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**ORGANIC GEOCHEMISTRY AND PETROLOGY
OF THE SEDIMENTARY SEQUENCE
OF LABUAN ISLAND OFFSHORE SABAH, EAST
MALAYSIA**

ALSHAREF ABDASSALAM ABDALLAH ALBAGHDADY

**FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
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**THESIS SUBMITTED IN FULFILMENT
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ABSTRAK

Batuan di Pulau Labuan terletak di luar pesisir pantai Barat Sabah, Malaysia Timur dibahagikan kepada Formasi Temburong, Formasi Syal Setap dan Formasi Belait. Hubungan di antara unit-unit ini adalah masih belum jelas.

Kajian geokimia organik dan petrografi telah dijalankan untuk menentukan komposisi bahan organik dan kematangan terma sedimen, untuk membuat perbezaan di antara formasi-formasi bagi menaksirkan keupayaannya dalam penjanaan minyak.

Hasil kajian petrologi organik terhadap sampel daripada unit I dan II Layang Layangan dalam Formasi Belait menunjukkan ia sangat kaya dengan maseral-maseral liptinit berbanding unit-unit yang lain. Maseral-maseral liptinit yang sering dijumpai di dalam batuan ini adalah suberinit, resinit, bitumenit, kutinit, sporinit, resinit dan eksudatinit. Kebanyakkannya sampel daripada unit Layang Layangan mempunyai potensi penjanaan minyak yang tinggi berdasarkan kepada kelimpahan maseral-maseral liptinit. Eksudatinit yang berasal dari maseral-maseral ini, terutamanya suberinit menunjukkan peringkat awal dalam penjanaan minyak.

Sebaliknya, sampel daripada unit Richardson Point, unit Temiang, Batu pasir Kiamsam Timur dan Tg. Batu bagi Formasi Syal Setap dan sampel daripada unit Tg. Punei bagi Formasi Temburong mengandungi kandungan maseral yang rendah, mungkin akibat daripada perekahan semasa penjanaan minyak di peringkat awal kematangan.

Kehadiran oleaan, umumnya dengan nisbah Pristan/Phytan dan CPI yang tinggi secara umumnya di dalam semua sampel kajian mencadangkan asalan terigen di bawah keadaan oksidasi. Ini turut disokong oleh nisbah $n\text{-C}_{31} / n\text{-C}_{17}$ yang tinggi kecuali untuk unit Tg. Punei, Unit Temiang, Batu pasir Kiamsam Timur dan Tg. Batu yang lebih rendah daripada 1 mencadangkan terdapatnya pengaruh marin.

Data pantulan vitrinit menunjukkan kematangan termal berjulat awal dan separa matang bagi kesemua sampel. Unit Layang Layangan dan unit Bethane Head adalah kurang matang berbanding unit Tg. Punei yang paling matang.

Data dari pantulan vitinit menunjukkan kematangan terma di peringkat awal dan pertengahan untuk semua sampel. Unit Layang Layangan dan unit Bethune Head adalah yang paling kurang matang manakala unit Tg. Punei adalah yang paling matang.

Pantulan vitrinit yang diukur berjulat 0.68-0.80 % R_0 bagi Tg. Punei, 0.56 – 0.58 % R_0 bagi Temiang, Richardson Point dan Batu pasir Kiamsam Timur dan 0.60 % R_0 bagi Tg. Batu. Unit I dan II Layang Layangan dan Bethune Head berjulat daripada 0.44% ke 0.552% R_0 .

Variasi kematangan termal ini disokong oleh data geokimia organik. Kematangan termal yang rendah bagi Unit I dan II Layang Layangan ditunjukkan oleh nilai CPI yang berbeza-beza dari 1.42 ke 2.33 dan nilai nisbah moretan / C_{30} hopana adalah tinggi. Kematangan unit ini adalah rendah di mana ia disokong oleh keisomeran hopana pada 22:22S / (22S + 22R) bagi C_{31} hopana dengan julat dari 0.21 ke 0.42 bagi C_{31} .

Sebaliknya sampel Tg. Punei pula menunjukkan kematangan yang tinggi berbanding unit Richardson Point, unit Temiang, unit Batu pasir Kiamsam Timur dan unit Tg. Batu. Nisbah moretana/ C_{30} -hopan adalah dari 0.11 hingga 0.13 bagi unit Tg. Punei dan 0.16 hingga 0.33 bagi unit Richardson Point, unit Temiang, unit Batu pasir Kiamsam Timur dan unit Tg. Batu. Turut menyokong adalah pengisomeran hopana pada C-22:22S/(22S+22R) bagi C_{31} dan C_{32} yang menunjukkan nilai berjulat dari 0.62 hingga 0.63 bagi Tg. Punei, di mana julat bagi C_{31} di Richardson Point, Temiang, Batu pasir Kiamsam Timur dan Tg. Batu adalah 0.55 ke 0.60.

Berdasarkan kajian data geokimia organik dan petrologi organic, suatu turutan sedimen di Labuan telah dicadang semula. Kajian ini menyokong unit I dan II Layang

Layangan iaitu dikekalkan dalam Formasi Belait, Batu pasir Kiamsam Timur, Temiang, Richardson Point dan Tg. Batu letak dalam Syal Setap. Unit Tg. Punei pula mewakili Formasi Temburong.

ABSTRACT

The rocks on Labuan Island, located offshore west of Sabah, East Malaysia are divided into the Temburong, Setap Shale and Belait formations. The relationship between these units was still unclear.

An organic geochemical and petrographical study was performed to determine the organic matter composition and the thermal maturity of these sediments, to differentiate between the formations and to assess their oil generating potential

Petrological study shows that the samples from the Layang Layangan unit I and unit II of Belait Formation are very rich in liptinitic macerals compared to the other units. The common liptinitic macerals within these rocks are suberinite, resinite, bituminite, cutinite, sporinite, resinite, and exsudatinit. Most samples of Layang Layangan units possess a higher oil-generating potential based on this abundance of liptinitic macerals. Exsudatinit derived from these macerals, especially suberinite represents an early stage of oil generation.

In contrast, the Setap Shale samples from Richardson Point unit, Temiang unit, East Kiamsam Sandstone and Tg. Batu, and Temburong Formation samples from Tg. Punei are poor in these macerals, which have probably disintegrated as consequence of hydrocarbon generation at an early maturity stage.

The occurrence of oleanane, generally high CPI and Pristane/Phytane ratios in all samples studied suggest a terrigenous origin under oxidizing conditions. In support the n-C₃₁/n-C₁₇ ratios are also high except for Tg. Punei unit, Temiang unit, East Kiamsam Sandstone and Tg. Batu unit with values lower than 1, thus suggests some marine contribution.

Vitrinite reflectance data shows early mature to mid mature thermal maturity for all samples. The Layang Layangan units and Bethune Head unit are the least mature and Tg. Punei unit most mature.

Vitrinite reflectance's values range from about 0.68 – 0.80 % Ro for Tg Punei, 0.56-0.58% Ro for Temiang, Richardson Point and East Kiamsam Sandstone, and 0.60 %Ro for Tg. Batu. Layang Layangan unit I and Layang Layangan unit II and Bethune Head range from 0.44% to 0.52%Ro.

The variations in thermal maturity are supported by organic geochemistry data. Low thermal maturity of Layang Layangan unit I and Layang Layangan unit II is reflected in the CPI values which vary from 1.42 to 2.33 and in the high ratios of moretane/ C₃₀ hopane. The low maturity for these units is also seen in the hopane isomerations at C-22: 22S / (22S+22R) for C₃₁ hopane which range from 0.21 to 0.42 for C₃₁.

In contrast, the Tg. Punei shows higher maturity than the Richardson Point, Temiang, East Kiamsam Sandstone and Tg. Batu units. The moretane/C₃₀-hopane ratios are from 0.11 to 0.13 for Tg. Punei unit and 0.16 to 0.33 for Richardson Point unit, Temiang unit, East Kiamsam Sandstone and Tg. Batu. In support the hopane isomeration at C-22: 22S / (22S+22R) for C₃₁ and C₃₂ also show values ranging from 0.62 to 0.63 for C₃₁ for Tg. Punei, whereas they range from 0.55 to 0.60 for C₃₁ for Richardson Point, Temiang, East Kiamsam Sandstone and Tg Batu.

Based on the organic geochemical and petrological data in this study, a revised stratigraphic division for the Labuan sedimentary sequence is proposed. This study supports the Layang Layangan unit I and unit II be left within the Belait Formation, the East Kiamsam sandstone, Temiang, Richardson Point, and Tg. Batu units be placed within the Setap Shale. The Temburong Formation is represented by the Tg. Punei unit.

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DEDICATION

Dedicated to My

Parents

Brothers

Sisters

Wife

Daughter

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Abbreviations

CPI	Hydrocarbon Preference Index
cm	Centimeter
EOM	Extracted Organic matter
g	Gram
GC	Gas Chromatogram
H	Hydrogen
Km	Kilometer
Ro	Mean vitrinite reflectance
mg	Milligram
ml	Milliliter
mm	Millimeter
m/z	Mass to charge ratio of an ion in mass spectrometry
NSO	Nitrogen, Sulphur, and Oxygen-containing compounds
n-C _x	Normal alkane C _x
Ph	Phytane
Pr	Pristane
Tg.	Tanjung
TIC	Total Ion Current