environmental Impact Report (EIR) must be prepared by the licensee in consultation with all potentially affected people, enterprises and organisations. This document addresses the potential impacts on the social, natural and economic environments (which includes public health and impacts on brands), and outlines the extent to which these impacts are likely and manageable.
- On the basis of the information provided in the EIR and in accordance with Section 98 of the PGE Act, the EIR is reviewed by experienced professionals in (DEM ERD) in consultation with other relevant co-regulatory agencies not limited to: the Department for Environment and Water; the Environment Protection Authority; Health SA; Department of Planning, Transport and Infrastructure; Safework SA and Primary Industries and Regions – South Australia. The consultation process with co-regulatory agencies results in the classification of the level of impact (low, medium or high) of the proposed activity using a set of publicly developed and disclosed criteria[1]. A Statement of Environmental Objectives (SEO) must then be prepared:
  a) For low impact to medium impact activities
  b) on the basis of an EIR; or
  c) For high impact activities – on the basis of an environmental impact assessment under Part 8 of the *Development Act 1993*.
- The SEO must state the environmental objectives to be achieved in carrying out specified activities, as well as the assessment criteria used to assess whether the objectives have been achieved by the licensee.
- The EIR/SEO must demonstrate how potential negative impacts are prevented through appropriate design, construction and modelling and importantly how this will be measured and monitored. The approval of an EIR/SEO must be in accordance with consultation requirements under Section 101 to 103 of the PGE Act. If a petroleum project cannot demonstrate compliance with these regulatory requirements, then approval for the project will not be granted. This holds true for all projects regulated under the PGE Act.

1 *The Criteria for Classifying the Level of Environmental Impact of Regulated Activities* (PDF 232KB) https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGRG004.pdf

- In addition to the requirements of the PGE Act, SEOs refer to requirements of co-regulation (for example for the protection of water) of other Acts. In this way, non-compliance with relevant co-regulation becomes a non-compliance under the PGE Act. In short – the SEO is a co-regulatory instrument that allows South Australia to be efficient and effective, without duplicative processes to assess and regulate land access for all proposed petroleum, geothermal energy and gas storage exploration, development and production projects.

The successful bidder will be required to meet South Australia's best practice environmental requirements before being approved to conduct exploration activity on the block.

DEM ERD acts as a one-window to government for explorers in obtaining necessary environmental approvals on the occasions when they are required from co-regulators in other government agencies. Approvals to conduct field operations etc. are first submitted to DEM, which arranges distribution to the other relevant government agencies for comment. DEM ERD personnel are available to assist licensees prepare the necessary paperwork. Only after the robust approvals process described above does the Minister for Energy and Mining issue necessary approvals (or otherwise).

The steps involved in the exploration, retention, production and associated activities approval processes are detailed in the flow-chart or visit the DEM website referring page.

http://www.energymining.sa.gov.au/petroleum/legislation_and_compliance/activity_approvals_process

An objective based co-regulatory approach applies in South Australia for the regulation of the upstream petroleum industry to reduce compliance costs and deliver better environmental outcomes.

The following EIR and SEOs exist for area-specific and location-specific upstream petroleum and geothermal operations in the Cooper Basin:

DSD 2014, Geophysical Operations in the Cooper Basin, South Australia - Environmental Impact Report. PGER 00049.

DSD 2014, Geophysical Operations in the Cooper Basin, South Australia - Statement of Environmental Objectives. PGER 00050.

Senex Energy 2013, Geophysical Operations in PEL 182 Cooper Basin, South Australia - Environmental Impact Report. PGER 00055.

Senex Energy 2013, Geophysical Operations in PEL 182 Cooper Basin, SA - Statement of Environmental Objectives. PGER 00056.

KJM 2013, Logistics Support Hub Cooper Basin - Environmental Impact Report. PGER 00110.

KJM 2013, Logistics Support Hub Cooper Basin - Statement of Environmental Objectives. PGER 00111.

DMITRE 2013, Preliminary Exploration and Survey Activities (Ground Based Geophysical (Non-Seismic), Pipeline Preliminary Survey and other Low-Impact Survey Activities) - Environmental Impact Report. PGER 00113.

DMITRE 2013, Preliminary Exploration and Survey Activities (Ground Based Geophysical (Non-Seismic), Pipeline Preliminary Survey and other Low-Impact Survey Activities) - Statement of Environmental Objectives. PGER 00114.

Santos 2015, South Australian Cooper Basin Drilling, Completions and Well Operations - Environmental Impact Report. PGER 00245.

Santos 2015, South Australian Cooper Basin Drilling, Completions and Well Operations - Statement of Environmental Objectives. PGER 00246.

APA Group 2015, PL 07 and 08 Moomba to Sydney Gas Pipeline and Moomba to Sydney Ethane Pipeline - Environmental Impact Report. PGER 00248.

APA Group 2015, PL 07 and 08 Moomba to Sydney Gas Pipeline and Moomba to Sydney Ethane Pipeline - Statement of Environmental Objectives. PGER 00249.

Epic Energy 2016, PL 1 & 12 Moomba to Adelaide Pipeline System & Beverly Lateral Pipeline - Environmental Impact Report. PGER 00254.

Epic Energy 2016, PL 1 & 12 Moomba to Adelaide Pipeline System & Beverly Lateral Pipeline - Statement of Environmental Objectives. PGER 00255.

Senex Energy 2016, PEL 182 Controlled Access Zone Drilling, Completions and Well Operations - Statement of Environmental Objectives. PGER 00260.

Senex Energy 2016, PEL 182 Controlled Access Zone Drilling, Completions and Well Operations - Environmental Impact Report. PGER 00261.

DSD 2016, Airborne Preliminary Surveys and Geophysical Operations - Environmental Impact Report. PGER 00266.

DSD 2016, Airborne Preliminary Surveys and Geophysical Operations - Statement of Environmental Objectives. PGER 00267.

Santos 2017, PL 2 Moomba to Port Bonython Liquids Pipeline - Environmental Impact Report. PGER 00275.

Santos 2017, PL 2 Moomba to Port Bonython Liquids Pipeline - Statement of Environmental Objectives. PGER 00276.

Santos 2018, Geophysical Operations in the Cooper Basin and Arid Regions within SA - Environmental Impact Report. PGER 00287.

Santos 2018, Geophysical Operations in the Cooper Basin and Arid Regions within SA - Statement of Environmental Objectives. PGER 00288.

Control zones can be specified in SEOs to protect unique values and importance. The appropriateness of defined upstream petroleum operations within control zones will be informed with targeted consultation focused on potentially affected people, enterprises, organisations and co-regulators. This will ensure that relevant risks to unique values are managed to an acceptable level through appropriate design, location, construction and operation, including monitoring of any proposed activities.

The Department is implementing an updated and risk based approach to financial security bond arrangements. The risk based approach to managing liabilities will use a range of regulatory tools in a principled and consistent way to ensure an appropriate security bond is held. Prospective licence holders will have their financial and operational capabilities assessed and the level of financial security will be set as a proportion of the total rehabilitation liability estimate of the proposed work program.

National parks and reserves

Parts of the Cooper Creek system are listed as wetlands of international significance under the Ramsar Convention (1971), the Ramsar area and release blocks are shown on Figure 11. South Australia's obligations are to manage the wetlands wisely to maintain their ecological character; this does not necessarily restrict exploration access.

The Strzelecki and Innamincka Regional Reserves are located in the core of Australia's arid region and overlie the Cooper Basin as well as some of the CO2019 release blocks (Figure 11). Regional Reserve is a reserve classification under the *National Parks and Wildlife Act 1972* that specifically accommodates multiple land use. A PEL application incorporating any portion of these Regional Reserves will be referred to the Minister for Environment and Water and their views must be taken into account when granting the PEL. In the case of Petroleum Production Licences within the Strzelecki and Innamincka Regional Reserves, approval must be obtained from the Minister for Environment and Water. Failing such Minister's approval, the issue is referred to the Governor for decision.

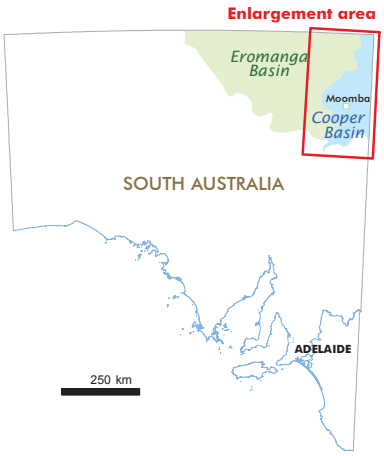
Land access agreements

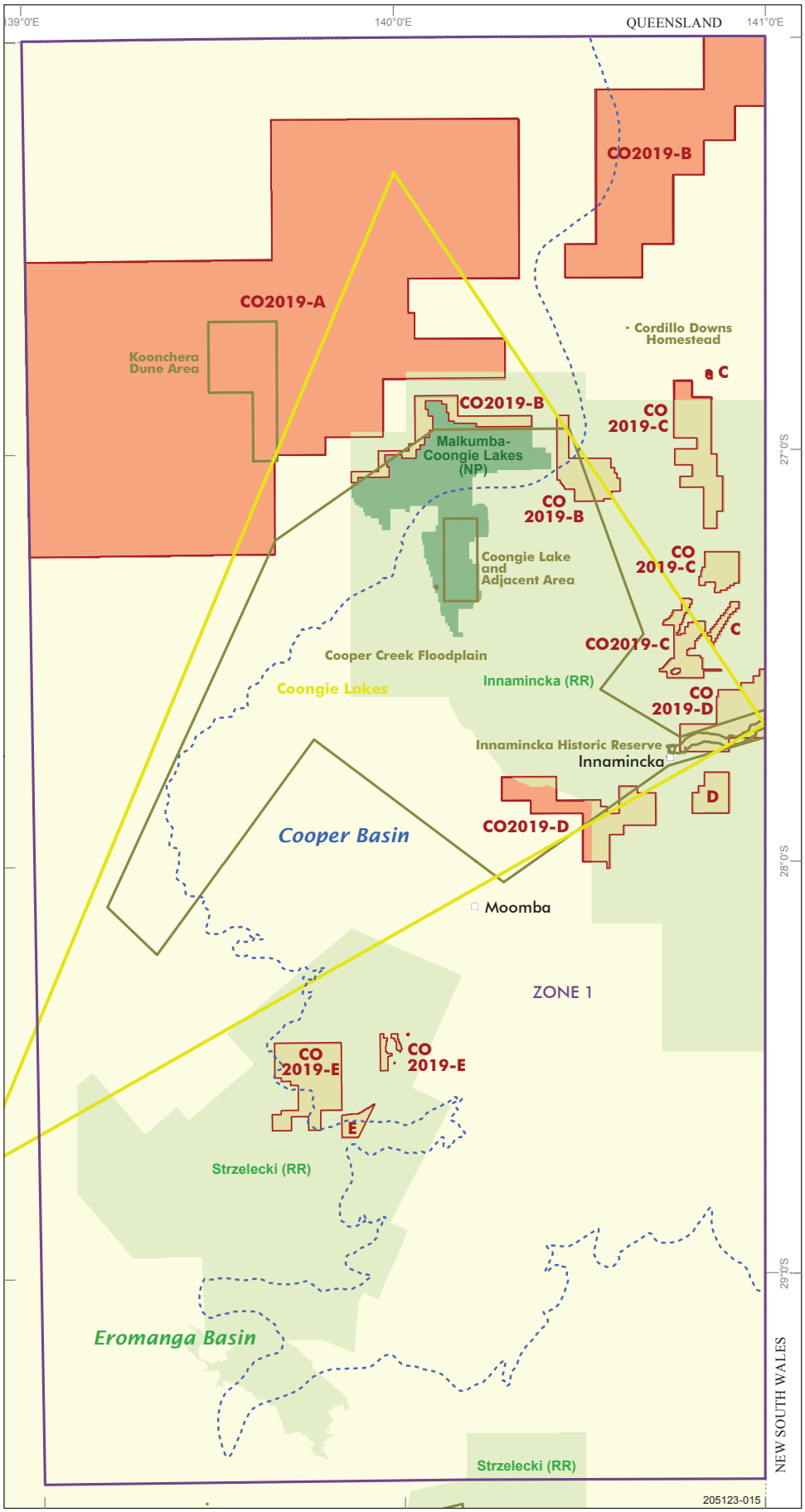
A PEL cannot be granted in the Cooper Basin unless an appropriate land access agreement is in place with the recognised native title parties (Figure 12), the State Government and the explorer. Indigenous Land Use Agreements (ILUAs) are an alternative to the right-to-negotiate (RTN) process pursuant to the Commonwealth *Native Title Act 1993* and now cover most of the Cooper Basin. All South Australian land access agreements cover the full cycle of petroleum activities including exploration, development and production.

Conjunctive ILUAs are being used to expedite land access with lower transaction costs than RTN proceedings. The negotiations for an ILUA for the South Australian Cooper Basin region (already covered with RTN land access agreements) commenced in 2006, and in February 2007 the Yandruwandha/Yawarrawarrka peoples entered into the first petroleum ILUA. This agreement was the first conjunctive petroleum ILUA in a producing basin in Australia. Negotiations for additional ILUAs have progressed with the two relevant native title parties over the remainder of the Cooper Basin, with the Wangkangurru/Yarluyandi peoples petroleum ILUA achieving formal registration in March 2012. The State Government intends to propose enhancements to the existing Yandruwandha/Yawarrawarrka ILUA to match any significant enhancements agreed with the other two relevant native title parties in the Cooper Basin region. Establishing essentially common terms for all three ILUAs will be fair, efficient, and foster sustainable

Cooper and Eromanga basins, South Australia

REGIONAL RESERVES and ENVIRONMENTAL ZONES





Parks and reserves

- Park or reserve – petroleum exploration access
- Park or reserve – no petroleum exploration access

Environmental areas

- National Estate Register
- Ramsar site

- CO2019 acreage release blocks
- Zone 1: Cooper Competitive Tender Region

Current tenements not shown

0 25 50 75 km

GDA 94: Projection MGA Zone 54

Government of South Australia
Department for Energy and Mining

Figure 11 Regional reserves and environmental zones.

Cooper and Eromanga basins, South Australia

INDIGENOUS LAND USE AGREEMENTS with NATIVE TITLE DETERMINATIONS and CLAIM

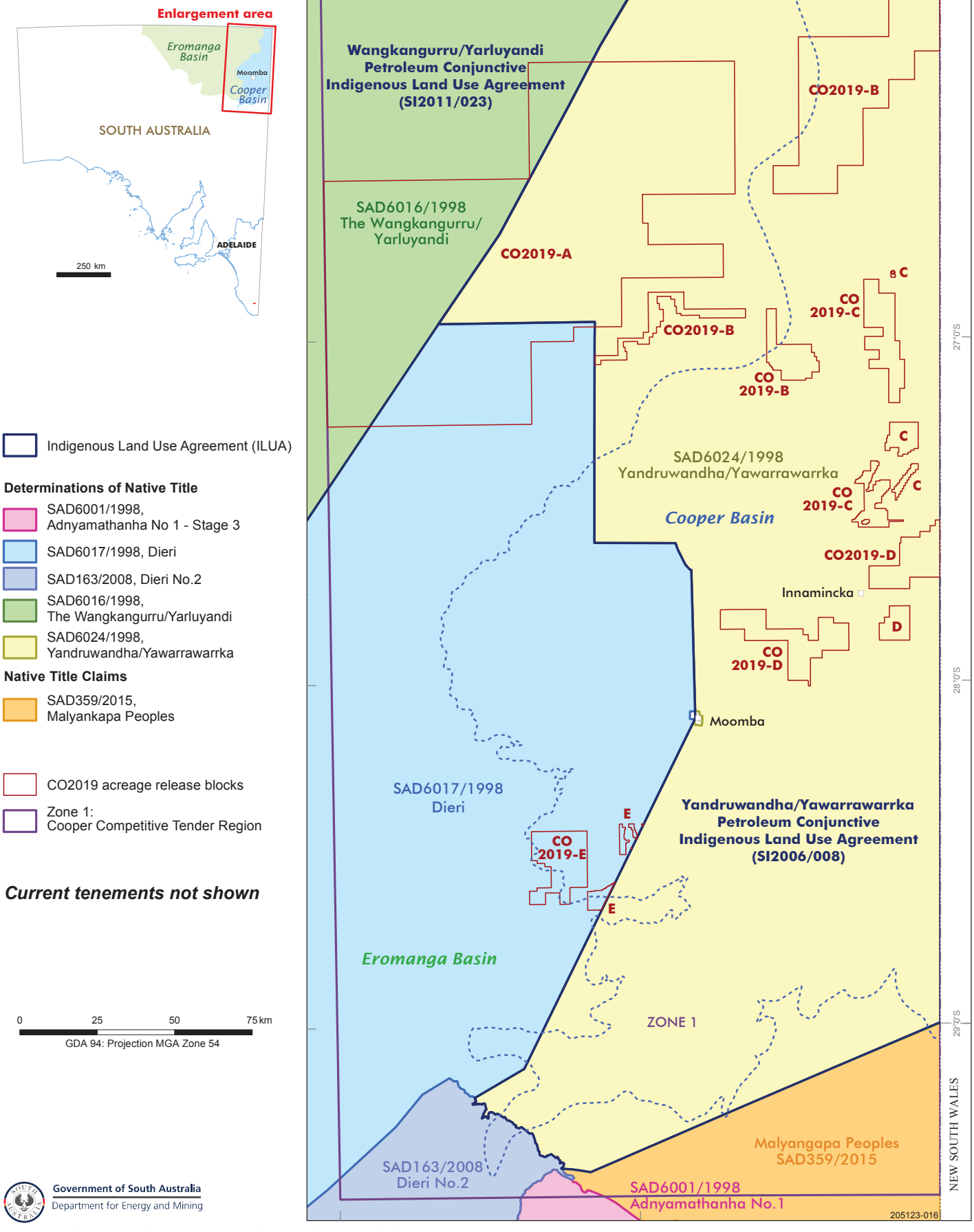


Figure 12 Indigenous Land Use Agreement and registered Native Title claimants.

development for the whole of the Cooper Basin and most of the Eromanga Basin in South Australia.

The RTN, ILUA and legislation-specific processes will continue to be developed with a desire to enable the expeditious grant of new PELs in ways that remain fair to traditional owners and sustainable in relation to exploration and production investment. The native title land access agreements for all South Australian petroleum exploration licences subject to the right-to-negotiate or ILUA process pursuant to the Commonwealth *Native Title Act 1993* are available for public inspection on the Department for Energy and Mining website.

For further details on the right-to-negotiate or ILUA process, please contact Shane Farrelly, General Manager, Licensing and Legislation, email shane.farrelly@sa.gov.au, or phone (08) 8429 2443.

A number of sites of European heritage significance such as historical buildings, structures and geological monuments may also occur in the area. The majority of these sites are small and easily avoided by exploration activities.

Geothermal licences

A number of Geothermal Exploration Licence Applications (GELAs) and Geothermal Retention Licence 3 (over the Habanero geothermal exploration wells) coincide with petroleum licences (Figure 13). The GEL licensee must be notified of activities in PELs, and may object to the activity and claim compensation if their activities or resources are affected. Likewise the GEL holder must notify the PEL holder of their activities, and the PEL holder may also object and claim compensation.

CLIMATE

Australia's seasons are opposite to those of the northern hemisphere – the hottest months are January and February, and the coldest month is July. The Cooper Basin is located in the core of Australia's arid region. Moomba temperatures can range as high as 48 °C (118 °F) in summer, while overnight temperatures can drop to 2 °C (36 °F) in winter. The average annual rainfall in far northern South Australia is 176 mm (7 in), with the heaviest rainfall during December–February.

The northern part of South Australia is sparsely populated and relatively undeveloped due to its remoteness and harsh climate. The main industries are petroleum exploration and development, followed by large pastoral leases producing cattle and tourism.

BIDDING AND AWARD PROCESS

Winning bidders will be selected on the basis of the total five-year work program bid. The work program must be completed within the overall area of the PEL. It must include a statement of exploration operations the applicant proposes to carry out in the first five-year licence term. It is expected that at least one petroleum exploration well would be included in the program.

Bids will be assessed using the philosophies expressed in *Selecting the winning bid*. For a review of how this process has been applied see *Shaping the Cooper Basin 21st century renaissance*. The specific scoring scheme is detailed in *CO2019 Bid Assessment Policy*.

Relevant CO2019 Application and Award procedures and forms can be accessed at the following links:

CO2019-A to E PEL Application forms

Application and Award Procedures and Forms
CO2019-A to E Acreage Release

In general, it is important to note that the timing of well drilling and seismic or other data acquisition will be taken into account. Key assessment criteria include:

- The number of exploration wells to be drilled in the PEL, their nature of subsurface targets to be drilled and their timing *(appraisal and development wells are not considered)*.
- The number of years the applicant is prepared to guarantee the program. **Non-guaranteed years cannot be followed by later guaranteed years.**
- The extent to which proposed wells are supported by existing or newly programmed seismic data.
- For frontier blocks where only sparse circa 1950–60 regional 2D lines exist, other data acquisition including aerogravity and aeromagnetic surveys may prove useful to better locate 2D (or 3D) seismic surveys. In core blocks, 3D seismic has been linked to increased exploration success.
- The amount and nature of seismic surveying (i.e. 2D versus 3D) to be carried out and its timing.
- Seismic reprocessing, especially for core blocks with existing adequate 3D seismic coverage.

Cooper and Eromanga basins, South Australia

GEOTHERMAL LICENCES

Geothermal wells

- Abandoned well
- Suspended well

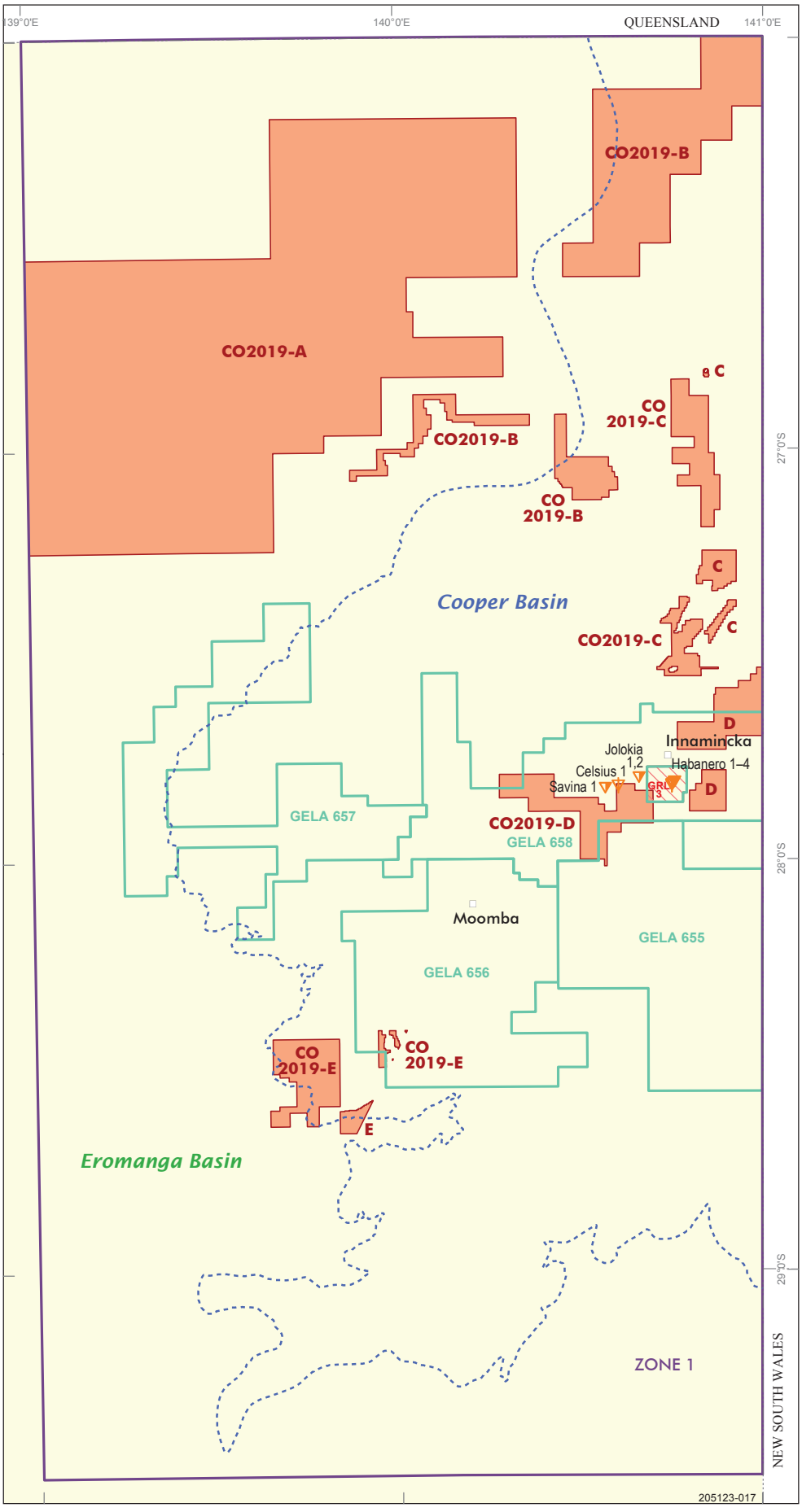
Geothermal tenements

- Exploration licence application (GELA)
- Retention licence (GRL)

- CO2019 acreage release blocks
- Zone 1: Cooper Competitive Tender Region

0 25 50 75 km

GDA 94: Projection MGA Zone 54



Government of South Australia
Department for Energy and Mining

Figure 13 Geothermal licences.

- The adequacy of the applicant's financial resources and technical expertise to satisfactorily undertake the proposed work program and overall regulatory compliance.

On the latter point, checks on the financial status of the highest ranking applicants are undertaken, with the applicants being classified as 'adequate', 'marginal', or 'inadequate'. The financial assessment includes both other licence commitments in South Australia (or if more than one block is to be offered to an applicant, the commitments in all blocks) and the previous performance in meeting work program commitments (including a new company with a Director of a previously poor performing company). If the applicant is classified as 'inadequate', the application may be refused.

In addition to the above criteria, where bids are similar, the benefits of the introduction of new explorers into the area may be taken into account. In the case of cascading bids (i.e. multiple or hybrid bids by one applicant or joint venture), only the highest bid will be considered.

Refer to the section describing South Australia's regulatory framework to gain an appreciation of the activity approvals process that follows the grant of a petroleum licence pursuant to the *Petroleum and Geothermal Energy Act 2000*.

Closing date and time

The closing date for CO2019 A-E applications is **4.00 pm Australian Central Daylight Time on Friday 29 November 2019**.

APPLICATIONS FOR EXPLORATION

Executive Director, Energy Resources Division
Department for Energy and Mining
Level 4, 11 Waymouth Street
Adelaide SA 5000 AUSTRALIA

The envelope containing your application must be marked **'Confidential — contains PEL application'**

The Minister is expected to announce the winning bidder(s), together with details of work programs, by no later than January 2020.

COMMENTS AND ENQUIRIES

Elinor Alexander
Phone National (08) 8429 2436
Phone International +61 8 8429 2436

or

Shane Farrelly
Phone National (08) 8429 2443
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http://www.energymining.sa.gov.au/petroleum

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