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UNIVERSITI TEKNOLOGI PETRONAS

FACIES MODEL AND STRUCTURAL FRAMEWORK OF THE

MIRI FORMATION (MIDDLE – LATE MIOCENE), SARAWAK, MALAYSIA

by

YUNIARTI ULFA

The undersigned certify that they have read, and recommend to the Postgraduate Studies Programme for acceptance this thesis for the fulfillment of the requirements for the degree stated.

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# FACIES MODEL AND STRUCTURAL FRAMEWORK OF THE MIRI FORMATION (MIDDLE – LATE MIOCENE), SARAWAK, MALAYSIA

by

YUNIARTI ULFA

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MAY 2010

DECLARATION OF THESIS

| Title of thesis | Facies Model and Structural Framework of the Miri Formation (Middle – Late Miocene), Sarawak, Malaysia |
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I **YUNIARTI ULFA** hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UTP or other institutions.

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| Date: _____ | Date: _____ |

DEDICATIONS

*This thesis is dedicated to all woman geologists who can also be a good wife…a good mother*

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# ABSTRACT

Miri is the birthplace of Malaysian petroleum industry. It was discovered in 1910 and was totally abandoned in 1972 after producing about 80 million barrels of oil. However, geologically Miri remains one of the most interesting and challenging place to be resolved stratigraphically and structurally. The primary objective of the present study is to provide additional interpretation on the stratigraphy and structural geology of the Miri Formation in the Miri Field based on the new information gathered from new outcrops in the area. Eighteen outcrops were examined in detail on structural geology. Among these eighteen outcrops, five outcrops were chosen also for detail sedimentology and stratigraphy studies.

Based on lithology, sedimentary structures, bedding geometry and traces fossil, the sediments of the Miri Formation were grouped into fourteen lithofacies. These facies were grouped into two main facies associations which are: (i) tide-dominated estuary; and (ii) wave-and-storm dominated facies associations. The tide-dominated estuary system of the Miri Formation are includes variety of sub environments: estuary mouth or tidal channel and sand bars (characterized by trough cross-stratified sandstone with mud drapes facies), estuary channel or upper flow regime of sand flat (characterized by parallel stratified sandstone with mud-laminas facies), mixed-tidal flat (characterized by wavy and flaser bedded sandstone facies), and mud-tidal flat (characterized by rhythmic stratified sandstone-mudstone and lenticular bedding facies). The wave-and-storm dominated varied from lower to middle shoreface (characterized by hummocky cross-stratified sandstone and rhythmic parallel stratified sandstone and laminated siltstone facies), upper shoreface (characterized by swaley cross-stratified sandstone), lower shoreface (interbedded to bioturbated sandstone and siltstone facies), and offshore transitional (characterized by bioturbated sandstone and mudstone interbedding with parallel to hummocky cross-stratified sandstone facies).

Results for the structural geology analysis indicate that the development of the Miri structure is interpreted into two separate periods of deformation: (i) an early period of compression, indicated by the asymmetric anticline and the reverse fault; and (ii) a later period of extension, indicated by a set of normal faults. The early period of compression related to a NW / SE compressive stress field gave rise to anticlinal feature trending in NE-SW direction. Warping and uplifting of the Miri anticline accompanied the period of compression caused brittle deformation and rupture manifested by the reverse fault.

Later period of extension may have resulted from local to regional outer-arc extension. It was indicated by most of conjugate normal faults in Miri Formation has NE-SW strike orientation or parallel to the anticline axis of the Canada Hill. Rotational movements on the competent sediment of the Miri Formation also happen due to the local space created during the extension periods, thus it is possible to explain the existence of a very big contrast of thick sequence of vertically dipping section with a sub-horizontal or gently dipping sequence situated side-by-side at the Miri Hospital Road 1 outcrop. The effect of thrusting followed by the rotational movement of the sediments is the reason for the drastic change of the sequence within a very short contact zone without any significant brecciation.

The tectonic system of the Miri Formation was probably the result of compressional phase occurred during the early Late Miocene while the deposition of deltaic sediment of the Miri Formation started since the Middle Miocene times. The later stage of deformation was dominated by extensional phase and probably happened shortly before the depositional loading of the West Baram Delta ends, during Late Miocene to Pliocene times. This resulted in the developments of normal faults and the associated growth fault.

# ABSTRAK

Miri merupakan tempat kelahiran industri petroleum di Malaysia. Operasi industri petroleum di Miri telah bermula pada tahun 1910 dan berakhir pada tahun 1972 selepas menghasilkan minyak sebanyak 80 juta barel. Meskipundemikian, Miri, masih menarik dan mencabar untuk di kaji semula terutama sekali dari segi stratigrafi mahupun struktur geologinya. Tumpuan utama daripada kajian ini adalah untuk melengkapi kajian-kajian sebelumnya dalam bidang stratigrafi dan struktur geologi, berdasar kepada maklumat-maklumat baru yang diperolehi dari beberapa singkapan bebatuan yang mempunyai struktur dan model stratigrafi yang baru. Terdapat lapan belas singkapan di Miri telah dipilih untuk kajian struktur geologi, dan lima diantaranya digunakan untuk kajian stratigrafi.

Berdasarkan kepada jenis bebatuan, struktur pengendapan, geometri perlapisan dan fosil jejak, empat belas litofasies telah dikenalpasti dalam kajian ini. Keseluruhan fasies ini dibahagikan kepada dua kumpulan fasies iaitu: (i) sekitaran muara yang didominasi pasang-surut; dan (ii) sekitaran laut yang didominasi ombak dan ribut. Sistem sekitaran muara yang didominasi pasang-surut memuat pelbagai sub-sekitaran termasuk alur-alur dan beting-beting pasang surut di mulut muara (dicirikan oleh fasies batupasir berlapisan silang dengan noktah lumpur), dataran pasir regim aliran atas muara (dicirikan oleh fasies batupasir berlapisan selari dengan sisipan lumpur), dataran bercampuran dengan sekitaran pasang surut (dicirikan oleh fasies batupasir perlapisan berombak), dan dataran berlumpur sekitaran pasang-surut (dicirikan oleh fasies perlapisan melensa dan perulangan perlapisan antara batupasir dan batulempung). Sistem sekitaran laut yang didominasi ombak dan ribut dibezakan kepada sub-sekitaran mukapantai pertengahan – bawah (dicirikan oleh fasies batupasir berlapisan silang bergum dan perulangan batupasir berlapisan selari nipis dengan sisipan batulanau), mukapantai bawahan (dicirikan oleh fasies batupasir dan batulanau berlapisan ke terbiokacau), dan sekitaran transisi laut lepas (dicirikan oleh

fasies batupasir terbiokacau dan perselingan batulempung berlapisan selari ke batupasir bergum).

Hasil daripada analisa struktur geologi menunjukkan bahawa pembentukan struktur Miri dapat dibahagikan kepada dua tempoh deformasi iaitu: (i) tempoh awal mampatan, ditandai oleh antiklin asimetris dan sesar songsang, dan (ii) tempoh akhir regangan, ditandai oleh serangkaian sesar normal. Tempoh awal mampatan berkaitan dengan medan tegangan berarah barat laut - tenggara, memunculkan ciri antiklinal berkecenderungan arah timur laut - barat daya. Berikutnya fasa pelengkungan dan pengangkatan daripada antiklin menyertai tempoh mampatan, menyebabkan formasi menjadi rapuh dan pecah sehingga menjadikan kepada sesar songsang menghadap ke barat laut. Tempoh akhir regangan mungkin dihasilkan dari regangan busur-luar baik dalam liputan tempatan maupun regional . Hal ini ditunjukkan oleh sebahagian besar sesar normal yang dijumpai di Miri memiliki jurus berarah timur laut - barat daya atau sejajar dengan paksi antiklin Bukit Kanada. Sebuah gerakan memutar mungkin juga berlaku pada Formasi Miri yang terjadi disebabkan oleh ruangan tempatan mencipta selama tempoh regangan. Hal ini boleh menjelaskan kewujudan sebuah perbezaan yang sangat besar antara urutan perlapisan tegak yang tebal dengan urutan perlapisan yang hampir mendatar yang berkedudukan sebelah-menyebelah di singkapan Jalan Miri Hospital 1. Pengaruh penujahan yang diikuti oleh pergerakan memutar daripada sedimen Formasi Miri menunjukkan mengapa perubahan-perubahan dari kedudukan jujukan sekuen sedimen dijumpai dalam zon yang sangat pendek tanpa zon membreksi yang signifikan.

Sistem tektonik dari Formasi Miri mungkin diinduksi oleh tempoh mampatan yang berlaku pada awal Miosen Akhir sedangkan mendapan Formasi Miri bermula sejak Miosen Tengah. Sebagai tahap kemudian deformasi, tempoh regangan mungkin berlaku sesaat sebelum pemuatan pengendapan Baram Delta Barat berakhir, iaitu selama Miosen Akhir hingga Pliosen, yang menjadikan terbentuknya sesar normal dan sesar tumbuh.

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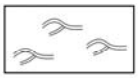
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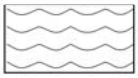
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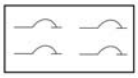
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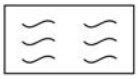
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