Sedimentological Lithofacies, Internal Architecture and Evolution of Deep Marine Fans of the Tithonian Angel Formation, Northwestern Dampier Sub-basin, North West Shelf, Australia

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This thesis is submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Faculty of Science, The University of Adelaide

Abstract

This thesis examines the sedimentological processes, internal architecture and depositional evolution of the deep marine Tithonian succession of the Angel Formation located within the Dampier Sub-basin on the North West Shelf of Australia. It is a mature basin containing 149 hydrocarbon fields with combined reserves of 34tcf of gas, 1037mmbbls of condensate and 633mmbbls of oil within fluvio-deltaic and deep marine reservoirs. The rationale of this research is to improve current understanding of the highly prosperous deep marine reservoirs whose architecture is primarily of sub-seismic resolution. It was accomplished using lithofacies classifications and the establishment of an architectural scheme comprising seven orders in combination with wireline, biostratigraphic and seismic reflection data and applicable analogues.

Eleven cores totalling 547 metres were analysed to identify sedimentological processes responsible for the deposition of the Angel Formation and to develop lithofacies schemes. The depositional lithofacies scheme contains six types formed through the deposition of quasi-steady high density turbidity flows and debrites. The lithofacies scheme for deformed sediments contains five types generated by post-depositional sediment movement, including soft sediment slumping and subsurface remobilization. These core-scale lithofacies represent first and second order architectural elements.

Third order architectural elements are represented by seven lithofacies associations. They are grouped into two categories dependent on their association with channelisation. Channelised lithofacies associations include crevasse splays, channel axis units, channel margin units, and channel abandonment units. Unchannelised lithofacies associations include proximal sand-dominated frontal splays, distal silt-dominated frontal splays and splay abandonment units.

Third order lithofacies associations are grouped into fourth and fifth order architectural elements that represent the development of composite channel-splay or sheet complexes. A fourth order architectural element is represented by a single storey migrational channel feature. Five differing fifth order architectural elements are separated into two complexes dependent on their degree of internal channelisation. A composite channel-splay complex comprises stacked fourth order channel forms that develop through multiple episodes of infilling and reincision. They are overlain by retrogradational splay or lateral channel margin deposits dependant on their place within a sixth order setting. A composite sheet complex comprises solely of stacked progradational and retrogradational splays.

Sixth order architectural elements group multiple fifth order complexes amalgamated through autocyclic processes into allocyclic successions bound by sequence boundaries and maximum flood events. Sixth order progradational models are related to early and late lowstand time. Stacked fifth order architectures deposited during sixth order progradational cycles display high net to gross sandstones, low channel sinuousity and increased amalgamation of channel forms. Sixth order aggradational and retrogradational models are related to transgressive periods. Stacked fifth order architectures deposited within these systems become increasingly clay-rich, are more sinuous, have

more avulsive events as channels aggrade above the equilibrium profile, and become less amalgamated as fourth order channel forms decrease in size and become interbedded with sheet complexes.

Sixth order architecture and seventh order fan evolution is examined using a combination of fifth order stacked architectures, wireline and seismic data. The Parker Terrace, which contains the Mutineer, Lambert, Egret and Montague fields, contains a seventh order system that comprises curved, coalescing fan systems up to 15 kilometres long separated by up to six lowstand events. The central Dampier Sub-basin, which contains the Angel, Cossack and Wanaea fields, contains a seventh order fan system up to 50 kilometres long also separated by up to six lowstand events. This regional architectural analysis demonstrates that the majority of sediment in the Dampier Sub-basin during Tithonian time was deposited along the basin's central axis. Additional sediment was sourced from the Rankin Trend in the west to form small fan systems along the Parker Terrace.

Non-depositional processes play a critical role in the lateral distribution and post-depositional subsurface profile of architectural elements. Active tectonism may have influenced lithofacies distribution and the location of feeder complexes in the Angel, Egret and Montague fields. Subsurface remobilisation of sandstones led to the formation of clastic injectites in fields along the Parker Terrace and sub-vertical polygonal fault injectites in fields within the central basin axis. These features can influence the lateral and vertical connectivity of depositionally independent reservoir intervals.

The high resolution sub-seismic scaled architectural system can be applied in combination with seismic interpretation to help constrain the exploratory risk of stratigraphic plays. Furthermore, it can assist future development programs of discovered hydrocarbon accumulations by enhancing knowledge of lateral architectural variability away from the borehole.

Declaration

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Acknowledgements

I would like to acknowledge the following people:

i. Supervisors Dr Richard Daniel and Dr Bruce Ainsworth at the Australian School of Petroleum and Dr Tobi Payenberg at Chevron Energy Technology Company Perth for supporting, quality controlling and providing feedback on the interpretation and final thesis.

ii. Dr Simon Lang of Woodside Energy Ltd for his general support.

iii. Neil Tupper, Glenn Scotford and Tim Cotton of Santos Ltd for providing data.

iv. Dr Scott Mildren and Dr Jerry Meyer of JRS Petroleum Research for the use of in-house log interpretation software.

v. The students and general staff both in the Australian School of Petroleum and the Geology and Geophysics Department of the University of Adelaide.

Financial support was gratefully received from the following organisations.

i. The Australian Government and the University of Adelaide for the Australian Postgraduate Award (APA) to undertake this research.

ii. The Australian Research Council (ARC) for the Deepwater Discovery Grant.

iii. The American Association of Petroleum Geologists (AAPG) and the family of Archie Augustus for the International Archie Grants-In-Aid award. Please continue to support the scheme.

iv. The Petroleum Exploration Society of Australia (PESA) for the 2007 Federal Postgraduate Prize.

The greatest words of appreciation belong to my family residing in Melbourne.

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