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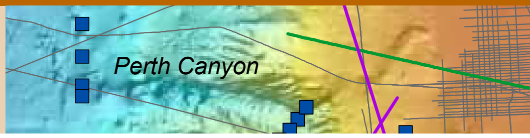
First acreage release in frontier Mentelle Basin

Significant potential to become new petroleum province



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The Australian Government's 2010 release of offshore petroleum exploration areas included, for the first time, a large exploration block in the frontier Mentelle Basin. This large sedimentary basin (36 400 square kilometres) is located about 150 kilometres to the west of Cape Leeuwin. It lies beneath the Yallingup Shelf and the Naturaliste Trough, a bathymetric saddle, separating the Australian margin from the Naturaliste Plateau (figure 1). Water depths range from 500 to 1500 metres on the continental slope to almost 4000 metres in the central part of the Naturaliste Trough.

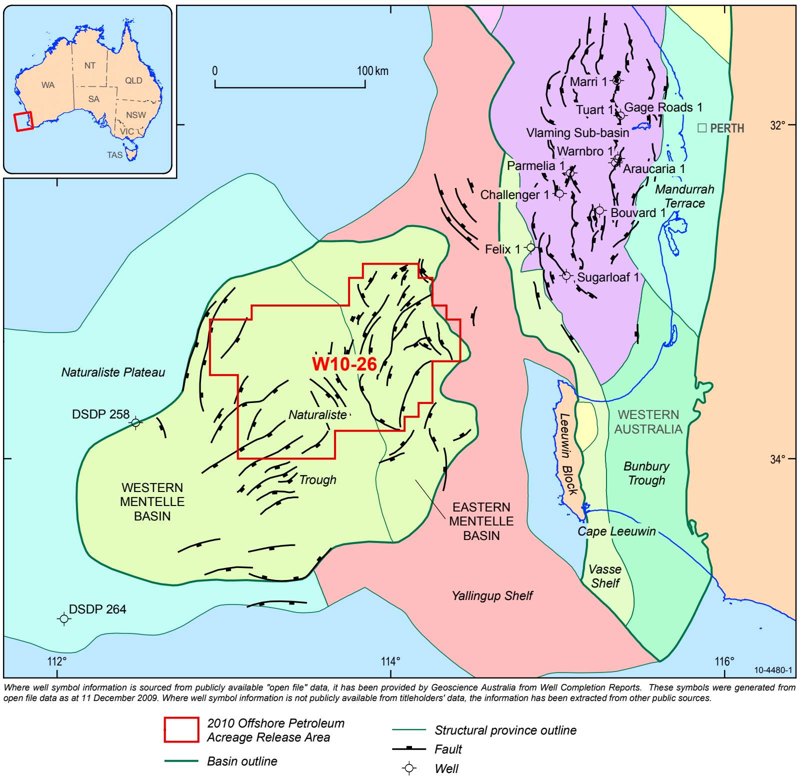

Figure 1. Regional setting and major structural elements of the Mentelle Basin and the Vlaming Sub-basin.

Seismic data collected by Shell in 1973 showed the presence of thick sedimentary successions in the basin, however there has been no follow-up exploration. This lack of interest was because of the deep water depths and the prevailing geological interpretation of the Naturaliste Plateau and the Naturaliste Trough. They were seen as oceanic features that formed as a result of volcanism during the breakup on the southwestern margin (Coleman et al 1982; Storey et al 1992).

More recent analyses of existing seismic data and sampling results from this margin (Beslier et al 2004) have shown that the basin is underpinned by continental crust (Borissova 2002; Direen et al 2007). The sedimentary successions in the Mentelle Basin are likely to be of similar age to those in the adjacent southern Perth Basin, (Bradshaw et al 2003) and the basin is potentially prospective for hydrocarbons.

Recent data acquisition

Because of this new understanding and industry's increased interest in deep-water exploration, Geoscience Australia acquired 1060 kilometres of seismic data across the Mentelle Basin in 2004 (seismic survey 280: figure 2). Interpretation of this dataset (Borissova et al 2006) confirmed the presence of a very large depocentre (or area of thick sediments in a sedimentary basin) with up to ten kilometres of sediments in the deep-water part of the basin. It also confirmed several significant depocentres with up to eight kilometres of sediments in the shallow part of the basin. The analysis also showed that the structural complexity of the basin could not be resolved with the previous sparse seismic grid.

To complete an assessment of the petroleum prospectivity of this frontier basin, Geoscience Australia acquired an additional 2570 kilometres of industry-standard seismic data in 2008–09 (GA seismic survey 310; Foster et al 2009) as well as gravity and magnetic data. Together with the existing data, this new dataset created a regional seismic coverage with 10 to 20 kilometre line spacing (figure 2).

A team of Geoscience Australia scientists undertook an assessment of the petroleum prospectivity of the Mentelle Basin between August and November 2009. This study included seismic interpretation combined with analysis of gravity and magnetic data. Correlations with the South Perth Basin stratigraphy led to the development of a tectonostratigraphic framework and petroleum systems model for the basin (Borissova et al 2010).

Interpretation of the new data

Based on the interpretation of the new seismic data, the Mentelle Basin can be divided into two key structural domains with different fault and depocentre geometries: the western and eastern Mentelle basins (figures 1 and 2). In the northern part of the western Mentelle

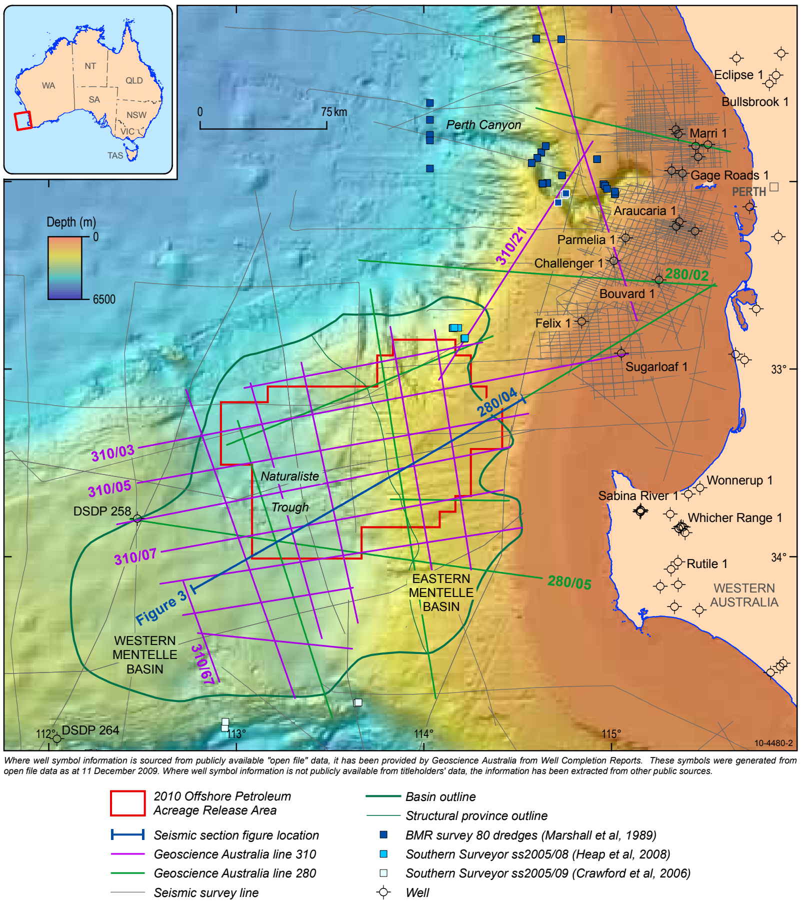

Figure 2. Location of seismic lines, wells and dredge sampling sites in the Mentelle Basin region.

and over most of the eastern Mentelle Basin, major structural elements correlate with the north–south trending Permian to Jurassic rift system of the Perth Basin. This contrasts with the southern part of the western Mentelle Basin which displays similarities to the northeast–southwest trending Jurassic to Early Cretaceous rift basins of the southern Australian margin.

Analysis of the seismic, well (DSDP 258) and sampling data (figure 2) as well as comparisons with the stratigraphy and petroleum systems elements in the adjacent Perth Basin, revealed a multi-phase history of extension and volcanism in the Mentelle Basin (Borissova et al 2010). Initial rifting in the Mentelle Basin occurred in the Early Permian, followed by thermal subsidence during the Triassic to Early Jurassic. However, Permo–Triassic depocentres containing sedimentary successions up to seven kilometres thick are preserved only in the eastern Mentelle Basin. The second stage of rifting in the Middle Jurassic to Early Cretaceous led to accumulation of very thick sedimentary successions in half-graben depocentres of the western Mentelle Basin (up to nine kilometres of syn-rift strata).

Early Cretaceous continental breakup on the south-western margin was accompanied by extensive volcanism. In the western Mentelle Basin, multiple overlapping lava flows and volcaniclastic sediments form a thick syn-breakup volcanic succession up to one kilometre thick. During the thermal subsidence that followed the breakup, several tectonic events in the surrounding region led to fault reactivation, structuring and renewed igneous activity. In the Paleocene the western Mentelle Basin started to collapse with a hinge developing along the boundary with the eastern Mentelle Basin. The onset of fast spreading in the Southern Ocean in the mid-Eocene had a profound impact on the Mentelle Basin, causing reactivation of many faults and partial inversion of the western Mentelle Basin, massive slumping, and some volcanism. The next structuring event occurred in the Miocene. Compressional anticlinal structures formed during this time are possibly related to the collision between the Australian and Eurasian plates.

Potential petroleum prospectivity and play types

Petroleum prospectivity assessment of the Mentelle Basin (Borissova et al 2010) confirmed significant potential to become a new petroleum province. The basin is likely to contain multiple source rock intervals associated with coals and carbonaceous shales, as well as regionally extensive reservoirs and seals within fluvial, lacustrine and marine strata. Petroleum systems modelling indicates that potential source rocks are thermally mature and started to generate during the Early to Middle Jurassic in the eastern Mentelle Basin and during the Early Cretaceous in the western Mentelle Basin. Some source rocks probably continued to generate and expel hydrocarbons after breakup, charging existing and newly-created traps. A wide range of play types have been identified in the Mentelle Basin (figure 3), including faulted anticlines and highside fault blocks, sub-basalt anticlines and fault blocks, drape and forced fold plays, and a large range of stratigraphic and unconformity plays.

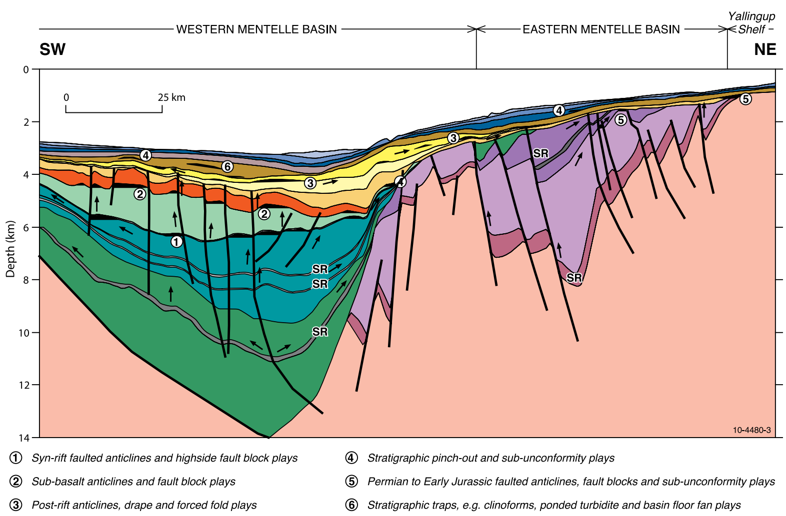

Figure 3. Conceptual play diagram for the Mentelle Basin.

In the western Mentelle Basin the main potential plays include highside fault blocks and sub-basalt anticlines. Highside fault blocks (Play Type 1, figure 3) which developed during the syn-rift phase form potential structural traps, where these blocks have favourable location and timing to be charged from the Middle Jurassic to Lower Cretaceous coals and lacustrine mudstones. Fluvial sandstones of the same age are likely reservoirs. Sub-basalt anticlines (Play Type 2, figure 3) are structural traps that formed during the breakup which incorporates Lower Cretaceous fluvial reservoirs sealed by thick syn-breakup volcanics. A number of potential plays formed after the breakup (Play Type 3, figure 3). Lower Cretaceous marine sandstone, including turbidite units, are likely to form good reservoir intervals, while overlying marine mudstone are potential regional seals. Trap types include:

- dome structures and forced folds which originated during Cretaceous to Cenozoic igneous events
- inversion anticlines that formed during the Cenozoic margin flexure and subsidence
- drape structures.

Combined structural–stratigraphic traps (Play Type 4, figure 3) are likely to occur along the hinge zone separating the eastern and western Mentelle basins. This is where Lower Cretaceous fluvial sandstones onlap on basement or pre-rift strata. This trap type has favourable location and timing for charge from syn-rift source rocks in the western Mentelle Basin, and may be a significant exploration play.

In the eastern Mentelle Basin potential trap types include faulted anticlines, highside fault blocks, and sub-unconformity traps (Play Type 5, figure 3). Reservoirs are likely to be present throughout the pre-breakup succession and Lower Permian coals should provide mature source rocks. Potential stratigraphic traps (Play Type 6, figure 3) occur within post-rift strata, both in the eastern and western Mentelle basins. These traps include turbidite sandstones sealed by slope mudstones within prograding shelf-slope wedges and ponded turbidite sandstones encased in slope mudstones.

Summary

New data collected during the Geoscience Australia seismic survey 310 in 2008–09 enabled an assessment of hydrocarbon prospectivity of the frontier Mentelle Basin and resulted in the first release of exploration acreage in this basin. Sustained efforts by Geoscience Australia in advancing the geological knowledge of frontier basins have provided explorers with a new target in offshore Australia.

For more information

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References

Beslier MO, Royer JY, Girardeau J, Hill PJ, Boeuf E, Buchanan C, Chatin F, Jacovetti G, Moreau A, Munschy M, Partouche C, Robert U & Thomas S. 2004. Une large transition continent-océan en pied de marges sud-ouest australienne: première résultats de la campagne MARGAU/MD110. Bulletin de la société Géologique de France 175:629–41.

Borissova I, Bradshaw BE, Nicholson C, Struckmeyer HIM & Payne D. 2010. New exploration opportunities on the southwest Australian margin–deepwater frontier Mentelle Basin. APPEA Journal 50, 1–13.

Borissova I, Krassay AA, Nicholson C, Monteil E, Boreham C & Bradshaw B. 2006. The Mentelle Basin - a Deepwater, Frontier Gondwanan Basin. Abstracts volume of the 2006 AAPG International Conference and Exhibition, Perth, Australia.

Borissova I. 2002. Geological framework of the Naturaliste Plateau. Geoscience Australia Record 2002/20.

Bradshaw BE, Rollet N, Totterdell JM & Borissova I. 2003. A revised structural framework for frontier basins on the southern and southwestern Australian continental margin. Geoscience Australia Record 2003/03.

Coleman PJ, Michael PJ & Mutter JC. 1982. The origin of the Naturaliste Plateau, SE Indian Ocean–implications from dredged basalts. Geological Society of Australia Journal 29:457– 68.

Crawford AJ, Direen NG, Coffin MF, Cohen B, Paul B & Mitrovic L. 2006. Extensive basaltic magmatism on the Naturaliste Plateau, offshore SW Australia. Geochimica et Cosmochimica Acta 18:A116.

Direen NG, Borissova I, Stagg HMJ, Colwell JB & Symonds PA. 2007. Nature of the continent-ocean transition zone along the southern Australian continental margin: a comparison of the Naturaliste Plateau, south-western Australia, and the central Great Australian Bight sectors. In: G Karner, G Manatschal & L Pinheiro (eds), Imaging, mapping and modelling continental lithosphere extension and breakup. Geological Society Special Publications 282:235–61.

Foster C, Goleby B, Borissova I & Heap A. 2009. Southwest margin surveys completed. AusGeo News 94.

Heap AD, Edwards J, Fountain L, Spinnocia M, Hughes M, Matthews E, Griffin J, Borissova I, Blevin J, Mitchell C & Krassay A. 2008. Geomorphology, sedimentology and stratigraphy of submarine canyons on the SW Australian slope, RV Southern Surveyor, September–October 2004. Geoscience Australia Record 2008/16.

Marshall JF, Ramsay DC, Lavering I, Swift MG & Shafik S. 1989. Hydrocarbon prospectivity of the offshore South Perth Basin. Geoscience Australia, Record 1989/23.

Storey M, Kent RW, Saunders AD, Salters VJ, Hergt J, Whitechurch H, Sevigny JH, Thirlwall MF, Leat P, Ghose NC & Gifford M. 1992. Lower Cretaceous volcanic rocks on continental margins and their relationship to the Kerguelen Plateau. In: Wise et al, Proceedings of the Ocean Drilling Program, Scientific Results, Leg 120, Texas A&M University, College Station.