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Research paper

Fault-related biogenic mounds in the Ceduna Sub-basin, Australia. Implications for hydrocarbon migration

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ABSTRACT

The Early Cenozoic in the Bight Basin represents a transitional period from the slow to fast oceanic crust spreading of the Southern Ocean between Australia and Antarctica. This period is characterised by widespread igneous activity and the occurrence of biogenic mound complexes. In the proximal part of the Ceduna Sub-basin these mound complexes thrive on local topographic highs, exploiting the shut-down in siliciclastic sediment supply during the Eocene. New interpretation of 2D and 3D seismic data from the central Ceduna Sub-basin shows additional, undrilled, Paleocene-Eocene biogenic mound complexes. They display rugose morphology, progradational and aggradational internal organisation and high impedance contrast with the surrounding sediments. These mounds typically show a clear relationship with underlying reactivated fault segments. These faults intersect potential oil mature Cretaceous source rock intervals and therefore one plausible mechanism for the development of fault-related mound complexes in the central Ceduna Sub-basin relies on natural hydrocarbon seeps along faults supplying nutrients for a benthic chemosynthetic organisms and localised biogenic mound growth. The presence of a sub-bottom profile anomaly overlaid by a vertical water column acoustic contact in close vicinity of a mound complex support this model. The occurrence of seep related biogenic mounds would validate the presence of mature source rock(s) and hydrocarbon charge in the central Ceduna Sub-basin. If confirmed the biogenic mounds would imply fluid migration occurrence until at least the Eocene.

1. Introduction

The Mesozoic to Cenozoic Bight Basin (Fig. 1) is a large, mainly offshore basin along the continental margin of southern Australia which resulted from the separation of Australia and Antarctica (e.g. Veevers, 1986; Teasdale et al., 2003). The basin underlies the continental shelf and slope in water depths ranging from less than 200 m to over 4000 m. The main depocentres (including the Ceduna Sub-basin) occur in the eastern part of the Bight Basin and is potentially one of the most prospective deep-water frontier area in offshore Australia (Totterdell and Mitchell, 2009). The Ceduna Sub-basin in particular contains a sedimentary thickness in excess of 15 km (Fig. 2) due to an extended period of extension prior to breakup followed by a Late Cretaceous to Early Cenozoic period of slow seafloor spreading (e.g. Veevers et al., 1991). The most prospective petroleum systems are believed to be associated with thick Mid to Late Cretaceous deltaic and marine siliciclastic sediments, which provide reservoirs, seals and potential oil-prone source rocks at several stratigraphic levels (Fig. 3, Blevin et al., 2000; Totterdell et al., 2000; Struckmeyer et al., 2001).

In the Ceduna Sub-basin the Early Cenozoic represents the transition from the slow to the fast oceanic crust spreading of the Southern Ocean and is associated with the transition between siliciclastic (Hammerhead and Wobbegong supersequences) and cold water carbonate (Dugong Supersequence) depositions (Fig. 2). This period is also characterised by widespread volcanic and intrusive bodies (Schofield and Totterdell, 2008) as well as biogenic mound complexes constructed primarily by bryozoans (Feary and James, 1995, 1998; Feary et al., 2000; James et al., 2004; Sharples et al., 2014). These cold water biogenic mounds were described in the Eyre Sub-basin, Madura Shelf (Feary and James, 1995, 1998) and northern Ceduna Sub-basin (Sharples et al., 2014), thriving on local topographic highs (i.e. shelf break) in the proximal part of the Ceduna Delta, exploiting the shut-down in siliciclastic sediment supply to become the dominant benthic organisms in the Eocene.

Additional geobodies with some similar characteristics as the documented biogenic mound complexes are present in the central

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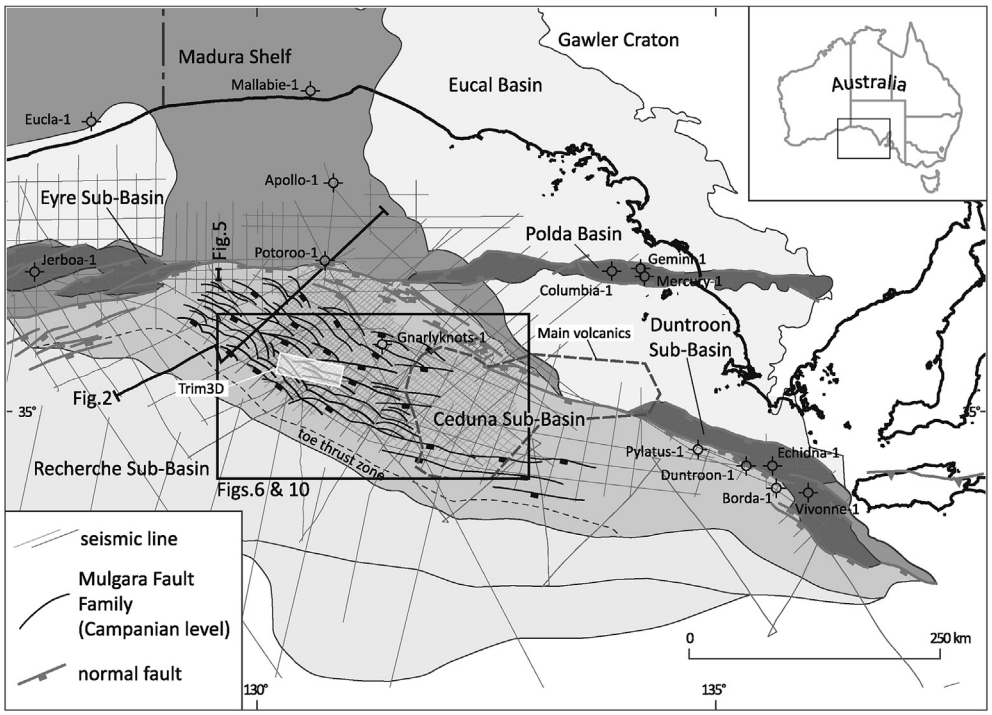

Fig. 1. Structural elements map of the Bight Basin. Modified from Bradshaw et al. (2003).

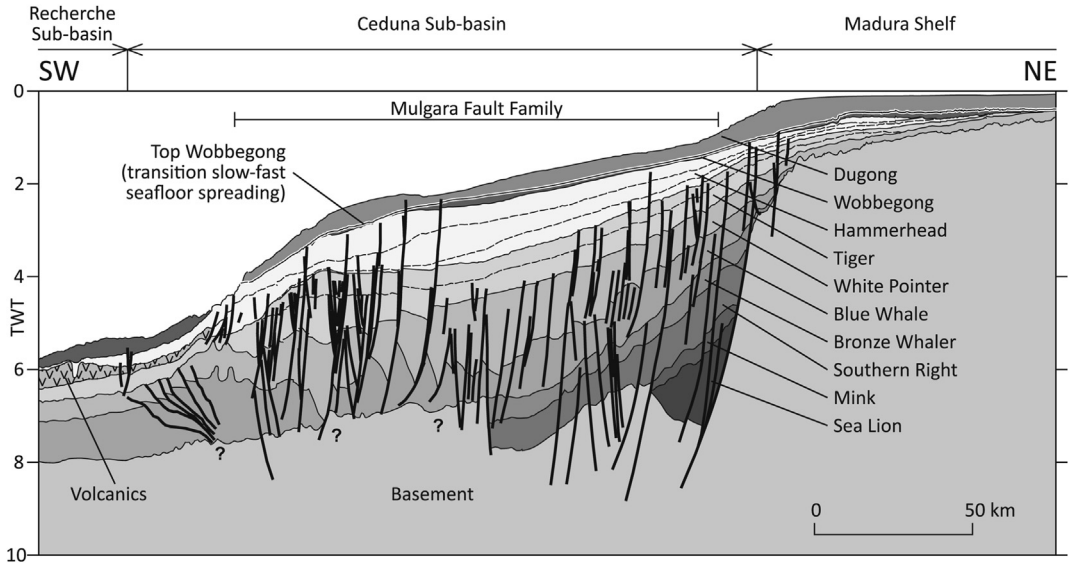

Fig. 2. Cross-section through the Ceduna Sub-basin showing the supersequences and the Mulgara Fault Family. The top Wobbegong Supersequence where volcanics and biogenic mounds are interpreted is highlighted. Location on Fig. 1.

and southern Ceduna Sub-basin at the Eocene transition between siliciclastic and carbonate deposition. However unlike the bryozoan mounds of the Madura Shelf and Eyre and northern Ceduna Sub-basins, these newly interpreted mounds show a clear relationship with underlying Late Cretaceous to Paleocene faults.

2. Geological setting

The Ceduna Sub-basin is one of the main depocentres of the Mesozoic to Cenozoic Bight Basin (Fig. 1). The Ceduna Sub-basin has an area of approximately 90,000 km^2 and contains in excess of 15 km of syn- and post-rift Mesozoic sediments (Figs. 1 and 2). The northern margin is characterised by a series of fault-bound half grabens that contain Middle Jurassic to Early Cretaceous syn-rift fill (Fig. 2). The southwestern boundary is interpreted at the basinward edge of an associated toe-thrust zone (Fig. 1).

The Bight Basin developed along the southern margin of Australia during extension and passive margin evolution that commenced in the Middle–Late Jurassic. The reader is referred to King and Mee (2004) and Totterdell and Bradshaw (2004) for detailed descriptions of the tectonic history of the Bight Basin and the Ceduna Sub-basin. The Bight Basin was initiated in the Middle