



Research paper

Organic geochemical and petrographic characteristics of Neogene organic-rich sediments from the onshore West Baram Delta Province, Sarawak Basin: Implications for source rocks and hydrocarbon generation potential



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ABSTRACT

The Neogene succession of the onshore petroleum prolific West Baram Province of North-West Borneo contains organic-rich sediments particularly within Sarawak Basin. Bulk and quantitative pyrolysis results, coupled with organic petrographic characteristics of Neogene organic-rich sediments have enabled investigation of the source rock characteristics and evaluation of the hydrocarbon generation potential. The results were used to assess the quantity of organic matter, kerogen composition, thermal maturity and type of petroleum that could possibly be generated from these Neogene sediments.

The total organic carbon (TOC) contents of the Neogene sediments range between 1.06 and 11.11 wt. % and Hydrogen Index (HI) values are largely below 105 mg HC/g TOC, suggesting that the sediments are organically rich and contain gas-prone Type III kerogen. This kerogen type is supported by the abundant terrestrial materials (i.e., vitrinite phytoclasts, spores and pollen), low atomic hydrogen-to-carbon atomic (H/C) ratio and high abundance of aromatic hydrocarbons in Pyrolysis GC pyrograms and would likely generate mainly condensate and gas. The analysed samples have vitrinite reflectance in the range of 0.39–0.48 %Ro and pyrolysis T_{max} in the range of 401–434 °C which indicate that these Neogene sediments contain immature to very early-mature organic matter. This implies that these onshore sediments have not been buried to a sufficient depth, however the offshore stratigraphic equivalent of these sediments are known to have been buried to deeper depth and could therefore act as an effective petroleum source rock in particular for natural gas.

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1. Introduction

The West Baram Delta of NW Borneo (Fig. 1) is known to be a petroleum prolific basin (Rijks, 1981; Tan et al., 1999). Within this onshore area, the Neogene sedimentary successions has been grouped into the Lambir (Middle-Late Miocene), Miri (Middle–Late Miocene) and Tukai (Late Miocene–Early Pliocene) formations which are equivalent to the oil bearing Cycles V and VI in the offshore area (Fig. 2). There have been three hydrocarbon discoveries in the onshore West Baram Province, Sarawak, i.e., the

Miri Anticline in 1910, Asam Paya in 1989 and the recent discovery of Adong Kecil West reported to produce over 440 barrels of crude oil per day and 11.5 million standard cubic feet of gas per day (PETRONAS, 2013). To date, the West Baram Delta petroleum system has never been truly defined despite prolific hydrocarbon occurrence, often fraught by the inability to identify discrete source intervals (Rijk, 1981; Anuar and Hoesni, 2008). Preliminary oil-source rock correlations in the offshore indicate a Late Miocene coastal–fluvial shale interval as a potential source rock (Anuar and Hoesni, 2008). Previous source rocks studies was performed on Tertiary sediments of the Sarawak (e.g., Abdullah, 1999, 2003; Hakimi and Abdullah, 2013; Hakimi et al., 2013a,b). The Nyalau Formation was identified as the major source rock unit and its source rock character was expected to be regionally

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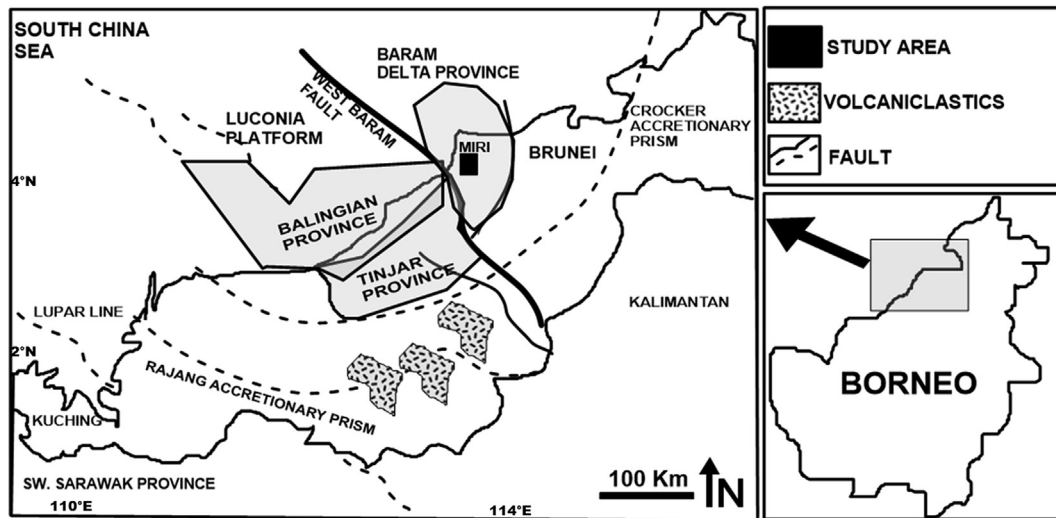


Figure 1. Geological Province map of Sarawak showing the study area within the West Baram Delta Province (modified after Hall and Nichols, 2002).

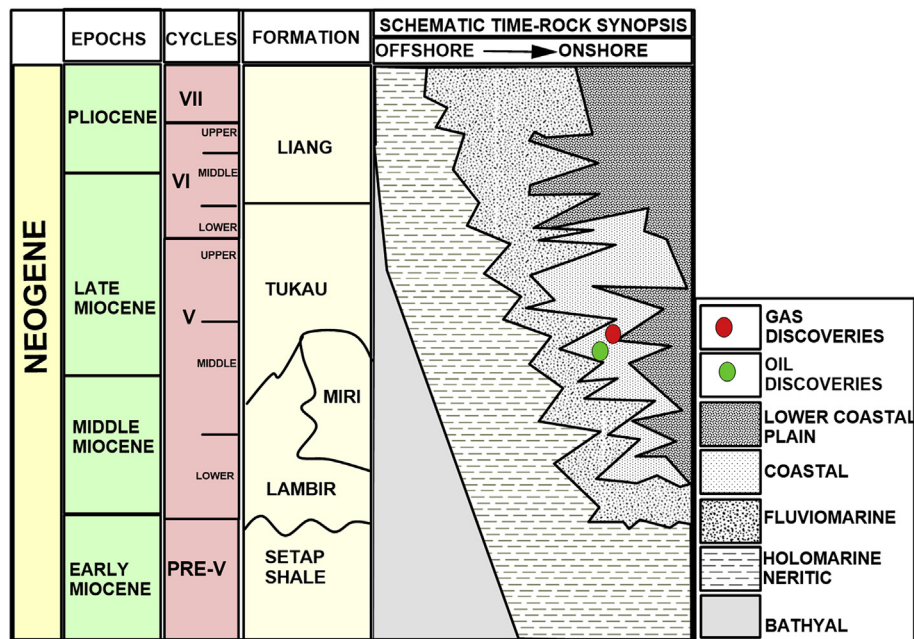


Figure 2. Stratigraphic Synopsis of the West Baram Delta Province (modified after Leichti, 1960; Rijks, 1981; Hutchison, 2005).

extensive throughout the Sarawak Basin (Abdullah, 1999, 2003; Hakimi and Abdullah, 2013; Hakimi et al., 2013b). The Nyalau shales have been interpreted to be mainly gas-prone (e.g., Abdullah, 1999), whereas Nyalau coal and carbargilite sediments are known to have higher potential for liquid hydrocarbon generation (Abdullah, 1999, 2003; Hakimi and Abdullah, 2013; Hakimi et al., 2013b). Several studies had also been performed on the basin's source rock potential and level of thermal maturity of the organic matter (e.g., Sia and Abdullah, 2012; Hakimi et al., 2013a). Hakimi et al. (2013a) suggested that the upper Miocene to Upper Pliocene coals from Balinian and Liang formations in the northwest Sarawak are mainly gas-prone source rocks. However, the geochemical characterization of the source rocks in the West Baram Delta Province has received less attention (e.g., Tan et al., 1999; Warnier et al., 2011). Tan et al. (1999) and Warnier et al.

(2011) have concluded that the oil-bearing sedimentary strata of the Miri oilfield possibly correspond to upper Cycle IV to Cycle V of the offshore stratigraphic units (Fig. 2). The aspects related to source rock and hydrocarbon characterisation of the Tertiary sediments in the onshore West Baram Delta Province are lacking. In this respect, the onshore Neogene organic-rich sediments (Lambir, Miri and Tukai formations) are evaluated for source rock properties and hydrocarbon generation potential. The aim of this current study is to determine the organic matter content, kerogen composition, thermal maturity and petroleum type that might be generated based on organic geochemical and petrological methods. The outcome of this study would provide relevant information for better understanding of the petroleum system, especially the potential source rocks within the West Baram Delta Province.

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