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Facies Model and Structural Framework of the Miri Formation
(Middle – Late Miocene), Sarawak, Malaysia

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UNIVERSITI TEKNOLOGI PETRONAS

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

by

YUNIARTI ULFA

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

by

YUNIARTI ULFA

A Thesis

Submitted to the Postgraduate Studies Programme

as a Requirement for the Degree of

MASTER OF SCIENCE

GEOSCIENCE AND PETROLEUM ENGINEERING DEPARTMENT

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR,

PERAK

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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DEDICATIONS

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

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my supervisors Assoc. Prof. Dr. Zuhar Zahir Tuan Harith and Assoc. Prof. Dr. Nasiman Sapari for the support, patience and friendship they showed to me during my studies.

During my studies, I had many opportunities to interact with people who greatly enhanced my learning. Prof. Dr. Bernard J.M. Pierson, Assoc. Prof. Askury Abdul Kadir and Dr. Maarten Wiemer (Sarawak Shell Berhad), through fruitful discussions and new ideas they guided my steps during the development of this work, and I thank them. I am very grateful for Yusop Sulaiman (Sarawak Shell Berhad) for the days he spent with me on the amazing Miri outcrops, for the knowledge sharing and discussion we had in the field.

I would also like to thank all the postgraduate students of the Geoscience and Petroleum Engineering Department of Universiti Teknologi PETRONAS. Special thanks to Adi Rahmansyah, Hilfan Khairy, Ika Fariha dan Merry Hastuti for the discussion, friendship, help, laugh and patience in dealing with me so far.

I wish to thank my father and my mother for their support, encouragement and understanding during my studies. Last, but most important, I thank my husband 'Mas Hilal', my son 'Dimas', and my unborn baby for their love, friendship, patience and inspiration that made this whole effort possible.

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. Meskipun demikian, Miri, masih menarik dan mencabar untuk di kaji semula terutama sekali dari segi stratigrafi mahupun struktur geologinya. Tumpuan utama daripada kajian ini adalah untuk melengkapkan 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 berlapis 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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TABLE OF CONTENTS

STATUS OF THESIS.....	i
APPROVAL PAGE.....	ii
TITLE PAGE.....	iii
DECLARATION PAGE.....	iv
DEDICATION.....	v
ACKNOWLEDGMENTS.....	vi
ABSTRACT	vii
ABSTRAK.....	ix
COPYRIGHT PAGE.....	xi
TABLE OF CONTENTS.....	xii
LIST OF TABLES.....	xv
LIST OF FIGURES.....	xvi
SEDIMENTOLOGICAL LEGENDS.....	xxiii

Chapter

1. INTRODUCTION.....	1
1.1. Introduction.....	1
1.2. The Study Area.....	2
1.3. Previous Studies.....	2
1.4. Scientific Problems.....	5
1.6. Objectives of the Study.....	6
1.7. Thesis Outline	6
2. LITERATURE REVIEW.....	8
2.1. Introduction	8
2.2. Geological Setting of the Miri Formation.....	8
2.2.1. The Miri Formation.....	9
2.2.2. The Miri Structure.....	12
2.3. Fundamental Concept of Geology Applicable to Miri.....	15
2.3.1. Stratigraphy.....	15
2.3.1.1. Sedimentary Environments.....	16
2.3.1.2. Methods for Environments Diagnosis.....	23
2.3.2. Structural Geology.....	26
2.3.2.1. Deformation Processes	26
2.3.2.2. Geological Structures of Planar Type.....	27
2.3.2.3. Stereographic Projection Techniques in Structural Geology.....	35

3. METHODOLOGY.....	38
3.1. Introduction.....	38
3.2. Outcrop Descriptions.....	38
3.2.1. The Northern Part.....	39
3.2.2. The Middle Part.....	41
3.2.3. The Southern Part.....	43
3.3. Stratigraphic and Facies Studies.....	44
3.4. Structural Studies.....	45
4. RESULT AND DISCUSSION.....	49
4.1. Introduction.....	49
4.2. Facies Characteristic and its Model.....	49
4.2.1. Facies of the Miri Formation.....	61
4.2.1.1. Facies A: Hummocky Cross-stratified Sandstone.....	61
4.2.1.2. Facies B: Massive Sandstone.....	62
4.2.1.3. Facies C: Swaley Cross-stratified Sandstone.....	64
4.2.1.4. Facies D: Rhythmic Parallel Stratified Sandstone and Laminated Siltstone.....	64
4.2.1.5. Facies E: Trough Cross-stratified Sandstone with Mud-drapes.....	66
4.2.1.6. Facies F: Parallel Stratified Sandstone with Mud-laminas.....	68
4.2.1.7. Facies G: Wavy-bedded Sandstone.....	69
4.2.1.8. Facies H: Rhythmic Stratified Sandstone and Mudstones.....	70
4.2.1.9. Facies I: Lenticular Bedding.....	72
4.2.1.10. Facies J: Interbedded to Bioturbated Sandstone and Siltstone.....	73
4.2.1.11. Facies K: Bioturbated sandstone.....	75
4.2.1.12. Facies L: Mudstone Interbedding with parallel to Hummocky Cross-stratified Sandstone.....	76
4.2.1.13. Facies M: Flaser Bedded sandstone.....	77
4.2.1.14. Facies N: Bioturbated Siltstone.....	78
4.2.2. Facies association.....	79
4.2.2.1. Tide-dominated Estuary Facies Association (FA-1)....	79
4.2.2.2. Wave-and-storm Dominated Facies Association (FA-2).....	81
4.2.3. Facies Model.....	84
4.3. Structural Characteristic and its Framework.....	89
4.3.1. Measured Structural Data.....	89
4.3.2. Structural Characteristic of Northern Miri.....	92
4.3.3. Structural Characteristic of Middle Miri.....	96

4.3.4. Structural Characteristic of Southern Miri.....	103
4.3.5. Structural Framework.....	108
5. CONCLUSION AND RECOMMENDATION.....	116
5.1. Conclusions.....	116
5.3. Recommendations for Further Study.....	120
REFERENCES	121
APPENDICES	
A. Publications	
B. Stratigraphic Succession of Hospital Road 2 Outcrop	
C. Strike and Dip Plotting	

LIST OF TABLE

Table 2.1	Stratigraphic framework of the Miri Field	11
Table 2.2	The relationship between the sedimentary environments and sedimentary facies	23
Table 2.3	Fold classification based on the interlimb angle	33
Table 2.4	Fold classification based on plunge	34
Table 2.5	Fold classification based on dip of axial surface	34
Table 3.1	An example of sedimentology log chart	48
Table 4.1	Strike and dip orientation of the sedimentary beds	89
Table 4.2	Strike and dip orientation of the joint planes	90
Table 4.3	Strike and dip orientation of the normal fault planes	91
Table 4.4	Strike and dip orientation of the reverse or thrust fault planes	91
Table 4.5	Summary of the bedding and fold trend orientation analysis of the Miri Formation	108
Table 4.6	Summary of the fault trend and stresses orientation analysis of the Miri Formation.	109

LIST OF FIGURES

Figure 1.1	(A) Study area with exposures of Miri Formation at the northeastern part of Sarawak, Malaysia. (B) Satellite image of the Canada Hill.	3
Figure 2.1	Baram Delta Province structural map.	10
Figure 2.2	Schematic Stratigraphic successions and correlations of Neogene formations in Miri area.	10
Figure 2.3	(a) Miri Field structural map. (b) The Sarawak Shell geological map of the Miri Hill, showing the subdivision of the hill into different reservoir producing units.	13
Figure 2.4	The NW-SE cross section of the Miri Field and the stratigraphic-structural position of the different reservoir units according to the Shell interpretation.	14
Figure 2.5	Subenvironments for a beach-barrier island and lagoon shoreline system.	19
Figure 2.6	Block diagram of a typical siliciclastic tidal flat.	19
Figure 2.7	Tidal bedding changes from (C) lenticular through (B) wavy and (A) flaser bedding as the proportion of mud decreases, seaward.	20
Figure 2.8	Diagrams showing common types of cross bedding; (a) planar cross-bedding, with planar bedding surfaces and tabular to wedge-shaped cross-bedded units, (b) trough cross-bedding in horizontal, transverse and longitudinal sections, (c) herringbone cross-bedding showing foreset lamina dipping in opposite direction, (d) tabular, planar and trough cross-bedding interbedding.	20
Figure 2.9	The subenvironments of a lobate and elongate (bird's foot) delta. Progradation of lobate delta give rise to a laterally extensive delta front, whereas a linear sand body is generated by an elongate delta.	21
Figure 2.10	Generalized shoreline profile showing subenvironments, processes and facies.	22

Figure 2.11	Features associated with normal fault zones. (A) Rotation of one block on a curved fault. (B) Reverse drag. (C) A small graben formed along the fault zone as a result of movement on antithetic faults.	29
Figure 2.12	Cross section of St. Genevieve fault zone, Ozora, Missouri, showing drag along one of the reverse faults in the zone.	29
Figure 2.13	Features of growth fault shows the thickening strata on the hanging wall.	31
Figure 2.14	Initial stress distribution on the mechanism of faulting.	32
Figure 2.15	Example of various types of fold symmetry as viewed in cross sections normal to the fold axis.	33
Figure 2.16	Distribution of tension and compression within a bent slab.	34
Figure 2.17	A scheme shows the idea of stereographic projection of the structural line and plane.	36
Figure 2.18	(a) The poles of planar or linear structures plotted using a Schmidt net. (b) The Kalsbeek counting-net. (c) The number of points occurring in each hexagon, and (d) the resulting contour lines.	37
Figure 3.1	Topographic map showing location of the eighteen outcrops. All outcrops were selected for structural studies (●), except for five outcrops (□) which were selected for structural, and also stratigraphy and sedimentological studies.	40
Figure 4.1	Photograph shows an overview of the stratigraphy at the Boulevard 1 outcrops exposes thick beds of sandstone. (a) Zoom for the south view of the outcrop. (b) The overall view of the outcrop (picture taken from the west side).	50
Figure 4.2	Photograph shows an overview of the stratigraphy at the Airport Road 1 outcrops exposes thick sandstone beds interbedded with thin muddy interval.	51
Figure 4.3	Photograph shows an overview of the stratigraphy at the Hilltop Garden 1 outcrops exposes thick beds of sandstone with intensely bioturbation imprint.	52

Figure 4.4	Photograph shows an overview of the stratigraphy at the Hospital Road 1 outcrops exposes thick beds of sandstone interbedded with muddy sediments in sub horizontal or gently dipping beds.	53
Figure 4.5	Photograph shows an overview of the Hospital Road 2 outcrops exposes vertical dipping beds.	54
Figure 4.6	Stratigraphic succession of the Boulevard 1 outcrop, complete with brief facies description and the interpreted depositional environment.	55
Figure 4.7	Stratigraphic succession of the Airport Road 1 outcrop, complete with brief facies description and the interpreted depositional environment.	56
Figure 4.8	Stratigraphic succession of the Hilltop Garden 1 outcrop, complete with brief facies description and the interpreted depositional environment.	57
Figure 4.9	Stratigraphic succession of the Hospital Road 1 outcrop, complete with brief facies description and the interpreted depositional environment.	58
Figure 4.10	Stratigraphic succession of the Hospital Road 2 outcrop, complete with facies codes and the interpreted depositional environment.	59
Figure 4.11	Facies A, showing hummocky cross-stratified sandstone in between mudstone layers (location 10: Miri Hospital Road 1 outcrop).	62
Figure 4.12	Facies B, showing massive sandstones (Location 11: Miri Hospital Road 2 outcrop).	63
Figure 4.13	Facies B, showing thick coarse grain sandstones with <i>Liesegang</i> rings (Location 11: Miri Hospital Road 2 outcrop).	63
Figure 4.14	Facies C, showing swaley cross-stratified sandstone (location 1: Boulevard 1 outcrop).	65
Figure 4.15	Facies D, showing interbedded parallel-stratified sandstone and bioturbated siltstone (location 1: Boulevard 1 outcrop).	66
Figure 4.16	Facies E, showing trough cross-stratified sandstones separated by mud drapes surfaces (location 16: Airport Road 1 outcrop).	67








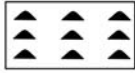

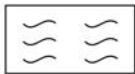


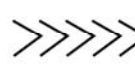


Figure 4.17	Facies E, showing herringbone cross-stratification (location 16: Airport Road 1 outcrop).	68
Figure 4.18	Facies F, showing parallel-stratified sandstone with mud drapes (location 16: Airport Road 1 outcrop).	69
Figure 4.19	Facies G, showing wavy bedded sandstone gradually changes in between lenticular and flaser bedding (location 11: Miri Hospital Road 2 outcrop).	71
Figure 4.20	Facies H, showing wavy bedded sandstone gradually changes in between lenticular and flaser bedding (location 11: Miri Hospital Road 2 outcrop).	71
Figure 4.21	Facies H, showing load cast structures (L) at the base of sandstone bed (location 11: Miri Hospital Road 2 outcrop).	72
Figure 4.22	Facies I, showing lenticular bedding facies (location 11: Miri Hospital Road 2 outcrop).	74
Figure 4.23	Facies J, showing interbedded to bioturbated sandstone and siltstone (location 13: Hilltop Garden 1 outcrop).	74
Figure 4.24	Facies K, showing moderately bioturbated sandstone (location 10: Miri Hospital Road 1 outcrop).	75
Figure 4.25	Facies L, showing mudstone interbedding with parallel to hummocky cross-stratified sandstone (location 10: Miri Hospital Road 1 outcrop).	77
Figure 4.26	Facies M, showing flaser bedded sandstone facies (location 11: Miri Hospital Road 2 outcrop).	78
Figure 4.27	Facies N, showing bioturbated siltstone facies (location 11: Miri Hospital Road 2 outcrop).	79
Figure 4.28	Repeated fining upwards cycles tide-dominated estuary facies association (FA-1) from location 11, Miri Hospital Road 2 outcrop.	80
Figure 4.29	Repeated fining upwards cycles tide-dominated estuary facies association (FA-1) from location 16, Airport Road 1 outcrop.	80
Figure 4.30	An ideal model for complete fining upwards succession of tide-dominated estuarine sedimentation.	81

Figure 4.31	Repeated cycle of wave-and-storm dominated facies association (FA-2) from location 10, Miri Hospital Road 1 outcrop.	83
Figure 4.32	Repeated cycle of wave-and-storm dominated facies association (FA-2) from location 1, Boulevard 1 outcrop.	83
Figure 4.33	Offshore profile locating foreshore, shoreface and offshore, as well as fair-weather wave base and ichnofacies occurrences.	84
Figure 4.34	Distribution in a tide-dominated estuary of (a) energy types, (b) morphological components and (c) sedimentary facies.	85
Figure 4.35	Facies model of tide-dominated estuary system of the Miri Formation.	87
Figure 4.36	Facies model of wave-and-storm dominated system of the Miri Formation.	88
Figure 4.37	Poles of bedding planes for the northern part of the Miri Formation on a (Schmidt net) stereogram.	92
Figure 4.38	Density of poles to bedding planes for the northern part of the Miri Formation suggesting the presence of fold. Components such as limbs, interlimb angle, fold axis and axial plane were indicated in this map.	92
Figure 4.39	Poles of normal fault planes for the northern part of the Miri Formation on a (Schmidt net) stereogram.	93
Figure 4.40	Density of poles to fault planes for the northern part of the Miri Formation suggesting the presence of conjugate pair of normal fault. Stress components of σ_1 , σ_2 , and σ_3 were indicated in this map.	94
Figure 4.41	Photograph shows an overview of the structural at the Boulevard 1 outcrop exposes series of normal faults. (A) Zoom for the south view of the outcrop. (B) Complete overview of the outcrop (picture taken from the west).	95
Figure 4.42	Photograph of mesostructures from Boulevard 1 outcrop (location 1) showing normal faults style with displacement around few centimeters.	95

Figure 4.43	Poles of bedding planes for the middle part of the Miri Formation on a (Schmidt net) stereogram.	96
Figure 4.44	Density of poles to bedding planes for the middle part of the Miri Formation suggesting the presence of fold. Components such as limbs, interlimb angle, fold axis and axial plane were indicated in this map.	96
Figure 4.45	Photograph shows an evidence of anticline indicated by a fold nose at location 10, Hospital Road 1 outcrop.	97
Figure 4.46	Poles of joint planes for the middle part of the Miri Formation on a (Schmidt net) stereogram.	97
Figure 4.47	Density of poles to joint planes for the middle part of the Miri Formation indicates sets of joint orientation.	98
Figure 4.48	Poles of normal fault planes for the middle part of the Miri Formation on a (Schmidt net) stereogram.	99
Figure 4.49	Density of poles to normal fault planes for the middle part of the Miri Formation suggesting the presence of two conjugates pair of normal fault. Stress components of σ_1 , σ_1' , σ_2 , σ_2' , σ_3 and σ_3' were indicated in this map.	100
Figure 4.50	Photograph shows an overview of the structural at location 15, Miri By-pass Road outcrop exposes bedding rotation indicates the normal faulting style.	101
Figure 4.51	Poles of reverse fault planes for the middle part of the Miri Formation on a (Schmidt net) stereogram	101
Figure 4.52	Density of poles to reverse fault planes for the middle part of the Miri Formation suggesting the presence of conjugate pair of reverse fault. Stress components of σ_1 , σ_2 , and σ_3 were indicated in this map.	102
Figure 4.53	Photograph shows a mesostructure at location 10, Miri Hospital Road 1 outcrop indicates the reverse faulting style	102
Figure 4.54	Poles of bedding planes for the southern part of the Miri Formation on a (Schmidt net) stereogram.	103

Figure 4.55	Density of poles to bedding planes for the southern part of the Miri Formation suggesting the presence of fold. Components such as limbs, interlimb angle, fold axis and axial plane were indicated in this map.	104
Figure 4.56	Photograph shows an evidence of anticline indicated by a fold nose at location 17, Airport Road 2 outcrop.	105
Figure 4.57	Poles of joint planes for the southern part of the Miri Formation on a (Schmidt net) stereogram.	105
Figure 4.58	Density of poles to joint planes for the southern part of the Miri Formation indicates sets of joint orientation.	106
Figure 4.59	Poles of normal fault planes for the southern part of the Miri Formation on a (Schmidt net) stereogram.	106
Figure 4.60	Density of poles to normal fault planes for the southern part of the Miri Formation suggesting the presence of conjugate pair of normal fault. Stress components of σ_1 , σ_2 , and σ_3 were indicated in this map.	107
Figure 4.61	Photograph shows an overview of the faults at the Airport Road 1 outcrop.	107
Figure 4.62	Illustration of the anticline orientation where the axis at the middle part changes in direction towards NNE – SSW.	110
Figure 4.63	Bedding and fault orientation of the Miri Formation .	111
Figure 4.64	The NW - SE and SW - NE geological cross-sections of the Miri Field. The sections were constructed based on field observation.	112
Figure 4.65	Interpreted seismic profile through offshore Miri. Analogue for the Miri Formation structural pattern is indicated by area in the red square	113

SEDIMENTOLOGICAL LEGENDS

	Sandstone
	Siltstone
	Mudstone
	Hummocky cross-bedding
	Swaley cross-bedding
	Trough cross-bedding
	Wavy bedding
	Lenticular bedding
	Flaser bedding
	Mud laminae
	Parallel bedding
	<i>Ophiomorpha</i> burrows
	Herringbone structure
	Fining upward
	Coarsening upward