DEPOSITIONAL CONTROLS ON SOURCE ROCK QUALITY AND HYDROCARBON POTENTIAL OF TERTIARY DELTAIC SEDIMENTS IN BRUNEI DARUSSALAM.

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Brunei Darussalam is situated on the north-western flank of Borneo. The country has over 85 years of petroleum exploration and production history with estimated recoverable reserves in excess of 8 billion boe (Wood Mackenzie 2014). The majority of these volumes reside in 10 to 14 km thick Neogene sandstones deposited from three different deltas systems within the Baram Delta Basin.

Studies to date in the basin have been unable to identify a source rock capable of generating Brunei's significant oil and gas volumes (Sandal, 1996; Curiale 2000). Geochemical characteristics of the produced gas and oil indicate an origin from terrigenous organic matter (Curiale, 2000). While it is clear that this terrestrial material is fed from the delta's source, the environment of deposition, preservation and burial within the delta and prodelta system is not widely understood (Sandal, 1996).

In this study, we evaluated a suite of rock/coal outcrop samples covering a range of different interpreted depositional settings. Samples were submitted for standard source rock analysis, state-of-the-art geochemical characterisation and detailed organic petrographic analysis. The objectives of the work were to determine how source rock richness and quality vary within a broader depositional context (focusing on *in-situ* versus transported deposition/preservation) and, *ipso facto*, to better understand the hydrocarbon potential of Tertiary deltaic sequences under current and future exploitation for petroleum development in the country.

Samples were collected from eight different outcrop locations near the capital city Bandar Seri Begawan. The sample set was classified into *in-situ* and transported coals/coaly shales (IC and TC, respectively) and prodelta shales (DS). The transported samples were further sub-divided into two distinct groups, *viz*. coal/coaly shale clasts in a sandstone matrix (TCC) and finely disseminated coals/coaly shales (including leaf fragments) in a sandstone matrix (TCF).

IC samples were found to have total organic carbon (TOC) contents of up to 66 wt % (average 13 wt %) and hydrogen index (HI) values up to 259 mg HC/ g TOC (average 133 mg HC/ g TOC). TCC samples displayed TOCs up to 61 wt % (average 26 wt %) with HIs as high as 318 mg HC/ g TOC (average 191 mg HC/ g TOC), while the TCF group displayed TOCs up to 8 wt % (average 3 wt %) and HIs up to 127 mg HC/ g TOC (average 78 mg HC/ g TOC). For the DS category, TOCs were less than 1 wt % and HIs less than 100 mg HC/ g TOC. All samples analysed were found to be thermally immature ($\%R_o \approx 0.5$; $T_{max} < 430^oC$), free of contaminants and largely unaffected by weathering processes.

Petrography results indicated vitrinite was the most abundant maceral in all samples. Liptinite content between 7 and 24 vol % on kerogen basis for both the IC and TCC/TCF sample sets. Cutinites and resinite were the main liptinite maceral groups identified.

Pyrolysis GC and Pyrolysis GC-GC using both FID and SCD detection indicate presence of a broad range of liquid hydrocarbon molecules.

In summary, geochemical and petrographic analyses indicated that source rock and hydrocarbon potential exists in both the *in-situ* and transported depositional settings evaluated from the onshore outcrops in Brunei Darussalam. The prodelta shales displayed only minor source potential with a propensity for generating gas. The IC and TCC samples showed higher quality and greater liquid potential over the TCF. However, it is notable that any source or liquid hydrocarbon potential is recognised in the delta shelf transported organic matter. These results indicate that the thick Tertiary clastics of Brunei cannot be excluded as being responsible in total or in part for the present day accumulations of liquid and gas in Brunei Darussalam, and that a dispersed source rock model might yet be the most accurate depiction of the active source rock system within the Baram Delta petroleum system.

Wood Mackenzie (December 2013) Brunei Darussalam Upstream Summary.
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