

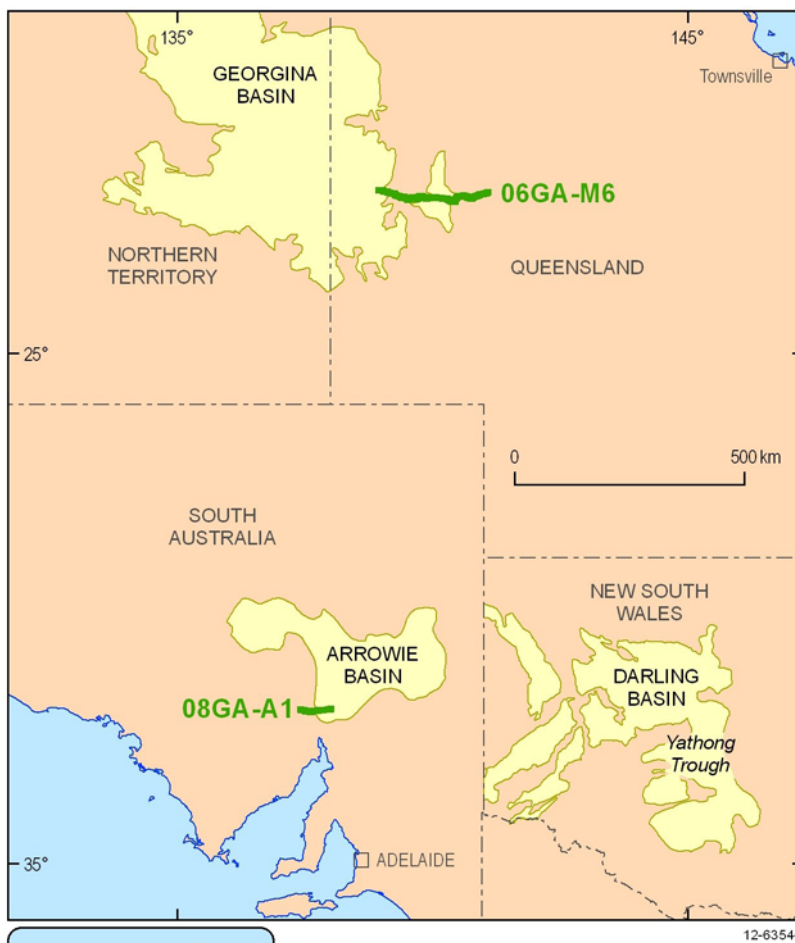
Petroleum potential of the Arrowie and Georgina basins

Deep seismic reflection data supports petroleum systems maturation modelling

Lidena Carr, Russell Korsch and Heike Struckmeyer



In 2006 the Australian Government expanded Geoscience Australia's program of seismic acquisition, data enhancement and client access through the commitment of almost \$134 million over five years to the Energy Security Initiative.



The focus of the Onshore Energy Security Program (OESP) was to stimulate exploration for energy resources, including non renewable resources such as hydrocarbons, uranium and thorium as well as renewable geothermal energy resources. The OESP was carried out under the National Geoscience Agreement between the Australian, state and Northern Territory governments. As part of the OESP, deep seismic reflection data were acquired across several frontier sedimentary basins to stimulate petroleum exploration.

This article reports on the interpretation of the deep seismic reflection profiles from the Arrowie Basin in South Australia and the Burke River Structural Zone of the Georgina Basin in northwest Queensland. The research focussed on their stratigraphic and structural architecture and was consequently utilised in petroleum systems maturation modelling to increase the understanding of their petroleum potential.

Arrowie Basin, South Australia

In 2008 Geoscience Australia, in conjunction with Primary Industries and Resources South Australia (PIRSA), acquired a

Figure 1. Map showing the locations of seismic lines 08GA-A1 across the Arrowie Basin in South Australia and 06GA-M6 across the Burke River Structural Zone in Queensland.

60 kilometre long deep seismic line (08GA-A1) across the western part of the Arrowie Basin, immediately to the west of the central Flinders Ranges (Figure 1). This part of the basin has received almost no attention for hydrocarbon exploration since the shallow Wilkatana 1 well was drilled in the 1950s, to a maximum depth of 670 metres. Some of these wells located 15 kilometres to the south of the seismic line encountered non-commercial bituminous hydrocarbons in the Cambrian succession (SANTOS 1957). Petroleum systems maturation modelling in the Arrowie Basin was carried out using the interpretation of stratigraphy and architecture of seismic line 08GA-A1. A full description of the parameters used for the modelling is included in Carr et al. (2012).

Georgina Basin, Northwest Queensland: Burke River Structural Zone

In 2006 Geoscience Australia, in conjunction with the Geological Survey of Queensland, the Predictive Mineral Discovery Cooperative Research Centre and Zinifex Limited, acquired a 283 kilometre long deep seismic reflection transect (06GA-M6) across the Burke River Structural Zone of the Georgina Basin in northwestern Queensland (Figure 1). This line was part of a larger, ~900 kilometre long seismic survey across the Mount Isa Province (Hutton and Korsch 2008). Only limited exploration has occurred in this region although the southern Georgina Basin is considered to be a significant potential hydrocarbon region, and includes a largely unexplored Middle Cambrian petroleum system (Ambrose et al. 2001; Boreham and Ambrose 2007).

Following the discovery of hydrocarbon indicators in water bores drilled into the Cambrian succession, exploration has included several petroleum exploration wells. Although there were numerous oil and gas shows and solid bitumen has been recovered from drillcore (Volk et al 2007) the wells proved unsuccessful for hydrocarbons (Ambrose et al. 2001). Draper (2007) suggested that an early Paleozoic carbonate petroleum system was present in the Georgina Basin in Queensland, and he considered that, although the Toko Syncline is more prospective, the Burke River Structural Zone is still worthy of further exploration. The Georgina Basin has been the subject of recent exploration, for both unconventional and conventional hydrocarbons, including the drilling of the Macintyre 2 well within the basin (Baraka Energy and Resources 2011). Petroleum systems maturation modelling in the Georgina Basin was conducted utilising information from the interpretation of the stratigraphy and architecture of seismic line 06GA-M6. A full description of the input parameters and modelling are available in Carr et al. (2012).

Results

The Arrowie Basin seismic data show an asymmetrical basin architecture, with the basin attaining a maximum depth of ~3800 metres. Several sequence boundaries mapped in this seismic section are correlated with the sequence boundaries between the major Neoproterozoic stratigraphic groups in the Adelaide Rift System. In the eastern most part of the seismic section a series of east-dipping thrust faults disrupt the stratigraphic section.

Petroleum systems maturation modelling conducted in the Arrowie Basin indicates that the generation and expulsion of hydrocarbons from mature source rocks occurred early during the burial history, and mostly prior to the Late Cambrian, consistent with previous findings (Figure 2). Potential Cambrian source rocks are probably immature to mature for oil generation at the modelled site in the basin. In contrast, potential Neoproterozoic source rocks are likely to be mature to overmature for oil generation, and immature to mature for gas generation. With hydrocarbon systems clearly present in the Arrowie Basin, future work, possibly with a focus on unconventional Cambrian hydrocarbons, is warranted.

Seismic data across the Burke River Structural Zone of the Georgina Basin show that the basin is about 65 kilometres wide, with a half graben geometry, being bounded in the west by a

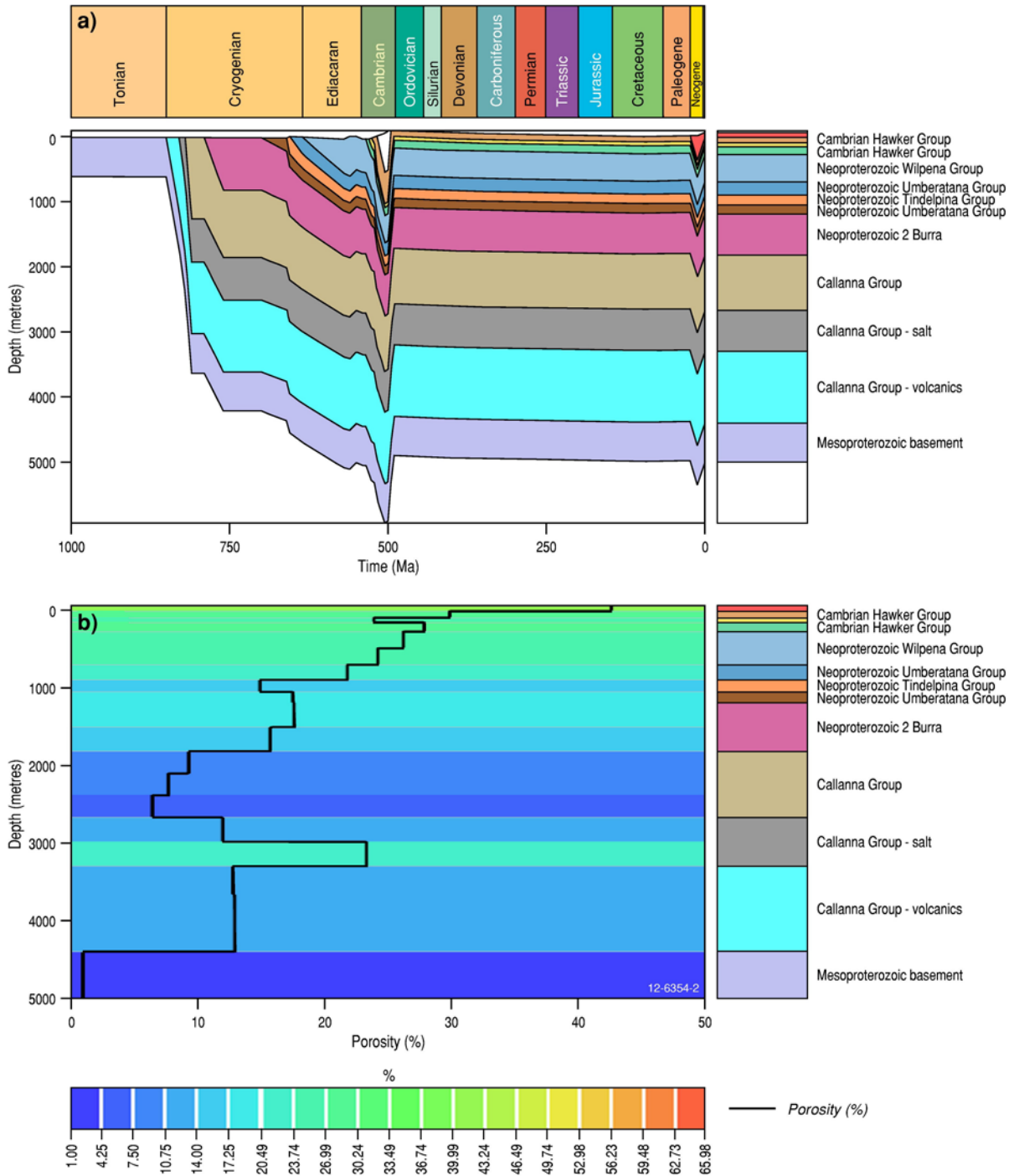


Figure 2. Results from petroleum systems maturation modelling in the Arrowie Basin showing: **a)** burial history plot modelled with rapid late Proterozoic and Cambrian burial and minor uplift in the last five million years; **b)** predicted porosity versus depth.

rift border fault. The basinal succession attains a maximum thickness of ~2800 metres, with the stratigraphy being relatively flat-lying and thickening towards the basin bounding fault. Petroleum systems maturation modelling for the Burke River Structural Zone indicates that potential Cambrian source rocks are likely to be oil mature. Significant generation and expulsion probably occurred early in the

burial history in response to Cambrian-Ordovician loading. Expulsion occurred after trap formation in the Neoproterozoic-Cambrian but before later trap formation in the Devonian. The

required long preservation time and unroofing are the major risk factors within the basin.

The main outcomes of the OESP have been the collection, interpretation and delivery of precompetitive data, significantly improving knowledge about Australian onshore frontier basins. This work has assisted in identifying the types of potential petroleum exploration targets to be expected in the onshore basins, and reducing exploration risk. It also provides baseline information for the future assessment of conventional and unconventional petroleum resources in Australia.

References

- Ambrose GJ, Kruse PD & Putnam PE. 2001. Geology and hydrocarbon potential of the southern Georgina Basin, Australia. *APPEA Journal* 41: 139–163.
- Baraka Energy and Resources. 2011. ASX Announcement: Elevated Hydrocarbon Shows Recorded from MacIntyre-2, Southern Georgina Basin, Australia. Available at: www.barakaenergy.com.au/announcements.php (accessed: December 2011).
- Boreham CJ & Ambrose GJ. 2007. Cambrian petroleum systems in the southern Georgina Basin, Northern Territory, Australia. In Munson TJ & Ambrose GJ (eds). Proceedings of the Central Australian Basins Symposium, Alice Springs, 16-18th August, 2005. *Northern Territory Geological Survey, Special Publication 2*: 254–281.
- Carr LK, Korsch RJ, Struckmeyer H, Jones LEA, Holzschuh J, Costelloe RD & Meixner AJ. 2012. The architecture and petroleum potential of Australia's onshore sedimentary basins from deep seismic reflection data and petroleum systems maturation modelling: the Arrowie, Georgina and Darling Basins. *Geoscience Australia Record* 2012/36.
- Draper J. 2007. Georgina Basin – an early Palaeozoic carbonate petroleum system in Queensland. *APPEA Journal* 47: 105–124.
- Hutton LJ & Korsch RJ. 2008. Deep seismic reflection interpretations, Mount Isa and Isa-Georgetown surveys. In Digging Deeper 6 Seminar Extended Abstracts. *Queensland Geological Record* 2008/06.
- SANTOS. 1957. Arrowie Basin: Wilkatana Well Completion Report numbers 1-19b. *Primary Industry and Resources South Australia Open File Envelope* No. 8577.
- Volk H, George SC, Kempton RH, Liu K, Ahmed M & Ambrose GJ. 2007. Petroleum migration in the Georgina Basin: Evidence from the geochemistry of oil inclusions. In Munson TJ & Ambrose GJ (eds). Proceedings of the Central Australian Basins Symposium, Alice Springs, 16–18 August, 2005. *Northern Territory Geological Survey, Special Publication 2*: 282–303.
- This work was presented at the Central Australian Basin Symposium on the 16 and 17 July, in Alice Springs.

Related articles/websites

The architecture and petroleum potential of Australia's onshore sedimentary basins from deep seismic reflection data and petroleum systems maturation modelling: the Arrowie, Georgina and Darling Basins (*Geoscience Australia Record* 2012/36).

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