Petrophysical study of Shale gas potential from the Permian Roseneath and Murterere Formations in the Cooper Basin, Australia.

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INTRODUCTION
During the Late Carboniferous and Early Permian a number of intracratonic basins were initiated on the Gondwana age part of the Pangean Supercontinent. The Cooper Basin is one of the largest of Australia's Gondwana intracratonic basins, and extends from northern South Australia into south-western Queensland covering approximately 130,000 km². The South Australia part of the basin is divided into three major depocentres, the Patchewarra, Nappamerri and Tenanparra troughs. The troughs are separated by two structural highs, the exoceanic complex, Goyder-Marnielma-Inminucca Ridge, and the smaller more central Murteree Ridge (Gravesock, et al, 1998; Hill and Gravesock, 1995). The ridges consist in the main of fault ruptured asymmetric anticlines that are generally eroded and devoid of marine sediments. Like most intracratonic settings, the Cooper Basin is polyphase and contains a thick Permain (1600m) to Triassic succession of fluvial, lacustrine and, at the base, glacial rocks. The succession overlies, in part, the early Paleozoic rocks of the Warburton Basin and in turn overlies by the Jurassic to Cretaceous rocks of the Eromanga Basin.

Study Data
Well data was analysed for structure, mainly shale volume, computed TOC curve, level of maturity, water saturation and hydrocarbon model. Due to lack of core data, conventional well data was used and it was not possible to identify the types of clays and minerals that might have been present. It was also not possible to obtain data such as grain size distribution, porosity and permeability distribution. Hence calibration of the log data to any meaningful reservoir parameter was untenable. The parameters derived therefore, were regarded as approximates. Shale volume was evaluated using Gamma Ray through the well, minimum and maximum values within clean sands and shales.

Methodology

Porosity:
Porosity was calculated by sonic data and used Wylie's equation as follows:

- Average porosity: PHIS = (DT - DTMa)/ (DTIa - DTMa).
- Effective porosity: PHE = PHT - 1/3 (Vshale).

An average porosity of 11% was calculated by sonic log with effective porosity of only 6% in the Roseneath formation and 5% effective porosity in the Murterere Formation.

Water Saturation:
Water saturation was calculated by Archie and Indonesian equations. An average 70% of water saturation was calculated in the Roseneath and 66% in the Murterere Formation.

Total Organic Carbon(TOC) of shale
Murterere and Roseneath Shale horizons were evaluated for organic richness and petroleum source potential using the DLog method applied to porosity and resistivity borehole geophysical logs with thermal maturity data taken from Vitrine resistance data, (Beach Energy, 2010). Profiles of TOC determined by the DLog method are reported for eight wells. In some parts of these wells, the DLog TOC profiles compare well with laboratory measured TOC results, and gamma ray logs.

The TOC of the source rock intervals is then calculated based on the DLog separation measured in logarithmic resistivity cycles and thermal maturity expressed as level of organic maturity(LOM) using the following empirical relationships (Passey et al., 1990).

\[ \text{DLog} = \text{LOG}(\text{LLD/RESDB}) - 0.02/0.07(\text{DTB}) \]

TOC = 100DLog * 10^(-0.297-1.668LOM)

Where laterolog deep (LLD) is resistivity measured on ohm-m by the logging tool, sonic (DT) is the measured transit time in µsec/ft, resistivity baseline (RESDB) is the resistivity corresponding to the sonic baseline (DTB) value when the curves are baselined in non-source, clay rich rocks, and 0.02 is based on the ratio of -50 µsec/ft per one resistivity cycle. The LOM is the level of organic maturity of shale.

Conclusion

TOC analysis on borehole cuttings is the best method to check for TOC determined by DLog calculations, because they both represent an interval average through the whole core, and is usually greater than ~1m resolution of the DLog values. Therefore, in heterogeneous sections, cuttings are better for comparison of validation from TOC data from a point source, such as core.

This initial study is not enough to declare the Roseneath and shale Murterere as potential shale gas reservoirs, but the data suggest that the Shales of the Roseneath and Murterere Formations do have potential as a source rock.

Acknowledgement
I am very grateful to Geoscience South Australia who provided well log data for this study. Jadon would like to acknowledge Prof.Tom Blinkinson, Prof. Paul Dirks, Dr. Raphael Wust Technical advisor Trican Alberta Canada.

References