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Fault linkage and reactivation on the northern margin of the Dampier sub-basin

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SUMMARY

The north-west margin of the Dampier sub-basin is characterised by a strongly segmented fault pattern. NE trending faults define the edge of the Rankin Platform, and separate it from the Kendrew Trough. However a secondary set of NNE trending faults define smaller scale graben on the edge of the Rankin Platform that preserve Lower and Middle Jurassic sediments. This strongly suggests oblique reactivation of an inherited NE trending basement fabric under WNW oriented extension during Middle Jurassic extension.

Key words: Northern Carnarvon Basin, Dampier sub-basin, oblique extension

INTRODUCTION

The northern margin of the Dampier sub-basin exhibits a complex, highly segmented fault pattern comprising NE-SW trending segments that parallel the basin margin, and secondary, more oblique segments that trend NNE, patterns that are indicative of the oblique reactivation of older, underlying basement fabrics (McClay et al., 2004). High resolution 3D seismic surveys provide the opportunity to study such fault patterns in detail, to elucidate the timing of fault reactivation and to determine the stress regimes that prevailed during each stage of fault growth.

This study is based primarily on interpretation of the Demeter 3D seismic survey. The main phase of fault growth occurred during the Late Triassic - Middle Jurassic, with minor reactivation following the Valanginian unconformity. Additional phases of fault activity during the Lower Cretaceous can be recognised with less certainty due to the limited preservation of syn-rift sediments beneath the Valanginian unconformity.

The aim of this paper is to unravel these different phases of deformation, to determine the extent to which successive episodes of fault growth have been influenced by inheritance of older structures, and to use this to explain the structural complexity observed both in cross section and map view.

REGIONAL SETTING

The Northern Carnarvon Basin is situated off the north western coast of Western Australia and comprises an area of approximately 500 000 km^2 (GSWA, 2011).

The main structural elements of the basin include the outer platform area of the Exmouth Plateau, the centrally located main depocenters comprising four north east trending graben structures (namely the offshore Exmouth, Barrow, Dampier and Beagle sub-basins) and shallower basement areas adjacent the shore, such as the Peedamullah shelf (Felton, 1993). The offshore sub-basins contain up to 15 km of mainly Mesozoic and Cenozoic sedimentary rocks dominated by deltaic to marine siliclastics and shelfal carbonates.

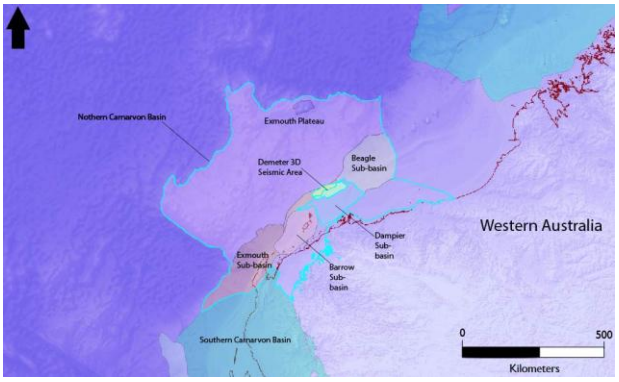

Figure 1. Study area location within the Northern Carnarvon Basin.

DATA SET AND METHODOLOGY

The Demeter 3D dataset covers 4055 km^2 area with an inline spacing of 12.5 m, a cross line spacing of 25m and a record length of 6000 ms two way time (msTWT). Twenty two wells were used to establish stratigraphic ties enabling the mapping of seven horizons and unconformities across the study area (top Mungaroo, the Middle Jurassic unconformity, the Forestier Claystone, Muderong Shale, Toolonga Calcilutite, Mira Formation and Walcott Formation; see Figure 2). Depth conversion was carried out using interval velocities derived from the wells. Correlation of Lower Jurassic & Upper Triassic sequences was subject to greater uncertainly as most wells targeted highs where these sequences are missing, and

due to the deterioration of data quality to the south and east where they are present in the deeper parts of the basin.

STRUCTURAL ELEMENTS

Rankin Platform

The Rankin Platform is comprised of mainly pre-kinematic Triassic and older sequences, overlain conformably by a thin layer of Lower Jurassic sediments and unconformily overlain by thicker Cretaceous sediments (Figure 2). Overall the margin strikes NE and extends over 500km in length. However the NE striking faults that separate the Rankin Platform from the Kendrew Trough are far from continuous and are linked to a series of NNE trending faults that dip both east and west, defining a series of smaller scale graben that segment the margin of the Rankin Platform. Preservation of Lower Jurassic sediments within these graben (Athol and Legendre Formations) indicate that they formed during the main Middle Jurassic rift phase of deformation.

Small-scale reactivation of both sets of faults during the Upper Cretaceous clearly reveals this same strongly segmented fault pattern at the Muderong Shale (Figure 3).

Kendrew Trough

The Kendrew Trough is an elongate depression situated between the Rankin Platform to the NW and Madeleine Trend to the SE. Deformation comprises SE dipping normal faults that terminate at the Middle Jurassic unconformity and extend down into the Triassic. The unconformity is less pronounced than on the Rankin Platform, but is still apparent from onlapping relationships of younger sequences.

The overlying Upper Jurassic sequences are un-faulted, exhibit a thickening towards the centre of the trough and onlap onto fault surfaces defining the Rankin Trend at the edge of the trough. They extend to the SE over the Madeleine Trend, forming an anticlinal structure.

Madeleine Trend

Faulting within the Madeline Trend comprises segmented NE striking, NW dipping normal faults that terminates below the Middle Jurassic unconformity. Consequently, the Madeleine Trend is comprised of eastward dipping rotated Triassic fault blocks, producing a relative topographic high. The draping of this structure by later sediments has resulted in the development of an antiformal structure. There is no evidence of reactivation of these faults within the Madeline Trend.

STRUCTURAL EVOLUTION

The preservation of Lower and Middle Jurassic sequences in the graben on the flanks of the Rankin Platform, in the Kendrew Trough and in the Madeleine Trend is controlled by NE and NNE striking faults. The termination of faults at the Middle Jurassic unconformity in the Kendrew Trough indicates that most of the deformation took place at this time. The uniform deposition of the Forestier Claystone and Muderong Shale indicates relatively little Lower Cretaceous fault activity associated with the Valanginian unconformity. However minor displacements of the faults making the edge of the Rankin Platform affect the Toolonga Calcilutite, indicating minor Upper Cretaceous reactivation.

The strongly segmented nature of the faults marking the edge of the Rankin Platform, and the evidence of synchronous fault activity on NE and NNE trending faults are strongly indicative of oblique rifting (McClay et, 2004), AGSO (1994), Etheridge and O'Brien (1994) and Pryer et. al. (2002) all identified a NE striking basement fabric across the Dampier sub-basin, believed to be inherited from pre-existing Pre-Cambrian structures, although the role of Permian and Carboniferous structures cannot be excluded. The fault pattern described here, also expressed in the Muderong Shale (Figure 3), is consistent with reactivation of this fabric during WNW oriented extension during the Jurassic.

DISCUSSION AND CONCLUSIONS

The oblique reactivation of the NE trending basement fabric during the formation of the Dampier sub-basin is consistent with similar fault patterns observed elsewhere in the Northern Carnarvon Basin and may also account for the en-echelon arrangement of the Exmouth, Barrow and Dampier sub-basins. The prominence of NNE trending faults within the NE trending Rankin fault array is strongly indicative of WNW oriented extension, consistent with the orientation of the western Australian margin.

ACKNWOLDGEMENTS

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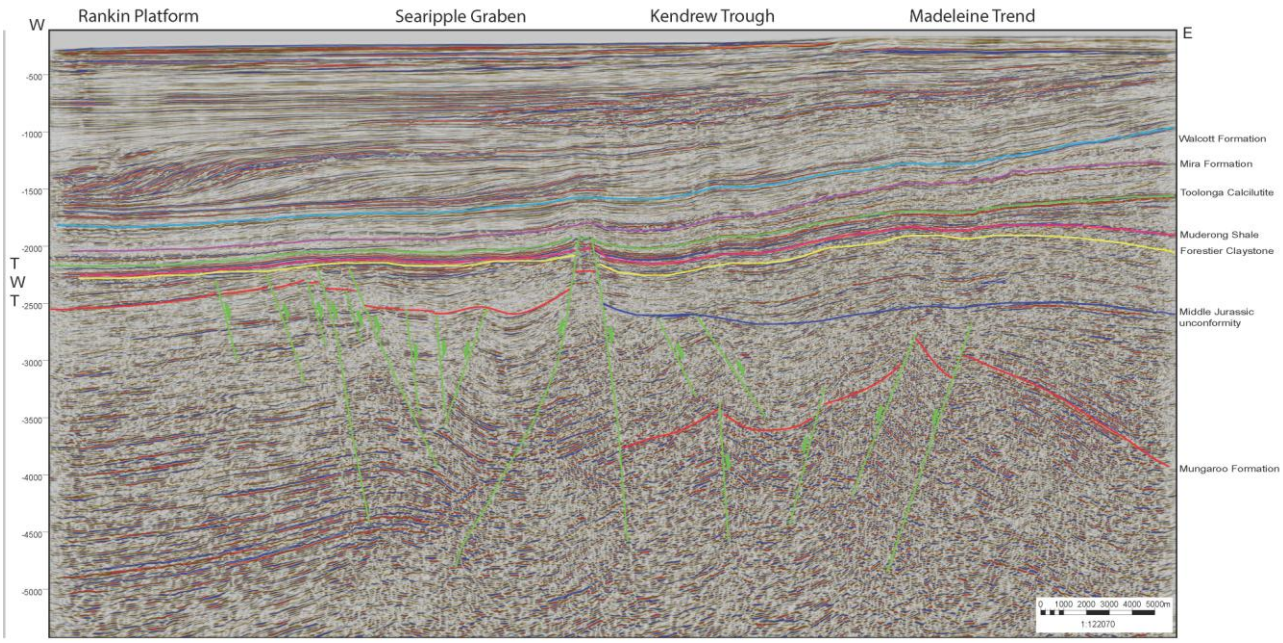

Figure 2. NW-SE oriented cross section showing the main structural elements of the northern margin of the Dampier sub-basin and the main horizons interpreted in this study.

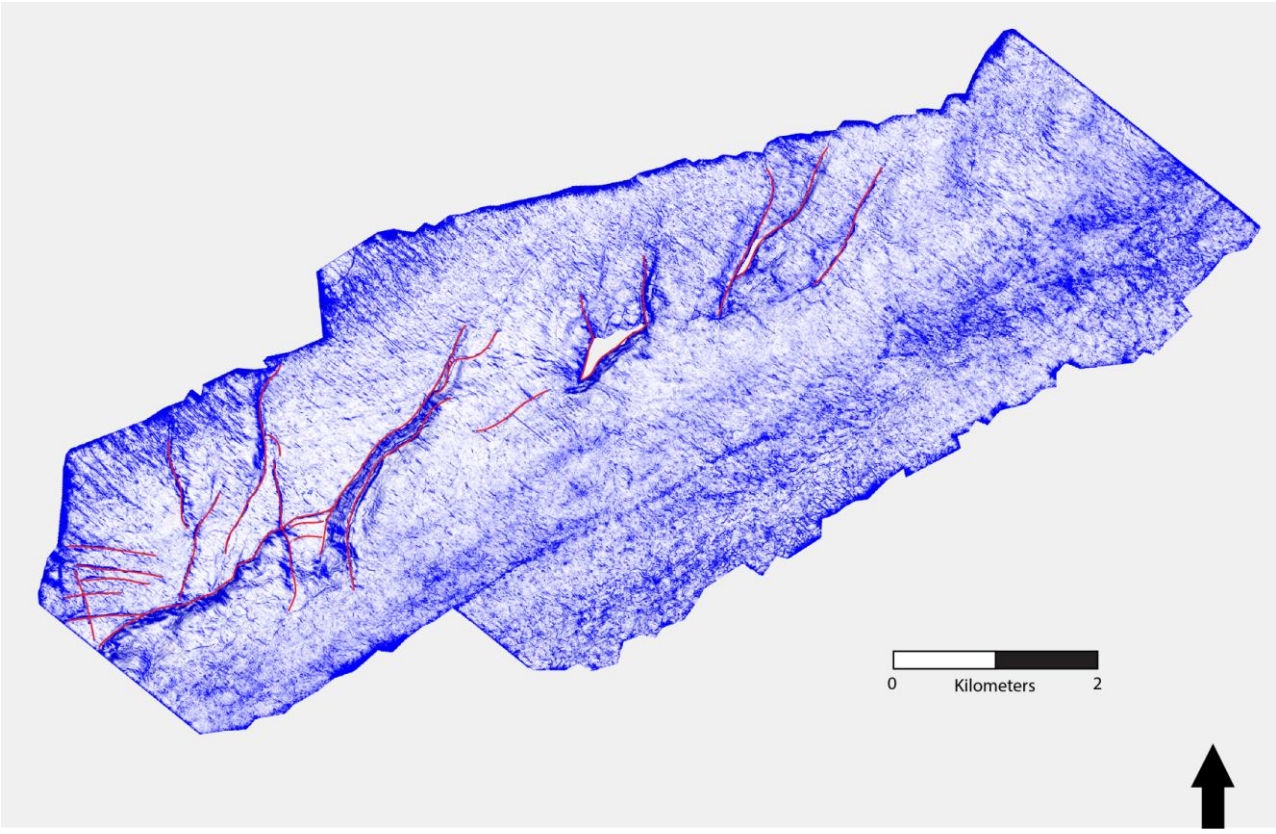

Figure 3. Variance extraction from the Muderong Shale horizon which reflects the geometry of the underlying Jurassic rift system. Note the NE and NNE trending fault segments that indicate WNW oriented reactivation of a NE trending basement fabric.