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

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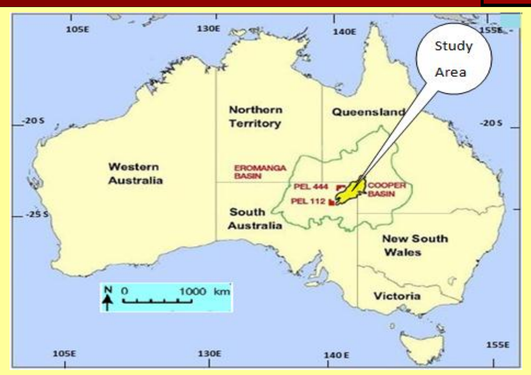

Fig.01: Location of the Australian Cooper Basin showing the extent of shale outcrop, (Adapted from Kukraa et al., 2010, reference 6.)

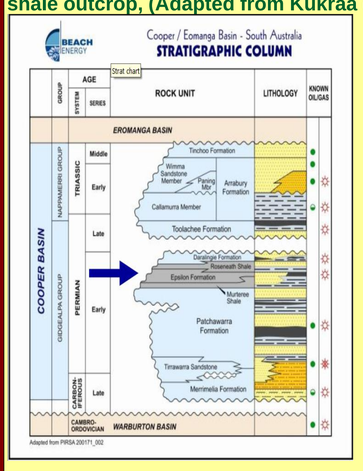

Fig.02: Stratigraphic section of the Cooper Basin (Beach Energy, 2010) arrow is showing the Murteree and Roseneath Formations.

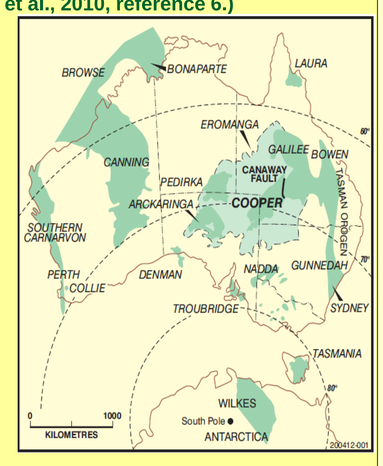

Fig.03: The Cooper Basin in relation to other Australian Gondwana sedimentary basins and late carboniferous palaeolatituds.

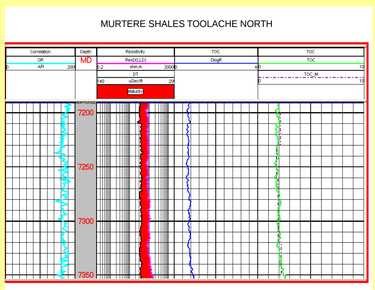

Fig.04: Computed generated curve for the TOC based on sonic and resistivity logs by ΔlogR method from the Murteree shale unit in the Toolachee North -01 well.

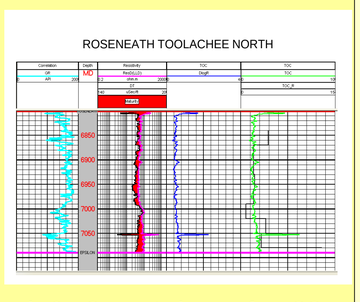

Fig.05: Computed curve for TOC based on sonic and resistivity logs using the ΔlogR method from the Roseneath Shale in Toolachee North-01 well.

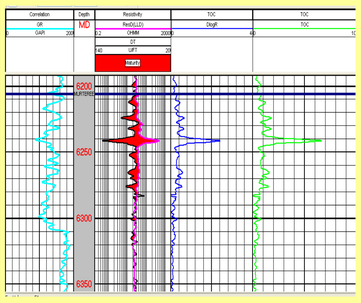

Fig.06: Computed curve for TOC based on sonic and resistivity logs using the ΔlogR method from Murteree shale unit in Murteree-02 well.

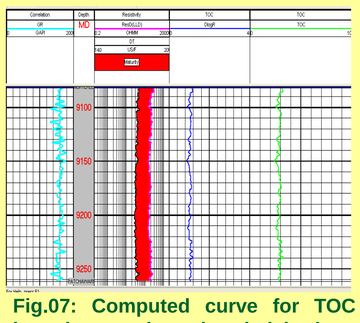

Fig.07: Computed curve for TOC based on sonic and resistivity logs using the ΔlogR method from Murteree shale unit in Moomba-73 well.

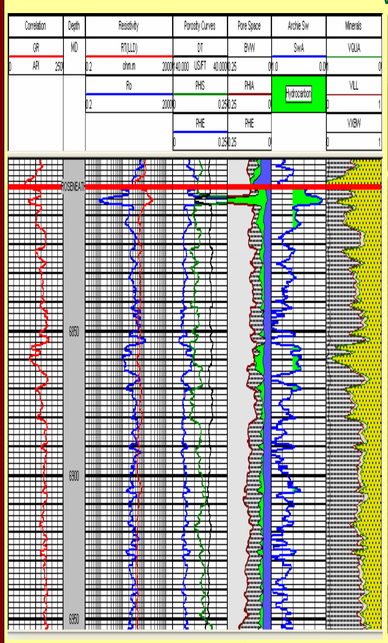

Fig.08: Answer Log Toolachee North 1 showing Roseneath shale's sweet spots at depth of 6800 ft, to 6820ft and 6850 to 6870ft.

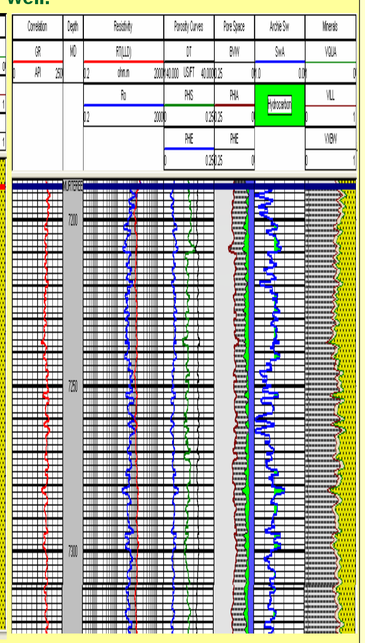

Fig.09: Answer Log Toolachee North-01 showing Murteree shale's sweet spots at depth of 7200 to 7210ft, and 7280 to 7300ft.

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 Gondwanan intracratonic basins, and extends from northern South Australia into south-western Queensland covering approximately 130,000km^2.The South Australia part of the basin is divided into three major depocentres,the Patchwara, Nappameri and Tenappera troughs. The troughs are separated by two structural highs, the elongate complex, Gidgealpa Merrimelia-Innmincka Ridge, and the smaller more quant Murteree Ridge (Gravesock, et al.,1998; Hill and Gravestock,1995).The ridges consist in the main of fault-ruptured asymmetric anticlines that are generally eroded and devoid of early Permian sediments. Like most intracratonic settings, the Cooper Basin is polyphase and contains a thick Permian (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 overlain by the Jurassic to Cretaceous rocks of the Eromanga Basin.

Study Data

Well data used for analysis include the well history, mud log, Sonic(DT), Resistivity(LLD), Gamma ray(GR), Caliper bore-hole log. Total Organic Carbon(TOC) curve has been generated from well log data using Prizm GGX(Geographix software), Landmark Resources (LMKR).

Methodology

The primary evaluation was based on models, namely 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, been regarded as approximates.

Shale volume was evaluated using Gamma Ray through the well, minimum and maximum values within clean sands and shales.

Shale Volume(Vshl)

The linear shale volume methodology is applied to calculate the shale volume.

Volume of shale = (GR_{log} - GR_{clean}) / (GR_{shale}-GR_{clean})

The values for Gamma ray(GR) parameters are:

Gamma ray clean; GRcln = 100 API

Gamma ray shale; GRshl = 180 API

As GR is high throughout the target formations a minimum GR_{clean} and maximum GR_{shale} was used. We correlated Vshale results with XRD results showing quartz percentage above 40% in the target formations. The average Vshale across Roseneath Formation is 47% and 57% in Murteree Formation.

Porosity:

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

Average porosity; PHIS= (DT - DTma) / (DTfld - DTma).

Effective porosity; PHIE=PHIT*(1-volume of shale).

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 Murteree Formation.

Water Saturation:

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

Total Organic Carbon(TOC) of shale

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

Toolachee North-01 was the only well containing both full log suit and geochemical studies. TOC was calculated using logs and laboratory (Fig.04 - 07). The TOC profiles best fit Murteree Shale where both overlay each other, the parameters were noted and used consistently in all wells.

The TOC of the source rock intervals is then calculated based on the ΔlogR 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).

ΔlogR = LOG(LLD/RESDB)+0.02*(DT-DTB)

TOC = 100* ΔlogR * 10^(0.297-0.1688*LOM)

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 ΔlogR calculations, because they both represent an interval average even though the interval of the cuttings is usually greater than ~1m resolution of the ΔlogR values. Therefore, in heterogeneous sections, cuttings are better for comparison of validation than TOC data from a point source, such as core.

❑This initial study is not enough to declare the Roseneath and shale Murteree as potential shale gas reservoirs, but the data suggest that the Shales of the Roseneath and Murteree 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. Jadoon would like to acknowledge Prof.Tom Blenkinsop, Prof.Paul Dirks, Dr. Raphael Wust Technical advisor Trican Alberta Canada.

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❑Beach Energy, 2010, Petroleum resources in Cooper Basin South Australia.

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❑ Serra.O., 1984, Fundamentals of well log interpretation.

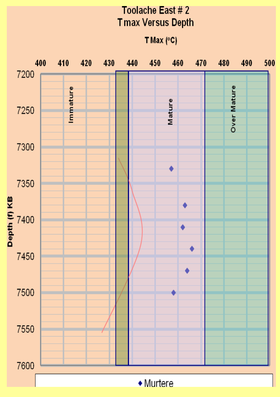

Fig.10: The Murteree shale at depth 7320 to 7550 ft is showing maturity .

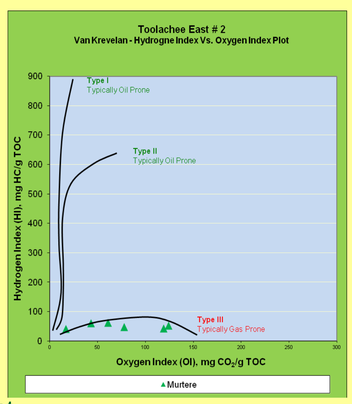

Fig.11 : Toolachee East -02 the Murteree Shale plots within the gas prone area.

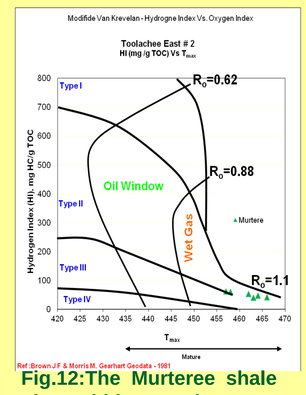

Fig.12:The Murteree shale plots within type three wet to dry gas zone.

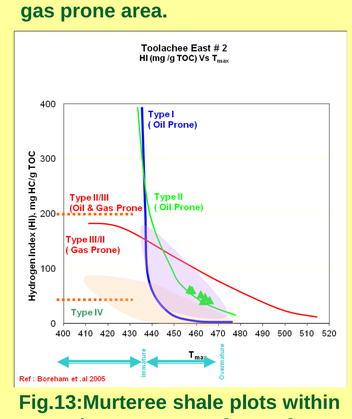

Fig.13:Murteree shale plots within type three to type four of gas prone area.

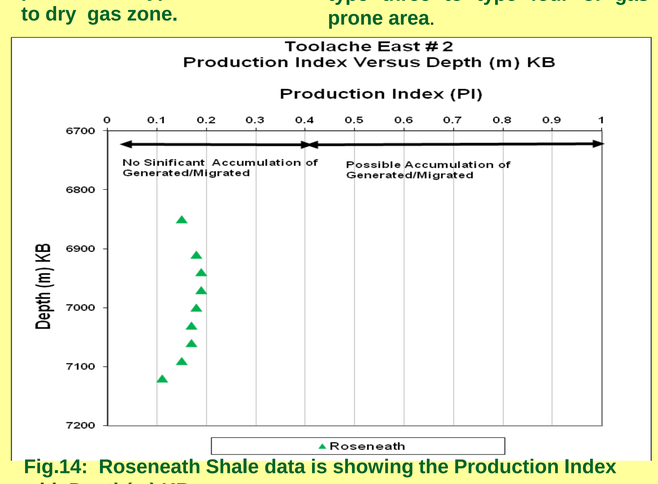

Fig.14: Roseneath Shale data is showing the Production Index with Depth(m) KB.

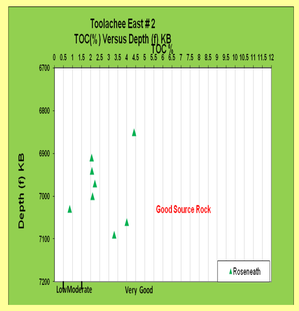

Fig.15 : Roseneath shale is showing the low moderate to very good source rock.

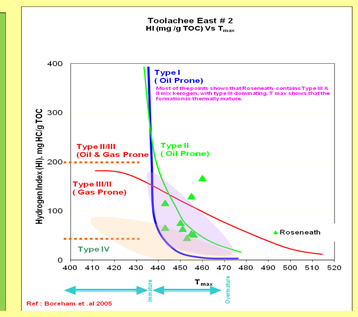

Fig.16: The Roseneath shale plots in type three to type four of gas prone area.

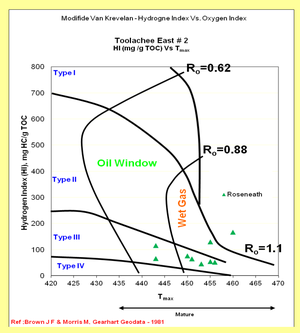

Fig.17: The Roseneath shale plots within type three wet to dry gas zone.

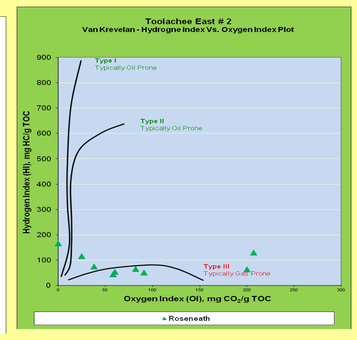

Fig.18: Toolachee East -02 the Roseneath Shale plots typically gas prone area.

Oxygen Index	
> 50	Oil
50-100	Oil & Gas
>100	Gas
Tmax	
<435	Immature
435-470	Mature
>470	Over Mature

Genetic potential	
< 2.5 mg/g	Non Source
2.5-5 mg/g	Fair source
<5 mg/g	Good source