ASEG-PESA 2015
Geophysics and Geology together for Discovery
24th International Geophysical Conference and Exhibition
15–18 February 2015 Perth, Western Australia

Oblique reactivation of inherited fabrics in rift basins: applications to the Northern Carnarvon Basin

Chris Elders
Department of Applied Geology
Curtin University
chris.elders@curtin.edu.au

SUMMARY

Rift basins are typically developed on heterogeneous continental crust. Inherited basement fabrics exert a fundamental control rift basin geometry, and on the geometry of individual faults. Many rift basins are also the result of multiple rift episodes and early formed structures will exert further control on the way in which faults evolve in subsequent rift events.

Inherited fabrics and fault reactivation are often invoked to explain rift orientation and segmentation, often with little independent evidence for their existence. However analogue models of orthogonal and oblique rifts show that predictable fault patterns result from the partitioning of stress between pre-existing structures and superimposed extension directions.

The Northern Carnarvon Basin provides an ideal laboratory in which to test these models. High resolution 3D seismic data allows detailed imaging of fault patterns developed during separate Lower-Middle Jurassic and Lower Cretaceous rift events. Fault patterns clearly reveal the influence of older structures, most likely related to Carboniferous and Permian rifting, enabling contemporaneous stress patterns to be revealed.

Key words: extensional faults, rift basins, Northern Carnarvon Basin

INTRODUCTION

The Northern Carnarvon Basin has experienced a long and complex history. Many of the hydrocarbon fields in Triassic reservoirs occur in fault blocks the developed during Lower-Middle Jurassic rifting, and in some cases were further modified by Lower Cretaceous reactivation. These two events can be linked to passive margin development associated with the formation of the Argo Abyssal Plain in the Middle Jurassic and the Gascoyne and Cuvier Abyssal Plains in the Lower Cretaceous (Figure 1), although the association may be more complex than first appears.

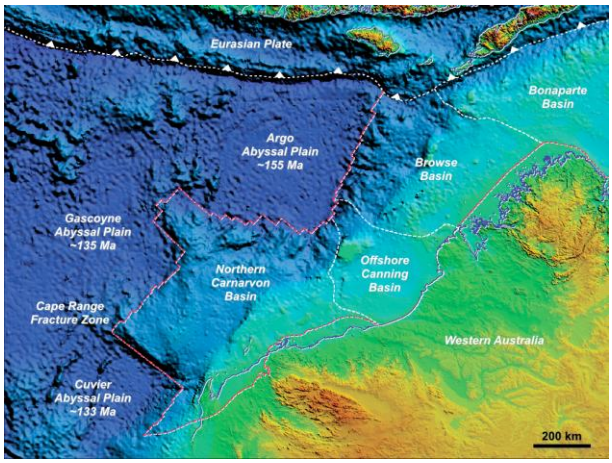

Figure 1. Geological setting of the Northern Carnarvon Basin.

While the fault patterns that result are striking, and certainly relate to significant tectonic events, they may in fact be minor compared to older Carboniferous and Permian events. With the exception of recently acquired deep seismic data, older structures are largely obscured beneath thick Triassic successions. Readily resolvable fault patterns within the Triassic, including the en-echelon arrangement of depocentres and extensional faults, give a clear indication of the location and orientation of older structures. Understanding of the events that gave rise to these features may in turn help to explain the tectonic setting in which unusually thick sequences of Triassic sediments were deposited.

EXTENSIONAL FAULT PATTERNS ON THE EXMOUTH PLATEAU

The Glencoe 3D seismic survey on the Exmouth Plateau reveals fault patterns within the Mungaroo Formation that are typical of many parts of the area (Figure 2). Planar domino style faults trend NE-SW forming a series of titled fault blocks, but the faults are strongly segmented, forming back-to-back half graben and offset depocentres that in some places define en-echelon NE to ENE trending arrays. The tips of the main extensional faults rotate to a more N-S orientation, forming relay structures between offset faults. Smaller scale faults are also arranged in NE-SW trending en-echelon arrays between the main half-graben bounding faults. Subsidiary, slightly curved, E-W trending faults in the southern part of the survey

area define a loosely concentric pattern and may be related to the emplacement of igneous intrusions.

INTERPRETATIONS

Analogue modelling of oblique rifts show that rift border faults typically initiate parallel to underlying oblique structures, but as they propagate laterally their tips rotate to orientations that are at a high angle to the extension direction (McClay et al., 2005). This results in en-echelon fault arrays in which individual faults are also oriented at a high angle to the extension direction while the en-echelon arrays follow the trend of the underlying inherited fabric.

Using this template to the Glencoe 3D data set, the long straight NE-SW trending fault segments which have accumulated relatively large displacements are most likely oriented parallel to inherited structures, while their N-S trending tips have rotated to a high angle to E-W oriented Jurassic extension directions. Rotation of the tips of faults that are propagating towards one another results in the formation of back-to-back graben and offsetting of depocentres. Further evidence of obliquely oriented NE-SW trending fabrics is the en-echelon arrays of minor faults that also follow this trend.

SUMMARY AND CONCLUSIONS

There is clear evidence from the Glencoe 3D survey of oblique reactivation of NE-SW trending fabrics (most likely Permian or Carboniferous in age) under E-W extension during the Jurassic in the Exmouth Plateau. The resultant pattern of en-echelon depocentres mimics the arrangement of the Exmouth, Barrow and Dampier sub-basins further to the south. It is therefore likely that significant NE-SW trending structures underlie this area too and have left a significant impact on the most recent, and perhaps more superficial, rift.

ACKNOWLEDGMENTS

Geoscience Australia is gratefully acknowledged for providing access to released seismic data. Schlumberger are thanked for their generous provision of the Petrel software used in this project for 3D seismic interpretation.

REFERENCES

McClay, K.R.; Dooley, T.; Whitehouse, P.S. and Anadon Ruiz, S. 2005. 4D analogue models of extensional fault systems in asymmetric rifts; 3D visualizations and comparisons with natural examples. In Dore, A.G. and Vining, B.A. (eds.). Petroleum Geology of Northwest Europe: Proceedings of the 6th Conference, 1543-1556

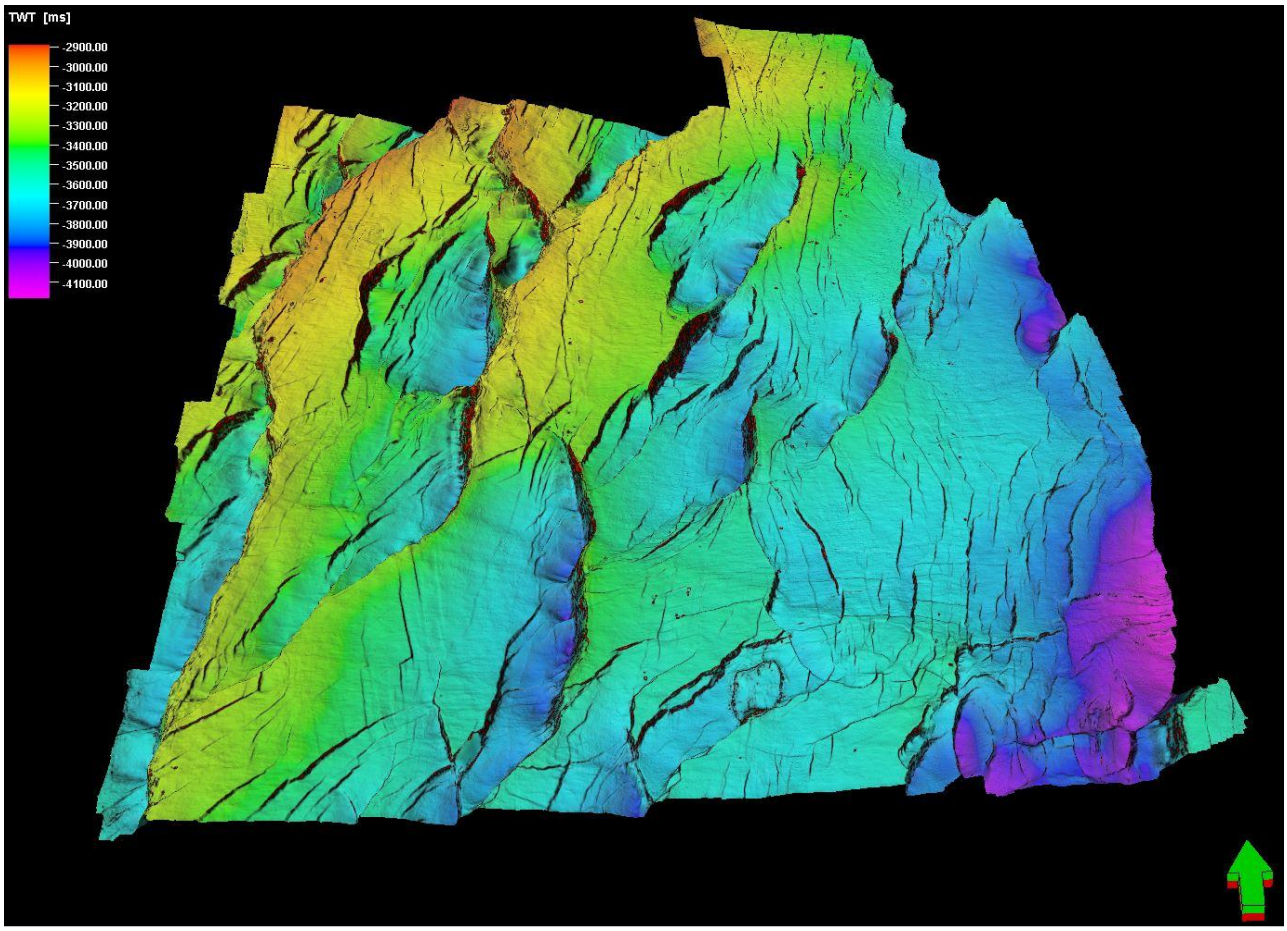

Figure 2. 3D image of extensional fault patterns in the Mungaroo Formation of from the Glencoe 3D seismic survey