Paper A2

The geochemical fingerprint of the Layang-Layangan Beds, Labuan Island, NW Sabah Basin: Belait or Temburong Formation?

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Labuan Island is located within the NW Sabah Basin of Northwest Borneo and consists of Tertiary sediments. The island itself is one of the many narrow anticlines in the area that are separated by broad synclines, believed to be formed by syn-sedimentary deformation since the Middle Miocene. The axis of the Labuan anticline plunges to the north.

For decades, the Layang-Layangan Beds that underlie the basal conglomerates of the Belait Formation in the northern part of Labuan Island have been a subject of debate. At present, the camp is mainly divided into two. The opinion that the Layang-Layangan Beds are part of the Temburong Formation (see Lee, 1977; Madon, 1994) is mainly based on its position beneath the Lower Miocene Te5 unconformity (after Brondijk, 1962). Others view that they are part of the Belait Formation (see Wilson, 1964; Albaghdady *et al*., 2003). The study by Lee (1977) noted that the lack of fossils in the Layang-Layangan Beds is indicative of Belait Formation. An older study by Liechti *et al*. (1960) puts the Setap Shale instead of Temburong Formation beneath the Belait Formation.

Limited data from a previous geochemical study on the Miocene sediments on Labuan Island (Albaghdady *et al*., 2003) indicate that the Layang-Layangan Beds have more similarities to the Belait Formation instead of the Temburong Formation. This is based on several maturity parameters derived from the GC-MS (gas chromatography-mass spectrometry) analysis of rock extracts.

This study emphasises the geochemical approach used to characterise the Layang-Layangan Beds when conventional sedimentological, stratigraphic and fiel observation data is inadequate to address the ambiguity between the Temburong and Belait Formations. Saturated hydrocarbon fractions from outcrop rock samples from the Northwest Borneo area, including Labuan Island were analysed using GC-MS in order to produce geochemical fingerprint of the various geological units. Vitrinite reflectanc measurements were also made to complement the GC-MS data. Analysis results of the Setap Shale Formation from nearby Klias Peninsula and Lawas were integrated for comparison purposes. Data from the previous geochemical analysis of Labuan samples by Albaghdady *et al*. (2003) were added to the current dataset for a more comprehensive analysis. In total, 29 samples were included covering various lithologies, i.e. shales, mudstones, siltstones, coals, and carbonaceous/coaly sandstones and shales.

Maturity-related geochemical parameters that have minimal influenc from the type of source were selected to describe and characterise the Layang-Layangan Beds. Carbon preference indices (CPI), isomerisation ratios of C_{31}- and C_{32}-hopanes, C_{30}-moretane/C_{30}-hopane ratios and vitrinite reflectanc (%Ro) plotted onto star diagrams clearly indicate the differences between the Belait and Temburong Formations. This in turn made it more obvious and easier to assign the Layang-Layangan Beds into the Belait Formation, based on these geochemical parameters alone.

In addition to that, it is noted that the Kiamsam Series has a geochemical profil similar to the Setap Shale Formation, although the available data is not complete. This is in agreement with the recent finding of Abdullah *et al*. (2009) that highlighted the similar thermal maturities of the Kiamsam Series and Setap Shale Formation (vitrinite reflectanc values are between 0.55 and 0.60%). The Temburong and Setap Shale Formations (including the Kiamsam Series) are quite similar to a certain extent. Only the Temburong Formation samples are within the oil generation window (vitrinite reflectanc ranging from 0.68 to 0.80%), while the Belait and Setap Shale Formations are mostly immature (vitrinite reflectanc ranging from 0.43 to 0.61%). This is consistent with the isomerisation ratios of the C_{31}- and C_{32}-hopanes.

This study is an example of a simple but successful application of geochemical data to support and aid the identificatio and classificatio of geological units in outcrop studies. Such a workflo should be considered when conventional lithostratigraphy methods do not work well, particularly when working in areas where the sediments appear similar in outcrops and depositional facies vary abruptly.

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