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

Victoria Gallagher (B.App.Sc)
Queensland University of Technology

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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 mineralologically 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 permeability 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 poikilitopic 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.
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