

CHAPTER 8: CONCLUSIONS

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Conclusions

Labuan Island is made up entirely of sedimentary rocks. These rocks range in age from Lower to Middle Miocene and cover a wide spectrum of depositional facies ranging from relatively deep water to shallow, nearshore coastal plain settings. The stratigraphy of Labuan can be correlated to that of onshore west Sabah, Brunei, and northern Sarawak. Although these rocks are generally divided into three main units Temburong, Setap Shale and Belait Formations the relation between them have been uncertain.

The aims of this study were to, identify the organic matter types within these rocks, to geochemically characterise and differentiate between the formations, to investigate their oil generating potential and to determine the thermal maturity of the Labuan sedimentary rocks.

From the petrological study, it is clearly demonstrated that the samples from the Layang Layangan units of the Belait Formation are very rich in liptinitic macerals. The common liptinitic macerals within these rocks are suberinite, resinite, bituminite, cutinite, sporinite, resinite, and exsudatinitite.

In contrast, the samples from Richardson Point unit and Tg. Punei (Temburong Formation of Lee (1977) or Setap Shale of Tongkul (2001) are poor in these macerals, which may be explained by generation of liquid hydrocarbon by these macerals at an early maturity stage and their subsequence disappearance.

Most of the samples of Layang Layangan unit studied appear to possess a very high oil-generating potential based on the abundance of liptinitic macerals and their apparent capability to generate hydrocarbon as seen under the microscope.

Exsudatinite derives from these macerals, especially suberinite represent an early stage of oil generation.

The vitrinite reflectances measured are about 0.56-0.58% Ro for the Richardson Point unit and East Kiamsam Sandstone, Tg. Batu unit is 0.60% Ro, 0.68% - 0.80%Ro for the Tg. Punei unit, and for Layang Layangan unit I (Lower Belait Formation of Wilson (1964) Lee (1977) and Tongkul (2001) and Layang Layangan unit II and Bethune Head (upper Belait Formation) from 0.52% to 0.44%Ro. These vitrinite reflectances indicate that the Layang Layangan unit I is thermally less mature than the Richardson Point unit and East Kiamsam Sandstone which is also less mature than Tg. Punei unit.

This range of maturity can also be seen in some organic geochemistry parameters. The low thermal maturity of Layang Layangan unit I and Layangan unit II is reflected in the CPI values which vary in the range 1.42 to 2.33 and in the high ratios of moretane/ C₃₀- hopane. The low maturity for these units can also be seen in the hopane isomerization at C-22: 22S / (22S+22R) for C₃₁ and C₃₂ which range from 0.21 to 0.42 for C₃₁ and for C₃₂ from 0.18 to 0.42.

In contrast, the Tg. Punei unit shows higher maturity than the Richardson Point unit and East Kiamsam Sandstone.

The CPI values of Tg. Punei unit are about from 1.09, but ranges from 1.20 to 1.37 for the Richardson Point unit, Temiang unit and the East Kiamsam Sandstone.

The moretane/C₃₀-hopane ratios are from 0.11 to 0.13 for Tg. Punei unit and for Richardson Point unit, Temiang unit and East Kiamsam Sandstone they range from 0.16 to 0.33.

The hopane isomerization at C-22: 22S / (22S+22R) for C₃₁ and C₃₂ also show higher thermal maturity, ranging from 0.62 to 0.63 and from 0.57 to 0.59 for C₃₁ and C₃₂, respectively for Tg. Punei unit, whereas for Richardson Point unit and East Kiamsam Sandstone range from 0.55 (0.48 for one sample) to 0.60 for C₃₁, and for C₃₂ range from 0.57 to 0.60 (except 0.66 for one sample).

The oleanane/C₃₀ hopane ratios (oleanane index) are generally high in both of Tg. Punei unit and Richardson Point unit samples

Similar to East Kiamsam Sandstone, the vitrinite reflectance for the Tg. Batu unit is about 0.60%Ro; with moretane/C₃₀ hopane ratios ranging from 0.20 to 0.23. The 22S/(22S+22R) for C₃₁ and C₃₂ hopane are 0.58-0.60 and 0.58-0.62 respectively. Therefore the Tg. Batu unit shows significant differences in maturity from Belait Formation.

According to the above, based on both petrographic and geochemical studies the Layang Layangan unit I and upper Belait formation are thermally immature and the Tg. Punei unit, East Kiamsam Sandstone and Richardson Point unit, Temiang unit and Tg. Batu unit are moderate in thermal maturity.

This thermal maturity and geochemical parameters supports the Layang Layangan unit I being grouped within Belait Formation, the Setap Shale being positional under Belait Formation, including Temiang unit, East Kiamsam sandstone, Richardson Point unit, and Tg. Batu unit. The Temburong Formation is representing by Tg. Punei unit.

The Pristane/Phytane and CPI ratios in all samples studied are greater than 1, suggesting terrigenous origin, deposited under oxidizing environments, even though the $n\text{-C}_{31}/n\text{-C}_{17}$ ratios for Tg. Punei unit is lower than 1, which suggests some algal contribution may be present in this unit.

Thus, based on the organic geochemical and petrological data gathered in this study, revised stratigraphic division for the Labuan sedimentary sequence is proposed.