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Reservoir Characterisation of the Jurassic Springbok Sandstone, Surat Basin, Queensland

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This thesis is submitted in partial fulfilment of the requirements for the
Honours Degree of Bachelor of Science (Petroleum Geology and Geophysics)

Australian School of Petroleum,
University of Adelaide

November 2012

Abstract

The Late Jurassic Springbok Sandstone unconformably overlies the mid-Jurassic Walloon Subgroup in the northeastern region of the Surat Basin, Queensland. The Walloon Subgroup contains significant economic coal seam gas (CSG) reserves which are currently under significant development. Development of CSG for production requires the extraction of significant volumes of water from the coal seams to enable the gas to flow. The dewatering process has the potential to affect the Springbok Sandstone as it may be in hydraulic connection with the coal seams. The aim of this study is to characterise the reservoir quality, stratigraphic architecture and primary geologic controls on the Springbok Sandstone in order to gain an understanding of the potential for hydraulic interaction with the underlying coal measures. The depositional characteristics of the Springbok Sandstone were evaluated by analysing wireline line logs and the cored intervals of wells, and the petrology and reservoir quality of the lower section of the Springbok Sandstone was conducted through statistical analysis of thin sections, XRD data and RCA data.

The Springbok Sandstone has been previously interpreted as a thick sequence of channel sands interbedded with relatively minor quantities of heterolithic sandstone, siltstone, mudstone and coal lithologies deposited in a vast intracratonic alluvial plain in warm temperate conditions. Core and wireline log analyses indicate that the Springbok Sandstone typically consists of a thin, low-permeability blocky basal sandstone and two major fining-upwards sequences, each consisting of channel sands at the base that fine-up into overbank and mire environments. An erosional unconformity exists at the base of the Springbok Sandstone and between each intraformational unit. The basal sandstone has been heavily eroded in the west of the study area by the later succession of channel sands. This lower section of the Springbok Sandstone appears to have been deposited in a high-energy braided stream environment, while the upper section of the Springbok Sandstone was deposited in a lower energy meandering stream environment. Isopach maps suggest that paleoflow was towards the centre of the basin and that there may have been syndepositional deformation of the basin during the Late Jurassic.

The geologic controls on the detrital composition and diagenesis of the Springbok Sandstone are complex. Analysis of thin sections indicates that the sediment in the lower Springbok Sandstone section is generally medium grained, well sorted and mineralogically immature volcanogenic feldspathic litharenite to litharenite. The formation contains abundant well preserved lithic clasts, feldspars and biotite. The small sample size and mixed sediment

composition of volcanic, plutonic and metamorphic fragments and post-depositional alteration precluded conclusive petrographic provenance analysis. High clay contents are present in the volcanic-rich sediments, predominantly including kaolin and highly smectitic mixed-layer illite interlayers, indicating that the formation may be freshwater sensitive.

The reservoir quality of the lower section of the Springbok Sandstone is principally controlled by depositional environments, detrital mineralogy, clay alteration and cementation, and ranges from poor to excellent. These controls are highlighted by the relationship between lithofacies, grain size, grain composition and diagenetic alteration. The highly heterogeneous cyclic nature of the Springbok Sandstone has made correlation and prediction of reservoir properties difficult. Reservoir quality tends to increase as grain size increases and is best developed in medium to coarse sandstones while lower energy depositional facies have substantially lower permeabilities. The basal calcite cemented sandstones potentially represent a sealing lithology however the unit is not laterally extensive across the study area. The areas with the highest risk of reservoir connectivity between the Springbok Sandstone and Walloons Subgroup were identified where porous sands directly overlie the Walloon Subgroup, particulary in the west of the study region.

Autocyclic processes were the primary driver for much of the local scale composition variation, which was largely a function of hydrodynamic sorting. Tectonic and climatic influence is also evident in the stacking pattern of the Springbok Sandstone succession. Mechanical compaction reduced the porosity and permeabilty of sandstones containing high labile grain content. Cementation involved early stage glaucony, pyrite, chlorite and siderite mineralisation, followed by later stage dissolution and kaolinisation of labile grains, illitisation of clays, fracture formation and poikilotopic calcite mineralisation. Diagenetic processes have diminished the reservoir quality of the deeper sandstone samples. Reservoir quality tends to reduce with increased burial, although moderate to high porosity and permeability are still observed at depth.

The results of this study highlight the heterogeneous nature of the Springbok Sandstone. The formation comprises a series of heterogeneous sandstone and mudstone units with variable reservoir quality. The stratigraphic and depositional trends identified in the stratigraphy, sandstone composition and reservoir quality of the Springbok Sandstone can be used in future predictive reservoir modelling.

Confidentiality Statement

Due to a confidentiality agreement between QGC Pty Ltd and the Australian School of Petroleum this thesis is not available for public inspection or borrowing until the 7th of December, 2014.

Acknowledgements

Firstly, I would like to thank QGC for the opportunity to undertake this project and for allowing me to continue to use their facilities for the duration of my work. My time in the QGC offices has provided valuable insight into the petroleum industry and the variety of roles a geologist can play, both within a team and throughout the company. I am also grateful to QGC for providing me with financial support and access to software, technical reports and the data needed for this thesis. I would particularly like to thank Damien Ryan for his guidance and vast expertise in this field of study, and the rest of the QGC Development Team for their advice and technical assistance.

I also thank John Kaldi for his valuable academic supervision and support throughout the semester and for his willingness to make time in his schedule for any query. Thanks to all the staff at the Australia School of Petroleum for their assistance throughout the year, specifically Kathryn Amos for the coordination of the coursework and honours projects and Maureen Sutton for her excellent admin support.

I must thank my family for supporting me throughout my tertiary education. I appreciate all the support and sacrifices they have made to provide me with the opportunity to pursue my dreams. I also thank my friends, both old and new, for all the interesting, educational and altogether enlightening experiences over the past few years.

Finally, I must express my gratitude to my partner for enduring my obsession with this project over the past semester and for his support of my move to Adelaide to pursue this degree. Your ongoing encouragement and support means the world to me. Thank you.

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