

## **Some insights into the source rocks of Central Luconia and the West Baram Delta area, Sarawak**

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This study is part of a Sarawak regional study covering the West Baram Delta and the eastern part of Central Luconia. Although few rock samples were available, several source rock types could be distinguished including a variety of marine and terrigenous source rocks. Several biomarkers from hydrocarbon fluids in the area suggest also a wide range of source rocks from marine to predominantly terrigenous origin. Even within a single field, such as in the case of the M4 Field, biomarkers suggest a different origin for the condensate than that for the underlying oil. The oil charge seems to have taken place later, from an oil source rock located above the gas source rock. Mixed charge may be more common in the area than previously anticipated.

Changes in geochemical composition, oil densities and oil/gas fractions vary within a distance of approximately 20 to 50 km. It is therefore likely that relatively short lateral migration distances prevail with fairly strong lateral depositional changes of source rocks. From the present data the occurrence of marine source rocks seems to be more common in the eastern part of Central Luconia, whilst in the Balingian province only indicators typical of terrigenous sources were found. The West Baram Delta source rock varies from dominantly terrigenous in the offshore to mixed in part of the onshore area (e.g. Engkabang).

Present geothermal gradients range from approximately 2.5°C/100 m in the West Baram Delta to 5.5°C/100 m in Central Luconia. The depth of the basement apparently influences this range. It shows an inverse relationship with the geothermal gradient. The spread of values is still large indicating that a further parameter, i.e. lithology dependent heat flow, may also be involved. Such a range impacts strongly on maturation resulting in a multivariate dependency of maceral maturity. Biomarkers, locally calibrated for this study, have been used as indicators for maturity of expulsion. The range of maturity suggested by these biomarkers is relatively narrow with a mean of VR 0.80%. This maturity of expulsion is reached in the West Baram Delta area at a depth of some 4,000 m below seabed and in Central Luconia at a considerably shallower depth of ca.

2,300 m. It is likely that in the West Baram Delta none of the penetrated shallow source rocks contributed to the charge and that there may be a charge risk due to very long vertical migration paths.

The distribution of gas, estimated largely from STOIIP and GIIP, shows a gas province trending roughly from F13 to Beryl/Helang to Baronia. To the north and the south of this gas trend there are stronger oil contributions. Estimated uplifts of more than 1,000 m in the onshore and near-shore area are thought to have contributed to the relatively higher oil fraction. In the north, the Tertiary sediment column thins considerably. The absence of gas directly north of G1, a decrease in maturity of expulsion to the north and lack of charge in G10, Mulu and Bako may therefore be attributed to low maturity of source rock caused by lack of overburden. It appears that pre-Tertiary sediments are not contributing to the charge in this area. In the dominantly oily southern province of the West Baram Delta some gas discoveries such as Laila-1 and Fatimah-1 are present at great depth (ca. 3,100 m). The maturity of expulsion estimated from condensates of these wells is 0.9 and 1.1 VR, suggesting source rock burial in excess of 4,000 m. It is likely that in these cases the HC charge was derived from an additional source rock situated below the oil source.

Previously the land plant derived source rock was considered the only contributor to economic hydrocarbon accumulations. However, with the present results it becomes clear that a whole suite exists in Sarawak that contributed to the strongly variable characteristics of hydrocarbons in the area. The existence of marine source rocks in Sarawak has implications regarding potential new HC charge plays. However, little is known yet of the geological controls on their distribution and extent.