New Interpretation and Modelling Results for a Late Triassic Isolated Pinnacle Reef Complex on the Exmouth Plateau, Western Australia

Jarrad Grahame*
CGG Multi-client & New Ventures
1 Ord Street, West Perth
Western Australia, 6005
jarrad.grahame@cgg.com

SUMMARY

The West Foxhound 3D survey is located approximately 200km from the north-west coast of Australia within the Exmouth Plateau, which represents the outermost structural element of the Northern Carnarvon Basin. The survey covers one of two known, isolated, Rhaetian pinnacle reef complexes that exist within the Exmouth Plateau making it of particular interest to enhance understanding of a new and under-explored exploration play.

The results presented herein are derived from the focused interpretation and analysis of the West Foxhound 3D, which makes up part of a larger, comprehensive regional Triassic study, covering the entire North West Shelf including the Northern Carnarvon, Browse and Bonaparte basins. Results of the interpretation and analysis confirm that the Late Triassic interval within Foxhound hosts a significant number of isolated pinnacle reefs with potential access to charge from underlying Triassic source rocks. The pinnacle reefs represent a new and emerging play with only one reef to date drilled as a primary target.

Key words: Exmouth Plateau, Late Triassic, pinnacle reefs

INTRODUCTION

The Carnarvon basin is an arcuate rift basin formed during the breakup of part of the continental margin of East Gondwana. The Northern Carnarvon Basin consists of onshore and offshore components, extending along the west coast of Australia, with a combined area of approximately 650,000 km². The offshore component of the Northern Carnarvon Basin is composed of three structural zones: the inboard, shallow basement Lambert and Peedamullah shelves; NE trending central horst / graben structures; and the outer Exmouth Plateau platform (Felton et al, 1993).

The Exmouth Plateau is a deep-water marginal plateau that represents the western-most structural element of the Northern Carnarvon Basin, with water depths ranging from 800-4000m. Sediment thickness within the Exmouth Plateau is known to exceed 15km, with several reservoir targets at multiple stratigraphic levels. Throughout the Late Triassic, the Exmouth Plateau was located at the southern margin of the Tethys Ocean, during a tropical to sub-tropical climatic phase which gave rise to abundant carbonate reef growth (Williamson, 1992, Metcalfe, 2013). Reef growth proliferated throughout the Late Triassic as new species of reef building organisms emerged, subsequent to the Late Permian mass extinction. The depositional environment was open marine to low-energy lagoonal, characterised by slow (nutrient rich) sedimentation (Williamson, 1992). Thick carbonate successions developed due to a combination of slow sedimentation rates and a depositional system that was able to keep pace with continued creation of accommodation space. These carbonate platforms represent large-scale depositional systems, including shoreline and platform slope settings with a range of depositional profiles including coastal, shallow marine, intra-shelf and deep marine (Tucker and Wright, 1990). Platform evolution is controlled primarily be sea level fluctuations, tectonic activity and rate of carbonate production (Williams et al., 2011).

Three known isolated reef complexes exist within the Northern Carnarvon Basin, an outboard pinnacle reef complex within the outer Exmouth Plateau, an inboard complex approximately 50km from the present day shelf break, and a platform carbonate complex beneath the Wombat Plateau. The Tiberius-1 exploration well located in the outer Exmouth Plateau is the only well to have drilled one of the Rhaetian pinnacle reefs as a primary target. The well intersected 330m of Late Triassic carbonate material, consistent with an isolated reef build-up, with wireline log evaluation indicating average porosity of 13% and higher porosity zones (Grain et al., 2013). The Foxhound survey located over the inboard complex provides rare 3D coverage of one of the isolated pinnacle reefs and is therefore an important focus element for the new regional Triassic study.

The prolific Rankin Platform and adjacent Io-Jansz field, in close proximity to the Foxhound 3D, have been the major focus for exploration. However, recent gas discoveries immediately south-west of the Foxhound 3D have extended the northerly limit of known hydrocarbon accumulations within the area.

METHOD AND RESULTS

The interpretation methodology includes a review of literature to establish a geological framework for the West Foxhound area, correlation of well formation tops with regional 2D to determine key events, mapping of key seismic events, analysis of seismic stratigraphic intervals and identification of potential traps. Regional interpretation of public domain 2D seismic data was undertaken to tie key stratigraphic intervals across the West Foxhound 3D, and to better understand tectonic elements. Nine key horizons were mapped for the Foxhound 3D to constrain stratigraphic intervals and produce depth converted surfaces, most importantly the Late Triassic pinnacle reef surface (Figure 1).

Attribute analysis and spectral decomposition were applied to investigate possible fluid effects and indications of increased porosity / permeability within the pinnacle reefs (Figure 2). Modern analogues have also been investigated to validate conclusions that many of the reefs are interconnected, based on the spectral decomposition results. Reef connectivity is an important consideration when evaluating the volumetric potential of prospects (Figure 3).

The study found that the isolated pinnacle reefs represent a potential, yet unexplored play type in this part of the Exmouth Plateau, as an extension of the hydrocarbon prolific trends to the south and east, which have previously been the main areas for exploration focus. Approximately 450 pinnacle reefs, both isolated and interconnected, can be mapped in considerable detail within the Late Triassic interval of the West Foxhound 3D. Vertical thicknesses of the reefs range from approximately 200-400m, calculated from an average p-wave velocity of 5250 m/s. A large structural closure is present at the Rhaetian level, covering approximately 75 sq. km of the northern area of the West Foxhound survey covered with a large number of reefs. The internal architecture of the reefs could not be evaluated due to inherent velocity distortions at the Triassic level.

Recommendations include: reprocessing of existing data to mitigate the effects of velocity distortions within the reefs and underlying strata; new acquisition of high quality, broadband seismic data, processed to PSDM to improve analysis and mature the area with detailed prospect evaluation; and further regional studies to evaluate source rock presence and migration potential.

CONCLUSIONS

Late Triassic carbonate build-ups on the Exmouth Plateau have emerged as a new play type, considered to be sourced from oily marine source rocks. Oil seeps on the Timor Island have been geochemically typed to outcropping marine Triassic rocks, which further suggests that there may be more of a marine influence in the distal parts of the Mungaroo Formation. Interpretation results for the West Foxhound 3D, confirm that the Late Triassic interval hosts a significant number of isolated pinnacle reefs with potential access to charge from underlying Triassic? source rocks. The Foxhound 3D is located such that hydrocarbons generated from underlying organic-rich sediments, may have migrated from the Kangaroo Syncline into Late Triassic reservoir rocks, including the Rhaetian pinnacle reefs. A prominent structural closure exists within the northern area of the survey covered with a large number of reefs, providing potential for hydrocarbon accumulation. The presence of sealing units at the top Triassic interval overlying this closure, is unclear; however Early Jurassic intra-formational marine muds and shales with sufficient thickness may be present.

Limitations of the analysis can be attributed to low seismic resolution resulting from limited bandwidth and frequency content, as well as significant velocity distortion throughout the Triassic interval. Strong velocity pull-ups below the Triassic level may be reduced by appropriate velocity model building and application of PSDM. The amplitude absorption can be compensated by using a Q-PSDM or FWI approach. Further regional studies, focusing on Mesozoic petroleum systems and paleogeography would be of great benefit to evaluate source rock presence and migration potential in this area. Better well control at the Triassic level in this area would be greatly beneficial to constrain stratigraphic events.

The study finds that the isolated pinnacle reefs are present in significant number and size throughout the Foxhound survey and represent a potential new play type in this part of the Exmouth Plateau. The West Foxhound 3D survey reveals potential for further discoveries in this part of the Exmouth Plateau as an extension of existing active petroleum systems in the area. Improvements in seismic data quality and coverage considerably enhance interpretation of the Triassic-Jurassic fault blocks, where reliable data is crucial to detailed prospect evaluation. Hydrocarbon charge and reservoir quality of the Late Triassic reefs represent the most important considerations that should underpin further exploration of this emerging play type.

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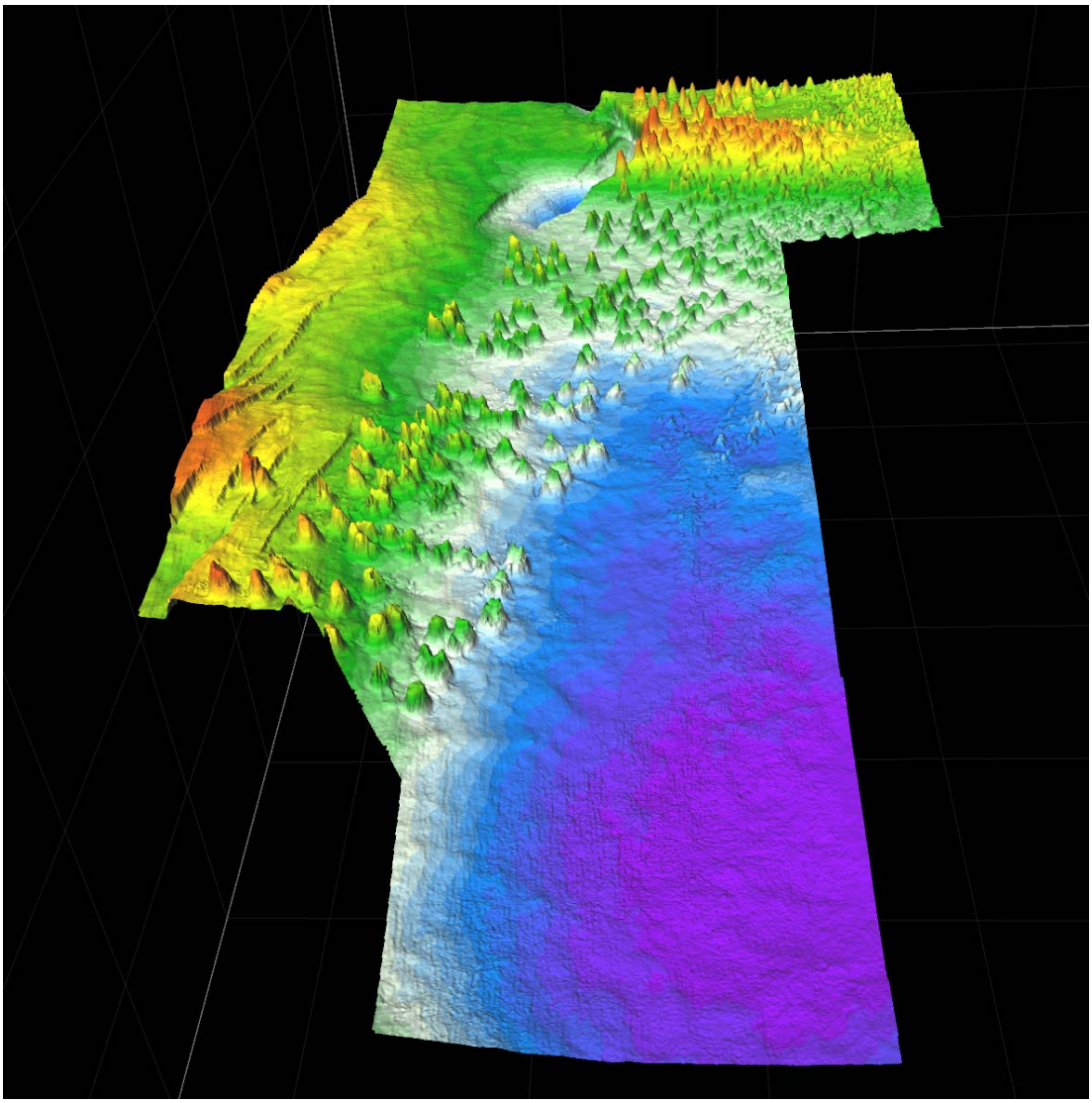

Figure 1. Foxhound 3D - interpreted Rhaetian pinnacle reef surface

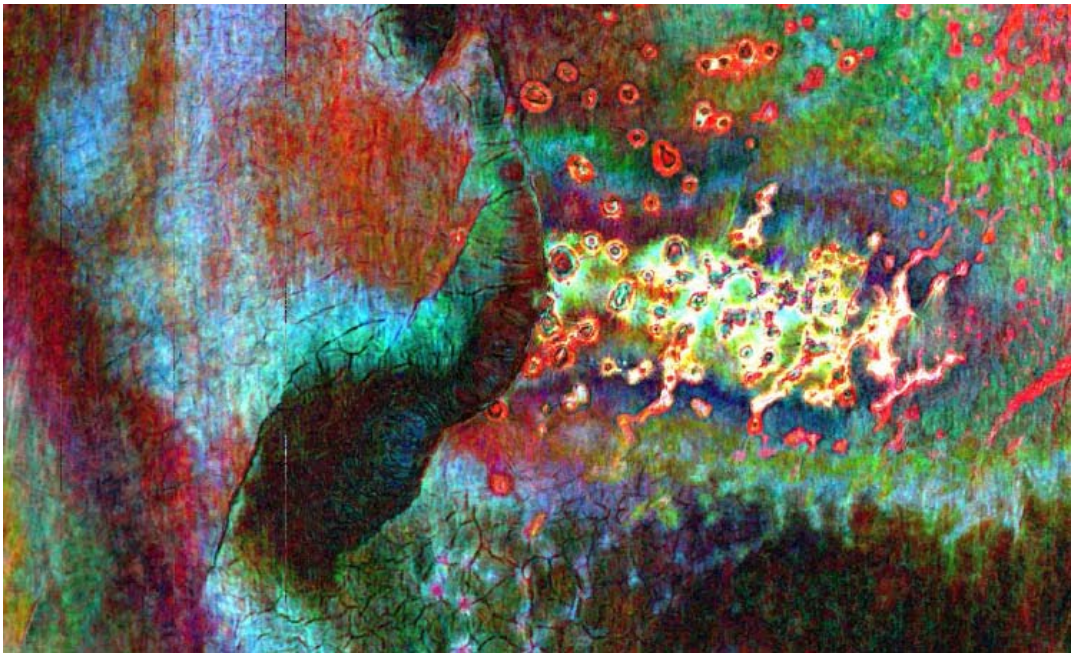

Figure 2. Foxhound 3D - Spectral decomposition indicating reef connectivity

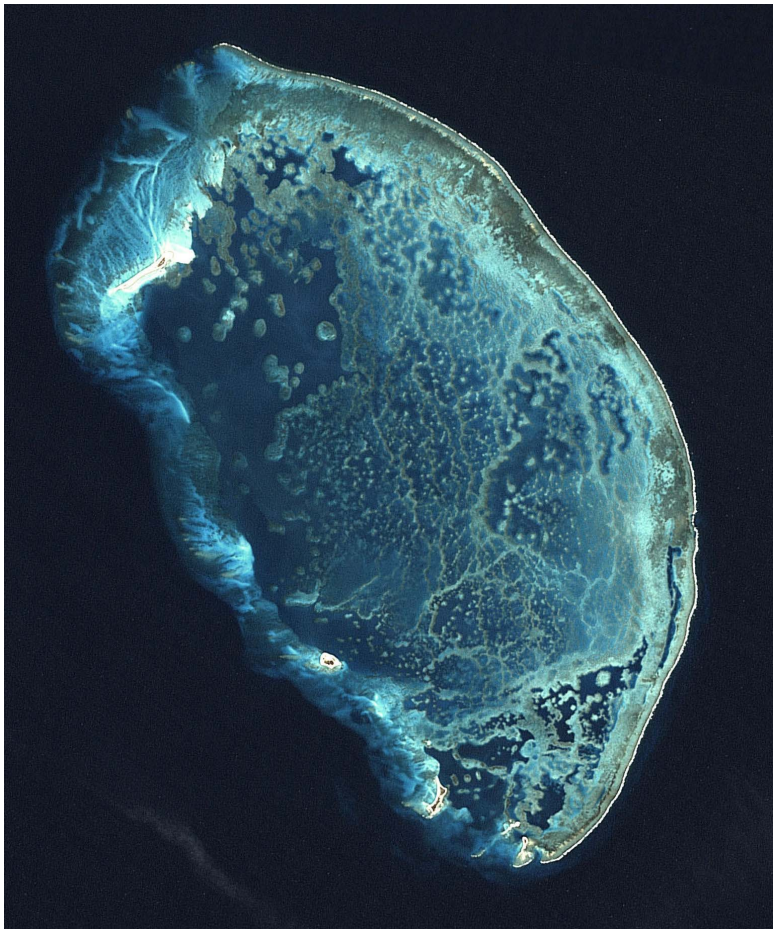

Figure 3. Modern analogue – satellite image of the Alacran reef