WARTA GEOLOGI

NATIONAL GEOSCIENCE CONFERENCE 2019 (NGC 2019)

1st - 3rd October 2019,
The Palace Hotel, Kota Kinabalu, Sabah

GEOLOGICAL SOCIETY OF MALAYSIA
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PERSATUAN GEOLOGI MALAYSIA
Geological Society of Malaysia

The Geological Society of Malaysia (GSM) was founded in 1967 with the aim of promoting the advancement of geoscience, particularly in Malaysia and Southeast Asia. The Society has a membership of about 600 local and international geoscientists.

Warta Geologi is published quarterly by the Society. Warta Geologi publishes peer-reviewed short geological communications and original research on Earth Science. The scope includes local and regional geology, conservation geology, economic geology, engineering geology, environmental geology, geochemistry, geomorphology, geophysics, hydrogeology, palaeontology, petroleum geology, sedimentology, stratigraphy, structural geology and tectonics. Warta Geologi also reports on activities and news about GSM and the geoscience community in Malaysia.

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Warta Geologi

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NGC 2019

NATIONAL GEOSCIENCE CONFERENCE 2019 (NGC 2019)

1st - 3rd October 2019
The Palace Hotel,
Kota Kinabalu, Sabah

"Geosciences for the Earth Sustainability"

Jointly organised by:

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Foreword by Chairman of NGC 2019 Kota Kinabalu

Assalammualaikum Warahmatullahhi Wabarakatuh

It is with great honour and privilege for me as the chairman to welcome all fellow participants, speakers, and invited guests in the National Geoscience Conference 2019 (NGC 2019). I am indebtly thankful to all the organizing committee that involved in the successful of this conference. My warm welcome also goes to the International and National attendees that coming from outside Sabah, 'Welcome the the State of Sabah, Land Below the Wind', there is a great opportunity to explore in the Nature Resort City of Kota Kinabalu.

The NGC 2019 is a continuation of the 31st annual conference series of The Geological Society of Malaysia to raise the cohesion of different research sphere. It is highly hope that the NGC 2019 would be a pre-eminent platform for the up-to-date research and innovation discussion and outcome sharing in various field. The conference theme on 'Geosciences for the Earth Sustainability', is in line with the prolonged aims of this conference to provide prospects for researchers and academicians to interact, expand and exchange ideas; centering on the latest research activities; to establish and strengthened multidisciplinary collaboration to enhance the nation's niche research and development. We are very privileged to have in attendance so many distinguished experts and researcher, as well as observers from various fields.

Correspondingly, the conference also highlights various concepts and topics in Geosciences encompassing disaster risk reduction, engineering geology & rock mechanics, mining & quarry, tectonic & structural geology, petroleum geology, sedimentology & paleontology, hydrogeology, environmental geology & geochemistry, conservation geology, geoarcheology & geotourism and any related to the applied or techniques in Geosciences. Again, I would like to extend my highest gratitude to those who had dedicated their time and efforts for the succesful preparation and organisation of the NGC 2019, the committee members, Faculty of Science and Natural Resources, Universiti Malaysia Sabah, keynote speakers, presenters, fellow participants for all the support and collaboration.

Finally, we hope this conference will benefit all participants and presenters and achieve their initial goals. I wish you all a very successful seminar and assure you of the full support from our committee.

Thank you.

"Innovative and Sustainable Research Excellence"

ASSOC. PROF. DR. RODEANO ROSLEE
Chairman
National Geoscience Conference 2019
Faculty of Science and Natural Resources

TENTATIVE PROGRAMME

Workshop 1

30th September 2019 (Monday)	
Workshop on Importance of Geosciences on Sustainable Development *Session Chair: Assoc. Prof. Dr. Rodeano Roslee, PGeol.*	
08:00 – 08:30	Registration
08:30 – 08:45	Welcoming speech
08:45 – 09:15	Invited Speaker 1: **Geologists Act – How It Will Affect Us** YBhg. Dato' Yunus Bin Abdul Razak, PGeol. (Presiden Lembaga Geologi Malaysia)(BOG)
09:15 – 09:45	Invited Speaker 2: **'Why Does Geology Matter for Sustainable Development? And the Roles of Learned and Professional Organisations'** Mr. Abd. Rasid Jaapar, PGeol. (Presiden Persatuan Geologi Malaysia)(GSM)
09:45– 10:15	Invited Speaker 3: **JMG Role in Sustainable Development and People Well-Being: Sabah Context** Dr. Frederick Francis Tating (Department of Mineral and Geoscience Sabah)
10:15 – 10:30	***Q&A Session***
10:30 – 11:00	Tea/Coffee Break
11:00 – 11:30	Invited Speaker 4: **Geoscience and the Changing Climate** Prof. Dr. Joy Jacqueline Pereira (Universiti Kebangsaan Malaysia)
11:30 – 12:00	Invited Speaker 5: **Natural Hazards in Malaysia – Why Geologists are Needed** Prof. Dr. Felix Tongkul (Universiti Malaysia Sabah)
12:00 – 12:30	Invited Speaker 6: **Geoscience Inputs for the Proposed Guideline on Vulnerability Assessment and Risk Index for Critical Infrastructures** YBhg. Dato' Zakaria Mohamad, PGeol. (Presiden Institut Geologi Malaysia)(IGM)
12:30 – 12:45	***Q&A Session***
12:45 – 14:00	Lunch
14:00 – 15:30	Discussion Session **Moderator: YBhg. Dato' Zakaria Mohamad, Mr. Abd. Rasid Jaapar and Dr. Frederick Francis Tating**
15:30 – 16:00	Tea/Coffee Break
16:00 – 16:30	Conclusion

Workshop 2

1st October 2019 (Tuesday)	
Workshop on Disaster Risk Reduction (DRR) ***Session Chair: Prof. Dr. Joy Jacqueline Pereira***	
14:00 – 14:15	**Enhancing Resilience to Geohazards through Communication: Key Principles and Approaches** Dr. Alan Thompson (Cuesta Consulting Limited, United Kingdom)
14:15 – 14:30	**Earth Observation and Geospatial Technology** Dr. Khamarrul Azahari Razak (Universiti Teknologi Malaysia)
14:30 – 14:45	**Debris Flow and Sediment-Related Disaster in Malaysia: A Perspective within DRR Framework** YBhg. Dato' Zakaria Mohamad, PGeol. (Presiden Institut Geologi Malaysia)(IGM)
14:45 – 15:00	***Q&A Session***
15:00 – 15:15	Tea/Coffee Break and Poster Presentation
15:15 – 15:30	**Disaster Risk Resilient: Reflecting on Some Landslide Disasters in Malaysia** Dr. Lim Choun Sian (Universiti Kebangsaan Malaysia)
15:30 – 15:45	**The Importance of Geological Input in Geohazards Risk Reduction** Dr. Frederick Francis Tating (Department of Mineral and Geoscience Sabah)
15:45 – 16:00	**Pengecaman Geobahaya Tanah Runtuh Pendam di Tanah Tinggi Tropika: Beberapa Contoh dari Cameron Highland dan Kundasang Malaysia** Assoc. Prof. Dr. Tajul Anuar Jamaluddin (Universiti Kebangsaan Malaysia)
16:00 – 16:15	**Greening the Slope: Public Works Department of Malaysia (JKR) Experience towards Sustainable Development** Nicholas Jacob (Department of Mineral and Geoscience Selangor)
16:15 – 16:30	***Q&A Session***
16:30 – 16:45	**Disaster Resilient Cities: Forecasting Multi-hazards for Kuala Lumpur** Dr. Nurfashareena Mohamad (Universiti Kebangsaan Malaysia)
16:45 – 17:00	**Landslide Susceptibility Analysis of Kuala Lumpur** Elanni Md Affandi (Universiti Kebangsaan Malaysia)
17:00 – 17:15	**Application of Multiple Geoscience Approach in Geohazards Assessment of Problematic Urban Highway Section in Kuala Lumpur** Abd Rasid Jaapar (President of Geological Society of Malaysia)
17:15 – 17:30	**Tsunami Induced Deposit in Semantan Formation around Jerantut Pahang: A New Perspective** Dr. Askury Abdul Kadir (Geological Society of Malaysia)
17:30 – 18:00	***Q&A Session*** Discussion / Conclusion

30th September 2019 (Monday): PRE REGISTRATION Time : 14:30 – 16:30 Venue : The Palace Hotel (Level 6)	
1st October 2019 (Tuesday)	
08:00 – 09:00	Registration
09:00 – 09.30	Opening Ceremony
Session Chair: Mdm. Melissa Sharmah Gilbert	
09:30 – 10:00	Keynote Speech 1: **Tsunami Hazard in Sabah – Way Forward** Prof. Dr. Felix Tongkul (Universiti Malaysia Sabah)
10:00 – 10:30	Tea/Coffee Break and Poster Presentation
Session Chair: Mdm. Melissa Sharmah Gilbert	
10:30 – 11:00	Keynote Speech 2: **Geoscience for Building Disaster Resilience** Prof. Dr. Joy Jacqueline Pereira (Universiti Kebangsaan Malaysia)
11:00 – 12:00	Parallel Sessions
12:00 – 14:00	Lunch
14:00 – 15:00	Parallel Sessions
15:00 – 15:30	Tea/Coffee Break and Poster Presentation
15:30 – 18:00	Parallel Sessions
19:00	Welcoming Dinner
2nd October 2019 (Wednesday)	
Session Chair: Mdm. Melissa Sharmah Gilbert	
09:00 – 09:20	Keynote Speech 1: **Conservation Geology: From Knowledge to Society** YBhg. Prof. Emeritus Dato' Dr. Ibrahim Komoo (Universiti Kebangsaan Malaysia)
09:20 – 09.40	Keynote Speech 2: **Nickel Mining and Its Environmental Impact** Prof. Dr. Muhammad Nurdin (Universitas Halu Oleo)
09:40 – 10:00	Tea/Coffee Break and Poster Presentation
10:00 – 12:30	Parallel sessions
12:30 – 14:00	Lunch
14:00 – 15:00	Parallel Sessions
15:00 – 15:30	Tea/Coffee Break and Poster Presentation
15:30 – 17:00	Parallel Sessions
17:00 – 17:30	Closing ceremony

KEYNOTE SPEAKERS

PROF. EMERITUS DATO' DR. IBRAHIM KOMOO
Universiti Kebangsaan Malaysia, Malaysia

PROF. DR. FELIX TONGKUL
Universiti Malaysia Sabah, Malaysia

PROF. DR. JOY JACQUELINE PEREIRA
Universiti Kebangsaan Malaysia, Malaysia

PROF. DR. MUHAMMAD NURDIN
Universitas Halu Oleo, Indonesia

LIST OF ORAL PRESENTATIONS

Disaster Risk Reduction, Engineering Geology & Rock Mechanics

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A068	Historical Earthquake Catalogue Data For Seismic Hazard Assessments In Peninsular Malaysia	Meldi Suhatril, Puteri Azura Sari, Ismail Othman and Hendriyawan
A069	Case Studies And Record For Induced Ground Deformation Caused By Retaining Wall Installation	Frankie Cheah, Mohd Ashraf Mohd Ismail and Law Kim Hing
A081	Spatial Statistical Analysis of Earthquakes In Sabah, Malaysia	Mohamad Bin Abd Manap
A098	Landslide Susceptibility Analysis Of Kuala Lumpur Using Bivariate Statistical Analysis For Geohazard Assessment	Elanni Md Affandi, Ng Tham Fatt, Ferdaus Ahmad, Vanessa J. Banks, Christian Arnhardt, Zamri Ramli and Qalam A'Zad Rosle
A108	Integration of GIS-Based MUSLE Model For Flood Disaster Assessment in Kota Belud Area, Sabah, Malaysia	Rodeano Roslee and Kamilia Sharir
A119	Pengecaman Geobahaya Tanah Runtuh Pendam Di Tanah Tinggi Tropika- Beberapa Contoh Dari Cameron Highland Dan Kundasang Malaysia	Tajul Anuar Jamaluddin
A126	Tsunami-Induced Deposit In Semantan Formation Around Jerantut, Pahang: A New Perspective	Askury Abd Kadir, Mohd Suhaili Ismail, Choong Chee Meng and Jasmi Ab Talib
A143	Disaster Resilient Cities: Forecasting Multi-Hazards For Kuala Lumpur	Nurfashareena Muhamad , Joy Jacqueline Pereira and Julian Hunt
A046	Modified Grout Pressure Method For Predicting Ground Surface Settlement In Kenny Hill Formation	Darvintharen Govindasamy, Mohd Ashraf Mohamad Ismail and Mohd Faiz Mohammad Zaki
A077	Rock Mass Classification in Tunnelling - A Practical Approach	Mogana Sundaram N
A152	Application of Multiple Geoscience Approaches In Geohazards Assessment of Problematic Urban Highway Section In Kuala Lumpur	Afiq Farhan Abd Rahim, Abd Rasid Jaapar, Mohd Farid Mohd Dali and Mohd Faruq Syahmi Md Aripin
A004	Evaluation Of Rock Cut Slope Stability Of Sandakan Formation By Modified-Slope Mass Rating (M-SMR) System, Sabah, Malaysia	Rasyidah Moneey, Ismail Abd Rahim and Baba Musta
A080	Probabilistic Seismic Hazard Assessment of Balik Pulau Region, Pulau Pinang	Siti Noor Shafiqah Badrolhisham And Abdul Halim Abdul Latiff
A025	Application Of Geohazard-Seismic: Influence Of Channel Structure Towards Gas Cloud Distribution At 'B' Field	Norazif Anuar Hasni, Nur Shafiqah Shahman, Deva Prasad Ghosh and Jasmi Ab Talib
A067	Greening The Slopes – Public Works Department Of Malaysia (JKR) Experiences Towards Sustainable Development	Nicholas Jacob T Jacob
A045	Correlation Between Uniaxial Compressive Strength, Point Load Test, Young Modulus And Schmidt Hardness For Weathered Limestone	Sharan Kumar Nagendran and Mohd Ashraf Mohamad Ismail
A064	Land Use/Land Cover Change Of Delhi Region Using Remote Sensing And Gis Techniques	Abdul Qadir, Ismail Ahmad Abir, Maryam Tahir and Naseem Akhtar
A106	Correlation For Estimating The Static Young's Modulus Of Limestone	Ailie Sofyiana Serasa, Goh Thian Lai and Abdul Ghani Ms. Rafek

Mining & Quarry

ID No.	Title	Authors
A023	Assessment of Spatial Distribution of Heavy Metal Associated with Mining Activities using Compositional Data Analysis in Sg Koyan, Pahang	Piseth Heng, Kamar Shah Arrifin and Hareyani Binti Zanidi
A095	Mineral Production and Mining Industry Linkages In The Economy of Malaysia	Mohd Suhaili Ismail and Haniza Zakri
A053	Source Rock Pyrolysis and Thermal Maturity of Tertiary Coals from the Merit-pila Coalfield, Central Sarawak, Malaysia.	Nor Syazwani Zainal Abidin, Wan Hasiah Abdullah and Khairul Azlan Mustapha
A036	Distribution Of Minerals From Sungai Terengganu: Upstream Vs Downstream Fluvial Section	Athia Dalily Baharuddin, Ahmad Mursyidi Alias, Ali Imran Azman, Mohamad Shaufi Sokiman, Md Yazid Mansor, Jasmi Ab Talib, M Suhaili Ismail, Abdullah Sulaiman, Effi Helmy Ariffin and Idham Khalil

Tectonic & Structural Geology

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A006	Crustal Thickness And Velocity Structure Of Kota Kinabalu Region	Abdul Halim Abdul Latiff and Faridah Othman
A012	The Jalan Wangsa Thrust In Eastern Kuala Lumpur; A Marker For A Major Crustal Boundary Between The Leading Edge Of The Sibumasu Block And The Sukhothai Arc?	A. Graham Leslie, Ng Tham Fatt, Qalam A'zad bin Rosle, Ramzanee Mohd Noh, Thomas J.H. Dodd, Martin R. Gillespie and Marcus R. Dobbs
A130	Palaeo-Channel Morphology And Distributions In The Straits Of Malacca During The Last Glacial Maximum	Abdullah Sulaiman, Hasrizal Shaari, Aidy M Muslim, Siti Aishah Ishak, Sumayyah Mohd Huri Al-Amin and Mohamad Shaufi Sokiman
A026	Seismic Attributes for Faults Interpretation and Geomorphology: Application to N-Field, Malay Basin, Malaysia	Nur Shafiqah Shahman, Norazif Anuar Hasni & Deva Prasad Ghosh

Petroleum Geology, Sedimentology & Paleontology

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A033	Lithofacies Of The Jurassic-Cretaceous Continental Deposit Along Jerantut-Maran Road In Jerantut, Central Pahang	Azyan Syahira Azmi, Mohd Suhaili Ismail and Jasmi Ab Talib
A052	Petrographic & Petrophysical Properties of Turbidite Sandstones of West Crocker Formation, Sabah	Nurul Syahidatul Balqis Haidzir
A115	The Idanre Granite Complex, Southwestern Nigeria: A Synopsis And Paradigm Of Petrographic And Petrochemical Characterization	Oluwatoyin Akinola
A124	The Continental Shelf Beyond 200 Nautical Miles: Overview Of Exploration And Exploitation of Its Natural Resources	Mazlan Madon
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A088	Analysis of Mechanical Behaviour of Reservoir Rock Properties	Kwan Mei Fern and Noraini Surip

A107	Litho- And Biostratigraphy Of The 'Black Shale' Facies (Chert Unit) Of The Semanggol Formation At Kampung Kubu Gajah (N Perak, Peninsular Malaysia)	Nurliyana Hamdan and José Antonio Gámez Vintaned
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A008	Lessons From Deep 2d Seismic Over Central Luconia Province, Offshore Sarawak	Siti Nur Fathiyah Jamaludin, Benjamin Sautter, Manuel Pubellier & Michael Poppelreiter
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A011	New Insights Into The Sedimentology of The Kenny Hill Formation, Peninsular Malaysia	Thomas J.H. Dodd, Ng Tham Fatt, Qalam A'zad bin Rosle, Ramzanee Mohd Noh, A. Graham Leslie, Marcus R. Dobbs and Martin R. Gillespie
A015	Deep Marine Paleogene Sedimentary Sequences Of West Sabah: Contemporary Opinions And Ambiguities	Muhammad Jamil, Abdul Hadi Abd Rahman, Numair Ahmed Siddiqui and Nisar Ahmed
A021	The Sedimentology And Depositional Environment Of The Late Jurassic - Cretaceous Pedawan Formation, Serian Area, West Sarawak	Najiatun Najla Mohamad, Abdul Hadi Abd Rahman and Mohd Suhaili Ismai
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A105	West Crocker Subdivisions: West Crocker, East Crocker, North Crocker & South Crocker Formations	Nurul Syahidatul Balqis Haidzir
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A022	Facies Analysis Of The Pedawan Formation In Kota Padawan - Siburan Area, Kuching, Sarawak.	Nur Marina Samsudin and Abdul Hadi Abdul Rahman
A057	Facies Analysis Of Deep Marine Channel To Lobe Deposits Of Maastrichtian Layar Member Of The Belaga Formation, Rajang Group, Sarawak	Nisar Ahmed, Hassan Baioumy, Ahmed Mohamed Ahmedsalim, Abdul Hadi Abd Rahman and Muhammad Jamil
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Conservation Geology, Geoarchaeology & Geotourism

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A104	Potential Geoheritage Values Of Gua Sireh, Baling Kedah	Nursufiah Sulaiman, Noorzamzarina Sulaiman, Norshafika Abdullah, Nur Syafiqa Mohd Sabari and Nur Farina Roslan
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Hydrogeology, Environmental Geology & Geochemistry

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A018	Geophysical Survey And Lineament Study For Groundwater Exploration At Pulau Mengalum, Sabah	Mohd Hariri Arifin, Muhammad Khairel Izzuan Ismail and Tajul Anuar Jamaluddin
A001	Cased Hole Formation Resistivity Contribution in Water Management and Production Enhancement of Mature Reservoirs	Ghareb Hamada, Osama Mahdy and Murro Chandran
A054	Analysis of Rare Earth Elements in Soil, Rock and Concentrate Samples by LA-ICP-MS from JMG's Experience	Mohd Zahar Ibrahim
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A030	Geochemistry Of Granites In Gua Musang	Nor Shahida Shafiee, Lilly Azleena Azreen Bahrin, Arham Muchtar, Ainaa Mardhiyah Hassin and Muhammad Muqtada Ali Khan
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A065	Zircon U-Pb And Hf Isotope Constraints On The Neogene Semporna Peninsula Volcanic Rocks And Its Tectonic Implications	Elvaene James and Azman A. Ghani
A070	Combined Of In Tank Aeration And Ozonation Groundwater Treatment System In Kg Melai, Tasik Chini, Pekan, Pahang.	Azrul Normi Idris, Ismail Tawnie, Anuar Sefie and Khairul Nizar Samsudin
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A084	Major And Trace Elemental Analysis Of The Belata Black Shales In Peninsular Malaysia	Esther Boateng Owusu, Tsegab Haylay & Cornelius Borecho Bavoh
A090	Study Of Ouw Natural Clay-Tio2 Composites Synthesis Method For Application To Linear Alkylbenzene Sulfonat Surfactant Degradation Reactions.	Catherina Bijang
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A097	Groundwater Hydrogeochemistry Assessment In Langat River Basin, Malaysia	Anuar Sefie, Ismail Tawnie, Mohd Khairul Nizar Shamsuddin, Azrul Normi Idris, Syaiful Bahren Saadudin and Munirah Abdul Zali
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A071	Calibration Of In-Situ Pressuremeter Test Using Numerical Simulation: A Case Study Of Kenny Hill Formation	Mohd Faiz Mohammad Zaki, Mohd Ashraf Mohamad Ismail, Darvintharen Govindasamy and Lim Siao Phin
A074	Enhancement Of Peat Soil Properties By Applying Electrokinetic Stabilization (EKS) Method At Parit Parit Kuari, Johor, West Malaysia	Abdul Wahab, Zaidi Embong, Qamar Uz Zaman & Hidyat Ullah
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A002	Developed Correlations Between Sound Wave Velocity And Porosity, Permeability And Mechanical Properties Of Sandstone Core Samples	Ghareb Hamada and Veronique Joseph
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A062	Integration Of Resistivity And Gravity Methods For Karstic Void Identification At Gua Serai-Gu	Zaitul Zahira Ghazali, Nurwahidah Mohd Idrus, Muhammad Ashiq Bin Abbas, Ismail Ahmad Abir, Khiruddin Abdullah and Mohd Nawawi Mohd Nordin
A017	Characterization Of Soft Marine Clay Deposits Using Geophysical And Geotechnical Methods	Najmiah Rosli, Rosli Saad, Nazrin Rahman & Nur Azwin Ismail

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2	A007	Assessment Of Petroleum Source Rock Potential And Paleodepositional Conditions Of The Paleozoic Carbonaceous Shales Of The Kubang Pasu And Timah Tasoh Formations In Central Perlis, Malaysia	Muhammad Nadzmi Abdul Ghofur
3	A016	Spatial Relationship Quantification of Mineralization Factors and Gold Potential Mapping in Kelantan, Malaysia	Mathew Gregory Tagwai
4	A029	Subsurface Investigation For Cocoa Cluster - Ranau Highland Cluster Development Project, Ranau, Sabah	Mohamad Kamal Izzat Najid
5	A032	Closer Look Of The Stratigraphy And Structural Patterns Of The Neogene Basin In The Offshore Of Kudat Peninsula	Siti Nur Fathiyah Jamaludin
6	A034	Subsurface Structures And Minerals Identification Using Electrical Method And Geological Analysis At Bojonegoro District, Indonesia	Nur Farhah Ali
7	A039	Survei Geofizik Menggunakan Kaedah Keberintangan Elektrik Dan Pengutuban Teraruh Bagi Profil Bawah Permukaan Di Loji Rawatan Air Sungai Bilut, Raub, Pahang	Zulaika Farhani Salehudin
8	A042	Kesan Pengunaan Bahan Perapi Tanah Organik Bagi Merawat Tanah Jerlus Di Kawasan Penaman Padi, Alor Senibong, Kedah	Wan Mohd Razi Idris
9	A043	Rock Slope Discontinuity Sets Extraction From Photogrammetric Point Cloud Using Cloud Compare And DSE	Sharan Kumar Nagendran
10	A044	A Study On Influence Of Twin Tunnel Configuration In Kenny Hill Formation Using Numerical Approaches	Darvintharen Govindasamy
11	A058	Prediction Of Unload-Reload Pressuremeter Modulus (EUR) Using Gmdh-Neural Network: A Case Study Of Kenny Hill Formation	Mohd Faiz Mohammad Zaki
12	A082	Geochemistry Of Permo-Triassic Meta-Sedimentary Rocks Of Southern Part Ulu Sokor Gold Mine Deposit, Kelantan, Peninsular Malaysia: Emphasizing On Source Area, Provenance, Recycling And Depositional Tectonic Setting	Ahmad Fauzan Yusoff
13	A102	Application Of Electrical Resistivity Tomography To Identify Suitable Location Of Shallow Tube Well For Irrigation	Muhammad Haniff Ahmad
14	A113	Mapping of Major Fault Structures By Gravity Technique In Peninsular Malaysia	Nurul Fairuz Diyana Bahrudin
15	A125	What Lies Beneath: Deep-Marine Trace Fossils In The West Crocker Formation And Their Palaeoenvironmental Significance	Mazlan Madon
16	A133	Trace Element Fractionation Behaviour of Soil From Benta Alkali Syenite	Siti Nadzirah Nazri
17	A141	Risk of Biotic Degradation on Structural Wood	Melissa Sharmah Gilbert Jesuet
18	A151	Slow Onset And Emerging Hazards In The Coastal Zone Of Kuala Selangor, Malaysia	Nurul Syazwani Yahaya

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20	A075	Basic Friction Angle Value of Planar Surface For The Sandakan Formation, Sabah, Malaysia	Ismail Abd Rahim
21	A109	Flood Susceptibility Analysis Using Geospatial Frequency Ratio In Kota Belud, Sabah	Kamilia Sharir
22	A110	Landslide Susceptibility Analysis Using Factor Analysis Model (Fam) In Kota Kinabalu, Sabah	Mahadi Santa
23	A111	The Sabah Annex For Did Guideline For Erosion And Sediment Control In Malaysia: A Case From Sabah West Coast	Jeffery Anak Pirah
24	A128	Utilizing The Magnetic Source Edge Detection (MSED) Method In Mapping Geologic Features Within A Sedimentary Basin	Gerald Eko Ejiga
25	A131	Slope Failure Run-Out Estimation From Earthquake Disaster: A Case Study In Mesilou, Kundasang	Hennie Fitria Wulandary Soehady Erfen
26	A132	Sedimentologi Jujukan Batu Pasir Bertangga Di Air Terjun Bukit Bertangga, Pahang.	Khor Wei Chung
27	A137	Characterization of Sacharomyces Cerevisiae Isolated From Sabah Soil For Fuel Ethanol Production	Rahmath Abdulla
28	A138	Mining The Microbiome: A Mini Review On Natural Products Discovery From Soil	Suraya Abdul Sani
29	A139	Environmental Attitudes And Preferences For Mangrove Conservation At Kilim Karst Geo-Forest Park, Langkawi, Malaysia	Fazilah Musa
30	A140	Oligosen Akhir – Miosen Awal Foraminifera Bentos Kecil Dari Formasi Crocker Dan Formasi Temburong, Selatan Semenanjung Klias	Junaidi Asis
31	A142	A Systematic Literature Review On Community Resilience To Natural Disaster: Enhance Risk Management For Sustainable Forest Management In Sabah	Hardawati Yahya
32	A144	Applying Fuzzy Contrast Enhancement On Earthquake Impact Images	Suzelawati Zenian
33	A145	Accumulation of heavy metals in rice grown from rainfed rice field in highland of Kiulu Valley, North Borneo	Diana Demiyah Mohd Hamdan
34	A146	Bioleaching: A Microbial Technology Approach On Environmentally Friendly Refinement Of Low Grade Metals - A Review	Suraya Abdul Sani
35	A148	Enforced Mechanical Properties Of Plaster Paris: Effect Of Organic Fibre	Asmahani Awang
36	A153	Model Fitting On Earthquake Occurrence In Sabah	Su Na Chin

SESSION KEYNOTES

SK-1

Tsunami hazard in Sabah – Way forward

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Abstract: The coastal areas of Sabah located near the seismically active zones of Philippines and Indonesia would be affected by future earthquake-induced tsunamis located in the Sulu Sea, Celebes Sea and South China Sea. Based on historical records of tsunamis and large earthquakes, the potential source of tsunamis would be along the trenches of Manila, Negros, Sulu, Cotabato, Sangihe and North Sulawesi. Based on tsunami propagation models from these sources, using worse-case scenarios (Magnitude 8 earthquake), it was found that tsunami waves can reach the coast of Sabah between 30-120 minutes, depending on the locations. The relatively wide continental shelf along most of coastal areas of Sabah, however, resulted in insignificant run-ups (less than a meter) of these distant tsunamis, except for some areas. The narrow continental shelf fronting the coastal areas of Tawau and Semporna resulted in locally significant run-ups (more than a meter). While tsunamis cannot be prevented, levels of risk can be reduced and sometimes eliminated with proper understanding of how it interacts with its surroundings. Tsunami waves tend to concentrate in certain locations because of wave refraction due to local bathymetry; the run-up and extent of inundation is similarly a function of land topography and near coastal geomorphology. Mapping vulnerable areas is essential for formulating emergency evacuation plans. At the same time public awareness campaign on tsunami hazard preparedness targeted specifically at communities in high risk areas such as in Tawau and Semporna should be carried out.

Keywords: Tsunami, earthquake, coastal geomorphology, tsunami modelling, tsunami inundation map, tsunami preparedness

SK-2

Geoscience for building disaster resilience

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The world is already seeing the consequences of 1°C of global warming through more extreme weather and rising sea levels among other changes. The 2018 Special Report of the Intergovernmental Panel on Climate Change (IPCC) on Global Warming of 1.5°C projects that tropical Southeast Asia will experience more severe and extreme events that will impact economic growth as global warming proceeds to 1.5°C. Even if the climate eventually equilibrates at 1.5° C above pre-industrial levels, anticipatory adaptation planning is required to eliminate the risk of large damages and adaptation costs in exposed and vulnerable areas. This situation calls for enhanced synergies between climate change adaptation (CCA) and disaster risk reduction (DRR).

Earth processes and society are connected in multiple ways and geoscience inputs provide invaluable insights to understanding hazards and its associated risks. Susceptibility modelling is advancing in the evaluation of climate-related hazards such as landslides, floods, erosion, subsidence and slow onset sea level rise, among others. Susceptibility modelling enables spatial demarcation of areas where a hazard event could occur, depending on contributing surficial features, geological conditions and processes that vary depending on the hazard. Modelling of hazards at the local level offer the best options for monitoring and early warning adaptation measures. Susceptibility modelling based on terrain morphology, geology, soils and land cover has been found to be cost effective, applicable at large or small scales, complementary to hydrological models and suitable for land use decision-making.

There is great potential for geosciences to progress susceptibility modelling for multi-hazards at the local level under a variety of climate settings, in collaboration with experts from diverse disciplines. The Asian Network on Climate Science and Technology (ANCST), facilitates the advancement of science, technology and innovation through multi-sector and multidisciplinary partnerships [http://ancst.org/]. ANCST has been instrumental in bringing together geoscience, climate and atmospheric experts from Malaysia and the UK, to jointly develop the project on “Disaster Resilient Kuala Lumpur”.

Geoscience is steadily increasing its contribution to the multidisciplinary solution space that addresses the challenge of climate change. Susceptibility modelling of hazards offer invaluable insights for understanding risk, exposure and vulnerability to predict and lessen the impact of natural hazards as the climate changes. Nationally available geoscience datasets can be leveraged to develop local level monitoring and early warning adaptation measures, under a variety of climate settings. This is an aspect that is being pursued by the Academy of Sciences Malaysia through its Disaster Risk Reduction Research Alliance Committee (DRR Research Alliance).

SK-3

Conservation Geology: From knowledge to society

Ibrahim Komoo

Universiti Kebangsaan Malaysia, Malaysia

Knowledge on Geology (Earth Science) has not been used extensively for societal well-being. Traditionally, geologists have been working for resource exploitation particularly in sectors or industries related to mining, quarrying and petroleum. These resources exploitative activities are associated with a set of values considered as unfriendly and unsustainable to nature conservation. The term Conservation Geology is derived from the idea of non-destructive utilization of earth resources with high heritage values. Conservation Geology is thus defined as the advancement of knowledge on earth's physical resources that contain heritage values and are connected to the human civilization in the context of history, culture and science. More importantly, knowledge and understanding of geoheritage should be translated into meaningful policy, process and product which can benefit the society at large. This presentation highlights our attempts to develop the above idea into a sub-discipline of geology, and consequently, use the knowledge for developing products for geotourism and geopark.

SK-4

Nickel mining and its environmental impact

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Abstract: In the last few years, natural resource management activities in Indonesia have mostly been carried out on mineral and ore resources, this is proven by the existence of various mining industries. Based on United States Geological Survey data in 2016, Indonesia is the 6th largest nickel producer in the world with a production of 168,500 metric tons. This was supported by the Government of Indonesia through the Ministry of Energy and Mineral Resources in 2017 by building 13 mineral processing and refining facilities (smelters). The Southeast Sulawesi Province is the largest supplier of nickel mining potential at 47.6%. To date, there are 18 nickel mining companies operating in Southeast Sulawesi. The distribution of nickel mining areas in Southeast Sulawesi covers the districts of Kolaka, North Kolaka, Konawe, North Konawe, South Konawe, Bombana, and Button. This study aims to analyze the nickel mining activities in Indonesia, especially Southeast Sulawesi and their impact on the environment.

Some negative impacts from nickel mining activities in North Konawe-Southeast Sulawesi have been reported, namely 1) Road damage 60.7%; 2) River, swamp pollution 78.6%; 3) Air pollution 64.3%; 4) Agricultural land disturbance 92.9%; 5) Plantation area disturbed / reduced by 75%; 6) Reduced agriculture / plantation productivity of 78.6%; 7) Flora damages 89.3%, and fauna 71.4%; 8) 75% no health empowerment and 57.1% no health improvement; 9) Changes in community behavior / norm 64.3%. This data is supported by the occurrence of flash floods in North Konawe in 2019. By 2020, an estimated 71.7 million tons of nickel ore will be absorbed by domestic processing and refining plants. Then from the factory products, around 24% will be absorbed by the domestic stainless steel industry. Based on the negative impacts reported there needs to be a serious effort in designing an environmental improvement program.

Keywords: Nickel, environment, Indonesia, Southeast Sulawesi

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ORAL PRESENTATIONS

DISASTER RISK REDUCTION, ENGINEERING GEOLOGY & ROCK MECHANICS

A068

Historical earthquake catalogue data for seismic hazard assessments in Peninsular Malaysia

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One of the most fundamental inputs required in Seismic Hazard Assessment is a reliable historical earthquake catalogue data for the region of study. In this paper, the process of earthquake catalogue data compilation for Peninsular Malaysia is discussed in detail. The earthquake catalogue data recorded for this study is compiled from several seismic sources such as local faults in Peninsular Malaysia, Sumatra Fault Zone (SFZ), and Sumatra Subduction Zone (SSZ) which consists of Megathrust and Benioff Seismic sources. The recorded earthquake data occurred around Peninsular Malaysia is collected from many sources such as United States Geological Survey (USGS), International Seismological Catalogue and Global Earthquake Model (ISC-GEM), individual earthquake catalogue (Centennial), and Malaysian Meteorological Department catalogue. Selection on the unit of measurements of earthquake size is needed in order to obtain the consistent unit of earthquake size in the seismic hazard analysis. Other types of magnitude scales in the catalogue are converted to moment magnitude scale (Mw) by using empirical correlations. Some statistical regression equations have been developed to generate empirical correlations for determining the relationship among the different magnitude scales such as moment magnitude (Mw), surface wave magnitude (Ms), body wave magnitude (Mb), local magnitude (ML), energy magnitude (Me), Japan Magnitude Scale (Mj) and others. The accuracy of the correlations is determined by using performance indices such as multiple coefficient of determination (r2), adjusted multiple coefficient of determination (ra2) and standard deviation (σ). The total number of earthquakes in the working file is 19355. The combined catalogue after removal of foreshock and aftershock events by using Gardner & Knopoff criteria (1974), contains 2805 records or less than 15% of the total earthquake records.

A069

Case studies and record for induced ground deformation caused by retaining wall installation

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Abstract: Development of major rail infrastructure project in Klang Valley will give rise to movements in the surrounding ground with consequent potential for damage to surrounding structures. In this case record, a series of finite element analyses has been carried out to investigate the impact of diaphragm wall installation in both two-dimensional and three-dimensional analysis on the vertical ground deformation and changes in the lateral stress during the installation process. The impact of the diaphragm wall installation will include the simulation of the diaphragm wall trenching works, stability of the wall trenching works using bentonite and till the completion of diaphragm wall casting works. Hardening Soil Small Strain model, an advanced constitutive model with the consideration of small strain stiffness on the soil will be adopted in this case study. The measured value of the ground displacement within the vicinity of the completed wall are tabulated and a good agreement is observed between the numerical results and the monitoring data with the consideration of small strain stiffness on the soil.

Keywords: Deep excavation, diaphragm wall installation, small strain, finite element analysis

A081

Spatial statistical analysis of earthquakes in Sabah, Malaysia

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Abstract: This paper presents an application of spatial pattern analysis techniques to a seismic data catalogue of earthquakes in Sabah, Malaysia. It's intended to try and detect clusters as well as explore global and local spatial patterns on earthquakes that were recorded between 1988 and 2018, having local magnitudes from the 1.0-6.0 using a geographical information system (GIS). For this purpose the spatial pattern analysis techniques chosen for this study were Average Nearest Neighbour, Spatial Autocorrelation (global Moran's I), High/Low Clustering (Getis–Ord general G), Cluster and Outlier Analysis (Anselin Local Moran's I), Hot Spot Analysis (Getis–Ord Gi*), kernel density estimation, and geographical distributions. In addition each of these techniques was implemented in the GIS so that computations could be carried out quickly and efficiently. From the results showed that (1) these techniques were capable of detecting clusters in the spatial patterns of the occurrence of the earthquakes; (2) both global and local spatial statistics indicate that earthquakes were clustered in the study area of Sabah, Malaysia; (3) earthquakes with strong magnitudes (6 – 6.9) on the Richter scale were found dispersed in the state of Sabah where seismic activities were most active compared to other states in Malaysia; (4) earthquakes with moderate magnitudes on the Richter scale (5-5.9) were randomly distributed in Sabah; and (5) earthquakes with weak magnitudes on the Richter scale (4-4.9) were particularly concentrated in the Ranau area and southeast area of Sabah. In this study, we have concluded that the pattern analysis techniques applied to the seismic data catalogue of earthquakes in Sabah, Malaysia could detect clusters in the occurrence of earthquakes from 1988 to 2018.

Keywords: Earthquake, spatial statistics, GIS, Sabah, Malaysia

A098

Landslide susceptibility analysis of Kuala Lumpur

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Abstract: In the aspect of geophysical hazard in Kuala Lumpur, landslide and flood are two major natural disaster that have degrade the country in all ways. Numerous studies have been done locally to investigate the mechanism and nature of geophysical hazards. Landslide is considered a prominent geohazard in the country and worth RM 34 billion economic losses for the past 34 years. What is worse is the fact that most landslide in Malaysia occurred on man-made slope due to anthropogenic causes and can be mitigated if action is taken fast (Mahmud, 2013). With more ambitious development projects set for Kuala Lumpur in the next decade to support the urban innovation and city performance, mitigation of hazard and emphasis on disaster risk reduction is imperative to ensure the city's sustainability, prosperity and resilience are secured. This paper presents the method of landslide susceptibility analysis in Kuala Lumpur using bivariate statistical analysis by correlating the level of dependency of each class factor with landslide occurrence in Geographical Information System (GIS). The deliverable of this study is primarily to provide a suggested 5 ranking classification for spatial probability of occurrence (very low, low, moderate, high, very high) and does not convey information on the hazard and risk as well as the return periods.

Landslide inventory within Kuala Lumpur which become the primary input for this paper was prepared by compiling and organizing the relevant landslide occurrences from the Department of Mineral and Geoscience (JMG) and the Kuala Lumpur City Hall (DBKL). Data were retrieved from various sources such as satellite imagery, topographical maps, LiDAR data, geological data, reports and previous land use maps. Media reports were used to cross-check the landslide events and complete the spatial and temporal data. Fourteen parameters for landslide occurrence were analysed which covers topographical, hydrological and geological which include bedrock geology, surface geology, distance to lineament, distance to road, distance to streams, slope gradient, elevation, topographical position index, curvature, Normalized Difference Vegetation Index (NDVI), surface roughness, slope aspect, stream power index and topographical index. Statistical (qualitative) approaches are data-driven method and rely on the functional relationships between known factors and the past landslide distribution (Guzetti *et al*., 1999). The individual parameters were compared to the landslide density map to obtain their relative importance that contribute to landslide occurrence. The weightage of each class is calculated based on landslide density occurrence of each class for every parameter.

The analysis showed 8.9% coverage of Kuala Lumpur classified as very high susceptible zone comprising of 524 landslide events (80.6%). The most relevant combination of parameter maps resulted in 88% of success rate. Cross validation technique done on the chosen map by subdividing it into 2 zones of alternating area whereby the first zone is tested and validated using weightage of the other zone which resulted to 88% and 85% of success rate for Zone A and Zone B respectively. The study will delineate landslide prone areas in support of city development and planning as well as disaster risk and reduction efforts. This research will help to refine the spatial forecasting ability of landslide disaster, improve slope management and land-use planning. Landslide inventory could be further improved by systematically collect data especially in terms of date, time and consistent record of landslide points and its type.

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A108

Integration of GIS-based MUSLE model for flood disaster assessment in Kota Belud area, Sabah, Malaysia

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Abstract: Soil erosion is one of the principal causes of soil degradation and flood disaster in Kota Belud area, Sabah, Malaysia. The 2015 Ranau earthquake had a major impact on the river basin system in Kota Belud area. Tremors caused a major earthquake and several aftershocks caused widespread landslides occurred around Mount Kinabalu area. The landslide took off around 1,500 hectares (15 km^2) of soils, rocks and vegetation on the slopes (Figure 1). Landslides not only causes damage to watersheds that lead to lack of water in the river, but also contributed to the debris flow occurrences during heavy rain. Some of the debris flow occurred in Mesilou River, Kilambun River, Kedamaian River and Penataran River few weeks after a major earthquake. The effects of debris flow occurrences have caused the river basin conditions to be shallow. The natural phenomenon of flood triggered by erosion in Kota Belud area is now accelerated by human activities that alter the natural mechanisms. This acceleration is caused by destruction of plant cover, the growing of wrong cultivations, unsuitable farming techniques etc., all of which may be prevented with correct management and land planning. Soil erosion has been identified as one of the important environmental issues or main contributors to the flood occurrences and therefore, detail assessment on prediction of soil loss and its impacts has been carried out using the application of the Modified Soil Loss Equation (MUSLE) model integrated with Geographical Information System (GIS). Identification of potential high-risk erosion areas was made using a thematic data layering approach to analyse risk areas. The quantitative soil loss (t $ha^{-1}yr^{-1}$) ranges estimates by MUSLE model by a spatial information analysis approach (GIS) were computed: (a) Very High risk (>15 tons/ha/year); (b) High risk (10-15 tons/ha/year); (c) Moderate risk (5-10 tons/ha/year); (d) Low risk (3-5 tons/ha/year); and (e) Very low risk (<3 tons/ha/year). About 61.50% (89 Acre) of the area was classified as very low, 2.67% (4 Acre) as low, 4.76% (7 Acre) as moderate, 3.57% (5 Acre) as high and 27.50% (40 Acre) as very high (Figure 2). All findings showed that integration of GIS can be used for spatial analysis in a regional scale. Production of A total value maps can be applied to particular development planning areas especially for housing and agriculture developments or disaster risk management program.

Keywords: Modified Universal Soil Loss Equation (MUSLE), empirical model, flood

ACKNOWLEDGEMENT

Sincere gratitude to Universiti Malaysia Sabah (UMS) for providing easy access to laboratories and research equipment. Highest appreciations also to the research grant award (SDK0012-2017) and to finance all the costs of this research.

Figure 1: Ranau earthquake 2015 caused a major earthquake and several aftershocks caused widespread landslides occurred around Mount Kinabalu area. The landslide took off around 1,500 hectares (15 km^2) of soils, rocks and vegetation on the slopes.

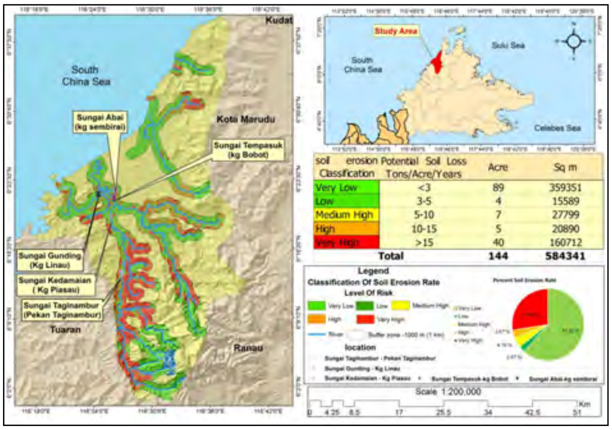

Figure 2: Erosion rates in selected rivers at Kota Belud area, Sabah.

A119

Pengecaman geobahaya tanah runtuh pendam di tanah tinggi tropika – Beberapa contoh dari Cameron Highland dan Kundasang, Malaysia

(Identification of dormant landslide geohazards in tropical highlands – Examples from Cameron Highlands and Kundasang, Malaysia)

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Abstrak: Tanah runtuh pendam lama adalah sejenis geobahaya yang masih kurang mendapat perhatian di kalangan geosaintis tempatan kerana kewujudannya sering terlepas pandang di sebalik kerencaman topografi dan tutupan tumbuhan yang tebal di kawasan tanah tinggi tropika. Proses pengecaman dan pemetaannya memerlukan kemahiran dan pengalaman kerana fitur-fitur geomorfologi yang berasosiasi dengannya telah diubahsuai akibat proses luluhawa, hakisan dan pemendapan yang pesat di rantau tropika. Akhir-akhir ini semakin banyak pembangunan infrastruktur berlaku di kawasan berbukit dan tanah tinggi Malaysia. Ini secara tidak langsung mendedahkan pelbagai masalah geoteknik dan risiko geobencana susulan pengaktifan semula tanah runtuh pendam apabila diganggu oleh aktiviti manusia. Tanah runtuh pendam lama boleh dikenalpasti melalui cerapan morfologi dan corak topografi cerun bukit secara teliti. Kini dengan penggunaan teknologi drone dan penderiaan jauh (seperti pengimbas laser, IFSAR, LiDAR, INSAR), proses pencerapan morfologi tanah runtuh lama semakin mudah dan lebih meyakinkan. Sesebuah tanah runtuh, samada yang baharu atau pendam lama mempunyai himpunan fitur-fitur geomorfik yang tersendiri, bergantung kepada jenis, saiz dan usia kegagalan. Antara fitur-fitur yang menjadi petunjuk utama adalah kerawang, tubir yang lengkuk di bahagian kepala, tubir sisi, cerun cekung di bahagian hulu, disusuli dengan topografi cembung dan beralun di bahagian kaki cerun. Tanda-tanda lain seperti kehadiran longgokan kolovium di kaki cerun atau di dasar lembah, anak-anak sungai yang bercabang bentuk-Y di bahagian hulu cerun, kewujudan teres-teres bertingkat, perbezaan kepadatan tumbuh-tumbuhan dengan cerun sekitarnya, juga boleh dijadikan petunjuk awal untuk mengenalpasti tanah runtuh pendam dan menganggarkan usia relatifnya. Beberapa contoh yang diperolehi dari kawasan Cameron Highlands dan Kundasang, boleh dijadikan panduan untuk mengecami dan mengenalpasti kehadiran geobahaya tanah runtuh pendam, samada muda, dewasa atau tua.

Katakunci: Tanah runtuh pendam lama, geobahaya, fitur geomorfologi

Abstract: *Old-dormant landslide is a type of geohazard that often been ignored by some local geoscientists because their occurrences are often overshadowed by topographic complexity and dense vegetation cover in the hilly tropical terrain. Their recognition and identification may require some basic skills in geomorphology and experience because the associated geomorphic features tend to be mollified by intense tropical weathering, erosion and sedimentation. Recently, more new infrastructural developments are encroached into the hilly terrains of Malaysia. This has indirectly exposed various geotechnical problems and geodisaster risks due to human-induced reactivation of the unsuspected old-dormant landslides. Old dormant landslides can be identified through detailed observation on the morphology and hill slope topography. Now, with the help of new and advanced remote sensing technology (such as air-borne laser scanning, LiDAR, IFSAR, INSAR, etc), geomorphological observation of old dormant landslide in remote natural terrains is getting easier and more convincing. A landslide, whether new or old, is often characterized by an assemblage of distinct geomorphic features depending on its type, size and age. Amongst the main signature features are arcuate crown and main head scarp, side scarps, concave upper slope, convex lower slope and followed by undulating hummocky topography at its toe. Other signs include the presence of the colluvial deposit at the foot of the slope or in the downstream valley floor, Y-shaped bifurcating streamlets in the upstream, the existence of stepped terraces, contrast in vegetation cover compared to the slope counterparts; can be used as indicators for the identification of and to estimate the relative age of old-dormant landslides. Some examples from the Cameron Highlands and Kundasang areas, are presented herein to serve as a guide in recognition and identification of dormant landslide geohazard, either young, mature or old.*

Keywords: *Old-dormant landslides, geohazards, geomorphic features*

A126

Tsunami-induced deposit in Semantan Formation around Jerantut, Pahang: A new perspective

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Semantan Formation is well-established in Malaysia with their stratigraphic thickness ranges from 2 to 4.3 km interpreted by previous researchers. This typical volcaniclastic mixed with any nonvolcanic fragment types, syngenetically formed during the closing up of paleo-tethys. The occurrence of conglomeratic bed within a thick sequence of turbiditic Semantan Formation is triggering some thought on the process of deposition. The thickness of matrix supported conglomerate is estimated about 30 m along Jerantut-Jengka road. It seems to be a chaotic and restricted sequence composed of rounded to sub-rounded fragments of volcanic origin, ranges from 10 to 150 mm in diameter. Chert clasts are also observed in minor composition with an average size of 10 mm. Unfortunately, the fragments are highly weathered with distinct volcanic texture assemblages through macroscopic identification, such as andesite, quartz porphyry, crystal-lithic tuff and rhyolitic tuff. It is a mixture of intermediate to acid in composition. In geological process, an enormous energy is required to transport the bigger fragments into the deep sea setting. We thought that the catastrophic tsunami was the main agent to shift those materials from coastal area (delta or river mouth) during the closing of paleo-tethys by the convergent between Sibumasu and Indochina. During the Permo-Triassic, the seismicity and volcanic eruption were extremely active. The previous researcher interpreted the intraformational conglomerate was tectonically juxtaposed against the younger turbiditic sediments of the Semantan Formation. Therefore, the uniformitarianism perspective can be adopted with recent tsunami occurrence in our region for revisiting the conglomerate bed in Semantan Formation.

A143

Disaster resilient cities: Forecasting multi-hazards for Kuala Lumpur

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Climate extremes are expected to be unprecedented as the climate changes. The risk of disasters will be determined by the exposure of assets and vulnerability of society. The cumulative impacts of disasters can affect the livelihood options and resources of a society as well as their capacity to prepare for and respond to future climate extremes. This calls for scientifically robust research to develop forecasting capacity, delineate vulnerable communities and exposed assets as well as identify short-term response and long-term planning, to support decision-makers in cities.

This is the context for the 3-year project on Disaster Resilient Cities funded by the Newton-Ungku Omar Fund, which is administered by the Malaysian Industry-Government Group for High Technology (MIGHT) and Innovate UK. The project aims to develop city-level multi-hazard forecasting capability to enhance the resilience of Kuala Lumpur in a changing climate. Carefully selected meteorological and hazard models have been adapted for tropical circumstances to be integrated onto a common multi-hazard platform designed for managing and communicating risks under the aegis of the City Hall of Kuala Lumpur (DBKL). City level assessments requires detailed understanding of risk in all its dimensions of hazards, exposure and vulnerability. The focus is on extreme rainfall, flash floods, landslides, air pollution, high temperatures and strong winds as well as information on exposure and vulnerability, which will benefit DBKL.

The project is jointly led by Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative, the IRDR International Centre of Excellence on Disaster Risks and Climate Extremes (ICoE-SEADPRI-UKM) and University of Cambridge. Primary geoscience partners from Malaysia include University of Malaya, Minerals and Geoscience Department of Malaysia, Geomapping Technology Sdn. Bhd., Param Agricultural Soil Surveys (M) Sdn. Bhd. and the Geological Society of Malaysia. Primary geoscience partners from the UK include the British Geological Survey and Cuesta Consulting. Partnerships between geoscientists and other specialists are being fostered to advance knowledge on multi-hazard risks and translate the project findings for routine operations, to enhance the resilience of Kuala Lumpur. The multi-disciplinary expertise brought together will be maintained beyond the project through several agreements. Project findings are disseminated through the Geological Society of Malaysia and Asian Network on Climate Science and Technology (www.ancst.org), coordinated by ICoE-SEADPRI-UKM, with support from the Cambridge Malaysia Education Development Trust Fund.

A046

Modified grout pressure method for predicting ground surface settlement in Kenny Hill Formation

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Underground structure has become the world's present trend as it can provide an efficient solution to the problems of metropolitan area limited ground space. However, settlement induced from tunnelling activity should consider mainly because it will affect the surrounding surface and subsurface structures. To study the settlement problems, Finite Element Method have been used widely by researchers, engineers and tunnel designers. Tunnel construction is a three-dimensional process. In practice, engineers prefer two-dimensional because of time consumption of three-dimensional analyses. Where three-dimensional analyses are not appropriate for a big tunnel project involving several kilometers of excavations and different cross sections (Moller & Vermeer, 2006). This paper will discuss about the simplified two-dimensional method which is modified grout pressure method. Modified grout pressure method is the modification of grout pressure method (Likitlersuang *et al*., 2014). The modified grout pressure method consists of three calculation phases as shown in Figure 1.

The study area is situated at the Klang Valley Mass Rapid Transit (KVMRT) system, the Sungai Buloh-Kajang (SBK) line. The geological conditions that deals with this project is the Kenny Hill Formation and Kuala Lumpur Limestone. But this study will only focus on the Kenny Hill Formation. The material in Kenny Hill Formation experience low grade metamorphism which changes sandstone to quartzite and shale to phyllite (Mohamed *et al.*, 2007). The methodology of the study will begin with 3D ground model development. Next, the required input parameter for Hardening Soil model will be determined. Then, tunnel and soil cross section will be selected and further analysis will be done in PLAXIS 2D using modified grout pressure method. For this study Hardening Soil model used as the constitutive model due to the validity of this model compared to the first well known constitutive model Mohr Coulomb. Mohr Coulomb do not replicate the real behaviour of soil where in actual case soil behave differently according to loading and unloading effect.

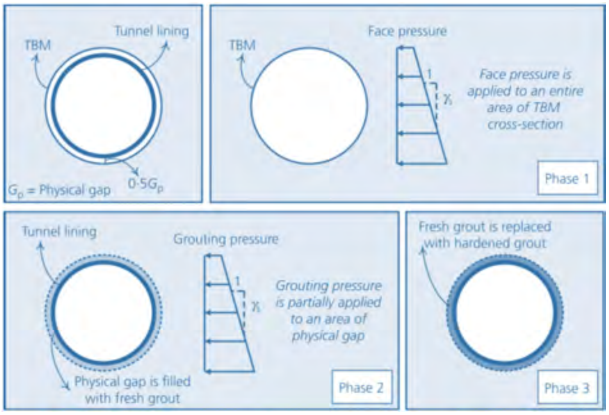

Figure 1: Modified grout pressure methods calculation phases.

The analysis will be continued to proceed until the settlement curve fit back well with the monitoring data. The main two parameters that plays role in the modified grout pressure method is the face pressure and grout pressure. Face pressure is important in tunnelling where lack of face support will lead to tunnel face instability. Normally several layers of loose soil or weathered rock will be found in underground. The face may not be strong enough to bear such pressures or unbalanced. So, soil collapse may occur which result unnecessary settlement at the above ground surface. So that, the face pressure should be correctly distributed or applied in tunnel projects. A support pressure will always necessary at the face of tunnel to counterbalance the pressure produced by the opposite side of tunnel face. The results from the analysis will be mainly on compare with maximum settlement of monitoring data. Besides that, the ratio of calculated to measured face pressure and ratio of calculated face pressure to maximum recommended face pressure will be also discussed in detail in this paper. This study will discuss the face pressure values to be used in Kenny Hill Formation in future.

Keywords: Modified grout pressure, face pressure, Kenny Hill Formation, surface settlement

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A077

Rock mass classification in tunnelling - A practical approach

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Abstract: As a tool to capture rock mass properties and input parameter in rock-engineering analytical and design works, rock mass classification systems are widely used in rock engineering. The systems heavily rely on the empirical assessment of the input parameters. Several rock mass classification systems have been developed since the 60's, primarily for underground support for tunnels and caverns. Overtime, their applications were expanded (Palmstrom, 2006) to other aspects of rock engineering such as machine excavation, productivity estimation and design input parameters in numerical analysis. Regardless, all rock mass classifications developed to-date utilises several fundamental rock mass properties as shown in Figure 1. However, the properties selected for the classifications by the developers can differ and the ratings given can be dissimilar.

Amongst the various rock mass classifications developed, two classification systems are widely accepted by the tunnelling practitioners namely, the Q-System by Barton *et al.* (1974) and the Geomechanics Classification (Rock Mass Rating) by Wieniawski (1989). With further upgrades by its developers, these systems use select parameters with a defined ratings to derive a single number to represent the rock mass conditions. These numbers are subsequently used to determine the level of support required during the planning stage and construction. The parameters selected for classifications are dependent upon observations, interpretation and estimation by the assessor(s). It must be stressed that, the experience of the assessor plays a significant role in the selection of the appropriate parameters, as only a discerning personnel will be able to identify the subtle features of the classification, along with those that are explicit. In short, before commencement of the project(s), the classifications must be understood, and cannot be applied as a "black box" system.

In this presentation, important factors that affect the rock mass classification such as the effect of weathering and uniaxial compressive strength on parameters are discussed. Further, to gain an effective understanding of what is involved in the rock mass classification for tunnels, this presentation will utilise case studies to highlight how the geotechnical information logged from rock cores, interpretation of geological and structural data from field mapping and aerial image interpretation can be used in deriving rock mass condition along the tunnels. The aim of the presentation is to create awareness amongst geologists, engineering geologists and geotechnical engineers, of the importance of capturing correct information at early stages of project, and how it can be best utilised in rock mass classification, interpretation and in application of empirical tunnel support. The steps involved in deriving the rock mass classification for tunnels is summarised in Figure 2.

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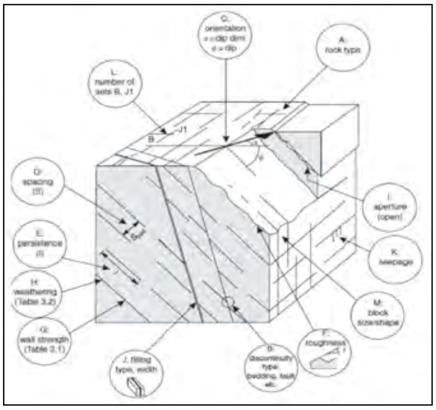

Figure 1: Basic rock mass properties (Wyllie & Mah, 2004).

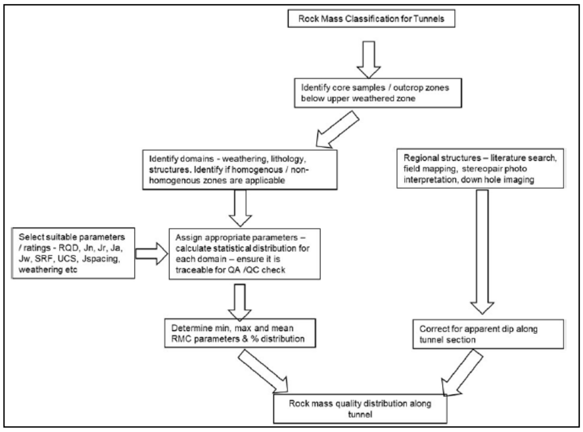

Figure 2: Steps for rock mass classification for tunnels E.

A152

Application of multiple geoscience approaches in geohazards assessment of problematic urban highway section in Kuala Lumpur

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Multiple approaches and methodologies have been used in geotechnical and geohazards assessment for development purposes especially in tropical environment of Malaysia. Recent local engineering geological studies incorporates terrestrial laser scanning method (TLS) for slope stability analysis (Idrees & Pradhan, 2018; Syahmi *et al*., 2011), geophysical surveys for subsurface profiling (Ashraf *et al*., 2018; Muztaza *et al*., 2018), discontinuity survey and subsequent stability rating for rock slope stability assessment (Ainul *et al*., 2018; Goh *et al*., 2018). Most methodologies are often applied separately, or failed to be fully utilized for the investigation, resulting in inadequate data hence the main engineering geological issue may not be fully resolved. In certain cases, the flaws in data acquisition and analysis often results in unforeseen problems during or post construction period.

This study emphasizes on the utilization of multiple geoscientific methodologies in conducting an engineering geological study for construction purposes. The study was on a section of highway construction with problematic and potentially unstable grounds. The main contractors with the advice of the consulting engineer approached geologists in investigating the issue and seek out suitable and cost effective solutions. In this presentation, the discussion focuses on the methodologies used, and its relevance in investigating the engineering geological issues. An example of alternate data presentation will be discussed in providing a set of data understandable by wide range of users including engineers and planners.

ENGINEERING GEOLOGICAL CHALLENGES IN STUDY AREA

The study area is situated near a steep hillslope and nearby residential areas, leaving a relatively tiny corridor for highway development without compromising the housing area or constructing in steep, challenging terrain. However, as construction progresses, multiple issues encountered including steep rock slopes, surface and subsurface boulders and water seepages. The granite weathering profile naturally means more boulders are expected beneath the surface and appropriate mapping must be done. An existing rock slope in the section also required proper investigation prior to excavation to identify potential instabilities.

METHODS

i. Geological Terrain Mapping

As part of requirement by Mineral and Geoscience Department (JMG) for hilly area development, the terrain mapping objective is to classify the terrain according to its geotechnical challenge for development. This mapping effort utilizes geospatial input and fieldworks on site.

ii. Geophysical Resistivity Survey

A total of 6 lines of geophysical resistivity survey each measuring 200 m in length were laid down in Schlumberger array. 3 lines downhill and 2 lines across the hillslope were made to gain a thorough subsurface visualization from multiple tomographic sections to understand the subsurface boulder distribution and groundwater flow regime. Another line (1 line) was laid down separately for determining bedrock layer for construction purposes.

As the users of the tomographic section usually involves engineers and non-geologist personnel, it is important to present the data in simplified manner making it easier to be understood. Figure 1 shows a tomographic section and its geological section derived based on correlations from borehole data and fieldwork observations.

iii. Boulders Mapping

Boulder mapping showed that the study area is highly unstable. Areas prone to boulder fall hazards were identified, (a) areas of boulder clusters along the stretch of stream channel and on slope steeper than 35 degrees and (b) areas prone to debris flow hazards.

iv. Discontinuity Survey and Rock Slope Stability Assessment

An existing rock slope requiring excavation means a study must be done to assess its stability prior to any excavation process. In this investigation, field data acquisition employed the traditional discontinuity survey using scanline method. However, due to limitations

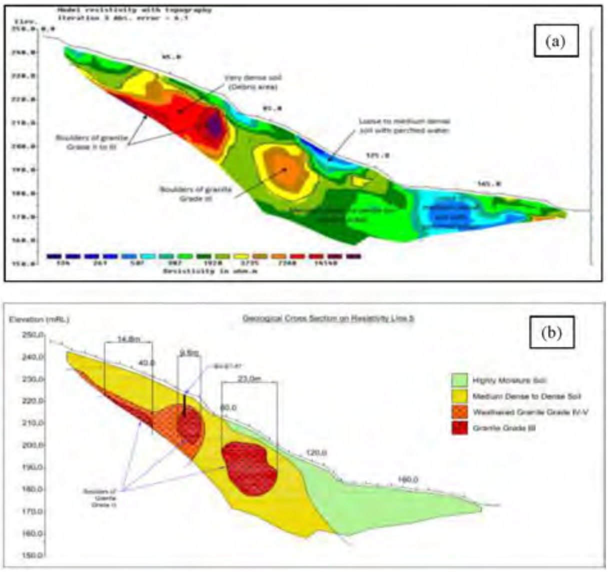

Figure 1: The geophysical resistivity survey tomographic section of a downhill line from study area (a) with its simplified geological section (b) for ease of understanding of users especially engineers for boulder removal during excavation process.

in manual data acquisition especially in analysing far-reached sections, Terrestrial Laser Scanning (TLS) and Photogrammetry methods were employed to model the slope discontinuities' distribution and orientation. 35 scan positions for TLS were identified throughout the slope and data acquisition was done using RIEGL VZ-400i.

Subsequent kinematic analysis was done to identify the potential failures and Slope Mass Rating (SMR) was done according to Romana (1985) methodology. For ease of data management, the slope was divided into multiple sections. The discontinuities set, and potential failures were presented in cross-sections to help users understand the nature of potential failures on site as shown in Figure 2. Apart from discontinuities assessment based on kinematic analysis, field observations were also deployed to study potential instabilities often associated with discontinuities on slope such as fallen blocks and overhanging blocks.

CONCLUSIONS

Multiple methodologies may be required in solving an engineering geological problem to identify and propose proper solution to arising issues. However, the methodologies must be incorporated properly to avoid

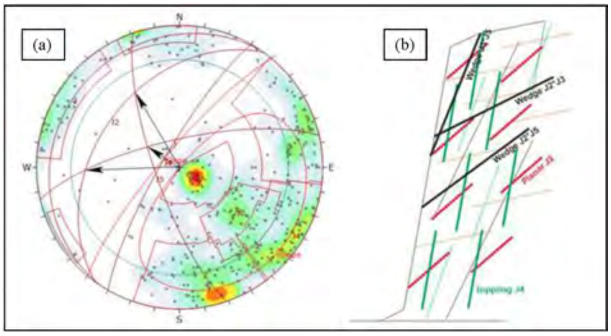

Figure 2: The stereographic plot of discontinuities data from a section of rock slope (a) with its cross- sectional view (b) to visualize the orientation of discontinuities and potential failures.

conflicting results and interpretations. Data presentation to the user must be clear and understandable especially when it involves non-geologist professionals. In this study, the methodologies incorporated are terrain mapping, geophysical resistivity survey, boulder mapping and discontinuity survey with rock slope stability assessment. Potential geohazards such as debris flow, rock fall and potential global scale landslide are presented in this paper.

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A004

Evaluation of rock cut slope stability of Sandakan Formation by Modified-Slope Mass Rating (M-SMR) System, Sabah, Malaysia

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This study has been conducted to evaluate the stability of sedimentary rock cut slope of Sandakan formation by Modified Slope Mass Rating (M-SMR) system. The objectives of this study are to determine the quality and to propose preliminary rock cut slope design such as slope stabilization and protection measures and to determine the recommendation levels for slope reinvestigation. The 'Lithological unit thickness' approach, Deere's RQD method, weighted average of discontinuity set spacing, weighted average and statistical mode, weighted average and new approach of adjustment factor (NAAF) methods were used to evaluate the uniaxial compressive strength, RQD, discontinuity spacing, discontinuity condition, water flow and discontinuity orientation parameters, respectively. The result of this study shows that the class of the slopes are class II (good) and class III (moderate). Recommended slope stabilization and protection measures are installation of weep holes, spot to systematic bolting for class II and surface drainage, horizontal drain, systematic bolting, wire mesh or rope nets and rock trap ditch for class III. Slope re-evaluation are recommended for normal DMR and detailed DMR and slope remapping by well-trained engineering geologist/ geotechnical engineer, respectively.

A080

Probabilistic seismic hazard assessment of Balik Pulau region, Pulau Pinang

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Malaysia is situated close to two seismically active plate boundaries which are Indian Ocean plate and Philippines plate. However, West Malaysia is still vulnerable and potentially exposed to earthquake from regional source as it is close to Sumatran Fault and Sumatran Subduction zone. Sumatra region is listed as one of the earthquake-prone area in Indonesia as it lies on an active tectonic zone. An earthquake with magnitude of 7.0 Mw in 2003 had caused the presence of cracks in buildings of Penang [1]. Studies on seismic hazard impact had discovered that Penang Island had been affected by series of neighbouring earthquakes that includes the Great Sumatran-Andaman earthquake in 2004, as highlighted in the report by Malaysia Meteorological Agency [2]. Thus, this study aimed to determine the dominant frequency distribution by generating microtremor peak amplitudes map in Penang through natural frequency measurement using horizontal-vertical spectral ratio (HVSR) as well as Peak Ground Acceleration (PGA) evaluation. The detail PGA evaluation of Penang Island was determined by incorporating suitable attenuation function of Ground Motion Prediction Equations (GMPE) which represents the correlation between the intensity of local ground movement, *a*, the earthquake's magnitude, *M*, and the distance between one point in the source of earthquake, *r* [3]. On the other hand, the HVSR method was implemented in order to determine the predominant frequency of the soil site, which then was use in establishing a map of predominant frequency that is useful in seismic microzonation analysis of Balik Pulau district in Penang Island. A total of 20 points had been recorded in Balik Pulau with recording time for each point is approximately 60 minutes with the interval of 500 m between each point. From the HVSR data acquired in Balik Pulau, it is concluded that the area is dominated by unconsolidated sediments and stiff soil, with the average resonant frequency is in between 3 to 4 Hz. Nevertheless, the finding on HVSR's amplification factor had indicated that the studied area consists of flat or lowlands area which has higher probabilities in seismic wave amplification compared to the highland area. In addition, the western part of the study area is more vulnerable towards seismic activity not only due to its distance from the source but also due to the ground condition of the area. By integrating the parameters of resonant frequency and amplification factor, it can be deduced that the West to Southwest of Balik Pulau requires more attention and mitigation plan compared to other region as it is more vulnerable towards any impact of earthquakes. From PSHA map generated for Penang Island for fixed intensity and fixed return period in 50

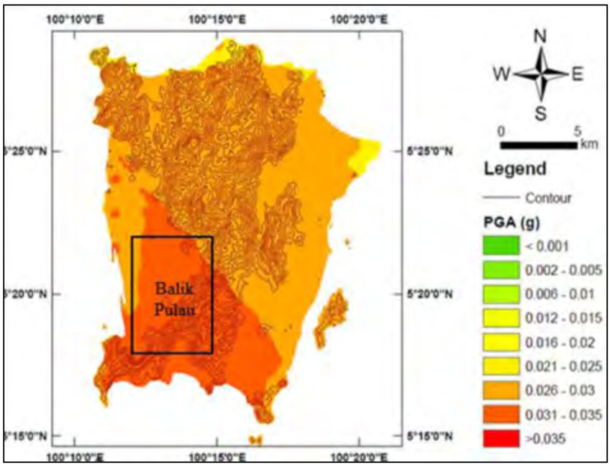

Figure 1: Seismic vulnerability distribution map for 20 microtremor points acquired in Balik Pulau, Pulau Pinang.

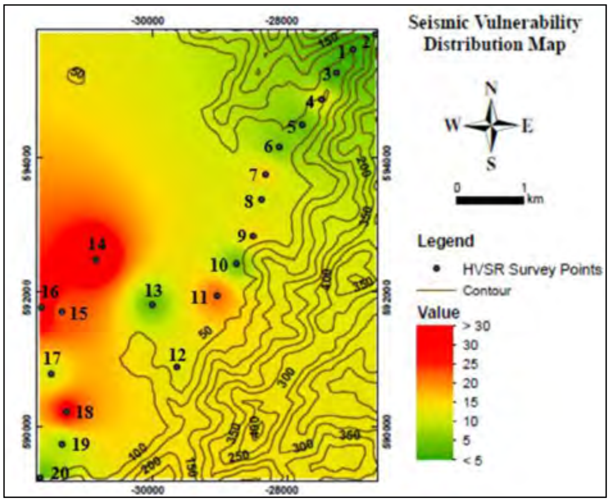

Figure 2: Peak Ground Acceleration distribution map of Pulau Pinang for fixed return period of 98 years or 40% probability of exceedance in 50 years.

Table 1: Summary of the output for 20 acquired microtremors points in Balik Pulau, Pulau Pinang.

No.	Latitude	Longitude	Resonant Frequency (F0)	Amplification Factor (A0)	Shear wave Velocity (Vs_{30})	Vulnerability Index (K_j)
1	5.3700	100.2480	3.36	1.49	403.2	0.66
2	5.3719	100.2514	3.706	2.24	444.72	1.35
3	5.3669	100.2464	3.34	2.5	400.8	1.87
4	5.3633	100.2442	0.944	3.51	113.28	13.05
5	5.3600	100.2417	3.34	3.84	400.8	4.41
6	5.3569	100.2386	5.999	5.88	719.88	5.76
7	5.3531	100.2367	1.925	5.56	231	16.06
8	5.3497	100.2364	2.001	4.97	240.12	12.34
9	5.3450	100.2350	2.04	5.68	244.8	15.81
10	5.3411	100.2328	1.021	2.38	122.52	5.55
11	5.3369	100.2300	1.479	5.87	177.48	23.30
12	5.3267	100.2253	1.835	4.96	220.2	13.41
13	5.3356	100.2219	1.925	2.89	231	4.34
14	5.3414	100.2142	0.981	6.11	117.72	38.06
15	5.3344	100.2097	1.134	5.2	136.08	23.84
16	5.3347	100.2067	1.558	7.66	186.96	37.66
17	5.3258	100.2083	2.57	5.61	308.4	12.25
18	5.3211	100.2103	1.134	5.81	136.08	29.77
19	5.3167	100.2072	3.117	5.37	374.04	9.25
20	5.3119	100.2069	3.27	3.58	392.4	3.92

years, the area closest to the source will have higher PGA values due to its short distance with the seismic sources. For fixed intensity in 50 years, the highest PGA value calculated is 0.025 g while the lowest is 0.006 g. For fixed return period of 100 years, the highest PGA value is 0.035 g and the lowest value recorded for Penang Island is 0.016 g.

Keywords: Probabilistic seismic hazard analysis, HVSR, Balik Pulau

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A025 No. 25 - 25

Application of geohazard-seismic: Influence of channel structure towards gas cloud distribution at 'B' Field

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For those areas that are likely to have offshore geohazards, it will contribute high risks to labor force, the offshore amenity and the environment as well as surrounding areas of oil and gas industry. As an advance precaution, a lot of study needs to be done properly in term of gas cloud distribution that is significant to the seismic exploration.

Generally, a gas cloud is an overburden region of low-concentration gas, escaping and migrating upward from a gas accumulation. It shows as a region of severely deteriorated seismic data quality associated with low velocity and with velocity sags (push down) underneath the gas cloud overburden (Ghazali, 2011). Due to above matter, this paper is focusing on identifying the gas cloud through channel structure by applying several seismic attributes on specify parameter. Volume attributes such as seismic-instantaneous attributes, remove bias, envelope, chaos and RMS amplitude will be applied at particular horizon.

Based on specified interested zone, surface and thickness map will be produced to analyse further the pattern of gas cloud distribution. Finalized geohazard map and ground model will be produced to prevent or reduce the impact of gas cloud geohazards.

Class 1: Structural/geomorphology

Geomorphological attributes – Stratigraphic channel play

The main criterion is the mapping of the structure. Geomorphological analysis is an important aspect of stratigraphic plays such as unconformity, pinch-out, toplap and downlap (Ghosh *et al*., 2014). Geologic depositional-environment studies leading to seismic-facies analysis using seismic attributes are useful in reservoir modelling and delineation in locating sweet spots and reservoir efficiency and productivity. In the Malay basin, several channels have been identified, characterized and used for exploration and field development.

Figure 1 shows the combination of seismic-instantaneous attributes such as instantaneous phase, instantaneous frequency, remove bias and envelope (reflection strength). All of this attribute will be compared with the main seismic section to undergo deeply understanding and interpretation towards channel structure at 'B' field. Channel for the 'B' field can be categorized as high sinuosity, possibly sand filled (in point bar) where the locating hydrocarbon (HC) is high. But for this research which more towards geohazard indication, the channel structure influence more on the gas cloud distribution in the 'B' field.

Geohazard Identification - Gas Cloud Distribution

Figure 2 is showing gas cloud characterization in 3D seismic obtained by using seismic attributes such as remove bias, instantaneous phase, Chaos and RMS amplitude at Z time slice. Based on these three attributes, the gas cloud distribution is briefly understood and it helps interpreter to identify the reason behind its formation. It also shows some of minor and major that might influence the gas cloud distribution.

For clearly understanding the concept, Figure 3 shows the cross section INLINE and XLINE seismic section towards time-slices layer at Z=-1300. The white rectangle dash line is showing the accumulated of the gas cloud in both seismic sections.

RESULT AND DISCUSSION

Detail understanding need to know regarding the physical cause of the gas cloud. Gas cloud simply described as a vertical disturbed zone corresponds with poor image quality caused by gas accumulations that might come from leakage through sediments. Fault and fracture become the contributor for the migration of gas towards shallower unconsolidated clastic sediments.

The gas is trapped in shallower reservoir sand which contains channels a few hundred meters below the sea bottom, sealed by clay, mud, shale or carbonate-cemented sediments (Ghosh *et al*., 2014). Other process like biogenic and thermogenic can also produce shallow gas. Regarding the information, it is very important to know the differences within the gas itself either shallow gas, gas cloud or gas chimney based on certain criteria such as interpretation, geological surface expression and the occurrence and origin of formation.

CONCLUSION

The geohazards-gas cloud in offshore oil and gas development projects causing a potential impact in term of increasing the intervention works which contribute side impact of project schedule and cost of project.

ACKNOWLEDGEMENT

We would like to thank the Center of Seismic Imaging (CSI), Universiti Teknologi PETRONAS (UTP), and PETRONAS for providing the fund, data and giving permission to publish this paper.

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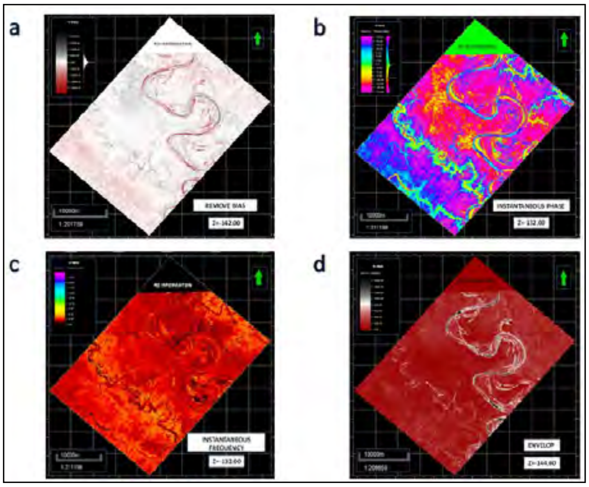

Figure 1: Channel characterization in 3D seismic obtained by using seismic-instantaneous attributes: (a) Remove Bias, (b) instantaneous-phase, (c) instantaneous-frequency, and (d) envelop.

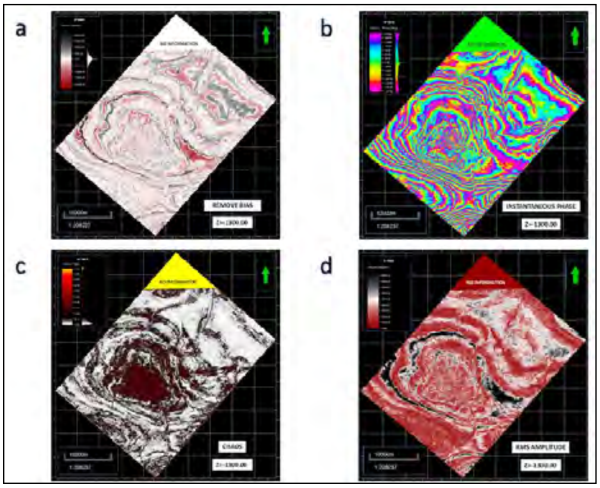

Figure 2: Gas cloud characterization in 3D seismic obtained by using seismic attributes: (a) Remove Bias, (b) instantaneous phase, (c) Chaos, and (d) RMS amplitude.

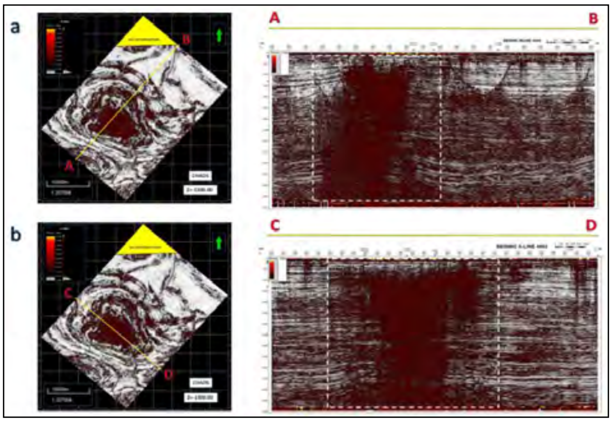

Figure 3: Cross section of time-slices layer (Z= -1300.00 with Chaos seismic attribute for gas cloud identification: (a) INLINE seismic section and (b) XLINE seismic section.

A067

Greening the slopes – Public Works Department of Malaysia (JKR) experiences towards sustainable development

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Greening newly formed slopes has not been treated with respect that it certainly deserved. That is one of the reasons why many slopes that fail to be greened after several attempts within the contract and defect liability periods were left barren until such time that the erosion becomes the talk of the town or landslide would occur and only then something is actually done. JKR has plenty of experiences on greening these slopes initially using closely turfed cow grass, then, followed by hydroseeding, using vertiver grass and more recently using hydroseeding with slopes covered with biodegradable fibre erosion control blanket. Since the establishment of the Slope Engineering Branch in 2004, studies on greening the slopes were carried out in earnest to establish effective means of erosion control especially for difficult to green slopes along the federal roads. As a result of these studies, guidelines for slope bio-engineering have been produced. The paper describes the path that JKR has trodden to green the slopes along the federal and state roads.

A045

Correlation between Uniaxial Compressive Strength, Point Load Test, Young Modulus and Schmidt Hardness for weathered limestone

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Uniaxial compressive strength (UCS) is considered to be one of the important parameters in rock engineering projects. In order to determine UCS, direct and indirect techniques are employed. In the direct approach, UCS is determined from the laboratory UCS test. In indirect techniques determine UCS based on the non-destructive test findings which can be easily and quickly performed and require relatively simple or no sample preparation. Indirect techniques are commonly preferred by rock and mining engineers because of their low cost and ease. To avoid these drawbacks, this paper focuses on the correlations between Schmidt hammer rebound values (Hr) and UCS, which only suitable for specific rocks. Accordingly, a correlation between L-type rebound value and UCS established for all rocks, which could use for estimate UCS, and an upper limit value line for N-type, are proposed. The correlation could be used for a rough estimate of UCS. Observed that Hr is a good alternative of UCS when within its validity ranges. And that correlation for all rocks is a good way to determine UCS rating for no specific correlation rocks. The proposed method contributes to an economic, time- saving, rapid, and convenient rock mass classification without sampling and laboratory testing. The results obtained using solely the Schmidt hammer test for estimating mechanical properties of rocks are less accurate than when a full suite of laboratory tests is carried out, but it is hoped that these empirical equations will help geotechnical engineers making practical decisions at a preliminary site investigation stage.

These studies mainly focused on using statistical methods to improve empirical correlations for specific rocks. However, because the operational principle of Schmidt hammer and the randomness of rocks, it is not possible to accurately obtain UCS from the rebound value. As such, it is necessary to introduce the concept of Hr in rock mass classification. UCS, which is also influenced by geometric size and shape, is not an essential property of rocks. The effect of size needs to be considered because UCS is obtained through standard laboratory specimen tests and surface hardness is determined through laboratory or in situ Schmidt hammer tests. As such, it is best to attempt to establish accurate relationships between UCS and laboratory or in situ determined Hr. Schmidt hammer rebound (Hr) value is well correlated with UCS. This correlation is essential for geotechnical design and stability analysis for rapid and convenient rock mass classification.

Rock strength test is used to verify the resistance of rock against loading. The rock strength test can be classified as direct or indirect based on comparison between the outputs of the test with the desired testing properties. As a matter of fact, many researchers have studied the relationship between indirect tests and UCS values. For point load test (PLT), the relationship between point load index and UCS for hard rock has long been introduced. The most frequently cited correlations between Point load index (Is) and UCS are UCS = 24Is, UCS = 22.7 Is , and UCS = 20-25Is.Unfortunately, the above mentioned empirical equations were dedicated for hard rocks and correlations for weathered sedimentary rock which is weak in nature are yet to establish.

Keywords: Uniaxial compressive strength, point load index, young modulus, Schmidt hardness, limestone

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A064

Land use/land cover change of Delhi region using remote sensing and GIS techniques

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The temporal land cover changes have a strong effect on the urban environment and its surroundings. In the present study, Delhi metropolitan area had been considered for the detection of land cover changes using Landsat images of 1991 and 2011. Emphasis had been given to identify the extent of urban expansion duly responsible for land cover changes. A change detection analysis was performed to determine the nature, extent, land use/cover and transformation over 20 years of time period. The study explores that the city has expanded significantly at the cost of non-built-up land, which has decreased in its area. Significantly, there was not only the expansion of city area but also there were interchanges of land between different land use/cover classes in the study area. It is found that urban area, fallow land and vegetation have changed drastically in Delhi.

A106

Correlation for estimating the static Young's modulus of limestone

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Abstract: The application of rock mechanics in the area of geotechnical engineering is important especially in describing the strength of rock material for assessing the stability of excavations, foundations and slopes in rock. In this study, the characterization of the rock material failure was investigated through the Young's modulus parameter, which describes the relationship between the stress applied to the rock material and the resulting strain. For an elastic and homogeneous solid, the measurement of Young's modulus can be determined either from the static or dynamic measurements. Numerous studies outline the differences between the Young's modulus obtained from static and dynamic measurement in the laboratory. Comparatively, the measurement using static methods are more direct and realistic, as it describes the behaviour of rock deformation until failure occurs. The dynamic methods are more versatile and continuous, as they rely solely on the measurement of elastic wave velocities. However, one of the most notable disadvantages of rock material characterization by means of dynamic methods is that it overestimates the failure of rock material when compared to its actual value. With this in mind, the aim of this study is to obtain the measurements of Young's modulus using both the static and dynamic methods. Based on the comparison made, an empirical equation of $E_{st} = 0.9264 (E_{dy}) + 0.4976$ with coefficient of determination, R^2 of 0.8 is obtained for estimating the static Young's modulus for limestone. The equation is applicable in situation where static measurement could not be carried out, and also serves as reliable estimation of Young's modulus from dynamic measurement.

Keywords: geomechanical characterization, Young's modulus, limestone, empirical equation

ORAL PRESENTATIONS

MINING & QUARRY

A023

Assessment of spatial distribution of heavy metal(s) in Sg. Koyan District using Compositional Data Analysis, Pahang, Malaysia

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INTRODUCTION

Sg.Koyan is located within an active gold district within Raub-Bentong Suture which host deposits rich in both precious and base metals (Ariffin, 2012). Within the area, there are currently active gold mines, such as Selinsing Gold mine and Penjum Gold mine. Besides gold productions which benefit the country's economy, great environmental risks may be posed like acid mine drainage. Moreover, the sampling area is largely occupied by oil palm and rubber plantations where source like fertilizers can largely increase certain elemental concentration. Assessment of elemental distribution in this area has yet to be studied applying the right multivariate analysis technique. This research aims to evaluate the distribution of element(s) showing abnormally high concentration present in water and to spatially interpolate the enrichment map using compositional data analysis.

METHODOLOGY

Water samples were collected in Sg. Koyan gold district where the locations are shown in Figure 1. The concentration of elements is analyzed using ICP-OES. since the data is known as compositional data which carries relative information rather than absolute measurement (Aitchison, 1986), direct implication of classical multivariate or univariate theoretically wrong. (Pearson, 1896) pointed out the spurious correlation between ratio of common parts. This required special transformation(s) known as log-ratio transformation(s) before proceeding to Cluster Analysis (CA), Principle Component Analysis (PCA), and spatial interpolation (Boogaart & Tolosana-Delgado, 2013).

In Figure 2, the results from ICP-OES which contain zero has to be replaced with other value(s) below detection limit of the instrument, this is known as below detection limit replacement (BDL). This replacement is done with zero-replace technique using expectation-maximization (EM) as described by (Palarea-Albaladejo & Martín-Fernández, 2008) while replacing a small fraction of value below detection limit greatly distort the data as what Aitchison did in 1982 (Aitchison, 1986).

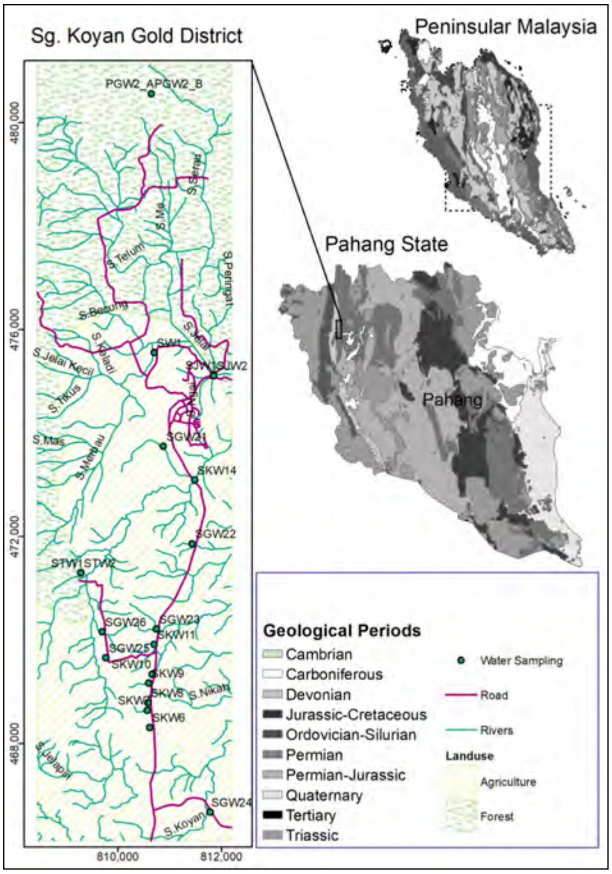

Figure 1: Map showing location of Sg. Koyan gold district, Raub, Pahang. Projection: WGS 1984 UTM Zone 47N.

This paper used two log-ratio transformations: Centred Log-Ratio (Clr) and Isometric Log-Ratio (Ilr), more details can be found in (Boogaart & Tolosana-Delgado, 2013; Pawlowsky-Glahn & Buccianti, 2011). Sub-composition of S, K, Ca, Na, Mg, Si, and Ba from completed result is analyzed. Lastly, Steps of Inverse Distant Weight are also detailed where the final results require the combination of the use of R Geostatistics and ArcGIS program to isometric log-ratio (ilr) transformed data.

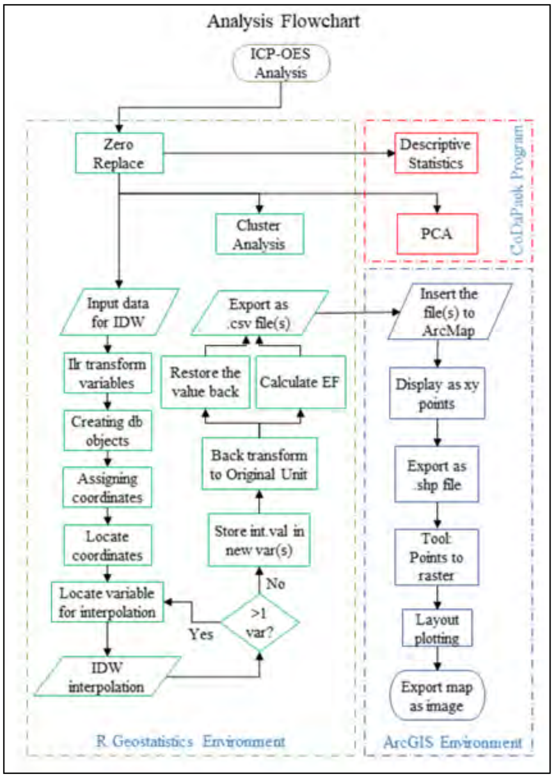

Figure 2: Analysis flowchart to generate Descriptive Statistics, Cluster Analysis, PCA, and Inverse Distant Weight Interpolation.

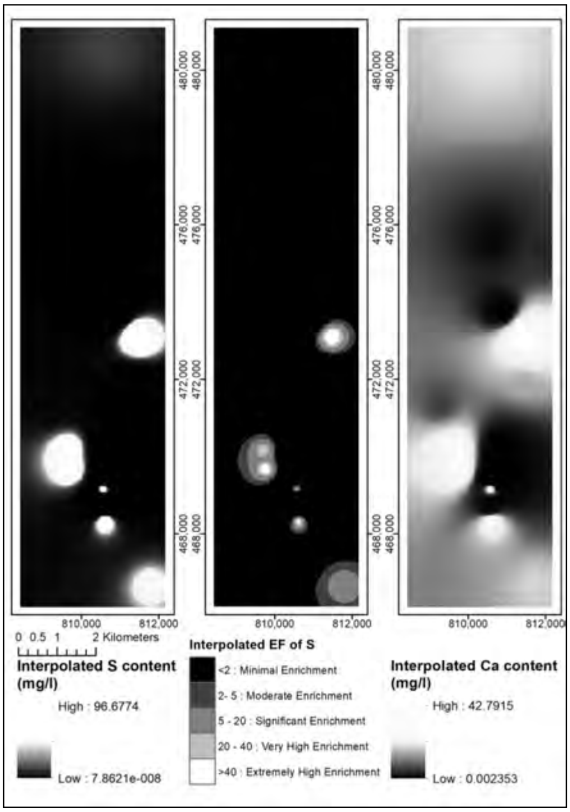

Figure 3: From left to right: Interpolated map of S content, EF and Ca content as proxy element for EF calculation. Visualization color stretching: Histogram Equalizer.

RESULTS AND DISCUSSION

As shown in Figure 3, the extremely high content of S (max=97mg/l) in water are found in several spots where the rest of the study area show much lower S (less than 1ug/l). The enrichment of S decreases rapidly away from those locations. These abnormally enriched S concentrations are found to be related with agricultural activities, specifically, oil palm plantation, except only one sample (SGW24) which was collected from fast flowing stream. Even though, this stream passing through oil palm plantation around a small town. The source is also pointed out by cluster analysis which suggests S has different origin from others elements (Ca, Na, Mg, Si, and Ba) in the cluster. From the same Cluster dendrogram, even the presence of K is low but it is partially influence by anthropogenic activities as it stays out of the group. Similarly, in PCA, in the first principle component having the highest variance, S has the highest score while its direction is about 90ºC to other element inferring its uncorrelated nature to the rest of elements in analysis.

CONCLUSION AND RECOMMENDATION

S content in water is caused by agricultural or anthropogenic activities which might be from fertilizer rather than from gold mining activities and it is highly uncorrelated with other elements in analysis. Even high S content can be found in one of the fast-flowing streams, this should not be serious as it will naturally be diluted in lower stream for it is not detected in big rivers.

Since EF is the ratio of ratios of two elements to their baseline or reference values, it is highly influenced by the choice of proxy element and its reference value. EF infers the richness of one element comparing to another element rather than expressing its abundance or scarcity in nature in general. Geo-processes, such as weathering, and mineral enrichment, accounted for the loss and gain of some mineral, without taking those activities into consideration EF is a very bias interpretation of elemental richness.

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A095

Mineral production and mining industry linkages in the economy of Malaysia

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Abstract: Ever since the downfall of the tin mining industry, the Malaysian mining industry is perceived to be no longer significant to the country's economy, a perception previously shared by some of the policy makers. The industry GDP contribution of less than 0.1% furthered strengthened the perception. The GDP contribution in term of percentage is not really a good tool to gauge an industry important to an economy especially the primary industry like mining. In an industrialised economy such as Malaysia, it is common that the mining industry percentage contribution to the nation's GDP is relatively low because of the enormous contribution from the manufacturing industries (which include the mineral-based industries). It would be better to look at the GDP contribution based on value.

Since the downfall of the tin mining industry and the country's turning to industrialisation, the structure of the mining industry was also changing. The dominant of the metallic minerals in overall mineral production is now replaced by the non-metallic minerals which include the rock and sand aggregates. For example, for the period between 2010-2016, production of rock aggregates had increased significantly from 101.8 Mt to 133.1 Mt, sand aggregates increased from 30.7 Mt to 44.9 Mt while limestone from 22.4 Mt to 25.4 Mt. Rock and sand aggregates are critical raw materials for the construction sector, the increase in production may indirectly associated with population growth. In contrast, the production of most metallic minerals, with the exception of tin and bauxite, declined.

Apart from the production, another way to gauge an industry contribution to an economy is by looking at the linkages of the industry with the rest of the economy. An industry purchased its input materials for its output production from the other industries within the economy, which is term as the backward linkage. An industry also sells its output to other industries within the economy which is term as the forward linkage. In general, any increase in the production output of the purchasing industry will have positive repercussions on the production output of the supplier industries. Similarly, with forward linkage the supply industries will increase its production if the demand for its output increase.

This study looks into both the production and the linkages of the Malaysia mining industry with the other industries within the overall economy of Malaysia. Integration of production data and the linkages data will be made to observe if there are links between production and the impact on the other industries that have linkages with the mining industry. This will, in a way, give an indication of the important of the mining industry to the country's economy. The data on the mineral production will be data published by the Department of Minerals and Geoscience, Malaysia, while the linkages data will be based on the Input-Output Table published by the Department of Statistics Malaysia.

Keywords: Mining industry, GDP contribution, mineral production, backward linkages, forward linkages

A053

Source rock pyrolysis and thermal maturity of Tertiary coals from the Merit-Pila coalfield, Central Sarawak, Malaysia

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Tertiary coals from the upper part of Nyalau Formation in Merit-Pila coalfield, central Sarawak are of interest in this study. The Merit-Pila coal is found to be related with Late Miocene to Late Pliocene sediments of Tertiary basins and likely to have upper and lower coal zones of Nyalau Formation. A total of seven coal samples were collected at the mine face and subjected to Rock-Eval pyrolysis, vitrinite reflectance analysis and proximate analysis to evaluate hydrocarbon generating potential and determine the thermal maturity stage of the Tertiary coals. Rock-eval pyrolysis indicates TOC content ranging from 15.78 to 62.16 wt.%, indicating the coals have excellent quality source potential for hydrocarbon generation. Pyrolysis data indicates that the coals are characterized by high S2 generative potential of 27 to 405 mg/g rock, high oxygen index value of 35 to 70 mg HC/g TOC and moderate hydrogen index value of 80 to 275 mg HC/g TOC. This suggests that the organic matter consists of a mixture of Type II/III kerogens with Type III being dominant (Figure 1) and is capable to generate gas and oil. Merit-Pila coal samples are found to be thermally immature for hydrocarbon generation based on the Tmax values that vary from 380 to 425ºC and the mean vitrinite reflectance value that ranges from 0.36 to 0.47% for the studied coals. The proximate data also supported this level of thermal maturity. These coals have high volatile matter with low fixed carbon which eventually indicate the coal rank as lignite to sub-bituminous.

Table 1: Bulk geochemical of pyrolysis analysis with calculated parameters of the analysed coals in Merit-Pila coalfield.

Seam	Sample ID	Lithology	TOC (wt%)	S_1	S_2 (mg/g rock)	S_3	Tmax (°C)	HI	OI	PY	PI	VRo (%)
Seam B	SB1	Coal	48.08	0.89	38.70	32.76	414	80	68	39.59	0.02	0.36
	SB2	Coal	51.29	1.74	86.66	28.53	415	169	56	88.40	0.02	0.47
Seam C	SC	Coal	56.68	2.13	103.65	26.28	416	183	46	105.78	0.02	0.42
Seam E	SE	Coal	62.16	29.70	404.99	21.07	386	652	34	434.69	0.07	0.43
Seam H	SH1	Coal	15.78	1.35	27.09	10.62	424	172	67	28.44	0.05	0.38
	SH2	Coal	20.88	3.45	57.93	9.86	421	277	47	61.38	0.06	0.41
Seam uB	SuB	Coal	54.79	10.06	128.97	38.87	380	235	71	139.03	0.07	0.42

TOC: Total organic carbon; S_1: Volatile HC; S_2: Remaining HC generative potential; S_3: CO_2 content; T_{max}: Temperature at maximum of S_2 peak; HI: Hydrogen index; OI: Oxygen index PI: Production index ($S_1/(S_1+S_2)$); PY: Potential yield (S_1+S_2)

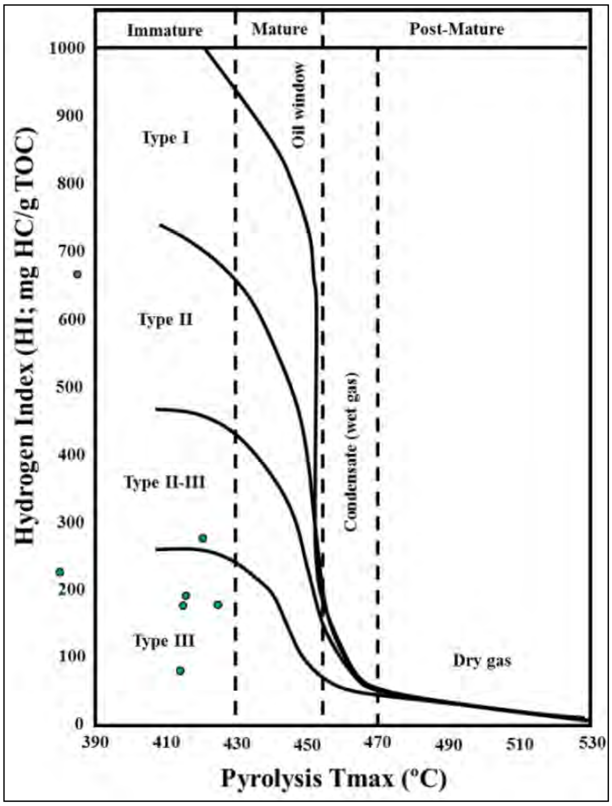

Figure 1: Plot of hydrogen index versus pyrolysis Tmax showing the kerogen type and thermal maturity of coal samples in Merit-Pila coalfield.

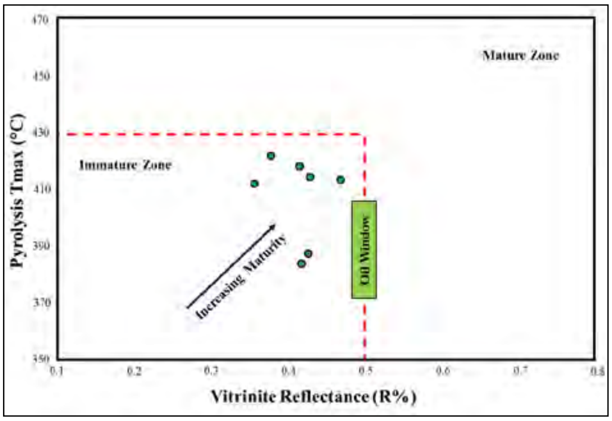

Figure 2: A plot of pyrolysis Tmax values versus vitrinite reflectance (R%) showing good agreement between hydrogen index value versus pyrolysis Tmax data, and generally an immature stage for coals samples in Merit-Pila coalfield.

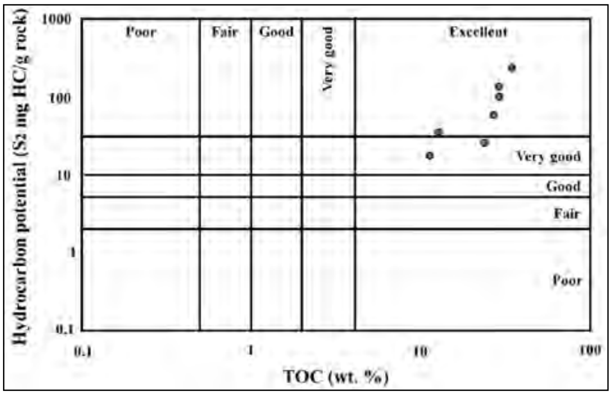

Figure 3: Pyrolysis S2 versus total organic carbon (TOC) content plot showing the hydrocarbon generation potential for Tertiary coals in Merit-Pila coalfield.

A036

Distribution of minerals from Sungai Terengganu: Upstream vs downstream fluvial section

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This project aims to understand the grain size distribution and its textural characteristics at Sungai Terengganu between the upstream and downstream section with respects to the current flow within the fluvial system itself. Quaternary deposits consist of gravel, sand, clay and peat were found along the east coast in the lower watershed of the Terengganu River basin (Khawar Sultan & Noor Azhar Shazili, 2009). Joshua & Oyebanjo (2010), stating that river sediments were originally emanated from the erosion of the nearby surface, exposed metamorphic, igneous or sedimentary rocks. According to Parrado-Román & Achab (1999), grain size trends make it possible to characterize both modern and ancient environments, and to identify net sediment transport patterns by using grain size distribution and factorial multivariate analysis. Thirty-one samples from systematically selected sampling points along the 10 km stretch of the Sg. Terengganu fluvial were collected using Ponar grab and was labelled and preserved accordingly for further analysis. The fluvial current flow was measured in-situ using lightweight current meter, Valeport's Model 106 and location of each sampling location were recorded using portable global positioning system (GPS). Laboratory analysis mainly focus on the sediments textural characteristics using both dry sieve and wet sieve method, and also by using laser diffraction particle size analysis (LDPSA) for samples that contain high percentage of finer particles such as muddy samples. All analysis was done at Technical Service Division, Department of Mineral and Geoscience Malaysia, Perak. Mean size distribution for the downstream section as per shown in Table 1 and Table 2 shows that the grain size relatively increases in the size towards the upstream part from clay size to coarse sand. On the other hand, for mean size distribution for the upstream section where the grain size distribution shows a little bit anomaly where the mean size from ST 6 and ST 7 were comprise of mainly mud while the rest were distributed within the coarse sand to gravel size sediments. The current flow variation was measured and the data were shown in Table 1 and Table 2. The average river flow distribution was then mapped. 0 to 1.0 m/s is classified as low, 1.0 to 2.0 m/s as moderate, and 2.0 to 3.1 m/s as high. From data shown in Table 1 and Table 2, it can be presumed that the flow of the fluvial within the downstream and upstream section is slow, as the values range from 0 to 0.301 m/s only. Theoretically, rivers tend to slow down at the downstream area and the velocity is much lower than the upstream area. Even though the relative current flow for both downstream and upstream were considered low, but within that range, the current flow that flowing within the upstream area were relatively higher compared to downstream section. Quartz dominating majority of the mineral composition from the samples taken from both downstream and upstream section. Following by percentage, other minerals that also found from the samples were Iron oxide, Ilmenite, Andalusite, Hematite, Zircon, Tourmaline and few other minerals as per shown from Table 1 and Table 2. As a conclusion, the sediments that collected from all the sampling location were dominant with sandy and coarse grain sediments with low energy flow and dominated by Quartz mineral.

Keywords: Downstream, upstream, current, sediment, texture, Quartz

Table 1: Data from sampling points at Sg. Terengganu downstream section (river mouth area).

Station	Coordinate		Depth (m)	Current Meter Data		Grain Size Data				Mineral Distribution	
	Latitude	Longitude		Flow (m/s)	Direction (°)	Mean	Sorting	Skewness	Kurtosis	Mineral	Percentage (%)
ST 1	05°20’41.0” N	103°07’45.7” E	1	0	26.7	9.537	4.301	0.009	0.725	No sample	
ST 2	05°20’31.6” N	103°08’02.4” E	1	0.187	352.1	9.116	4.513	0.020	0.709	No sample	
ST 3	05°20’22.4” N	103°08’19.2” E	1 2 3 4 5	0.130 0.130 0.130 0.130 0.244	65.5 49.5 47.3 125.8 271.7	8.904	4.620	0.033	0.706	No sample	
ST 4	05°20’24.4” N	103°07’17.8” E	1	0	255.1	-0.074	0.527	1.257	0.539	Quartz Rock fragment Iron oxide Hematite Ilmenite	88.0 5.0 5.0 1.0 1.0
ST 5	05°20’05.5” N	103°07’51.3” E	1 2	0 0.130	11.8 51.4	-0.130	0.470	1.385	0.543	Quartz Iron oxide Rock fragment Andalusite Hematite	86.0 5.0 5.0 3.0 1.0
ST 6	05°19’59.4” N	103°06’55.3” E	1 2	0 0.073	220.3 263.2	0.019	0.706	0.652	0.471	No sample	
ST 7	05°19’35.9” N	103°07’40.5” E	1 2 3	0 0.301 0.244	283.0 91.7 108.8	3.328	3.019	-0.125	0.576	Quartz Iron oxide Rock fragment Andalusite Ilmenite Amphiboles	85.0 5.0 5.0 3.0 1.0 1.0
ST 8	05°19’32.0” N	103°07’49.8” E	1 2 3	0.187 0.244 0.187	22.6 31.1 47.3	1.712	2.575	0.495	1.037	Quartz Iron oxide Rock fragment Andalusite	88.0 5.0 5.0 2.0
ST 9	05°19’35.0” N	103°06’34.6” E	1 2 3	0.073 0.130 0.130	213.7 205.8 207.2	0.522	1.090	0.086	0.602	No sample	
ST 10	05°19’26.3” N	103°07’02.6” E	1	0.187	109.6	-0.016	1.092	1.575	1.838	Quartz Andalusite Iron oxide Rock fragment Ilmenite Hematite Hydroilmenite Amphiboles	77.0 7.0 4.0 4.0 4.0 2.0 1.0 1.0
ST 11	05°19’25.6” N	103°07’18.7” E	1	0	49.8	0.026	1.048	1.605	1.437	Quartz Iron oxide Rock fragment Andalusite Hematite Ilmenite Hydroilmenite Amphiboles	84.0 5.0 5.0 3.0 1.0 1.0 0.5 0.5
ST 12	05°19’23.8” N	103°06’45.5” E	1 2	0.130 0.073	108.9 121.4	8.538	4.773	0.062	0.690	No sample	
ST 13	05°19’33.2” N	103°05’56.6” E	1 2 3	0 0.073 0.130	266.4 250.7 224.2	0.879	1.052	-0.179	0.404	Quartz Andalusite Ilmenite Rock fragment Zircon Hydroilmenite Leucoxene Tourmaline Gold	69.0 15.0 7.5 4.0 2.0 1.0 1.0 0.5 1 piece
ST 14	05°19’24.3” N	103°06’10.3” E	1 2 3	0 0.073 0.130	90.6 289.3 275.4	-0.235	0.396	2.049	0.934	No sample	
ST 15	05°19’20.3” N	103°06’12.6” E	1 2	0 0	130.4 65.0	-0.234	0.480	2.234	2.230	Quartz Iron oxide Andalusite Hematite	91.0 6.0 2.0 1.0
ST 16	05°19’13.8” N	103°05’32.0” E	1 2	0 0.187	242.1 41.5	-0.045	0.536	1.013	0.443	Quartz Iron oxide Rock fragment Andalusite	89.0 5.0 5.0 1.0
ST 17	05°19’11.0” N	103°05’35.6” E	1	0.073	320.3	-0.103	0.694	0.416	0.499	Quartz Hematite Andalusite	98.0 1.0 1.0

Table 2: Data from sampling points at Sg. Terengganu upstream section (Kuala Telemong).

Station	Coordinate		Depth (m)	Current Meter Data		Grain Size Data				Mineral Distribution	
	Latitude	Longitude		Flow (m/s)	Direction (°)	Mean	Sorting	Skewness	Kurtosis	Mineral	Percentage (%)
ST 1	05°13'58.6" N	103°02'15.4" E	1 2 3	0.073 0.073 0.073	9.7 14.7 129.4	2.124	2.685	0.295	0.710	Quartz Iron oxide Rock fragment Ilmenite Andalusite Hematite Pyrite Amphiboles Leucoxene	79.0 5.0 4.5 4.5 4.0 1.5 0.5 0.5 0.5
ST 2(1)	05°13'47.7" N	103°02'20.4" E	1 2	0.073 0.130	114.1 161.4	1.159	2.339	1.244	0.891	Quartz Rock fragment Iron oxide Andalusite	82.0 10.0 6.0 2.0
ST 2(2)	05°13'48.9" N	103°02'19.5" E				-0.035	0.640	0.582	0.448		
ST 3	05°13'47.3" N	103°02'17.6" E	1 2 3	0.073 0.073 0.130	313.7 221.9 177.8	-0.409	0.083	-2.426	-0.539	Quartz Iron oxide Rock fragment Andalusite Hematite Ilmenite	82.0 10.0 5.0 2.0 0.5 0.5
ST 4	05°13'47.2" N	103°02'13.7" E	1 2 3 4 5 6	0.187 0.073 0.073 0.187 0.130 0.073	346.9 296.7 158.6 169.4 182.5 217.8	0.208	0.940	0.691	0.639	No sample	
ST 5	05°13'15.3" N	103°02'23.3" E	1 2 3 5 6 7	0.073 0.073 0.073 0.073 0.073 0.130	327.2 347.0 33.5 126.8 183.7 205.6	-0.478	0.160	6.484	3.853	Quartz Iron oxide Andalusite Hematite Amphiboles Tourmaline Epidote	79.0 9.0 7.0 2.0 1.0 1.0 1.0
ST 6	05°13'13.8" N	103°02'21.5" E	1 2 3 4 5 6 7 8	0.130 0.244 0.073 0.130 0.130 0.073 0.073	324.9 36.2 310.4 318.6 310.1 312.6 279.1	8.698	4.758	0.035	0.714	No sample	
ST 7	05°13'14.3" N	103°02'20.6" E	1	0.187	30.7	9.078	4.496	0.031	0.695	No sample	
			2 3	0.073 0.130	330.3 272.8						
ST 8	05°12'57.1" N	103°01'55.6" E	1	0.130	210.3	-0.045	0.691	0.701	0.497	Quartz Rock fragment Iron oxide Andalusite Ilmenite Amphiboles	86.0 5.0 5.0 2.0 1.0 1.0
ST 9	05°12'58.5" N	103°01'55.2" E	1 2 3	0.130 0.073 0.073	77.0 94.5 144.6	0.135	0.752	1.073	0.574	No sample	
ST 10	05°13'00.1" N	103°01'55.3" E	1 2 3 4	0.187 0.073 0.073 0.073	69.1 60.3 109.9 152.4	0.092	0.763	1.404	0.709	Quartz Iron oxide Andalusite	91.0 5.0 4.0
ST 11	05°12'37.9" N	103°01'52.3" E	1 2 3 4	0.130 0.073 0.073 0.073	298.8 290.6 327.0 117.7	-0.264	0.391	2.338	1.082	Quartz Iron oxide Andalusite Hematite	92.0 5.0 2.0 1.0
ST 12	05°12'35.8" N	103°01'51.6" E	1 2 3	0.073 0.073 0.130	307.8 44.5 131.9	-0.426	0.142	8.175	-4.858	No sample	
ST 14	05°12'14.4" N	103°02'11.1" E	1 2 3 4 5 6 7 8	0.187 0.073 0.073 0.130 0.073 0.073 0.073 0.073	163.1 270.0 314.4 149.3 141.5 122.8 112.0 7.8	0.208	0.940	0.691	0.639	Quartz Iron oxide Andalusite Ilmenite	89.0 6.0 4.0 1.0

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ORAL PRESENTATIONS

TECTONICS & STRUCTURAL GEOLOGY

A006

Crustal thickness and velocity structure of Kota Kinabalu region

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The geology of Sabah is highly complex and mostly remain unravelled which resulted in an ambiguous understanding of its tectonics. The tomography of Kota Kinabalu region is mainly influenced by the collision between South China Sea and Sabah margins during Early Miocene which leads to crustal thickening (Balaguru, A., & Hall, R., 2009). At present, the subsurface properties, and structures underlying Kota Kinabalu region are yet to be recognized. Thus, this study aims to acquire the crustal properties beneath Kota Kinabalu seismometer station (KKM) in Sabah, Malaysia (Figure 1). Additionally, the thickness of the layer up to the Moho boundary as well as the velocity input within the layer are obtained. Receiver function analysis is chosen as the method to conduct this study (Langston, C.A., 1977) where responses of tele-seismic earthquakes recorded at KKM station are evaluated and processed through 2D rotation, iterative time deconvolution, signal-to-noise ratio analysis, stacking, H-k analysis (Zhu, L., & Kanamori, H., 2000), as well as forward modelling and waveform inversion. A total number of 916 time series data are retrieved from IRISDMC (ISC, 2016). Nevertheless, only 184 receiver functions are used in this study whereas the remaining 732 receiver functions are considered noisy and subsequently eliminated. The selected receiver functions have earthquake magnitude greater than 6 mb with signal-to-noise ratio of greater than 5. The processing steps included in this study are conducted by using computation programs such as Seismic Analysis Coding (SAC) and Generic Seismic Application Coding (GSAC) (Herrmann, R.B., 2013). 1-D velocity models via two-passes receiver function inversion are generated and interpreted at the end of this project so to infer on the subsurface structural framework and velocity anomalies within the crust beneath the station. Based on the H-k thickness analysis (Figure 2) and final velocity models (Figure 3), it is interpreted that the Conrad discontinuity is at 26 km depth, the Moho boundary is at 40 km depth whereas the Lithosphere-Asthenosphere boundary is found at 66 km depth beneath KKM station. The velocity profiles within the crust shows alternating patterns with V_P range of 5 km/s to 7 km/s and V_S range of 3 km/s to 4 km/s. The V_P and V_S readings reached 8 km/s and 4.5 km/s respectively as it hits the Moho boundary at 40 km depth. Hence, the crustal thickness underneath KKM station is 40 km where the upper continental crust is 26 km thick and the lower crust is 14 km thick.

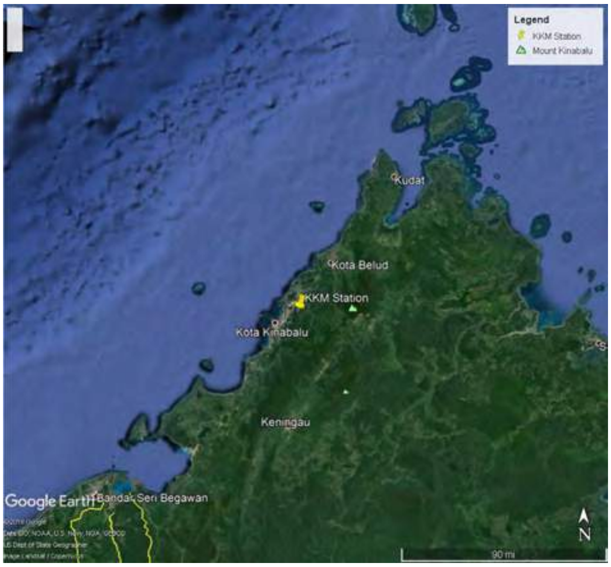

Figure 1: The location of Kota Kinabalu station, KKM (yellow pin), which is used for the earth crust and velocity structure analysis.

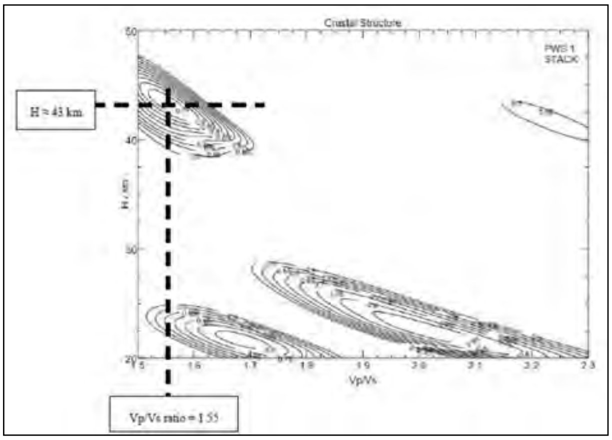

Figure 2: Moho depth and V_P/V_S determination from H-k analysis method. The result clearly indicate the Moho depth is found at 43 km with V_P/V_S ratio of 1.55.

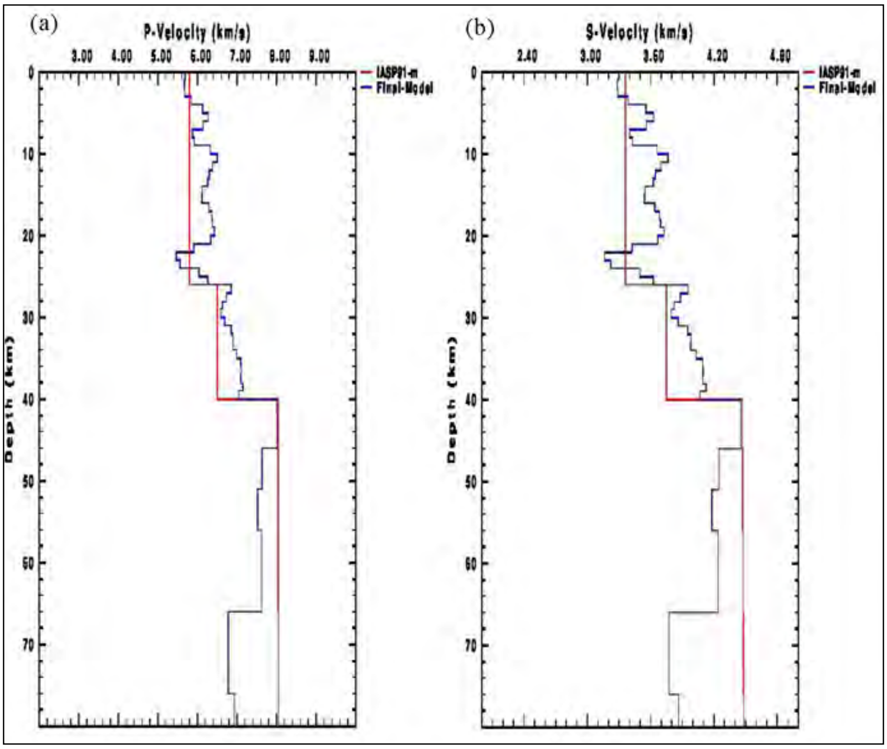

Figure 3: Final 1D velocity model (blue) derived for earth structure beneath Kota Kinabalu region in comparison with global IASP91 velocity model, with (a) indicate the P-velocity and (b) indicate the S-velocity.

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A012

The Jalan Wangsa Thrust in eastern Kuala Lumpur; a marker for a major crustal boundary between the leading edge of the Sibumasu Block and the Sukhothai Arc?

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Kuala Lumpur and Singapore lie on opposite sides of the Bentong-Raub Suture Zone: the locus of amalgamation and consolidation of the Sibumasu Block with the southern part of the Sukhothai Arc and Indochina-East Malaya Block. These continental blocks separated sequentially from the supercontinent of Gondwana during the Permian and Lower Devonian respectively, with the Sukhothai Arc system developing between them during the Permian to Triassic (Metcalfe, 2011).

Analysis of new data from the Bukit Timah Centre magmatic rocks of Singapore show that the final amalgamation of Sundaland into Mesozoic proto-Southeast Asia, succeeded a long record of then broadly north-directed subduction of Palaeo-Tethys Ocean crust, from at least the early Permian (Gillespie *et al.*, 2019). Cessation of I-type magmatism in this sector of the Sukhothai Arc occurred around 230–225 Ma. Pervasive and forceful upward release of hydrothermal fluids followed pluton assembly in Singapore, probably triggered by slab break- off processes that led to rapid crustal rebound and resultant uplift. Alteration of granitic rock, associated with that fluid release, is recorded by significant development of widely distributed tuff site in the Bukit Timah Centre rocks (Gillespie *et al.*, 2019).

A 'top-to-the-east' ultramylonite zone now identified in eastern Kuala Lumpur, named here as the 'Jalan Wangsa Thrust', is more than 300 m thick, east-verging, and superimposed on the later stages of assembly of the c. 200 Ma S-type granite plutons assigned to the Main Range Granite province that were generated by crustal thickening (Ghani *et al.*, 2013). Younger bodies of S-type granitic rocks cut mylonitic rocks in the field outcrop. Final amalgamation after 198±2 Ma thus apparently involved east-directed (080°N present day) over-thrusting of at least parts of the leading edge of a now relatively buoyant Sibumasu onto the Sukhothai Arc/Indochina-East Malaya margin. The accretionary Bentong-Raub Suture Zone was probably over-ridden at this time.

In Kuala Lumpur, Kenny Hill Formation strata intruded by Main Range granite plutons are disposed in the hanging wall of the Jalan Wangsa Thrust and preserve widespread evidence of a dominant phase of E- or ENE-verging, upward-facing fabrics and folds. Mesozoic strata in Singapore now assigned to the Middle Triassic Jurong Group, Upper Triassic Sentosa Group and Upper Triassic to earliest Jurassic Buona Vista Formation (Dodd *et al.*, 2019), were folded and thrust (towards 050-060°N) after 209 Ma and would lie in the shear zone footwall (Figure 1). This early-Mesozoic structural framework is likely to have dominated the Peninsular Malaysia region of proto-Southeast Asia assembly, prior to superposition of dextral strike-slip tectonics in the later Mesozoic (most likely from c. 90 Ma onwards).

The engineering and hydrogeological properties of rock volumes are profoundly affected by geological structures (Hoek, 2007; Gattinoni, 2012). Due to the fractal distribution of these structures (cf. Kruhl, 1994; Barton & La Pointe, 1995), understanding the nature and geometry of these features at a continental/orogenic-scale can also inform geoscience practitioners of the likely style of deformation and discontinuities that will be encountered in site-scale construction developments. Subsurface development across Peninsular Malaysia, in particular Kuala Lumpur and Singapore, should therefore take into account the record of Mesozoic tectonics presented here.

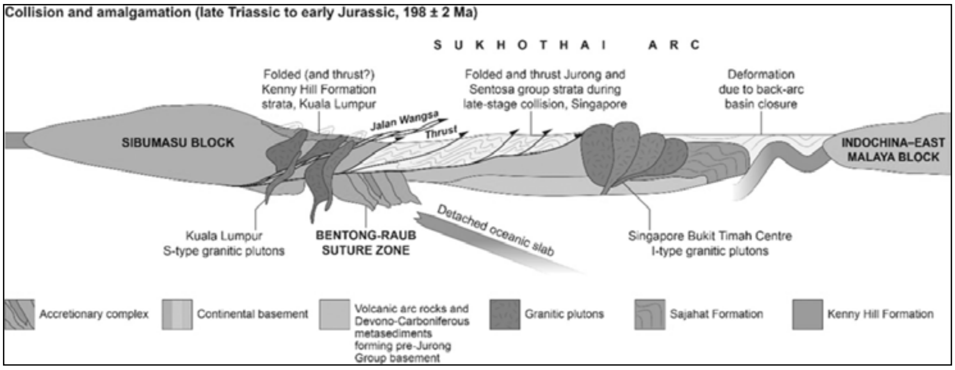

Figure 1: Cartoon showing the tectonic evolution of the Singapore/Kuala Lumpur crustal region during late Triassic to earliest Jurassic times. This representation relates to the orogenic deformation in this now southern sector of Sibumasu and the Sukhothai Arc, and the amalgamation of Sundaland (after Sone & Metcalfe, 2008). The Sibumasu and Indochina-East Malaya blocks are shown in simplified form (see also Metcalfe, 2017 for details of these elements). The Jalan Wangsa Thrust identified in eastern Kuala Lumpur is proposed as a marker for a major crustal boundary between the leading edge of the Sibumasu Block (Kuala Lumpur) and the now-shortened forearc basin of the Sukhothai Arc (Singapore). The accretionary Bentong-Raub Suture Zone was probably over-ridden in these later stages of collision and amalgamation.

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A130

Palaeo-channel morphology and distributions in the Straits of Malacca during the last glacial maximum

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Abstract: Palaeo-channel morphology and distributions in the Straits of Malacca was studied using high-resolution two-dimensional (2D) acoustic profiles. The shallow seismic data were obtained from the surveys conducted in year 2000 using boomer sub-bottom profiler. CODA Geosurvey software is used in processing and interpretation of the shallow seismic data. The Palaeo-channel were observed at depth ranging from 60 m to 88 m from mean sea level (msl). Two main shapes of channels, U-shape and V-shape were observed. The channels size is ranging between 4 m to 60 m and its depth ranging between 3 m to 17 m. Most of the channel is incised with sand while some of it was incised with mud and silts. The distributions of palaeo-channel can be observed especially in the direction of the NW-SE. The formation of palaeo-channel in the Straits of Malacca especially in Perak and Kelang offshore area is likely to be highly influenced by the sea level change during Last Glacial Maximum (LGM).

Keywords: Boomer sub-bottom profiler, palaeo-channel, sea level change, Last Glacial Maximum (LGM), Straits of Malacca

A026

Seismic attributes for faults interpretation and geomorphology: Application to N-Field, Malay Basin, Malaysia

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INTRODUCTION

In Malaysia, oil and gas reservoir are occurring in sedimentary rift basin. The region is geologically favorable for creations of hydrocarbon such as in Peninsular Malaysia. Structure and stratigraphic (geomorphologic) play an important role in understanding exploration targets especially in the Malay Basin. As mentioned by Ngah (1991), faults of Malay Basin were actively in Oligocene and Miocene in directions of E-W and NW-SE and continental was accumulated along very thick sediments. Growth of the N-Field structure can be documented by ExxonMobil as the first well drilled in the 1970s from Mid to Late Miocene (Group D and E), with the majority of the structural growth occurring in the Late Miocene (Group D). The N-Field prospect is subdivided into three major faults blocks which are east, central, and west. Generally, the presence of faults will change the trace characteristics in a very seismic trace loss of similarity. Faults is important to represent the boundaries of reservoirs, compartmentalize the reservoir, as a control connectivity and continuity of reservoir, as driver in fracture characterize. Quantifying the impacts of faults position uncertainty on hydrocarbon volume estimates and production forecasts that can affects by: in place volume estimates, well placement and production forecast and reserves. Therefore, in this paper, seismic attributes were used to analyze plausible faults in order to evaluate the change of faults propagation and to predict reservoir hydrocarbon distribution by understanding the geomorphology area.

METHODOLOGY

The methodology follows seismic interpretating and seismic attributes. Seismic interpretating approach by using manual picking.

According to Ghosh *et al.* (2014), attributes have three categories which is Class 1: Structure attributes, Class 2: Spectral attributes, and Class 3: Fluid or lithology attributes. This paper was used the Class 1 and Class 2 for identify of structural and geomorphology.

i) Ant-tracking attributes

Ant-tracking was developed of ant colony system to extract discontinuity structure. The workflow for ant-tracker algorithm was performed by completion of 4 main steps: seismic conditioning, edge detection, edge enhancement and surface extraction.

- Seismic conditioning-enhancing the seismic data volume by applying a spatial filter to reduce background noise and to improve the spatial continuity of seismic signal.
- Edge detection- finding the true edge by tracking the algorithms.
- Edge enhancement- two attributes were extracted (variance and chaos).
- Surface extraction- generation of faults surface.

ii) Spectral decomposition

The technique of spectral decomposition is based on 'tuning thickness' concept. The composite reflection offers averaged amplitude as a response to a bandwidth, and the amplitude is processed within different range of frequency response becomes apparent (Henderson *et al.*, 2007). The thickest channel will appear as orange and yellow and low reflectivity will show up as dark color. White indicates features have equally strong response at all frequency.

RESULT AND DISCUSSION

By applying structural smoothing (Figure 1), the Gaussian Filter parameter shows good discontinuity and better visualization than a without Gaussian Filter. The data set in Figure 2(a) and (b) was used to generate the variance and chaos attributes for running the ant-tracker attribute. The variance and chaos seen clearly for faults detection.

Seismic geomorphology using spectral decomposition volume reveals and allows to better delineate type of channels features (meandering, abandon channel, dendritic tributaries) in the N-Field. At the optimum frequency, as Figure 3 shows the increasing in volume of tributaries channel features are been identified in direction of N-W in map.

CONCLUSION

In conclusion, seismic attributes are useful as tools for interpretation structural and geomorphology of seismic data. Ant tracking is one of the excellence attributes for

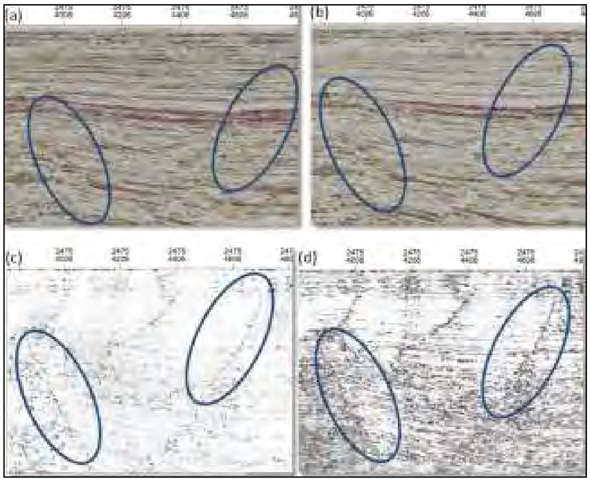

Figure 1: (a)Structural smoothing data applied without Gaussian Filter, (b) Structural smoothing data applied with Gaussiann Filter, (c) Structure in blue circular loop clearly seen in variance attribute, (d) Structure in blue circular loop is clearly seen in chaos attribute.

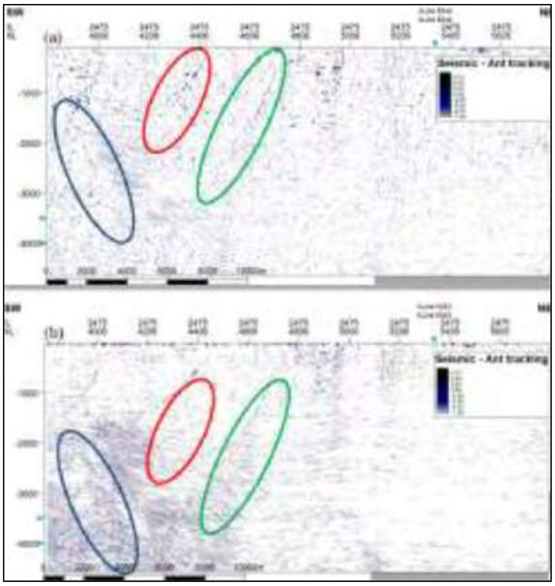

Figure 2: (a) Ant-tracking attribute using result with applying Chaos attribute, (b) Ant-tracking using result with applying Variance attribute.

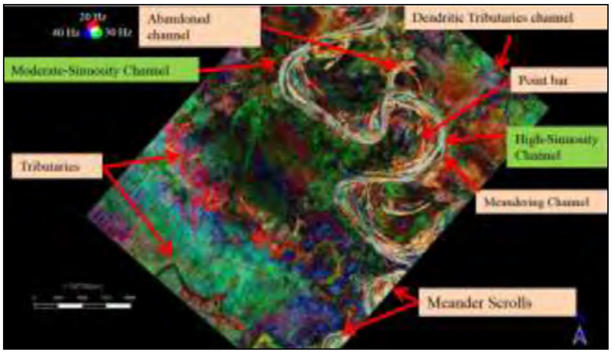

Figure 3: Shows delineate channel by using spectral decomposition at time slice, 134 ms.

faults interpretation in 3D seismic data set. Spectral decomposition is an effective tool to delineate channel and type of channel has been characterizing. For future study we can understanding the controlling effects of faults on hydrocarbon accumulation could help minimize uncertainty and improve the success rate in oil and gas exploration.

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ORAL PRESENTATIONS

PETROLEUM GEOLOGY, SEDIMENTOLOGY & PALEONTOLOGY

A033

Lithofacies of the Jurassic-Cretaceous continental deposit along Jerantut-Maran road in Jerantut, central Pahang

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INTRODUCTION

This paper presents the lithofacies analysis of four outcrops observed along the Jerantut-Maran road at the section between the Sungai Pahang and Kg. Pulau Tawar Baru (Figure 1), believed to be under the Jurassic-Cretaceous continental Tembeling Group. These outcrops, exposed due to the construction and realignment of the Jerantut-Maran road, have not been studied in detail. Furthermore, their occurrences are close to the contact with the Triassic marine Semantan Formation posing an ambiguous border between the two groups of rock (Tate, Tan & Ng, 2008).

METHODOLOGY

Field investigation was carried out on four road cut outcrops, designated as JB1, JB2, JB4 and JB5, along a 689.52-meter stretch of the Jerantut-Maran road. Each outcrop was described and logged together with observable strike and dips of directional properties. Facies analysis were then conducted by the measured sedimentological logs of the outcrops. Due to some constraints, the facies analysis in this study were limited to observable physical traits (lithofacies).

RESULTS

From the produced lithologic profile of each outcrops, distinguishing characteristics are analysed and grouped accordingly. Each lithofacies is distinguished with a combination code of lithology and key features for the later environmental interpretations modified after facies classification proposed by Miall (2006).

The first capitalized letter of lithofacies code represents a primary lithology

1. G, gravel;
2. S, sandstone;
3. F, fines (clay-silt);
4. M, mudstone;
5. C, coal

The second lower-case letter(s) represents key features for the later environmental interpretations such as sedimentary structures, bedforms, and grading for gravels and sandstones

1. m, massive;
2. l, laminated;
3. s, scoured;
4. i, interbedded;
5. h, heterolithic;
6. f, fining upward;
7. c, coarsening upward
8. mc, massive; channelized
9. ms, massive; sharp contact

and colours for mudstones

1. r, red.

Two conglomerate facies, eight sandy facies and five fine-grained facies were interpreted as follows: -

Conglomeratic Facies

(Gmc) Channel fill matrix-supported conglomerate
(Gms) Sheet of massive conglomerate

Sandy Facies

(Ss) Scoured upward fining package of sandstone facies
(Sf) Upward fining package of sandstone
(Sm) Massive sandstone
(Sc) Coarsening-upwards sandstone
(SFi) Interbedded sandstone and mudstone/siltstone
(SF) Muddy Sandstone
(Sl) Laminated sandstone
(Sc) Heterolithic sandstone

Fine-Grained Facies

(Fi) Interbedded mudstone and siltstone
(Fl) Siltstone/ Mudstone
(FC) Carbonaceous/coaly mudstone/siltstone
(FSl) Siltstone/mudstone with sand lamination
(Mr) Red mudstone

DISCUSSION

Sandy facies Ss (scoured upward fining package of sandstone) predominates where it often grades down to Sl (laminated sandstone) and Fl (siltstone/ mudstone) facies, showing a decrease in energy flow. Presence of red colored fine-grained facies Mr (red mudstone) could indicate an oxic environment or well drained environment that gives it the red colour or it could be a result of iron leaching due to the tropical climate of the study area. Presence of coaly facies FC (carbonaceous/coaly mudstone/siltstone) and coal clasts indicates a swampy and vegetated low energy environment where it could be inferred to be of lacustrine or floodplain.

Based on the predominance of a scoured bases with fining upwards sequence of sandstones, red fine-grained facies and presence of coal, these outcrops are preliminarily inferred to be deposited in a fluvial environment. The lithology of the study area bears a close resemblance to those of Tekai Valley by, Ariffin *et al*. (2005), Wafa *et al.* (2005), Koopmans (1968) and Jantan *et al*. (1991).

These classified lithofacies will be grouped into facies associations based on the trends and patterns observed in the sedimentary log. With this, a more precise interpretation of the sub-environment of the deposits can be done. The analysis of the facies associations will then be analysed to deduce the depositional environment.

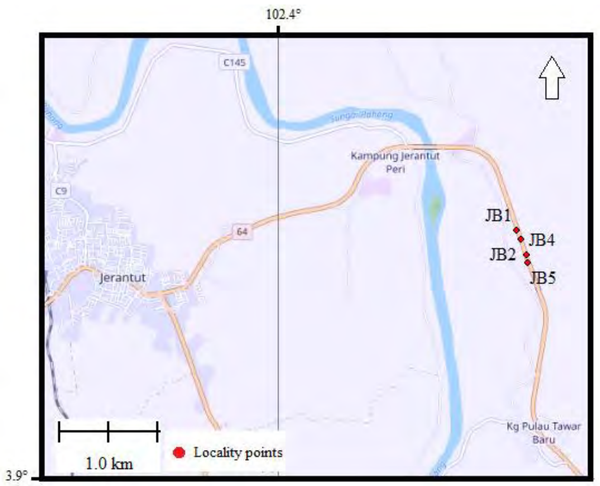

Figure 1: Locality points adjacent to Sungai Pahang and 8 km east of Jerantut town.

CONCLUSION

Along the Jerantut-Maran road at the section between the Sungai Pahang and Kg. Pulau Tawar Baru, three main lithofacies of conglomerate, sandy and fine-grained facies are inferred. It is divided further to fourteen lithofacies based on its geometry, sedimentary structure, grading and colour. Sandy facies Ss predominates and along with the presence of fine-grained facies Mr and lack of marine fossils, these outcrops could be preliminarily inferred to be deposited in a fluvial system of continental setting.

ACKNOWLEDGEMENT

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A052

Petrographic and petrophysical properties of turbidite sandstones of West Crocker Formation, Sabah

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Abstract: Turbidites deposits has been established as important hydrocarbon sources worldwide and understanding of their formation is needed for exploration success. Crocker Formation (Oligocene–Early Miocene) in Sabah is known as a deep-water succession interpreted as flysch, turbidite submarine fans, and/or Mass Transport Deposits (MTDs). Studies done over the years aided in the understanding of depositional environment, tectonic evolution, and source rock potential of the formation. However, less is known on the petrophysical properties of these turbidite sandstones and its potential as reservoir rock. Cementation is known to be prevalent in the sandstone due to compaction from intense tectonism, but without further information on the type of cement and its contribution to microporosity within the sandstone. This study aims to correlate petrographic and petrophysical properties of turbidite sandstone of Crocker Formation in Sabah in order to understand their impact in the reservoir quality of the rock. Preliminary results collected from fieldwork gathered geological knowledge to build basis for the study. West Crocker Formation in Kota Kinabalu comprises of 3 groups of facies: (1) Sand-dominated facies (F1-F3), (2) debris flow dominated facies (F4-F6), and (3) mud-dominated facies (F7). Petrographic and petrophysical characteristics of the turbidite sandstones of the sand-dominated facies will be studied to understand to delineate the reservoir quality of these turbidite sandstones.

A115

The Idanre Granite Complex, southwestern Nigeria: A synopsis and paradigm of petrographic and petrochemical characterization

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INTRODUCTION

Most Pan-African countries including Nigeria contain granite in their Precambrian terrains and are popularly called Older Granite in Nigeria. Voluminous granite like the Idanre granite complex occur in other parts of SW Nigeria (Oyinloye & Obasi, 2006). Beyond this domain, the Obudu Hills, southeastern Nigeria, Solli Hills, northcentral Nigeria (Ferré *et al*., 1998) and the Abuja Batholith, northern Nigeria (Goodenough *et al*., 2014) exist. Odeyemi, (1990) observed two problems are common to Nigeria granites. The first is linked with inconsistencies that greeted the geochemical characterization as well as the spatial and geodynamic setting of most Nigeria granites. The second is the impediment constituted to geological research by the rugged granite terrains. Field geology, optical microscopy and geochemical investigation of Idanre granite complex were undertaken in order to characterize them, evaluate their emplacement scenarios and discuss their tectonic significance. The granite occurs as intrusion into rocks of primarily migmatite gneiss with emplacement scenarios characterized by shattering of the host rock with evidence of large mafic enclaves at the margin of many plutons.

METHODS

These assessments were based on field evaluation and whole-rock geochemistry using XRF for major elements and ICP-MS for trace and REE composition on Resonatcs 193NM Excimer Laser (Agilent 7700) and He-Ablation gas at 0.3L/min with a Carrier gas of 1L/min Ar+ 0.003L/min Nitrogen at the University of Western Cape, South Africa.

RESULTS

Systematic geological mapping revealed three members forming the Idanre Granite Complex (IGC) are coarse-grained granite (undifferentiated) (OGu), porphyritic granite (OGp) and fine- grained granite (OGf) (Figure 1). OGu occurs towards the northern part, OGp forms the main body which represent almost 70% of the complex and occupies major parts of Idanre town while OGf form small plutons towards the northeastern part of the complex. Charnockite occurs at the core of the granite complex. Optical microscopy reveals large hornblende crystals in coarse-grained granite displays poikilitic texture and the porphyritic granite contains myrmekite perthite. The undifferentiated coarse-grained granite contains large and well- developed twin crystals of orthoclase, the granite porphyry contained biotite, muscovite and microcline with well-developed cross-hatched twinning while fine grained granite contained blades of haphazardly arranged biotite laths (Figure 2). Despite minor differences in petrographic features, the units display some geochemical similarities. The range and average SiO_2 contents in OGu (64.2-72.49%; 68.7%), OGp (67.92-73.76%; 70.49%), and OGf (63.6-67.87; 65.8%) are comparable to similar Pan-African suites in eastern and northern Nigeria. Na_2O+K_2O versus SiO_2 binary plot indicates the granitoid range in composition between granite, granodiorite and quartz monzonite (Figure 3). The rocks are generally calcic, K_2O vs SiO_2 plot classifies it as high-K calcic alkali to shoshonitic rock. ANK vs ACNK plot indicates the granite is peraluminous. Al/CNK vs SiO_2 and K_2O vs Na_2O diagrams classified the rock as S- type granite. The granitoids are calc-alkaline with elevated Na_2O (>2.6%), the range and mean values of $Al/(Na_2O+CaO)$ contents are OGu, 2.1-3.4; OGp, 2.4-3.1 and OGf, 2.2-2.9. The complex contains elevated Rb and Ba contents, Rb/Sr ratios between 0.32-0.89 and ΣREE between 335.3-1251. All members of the complex are LREE-rich and HREE depleted with granite profile exhibiting conspicuous similarity in REE shapes. LREE in the granite typically have higher (300-800) chondrite levels while HREE have lower (10-80 times) chondrite levels and negative Eu anomalies. Tectonic Nb vs Y, and Rb vs Y+Nb plots indicate that the granite complex occurs in Within Plate Granite (WPG) setting, La/Sm versus Sm variation plot indicates the granite originated largely from partial melting of sedimentary protoliths. K_2O versus Na_2O binary diagram indicates the units are S-type granite. TiO_2 versus Zr diagram indicates that fractionation of plagioclase was significant in the crystallization history of the granite while the contribution of monazite and allanite was indicated by (La/Yb)n versus La diagram. R1

Figure 1: Field pictures (above) of members of the Idanre Granite Complex (a) OGu (b) OGp (c) OGf and below are hand specimen samples of the different units.

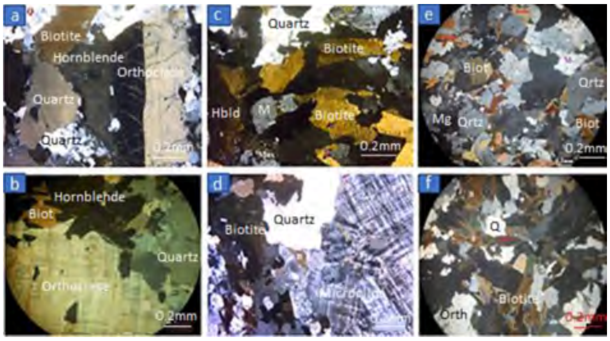

Figure 2: Photomicrograph of Idanre Granite Complex rocks in transmitted cross polarized light. (a-b) coarse- grained granite (OGu); (c-d) porphyritic granite (OGp); (e-f) fine-grained granite (OGf).

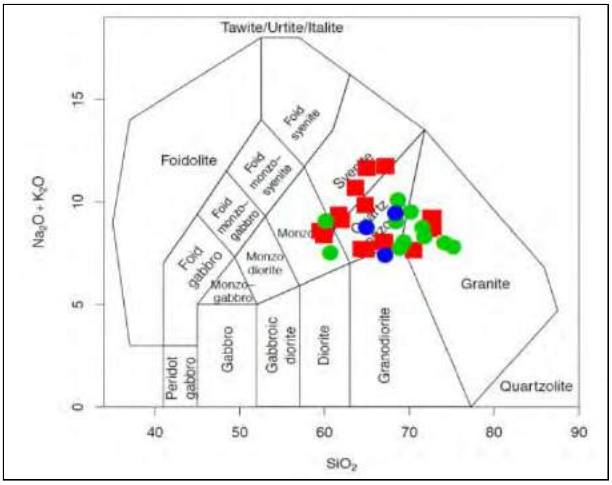

Figure 3: Geochemical classification of Idanre Granite Complex based on Na_2O+K_2O versus SiO_2 diagram.

versus R2 diagram where R1=[4Si-11(Na+K)-2(Fe+Ti)] and R2 = (Al+ 2Mg +6Ca) show the granite plot within syn-collisional to late orogenic granite fields. Similar geochemical trends in the granite's REE profile depict the different members in the suite are comagmatic.

CONCLUSION

Idanre Granite Complex was emplaced during late phase of tectono-thermal activities of the Pan-African orogenic cycle. The granitoids were of within-plate tectonic setting are chemically like other granite batholiths in Nigeria.

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A124

The continental shelf beyond 200 nautical miles: Overview of exploration and exploitation of its natural resources

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A global review of exploration and exploitation of natural resources on the continental shelf beyond 200 nautical miles or "M" (1 nautical mile = 1.852 km) is presented. According to Article 76 of the United Nations Convention on the Law of the Sea 1982 (UNCLOS) the breadth of a "continental shelf" is established by delineating an "outer limit", which extends at least up to 200 M from the territorial sea baselines or to the outer edge of the continental margin, if that outer edge lies beyond 200 M. The Commission on the Limits of the Continental Shelf (CLCS), an independent expert body created under UNCLOS, makes recommendations on the outer limits of the continental shelf beyond 200 M, based on the data and information provided by coastal States, in accordance with article 76. Upon those recommendations coastal States may establish their outer limits and henceforth exercise, with certainty, their sovereign rights over the "extended continental shelf" (ECS).

The two main types of non-living natural resources are of particular interest: hydrocarbons (including gas hydrates) and deep seabed minerals (e.g., Sterk & Stein, 2015). In the past, hydrocarbon exploration had been carried out within 200 M of the baselines of coastal States, but is gradually shifting further seaward, onto the ECS. This shift has been motivated primarily by the ever-depleting resources in the geomorphic shelf/slope areas, as well as by the prospect of larger "upside" potential of reservoirs in deep-water settings. Rapid improvements in petroleum exploration and exploitation technologies have been the main enabler of this shift.

Deep seabed minerals such as polymetallic nodules and cobalt-rich crusts generally occur in places that are remote from continental landmasses and where the sea floor is sediment-starved and affected by hydrothermal fluids (e.g. spreading ridges and fracture zones) (World Ocean Review, 2010). Exploration for these minerals is ongoing but no commercial exploitation has taken place yet. Hydrocarbons (including gas hydrates) occur in thick sedimentary basins on continental margins. Hence, typically, hydrocarbon potential diminishes with distance from the shore, while seabed mineral resource potential increases along with water depth. Generally, the sites for hydrocarbons and for deep-seabed minerals are mutually exclusive.

In some cases, exploration on the continental shelf beyond 200 M takes place where the outer limits of the continental shelf have been established based on the recommendations by CLCS. In other cases, such activities are being carried out but the outer limits have yet to be established. Most of the activities involve geological and geophysical surveys by the coastal State's agencies and the petroleum industry to assess the hydrocarbon and mineral resource potential of the outer continental shelf areas. In some areas, oil drilling has resulted in major discoveries, some of which are being planned for production by 2025.

Besides conventional hydrocarbons, continental margin sediments host significant accumulations of gas hydrates, regarded as "energy of the future". There has been no commercial exploitation of gas hydrates to date; most of the related activities thus far are considered as marine scientific research. The stability field of gas hydrates dictates their geological occurrences mainly in the outer continental slope and rise, in water depths greater than 500 m in the middle latitudes (Ruppel, 2018). In most continental margin settings, gas hydrates occur within the 200 M limit. Only in wide passive continental margins, significant gas hydrate accumulations are likely to occur in areas beyond 200 M.

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[*Disclaimer:* The author is a member of the Commission on the Limits of the Continental Shelf, based at the United Nations, New York. The views expressed in this paper are solely those of the author and do not necessarily reflect the views of the Commission on the Limits of the Continental Shelf.]

A086

Source rock evaluation of deep-marine turbidites in the Semanggol and Semantan formations, Peninsular Malaysia

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Triassic turbidites deposits of the Semanggol and Semantan formations are extensively distributed in the Central Belt and NW part of the Eastern Belt of Peninsular Malaysia (Abdullah, 2009; Figure 1). These turbidites deposits consists of black shales horizons, thick sandstone and volcanoclastic sequences. Despite of their same age of deposition in different sedimentary basins across suture and considerable sedimentary thicknesses, no systematic studies have been carried out previously. Moreover, the turbidites associated black shales in both the formations were not studied for their source rock potential in deep marine hydrocarbon bearing deposits. In the present study, systematic inorganic analysis and Rock-Eval analyses of turbidites associated sediments and black shales were carried out in order to investigate their provenance, maturation, depositional environment, tectonic setting and hydrocarbon potential.

Sandstone and volcanoclastic parts of the Semantan turbidites are more enriched in LREEs and HREEs as compared to Semanggol sediments. The X-ray diffraction (XRD) analysis reveal that major constituents of black shales are illite and kaolinite with abundant traces of detrital minerals (e.g. quartz) as well as few high mineral grains are also noted (Table 1). The siliciclastic rocks are classified as sublitharenite, and arkose- subarkose types based on geochemistry.

Al_2O_3/TiO_2 ratios in the turbidites sedimentary sequences of the both formations (i.e., black shales, sandstone and volcanoclastics) ranges from 15.91 to 22.68 and from 24.24 to 29.33 which suggest a mixture of felsic and intermediate igneous rocks as sources for their detrital fractions, which is also substantiated by the binary plot of Zr vs Ti. V/(V+Ni) ratios for turbidites deposits of the Semanggol and Semantan formations has average values between 0.88-0.98 and 0.88-0.93, V/Ni between 20.6-87.5 and 30.8-37 and Ni/Co between 0.08-0.84 and 0.56-1.24 respectively, indicating oxic to suboxic/anoxic depositional conditions for both the formations (Table 2).

Rock-Eval pyrolysis analysis demonstrates that black shales of both deposits contain Type III kerogens, which suggest similar organic input from terrestrial high plants. These rocks also contain mature to post-mature organic matter/or near to early metamorphism stage and cannot bear any substantial hydrocarbon potential. These characteristics along with the low TOC contents (poor to good) indicate that the black shales of Triassic turbidites cannot be considered as a potential source rocks for oil and gas fields in off-shore Peninsular Malaysia based on our limited dataset (Figure 2). The turbidites deposits from different localities were shown to have similar source area composition, climatic conditions as well as tectonic setting during their deposition, terrestrial organic input as well as oxic to suboxic/anoxic depositional conditions. However, these Triassic black shales from Semanggol and

Table 1: Mineralogical composition of the Triassic turbidites from Malaysia.

Age	Formation	Rock	Sample	Non-Clays minerals: Quartz	Non-Clays minerals: Alkali feldspar	Clay minerals: Illite	Clay minerals: Kaolinite	Clay minerals: Muscovite	Clay minerals: Biotite	Clay minerals: Chlorite	Mafic Minerals: Amphibole
T	Semanggol	BL	2	Tr	-	M	M	-	-	-	-
			3	Tr	-	M	M	-	-	-	-
	Semantan		4	Tr	-	M	M	-	-	-	-
			5	Tr	-	M	M	-	-	-	-
			7	Tr	-	M	M				
		Volcano-Clastic	22	28	50	-	-	-	-	22	-
			24	22	-	23	-	21	24	10	-
			29	28	52	-	-	-	-	20	-
			30	22	6	-	32	12	-	19	9

M = Major; Tr =Trace

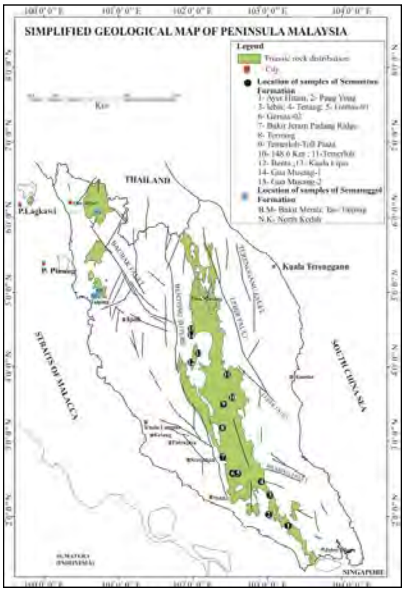
Table 2: Averages of some geochemical proxies in the Triassic turbidites bearing part of Semanggol and Semantan formations from Peninsular Malaysia.

Age	Rocks	Semanggol Formation turbidites: Al_2O_3/TiO_2	Al_2O_3/SiO_2	V/(V+Ni)	V/Ni	Ni/Co	Ce*	Eu*	Semantan Formation turbidites: Al_2O_3/TiO_2	Al_2O_3/SiO_2	V/(V+Ni)	V/Ni	Ni/Co	Ce*	Eu*
Triassic	Black shale	21.67	0.22	0.94	80.03	0.84	1.71	0.79	29.33	0.29	0.88	34.71	1.24	1.73	0.98
	Sandstone	22.68	0.06	0.88	20.6	0.28	0.56	0.23	24.24	0.27	0.93	37	0.56	1.31	0.82
	Volcanoclastic	15.91	0.05	0.98	87.5	0.08	0.63	0.36	25.55	0.25	0.92	30.82	0.72	1.09	0.92

Table 3: Mean element concentrations and ratios in the Triassic turbidite sequences compared to Upper Continental Crust (UCC), sands derived from mafic and felsic rocks.

Geochemical Proxies	Triassic turbidites Mean	Ainsa basin sediments Mean	UCC	Sands derived from mafic rocks	Sands derived from felsic rocks
K_2O/Al_2O_3	0.17	0.21	0.22		
Al_2O_3/SiO_2	0.24	0.14	0.23		
Cr/Ni	22.3	1.9	1.8		
Cr/V	0.68	0.8	0.6		
V/Ni	39.5	2.3	3		
Th/Cr	0.31	0.12	0.31	0.018-0.046	0.13-2.7
Th/Sc	1.05	0.35		0.05-0.22	0.84-20.5
La/Sc	3.40	1.44		0.43-0.86	2.5-16.3

Semantan turbidites sedimentary sequences (black shale, sandstone and volcanoclastics) exhibit higher Al_2O_3/SiO_2 ratios than the associated sandstone and volcanoclastics of Semanggol suggesting a prevalence of wetter climatic conditions during deposition (e.g. Moosavirad *et al.*, 2011). The bivariate plots of La/Sc versus Ti/Zr, SiO_2/Y, SiO_2/Nb and Y+Nb vs Rb, are all plotted on the fields of active continental margin to continental-island arc settings (continental collision zone) which is consistent with the known continental island arc setting (Table 3). In addition, these turbidites bearing sediments show moderately positive Ce* and negative Eu* anomalies, indicating the dominance of reducing conditions during the deposition of these formations (Dai *et al.*, 2016; Figure 3).



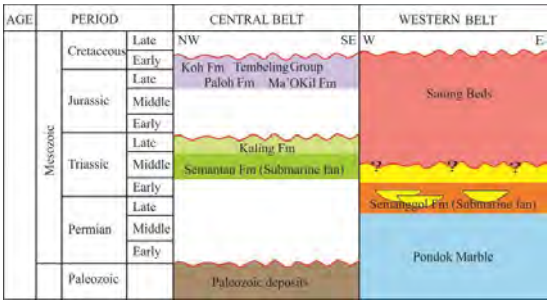


Figure 1: A) Simplified geological map illustrating the distribution Triassic rock in the Peninsular Malaysia (modified from Tan *et al.*, 2008), B) stratigraphy distribution of Triassic turbidites bearing part of Semanggol and Semantan formations in Central and Western Belt, Peninsular Malaysia (modified after Abdullah, 2009).

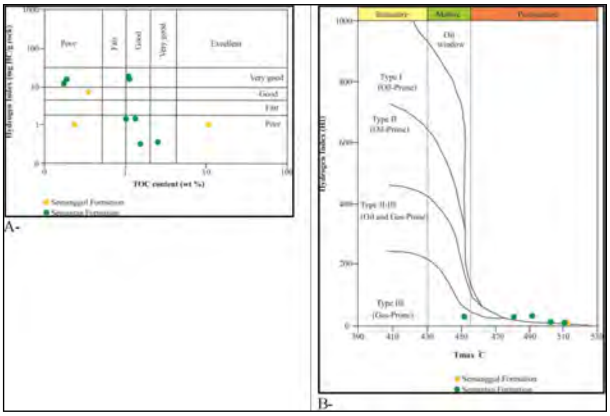


Figure 2: A) Plot of Total Organic Carbon (TOC) vs Hydrogen Index (HI) showing generative source rock potential for the Triassic turbidites associated black shales from Peninsular Malaysia (from Peters & Cassa, 1994). B) Plot of Hydrogen Index (HI) vs pyrolysis Tmax for the analyzed black shales of Semanggol and Semantan, showing kerogen type and thermal maturity stages (from Mukhopadhyay *et al.*, 1995a, b).

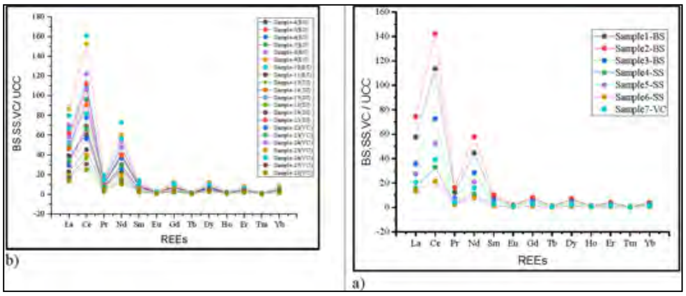


Figure 3: a) Upper continental crust (UCC)-normalized patterns of rare earth elements (using UCC REEs concentrations developed by Taylor & McLennan (1985)) of the Triassic turbidites black shales (BS), sandstone (SS) and volcanoclastics (VC) of average values of Semanggol Formation. b) Upper Continental Crust (UCC)-normalized patterns of rare earth elements of the Triassic turbidites associated black shales, sandstone and volcanoclastic of average values for Semantan Formation.

Keywords: Triassic turbidites, Semangol Formation, Semantan Formation

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A088

Analysis of mechanical behaviour of reservoir rock properties

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In petroleum industry, rock mechanical behaviour is a fundamental parameter for the development of oil and gas fields. Overburden stress must be accredited when determining the mechanical properties of rocks as it contributed to part of the rock strength. This paper is to study the influence of petrophysical properties, grain size, cement types, microfractures, mineral composition and mineral structure on the rock mechanical properties. Porosity and permeability of five sandstone cores were measured using Ultra-Pore™ 300 and CMS™-300 Automated Permeameter. Petrographic analyses of thin sections were performed to determine the mineral composition, while the mineral structure was observed by using Dino-Lite microscope. The cores were tested for present of carbonate minerals using hydrochloric acid. Finally, the rock mechanical behaviour was analyzed by relating all the factors mentioned with the fracture density of the rock. The result showed that the porosity, grain size, cement types, mineral composition and structure are closely related to the mechanical behaviour of rock. With the decrease in grain size and quartz grain along with depth, the porosity and fracture density of sandstones decrease, and thus having a greater rock strength. In addition, the sandstones with the present of clay matrix and carbonate cement have a lower mechanical strength as compared to the sandstones with clay matrix and quartz cement.

A107

Litho- and biostratigraphy of the 'black shale' facies (chert unit) of the Semanggol Formation at Kampung Kubu Gajah (north Perak, Peninsular Malaysia)

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INTRODUCTION

The age and depositional history of the 'black shale' facies of the Chert unit of the Semanggol Formation remain obscure while considering its whole area extent (Kedah and North Perak, Peninsular Malaysia). In Perak, the 'black shale' facies has only been dated in the central sector of the Semanggol Range, where a Lower Triassic age is inferred after the presence of the bivalve genus Claraia (Drahman & Gámez Vintaned, 2017). Herewith we present new litho- and biostratigraphic data on the mentioned 'black shale' facies from a quarry located in the northern sector of the Semanggol Range, north of Kampung Kubu Gajah, 0.4 km to the NW of the Toll Plaza Bukit Merah. The stratigraphic succession exposed there is mostly inverted and intensely deformed.

This study has rendered body fossils (bivalves) and trace fossils (bioturbation structures), both unknown in the northern sector of the Semanggol Range until now. Our data contribute to solving the controversy about the palaeoenvironmental interpretation of the 'black shale' facies in north Perak, consisting of whether considering the bivalves as indicative of fully oxygenated bottoms on the marine platform, as adapted to live in a poorly oxygenated environment, or as remains transported post-mortem onto deeper settings.

Bivalve biostratigraphy allows correlating the 'black shale' facies across the northern and central sectors of the Semanggol Range, as well as comparing their listhostratigraphic successions, which improves our understanding on the evolution of the basin. Data on the biometry of the bivalves and on the total organic carbon (TOC) contents of the rocks are also provided.

LITHOFACIES AND FACIES ASSOCIATIONS

An integrated lithofacies-biostratigraphic log of 38 m in thickness was obtained at scale 1:10 from the outcrop located at the quarry North of Kampung Kubu Gajah (Figure 1). Three facies associations were identified: sand-dominated, interbedded very fine- to fine-grained sandstone and shale (FA1), mud-dominated, interbedded very fine to fine-grained sandstone and shale (FA2), and thick fine- to medium-grained sandstone (FA3).

PALAEONTOLOGY

Bivalves found were identified in open nomenclature McRobert's (2010) (Figure 2). *Claraia* sp. was identified 8.75 m above the bottom of the stratigraphic log. This genus reached its acme during the earliest and mid Early Triassic (Induan and Early Olenekian ages). At 31.0 m, the bivalve *Daonella* aff. *moussoni* indicates a probable Ladinian (i.e. late Middle Triassic) age, while *Halobia* aff. *lenticularis* found at 37.5 m points to a late Carnian Age (i.e. early Late Triassic).

Biometry of bivalves indicates that they follow a natural distribution, reflecting that they were either accumulated in situ or deposited after a very short transport by marine currents.

TOTAL ORGANIC CARBON (TOC) CONTENT

The TOC values are very low – 0.397% to 0.468%, probably due to modern weathering. Bioturbation and bivalve occurrences indicate oxygenated benthic palaeoenvironments.

PALAEOENVIRONMENTAL RECONSTRUCTION

Based on the finding of bivalves, as well as that of *Palaeophycus* and *Thalassinoides* – indicative of the *Cruziana* ichnofacies, the setting is interpreted as in the circalittoral zone on the continental shelf (Figure 3). Absence of oscillation ripple marks and wavy beddings indicate a setting below the fairweather wave-base, while the abundance of sandstone bodies with erosional surfaces point to deposition above the storm wave-base, although sedimentation below it cannot be discarded.

The 'black shale' facies of the Chert unit of the Semanggol Formation at Kampung Kubu Gajah was, hence, deposited in much shallower environments than analogous, deep-water successions in Southern Kedah (Basir Jasin *et al.*, 2005).

CONCLUSION

Sedimentological and palaeontological evidence indicates deposition within the circalittoral zone, probably associated with a prograding delta apparatus. Based on the palaeontological findings, the environment was fairly

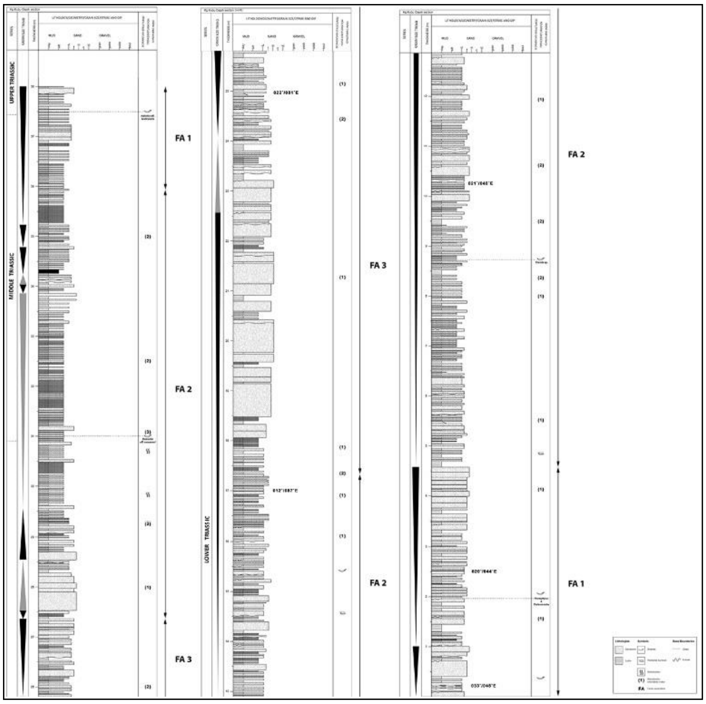

Figure 1: Integrated litho- and biostratigraphic log of the 'black shale' facies at Kampung Kubu Gajah. Ages are based on bivalve taxonomic identification.

oxygenated with low penetration of sunlight. Bivalves indicate an age range from Lower through Upper Triassic and a rather condensed succession, younger than the analogous one at the Central sector of the Semanggol Range.

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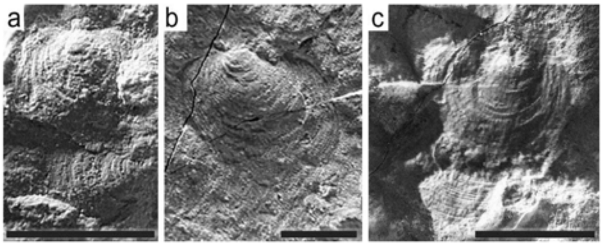

Figure 2: The three bivalve taxa identified, mostly preserved as inner moulds as the ones herein. Scale bars equal 5 mm. a) *Claraia* sp. b) *Daonella* aff. *moussoni*. c) *Halobia* aff. *lenticularis*.

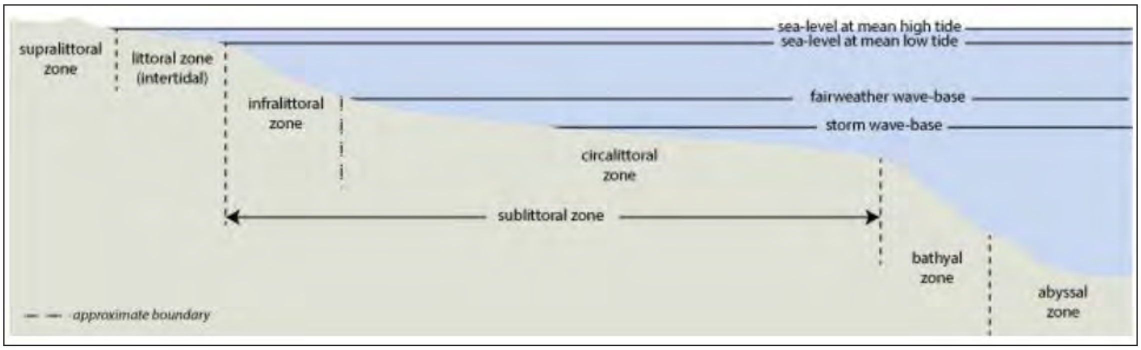

Figure 3: The circalittoral zone – interpreted as the ecological zone where the 'black shale' facies of the chert unit of the Semanggol formation at Kampung Kubu Gajah was deposited.

A121

Sequence stratigraphic interpretation for delineation of hydrocarbon sand in a shallow gas-prone reservoir, Baram Delta, Sarawak, Malaysia

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INTRODUCTION

The West Baram Delta, a prograding and retrograding wave-dominated delta lies offshore Sarawak, Malaysia, with a series of depositional units separated from each other by major E-W trending faults (Rijks, 1981). The field of study is a dome-like anticlinal structure dissected by 3 major E-W faults with few minor fault presences. A static model was constructed earlier with lack of consideration for the internal sequence stratigraphic interpretation. Moreover, shallow gas presence in the field have hindered the seismic interpretation. This research provides a sequence stratigraphic approach to enhance the model for the selected reservoir, R-A1, by constructing depositional facies distribution model through appropriate sequence stratigraphic methods.

SEQUENCE STRATIGRAPHIC INTERPRETATION

A high-resolution sequence stratigraphic analysis is employed to provide better solution to uncertainties in the facies association distribution within the field. Hence the re-evaluations of poroperm and net to gross can improve volumetric estimation. The geological concept in sequence was improved by a field study in Miri, Sarawak, where the Cycle V facies of the Miri formation outcrops provided suitable analogues to the Cycle VI facies of the reservoir model. The Canada Hill outcrops in Miri and reservoir R-A1 are likely from similar shoreface depositional environment settings, as evidenced by the interpreted well log and seismic section – within a highstand systems tract deposition period. The outcrop showed a generally coarsening upward facies, similar in interpretation to the well logs. Conceptual reservoir facies distribution and quality was also constructed based on log and seismic interpretation.

RESERVOIR MODELLING

During the depositional period in Late Cycle V to Cycle VI, the water depth was rising and progradation shifted toward the east (Zin, 1996) in accordance to the interpreted HST depositional period. The sand bodies were identified using gamma ray where clean sand is represented by depth intervals with lower than 60 API which is the mid value for the gamma ray readings of the well logs. The log motifs indicate progradational period spans for the reservoirs within the highstand system tracts (HST) and lowstand system tracts (LST), interpreted along with seismic section X1-A through seismic terminations and depositional sequence analysis (Mitchum, Vail & Thompson, 1997). This trend is gently dipping towards the North East and is overlain by retrogradational periods, a transgressive system tract (TST). The TST ends at the maximum flooding surfaces (MFS) which occurs at 4100 ft in general. The seismic section interpreted stratigraphic facies identified the hydrocarbon sand body which is validated by the well logs. The sand body is bounded by thick shale domains that are extensive. This phenomenon can cause the low resistivity sands presence within the reservoir. The lateral extent of the fluid-dominated clay shown in the resistivity logs corresponds to two shale-prone facies enclosing the low resistivity hydrocarbon sands.

CONCLUSION

The sand quality is expected to be very good in the prograding sequences where the poroperm values ranges from 100-1100 mD. Thus, the reservoir will have relatively good sequences of sands compared to the thinner sand bodies within TST (7-900mD) above. The prograding depositional facies model which implies deltaic fan system suggest better sand development over the transgressive periods. The sequence stratigraphic model also successfully alleviates the effects of shallow gas hindering the seismic image over the reservoir, and thus helps in reducing uncertainties in the geological static model.

ACKNOWLEDGEMENT

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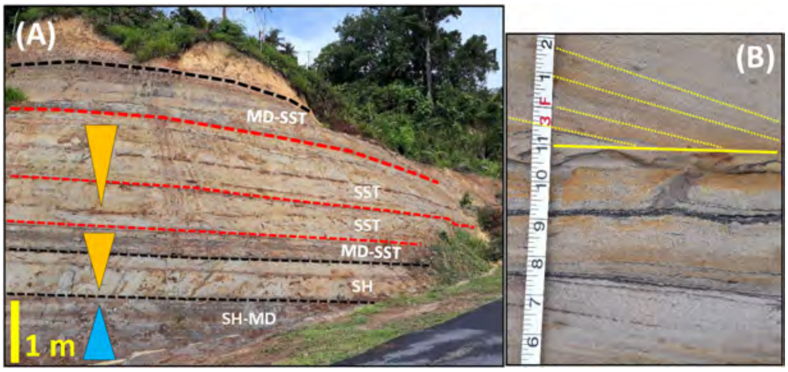

Figure 1: (A) Canada Hill outcrop in Miri, Sarawak, Malaysia. Displaying the beddings from a prograding Cycle V shoreface environment. Thick beds of sandstone dominate the outcrop, with varying periods of shale and mudstone interbedding (SST- sandstone, SH-shale, MD-mudstone). (B) Sandstone internal structure displaying herringbone crossbedding with shale (black streaks) and mudstone laminar.

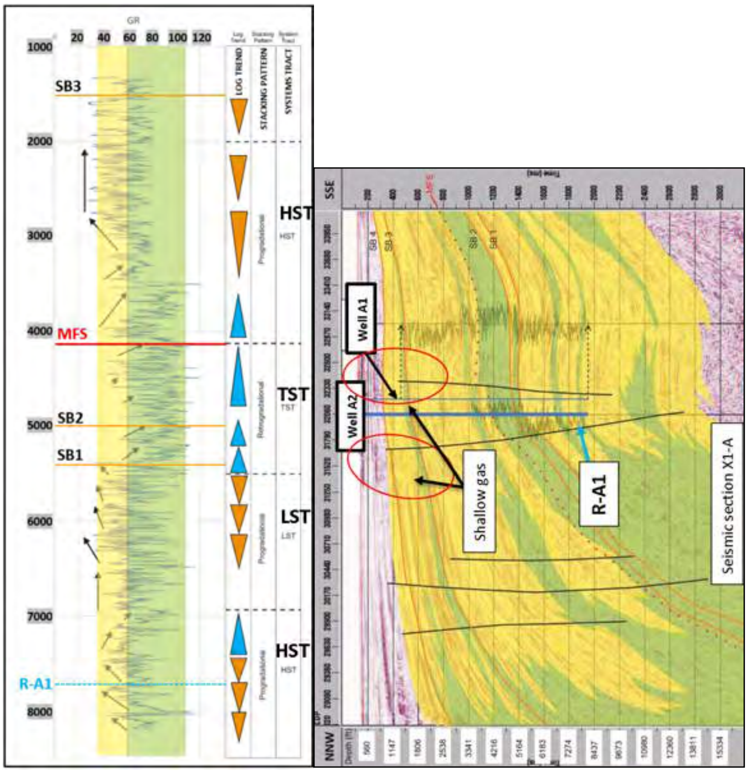

Figure 2: (A) Gamma ray log for Well A1, interpreted for sand-prone (yellow) and shale-prone (green) segregation; log trends for coarsening and fining upwards; stacking pattern and systems tracts. Three surfaces interpreted from the log and one maximum flooding surface. (B) Sequence stratigraphic interpretation for seismic section X1-A. Interpretation showing reservoir R-A1 within a prograding sequence of the HST. Shallow gas presence (red ellipses) at depths 500-1500 ft hindering past interpretations was overcome by sequence stratigraphic interpretation.

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A008

Lessons from deep 2D seismic over Central Luconia Province, offshore Sarawak

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The Central Luconia Province in offshore Sarawak have been modelled by Hazebroek & Tan (1993); James (1984); and Tan & Lamy (1990) as sitting on a continental crust rifted from the South China. Central Luconia continental block is interpreted to have experienced the two successive South China Sea (SCS) rifting events since 37.8 Ma ago. The rifting of the Luconia continental block ceased at 16 Ma (Savva *et al*., 2014) where it collides with the Argo block leading to the Sarawak Orogeny. Present-day Sarawak basement is composed of the continental fragment (mainly evidenced offshore), and shortened and uplifted pre-collision accretionary wedges. However, basin evolution across the Luconia block and its intricate relationship with the successive tectonic events that affected the SCS in the Cenozoic remain unclear.

Several seismic lines crossing major basement structures over Central Luconia were interpreted. Based on these seismic lines, the sediments are divided into pre-rift, syn-rift and post-rift sequences (Figure 1). Pre-rift sediments are usually thicker in the central and eastern sides of the basin and appear more stretched in the northern and western side. These differences in crustal thickness reflects the style of rifting from Southern China.

In the northern part of the province, the faults appear with lower angle and deep-rooted, offsetting deeper to shallower sediments, possibly Eocene-Miocene age. Whereas, on the eastern side of the province, faulting is mainly restricted within the Oligocene-Miocene sediments, highlighted by numerous carbonate platforms. Several small-offset faults are also common within the post-rift sequence. Indication of sediments progradation seawards into the basin is also observed in the post- rift sequence.

Stratigraphic horizons were interpreted based on the characteristics of the seismic reflectors. Accurate age controls for the seismic is calibrated within the Early Miocene to recent sediments and subsequently correlated laterally. A horizon reflecting the top of Cycle IV (Middle Miocene) sediments is noticed to be present in all the

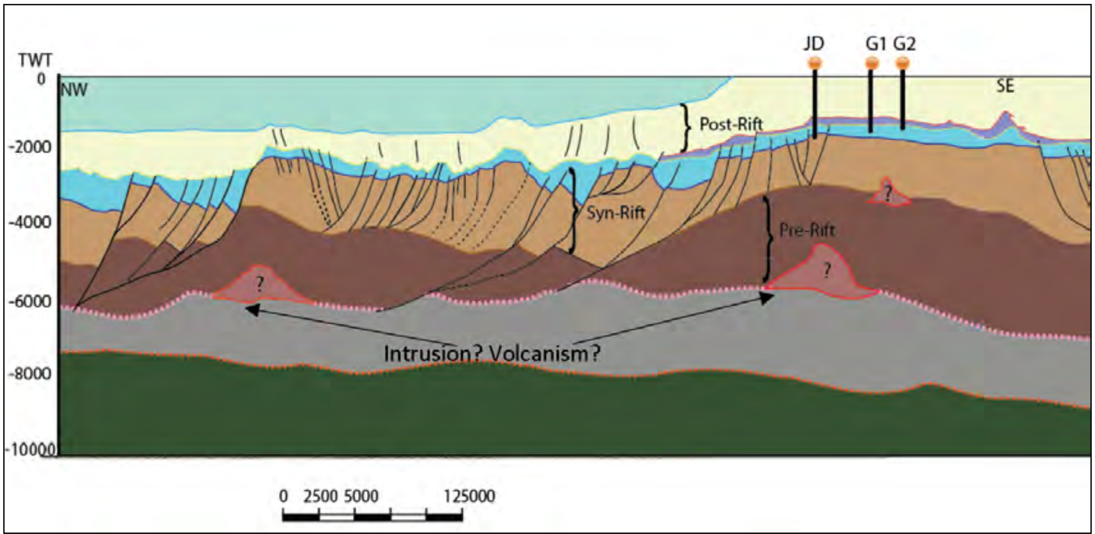

Figure 1: Closed-up image for one of the deep seismic line, oriented in NW-SE in the offshore of Central Luconia Province showing Pre-Rift, Syn-Rift and Post-Rift sequences. Different in crustal thickness is observed in the southeast and northwest section of the line, and possible thermal events indicated by the question mark.

seismic lines and widely distributed in the whole province. The geometry of this horizons reflected the shape of the basement and implies a tectonic influence during the sedimentation history of the basin.

Interestingly, high amplitude and strong reflectors are detected at several locations at depth -8000ms to -10000ms and can be associated with either volcanism or intrusions during the Paleogene or older. Several studies have evidenced the occurrence of the lower crust core complexes due to the presence of high thermal activities in this region during Paleogene (Moss *et al*., 1998, Carter & Moss, 1999; and Hall *et al*., 2008).

Significant evidence from the subsurface data indicates that the southern side of Central Luconia is less affected by the SCS rifting but has more impact of the compression of the Sarawak Orogeny. Whereas, the northern side of this province is more stretched with thinned crust and prominent syn- rifting structures. The central part of this province can be considered as transition zone between the stretching and compression events with proves of major crustal necking that allows intrusions to occur. These observations can provide new insight into the geological interpretation and modelling of this province and its relation to the geodynamics of the SCS.

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A010

Multiple-seismic attributes efficiency for seismic sequence stratigraphy interpretation

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BACKGROUND AND OBJECTIVE

Analysis of seismic attributes has been an integral part of reflection seismic interpretation for over two decades now. Seismic attributes are tools for inferring geology from seismic reflection data. These attributes aid seismic interpretation by revealing hidden features, by identifying similar patterns, and by quantifying specific properties. Attribute analysis is a vital facet of reflection seismology for petroleum exploration and finds wide application, from anomaly identification to feature extraction to lithological prediction. Seismic attributes quantify properties of seismic data; seismic attributes describe seismic data. As seismic data can be described in countless ways, the potential number of seismic attributes is likewise countless. Hundreds of diverse attributes have been invented and more appear each year. Their interpretation remains largely a matter of qualitative investigations with individual attributes, but the quantitative multi attribute analysis is slowly growing. Seismic attributes facilitate structural and stratigraphic interpretation as well as offer hints to formation type and fluid content estimation with the potential benefit of detailed reservoir characterization. The current study evaluated the use of seismic attributes generated from 3D seismic data volume and well log data for seismic sequence stratigraphy classification of some intervals in the Malay basin.

MATERIALS AND METHODS

Iso-frequency attribute, spectral decomposition, variance, geobody probes tool, integrate the picked seismic horizon with three different frequencies values and Seismic stratigraphic spectral analysis. These attributes were used to generate a high-resolution seismic sequence stratigraphy 3D seismic framework representing all the geological features in a high-resolution scale which would enhancing seismic interpretation and volumetric estimation of the interested interval units in Malay basin. The methodology involved tying well to the seismic data, time to depth conversion, generating the synthetic seismogram, seismic attributes analysis, seismic sequence spectral analysis, 3D geobody modelling, mapping the seismic horizons. Synthetic seismogram, seismic reflection terminations, well tops, seismic configuration, and seismic facies. Well logs and a volume of seismic data were used in this investigation.

RESULTS

Two main seismic sequence sequences were identified and mapped in the study area using 3D seismic visualization. Similarly, several minors and major faults were imaged using spectral decomposition attributes, major channel and some other minor channels were imaged using Ios-frequency spectral decomposition attributes. Depth structure maps generated exposed a huge East-West (E-W) trending anticlinal structure.

CONCLUSION

This study revealed that Melor Field" has a very good channel and some other minor channels which very good reservoirs with high hydrocarbon potentials is would has an excellent petrophysical characteristic favorable for hydrocarbon accumulation and production. The benefits of integrating structural interpretation and seismic attributes analysis in prospect identification and reservoir prediction were therefore highlighted in this study.

A011

New insights into the sedimentology of the Kenny Hill Formation, Peninsular Malaysia

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The Kenny Hill Formation (Yin, 1961) represents a heterogeneous metasedimentary succession of possibly upper Carboniferous to middle Permian age (Stauffer, 1973; Hashim, 1985) exposed in outcrop in the Western Belt of Peninsular Malaysia, including Selangor, Kuala Lumpur and Putrajaya. As these regions are already heavily urbanised, and continue to be the focus of development, the formation represents one of the most important bedrock units in the Peninsular Malaysia subsurface. Numerous problematic ground conditions and hazards are associated with the formation including: slope stability issues; collapse deposits at the interface with the underlying Kuala Lumpur Limestone; high tunnel boring machine disc cutter wear rates; variable residual soil strength caused by contrasting interbedded lithologies and lateritic concretions and hardpans (Tan & Komoo, 1990; Mohammed *et al*., 2007; Tan, 2017). Despite this, the lithological characterisation and interpretation of the depositional setting of the Kenny Hill Formation remains inconclusive; only a handful of publications from the 1970s and 80s document sedimentological studies of the unit (e.g. Stauffer, 1973; Rosly, 1980; Hashim, 1985).

This study describes a set of recently exposed sections of the Kenny Hill Formation in Kuala Lumpur, Putrajaya and Selangor; the outcrops no longer exist, having since been cleared or covered for construction purposes, and these data therefore provide the only record of sedimentary features in these areas. Based on the new data, the Kenny Hill Formation is here interpreted as the product of a complex, multi-component sedimentary system.

A shallow marine shelfal setting is exposed in outcrop near Salak Perdana in southern Putrajaya, characterised by a stacked succession of high-density turbidites, hybrid event beds (HEBs) and shallow water background sedimentation (Figure 1). High-density turbidites are characterised by beds of amalgamated, structureless sandstone with loaded bases, whilst HEBs are represented by structureless sandstones with clay-rich bed-tops (Figure 1A). HEBs are important to identify as they signify a fringe or more distal location within a turbidite fan system (Haughton *et al*., 2009; Kane *et al*., 2017; Dodd

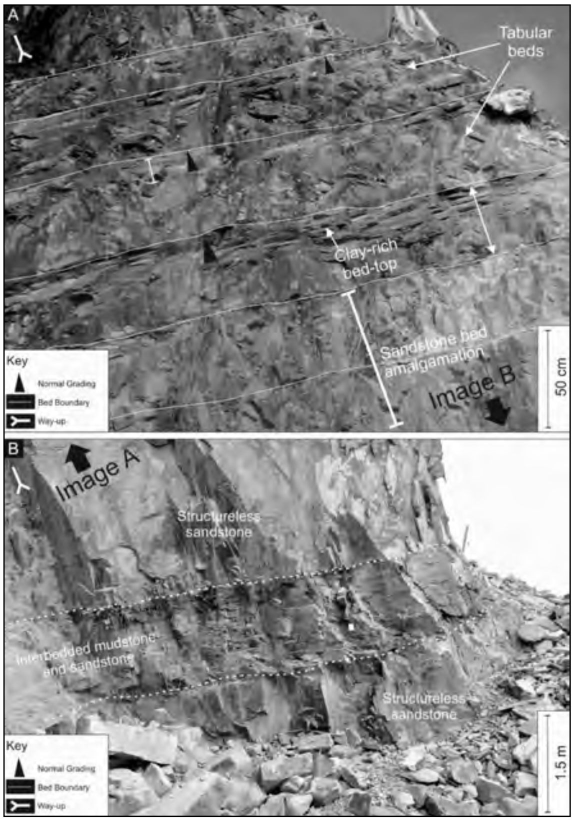

Figure 1: Outcrop of the Kenny Hill Formation from Salak Perdana. A.) The uppermost part of exposed section, showing tabular beds of structureless sandstones, some with normally graded clay- rich bed-tops. B.) The lowermost part of the exposed succession, showing thickly bedded structureless sandstones, overlain by interbedded mudstones and sandstones that contain flaser laminations and lenticular bedding. The overlying structureless sandstone unit displays load structures at the base, indicating instantaneous deposition into wet sediments.

et al., 2019 and references therein). Lenticular bedding, flaser lamination and low- density turbidites, which are present within the interbedded mudstones and sandstones in between event beds (Figure 1B), indicate a shallow water setting. A ten-metre thick succession of marginal marine mouth bar deposits are present in outcrop near Bukit Jalil in southern Kuala Lumpur. The sedimentary rocks are characterised by a thickening, coarsening and cleaning upward succession of sandstones, which display asymmetrical ripple lamination (oscillatory waves). The sandstones are overlain by a bar-crest succession, which is capped by laminated mudstones representing abandonment facies. Fluvial channel facies have also been identified near to Kuala Lumpur International Airport, comprising sandstones that display erosive bases, pebble lags, planar cross-bedding and normal grading. The fluvial channel facies incise into laminated mudstones that display mottling textures and pedogenic alteration fabrics. These deposits are indicative of stacked fluvial channel systems and associated overbank deposits, and reflect a probable meandering fluvial system.

Depositional environments indicated by the observed sedimentary facies include (from distal to proximal): a shallow marine shelfal setting with turbidite fan input; a marginal marine mouth bar setting; and a meandering fluvial setting. These environments likely existed coevally, developing alongside each other on an upper Carboniferous to middle Permian palaeo-shelf. Despite the recognition of multiple depositional environments in the Kenny Hill Formation, and an overall progression from distal to proximal facies, the spatial relationships of the resultant contrasting lithologies in the subsurface below Kuala Lumpur, Selangor and Putrajaya, remain poorly understood. Given the numerous problematic ground conditions and hazards associated with it, an improved understanding of the Kenny Hill Formation is vital to facilitate future sustainable development and resilience of urban areas and infrastructure across the western portion of Peninsular Malaysia and should therefore be a key focus for future research.

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A015

Deep marine Paleogene sedimentary sequences of West Sabah: Contemporary opinions and ambiguities

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The Paleogene of West Sabah comprised early Paleogene Trusmadi and East Crocker formations while the late Paleogene include West Crocker and Temburong formations. Trusmadi and East Crocker formations represent the eastward continuation of Crocker-Rajang Group that was metamorphosed, folded and uplifted in late Eocene. These early Paleogene successions were deposited, and these successions were later weathered and re-sedimented to form the younger West Crocker Formation of Oligocene to early Miocene age (Tongkul, 1995; Crevello, 2002).

An integrated sedimentological and stratigraphic understanding of these Paleogene deposits is still lacking. Previous work had focussed on the well-exposed late Paleogene West Crocker Formation. However, the early Paleogene East Crocker and Trusmadi formations have been less studied. The available data and interpreted geology to date are noticeably marked by numerous uncertainties. The major uncertainties are: 1)The detailed characteristics of the facies, facies associations and depositional model of Trusmadi, East Crocker, West Crocker and Temburong formations have not been clearly defined and differentiated; 2)The proposed stratigraphic framework has been described by numerous and sometimes conflicting terms like DRU, TCU, BMU and EMU. The nomenclature of various unconformities within Paleogene strata is confusing and multifaceted. The present study aims to contribute to an integrated sedimentological and stratigraphic framework of Paleogene West Sabah.

FACIES AND DEPOSITIONAL ENVIRONMENT

Asis *et al.* (2015) reported that the Temburong Formation in Tenom area of SW Sabah is dominated by fine-grained turbidite (Td and Te Bouma Sequence) of basin plain facies and was interpreted to represent the distal part of a deep marine fan. However, Jackson & Johnson (2009) stated that Temburong Formation in Labuan was deposited in lower slope to proximal basin floor environment containing debrites and turbidites (Ta to Te Bouma facies). Recent studies by Bakar *et al.* (2017) on Temburong shales exposed in Labuan area shows that the formation was deposited in deep marine bathyal to abyssal environment. Mohamed *et al.* (2016) and Zakaria *et al.* (2013) described sedimentary facies of West Crocker Formation from North Kinabalu to Tuaran, NW Sabah and Kota Kinabalu, SW Sabah with groups of sand dominated, sand and mud mixed, and mud-dominated which were deposited in inner, middle and outer fan environment. However, Leong *et al.* (2018) discussed the sedimentary facies of West Crocker Formation as middle and outer fan facies only in Weston-Sipitang areas of SW Sabah (Table 1).

Bakar *et al.* (2008) reported muddy and massive debrites in channel and slump facies of West Crocker Formation in Inanam, Kota Kinabalu. Zakaria *et al.* (2013), Jackson *et al.* (2009) and Shafi & Madon (2008) reported turbidites, debrites, co-genetic turbidite debrite (CGTD) and linked debrite facies in the West Crocker Formation which had been developed due to non-channelized and unconfined distal part of submarine fan. Tjia (2015) assigned bathyal to abyssal depth of Eocene to early Miocene Crocker sandstone. Nevertheless, Lambiase *et al.* (2008) suggested the West Crocker Formation contains dominantly high-density turbidites (partial Bouma divisions) developed in bathyal depths while Leong *et al.* (2018) reported both higher flow regime (Ta-Tc facies) and lower flow regime (Tc/d-Te Bouma divisions) in West Crocker Formation.

STRATIGRAPHY

Hutchison (2005) stated that West Crocker Formation is bounded by Deep Regional Unconformity (DRU) at the top of the formation. Hall (2013) placed the DRU at the top of Setap Shale while upper contact of Crocker Formation is marked by Top Crocker Unconformity (TCU). Both Crocker and Temburong formations were truncated by Top Crocker Unconformity (TCU) as reported by van Hattum *et al.*, 2013. Temburong Formation was deposited from early Oligocene to early Miocene

(Hutchison, 2000; Lambiase *et al*., 2008). However, Asis *et al*. (2015) designated the age of Temburong shales from late Oligocene and extends up to late early Miocene. Recent studies by Leong *et al*. (2018) suggested the age of Temburong Formation starting from upper Eocene which is older than previously reported work.

Hutchison (2005) reported Rajang Group that included both Trusmadi and Crocker formations while van Hattum *et al*. (2013) included only Sapulut Formation in the Rajang Group and reported an unconformable contact between Sapulut and Trusmadi formations (Figure 1). Lambiase *et al*., 2008 extended the base of West Crocker Formation from middle to late Eocene while it was previously thought to be deposited from lower Oligocene times (Hutchison *et al*., 2000). It is pertinent to mention here that the term 'Crocker Formation' includes both East Crocker and West Crocker formations. Hence, scientific work of Hall (2013) and van Hattum *et al*. (2013) had not differentiated between East and West Crocker formations.

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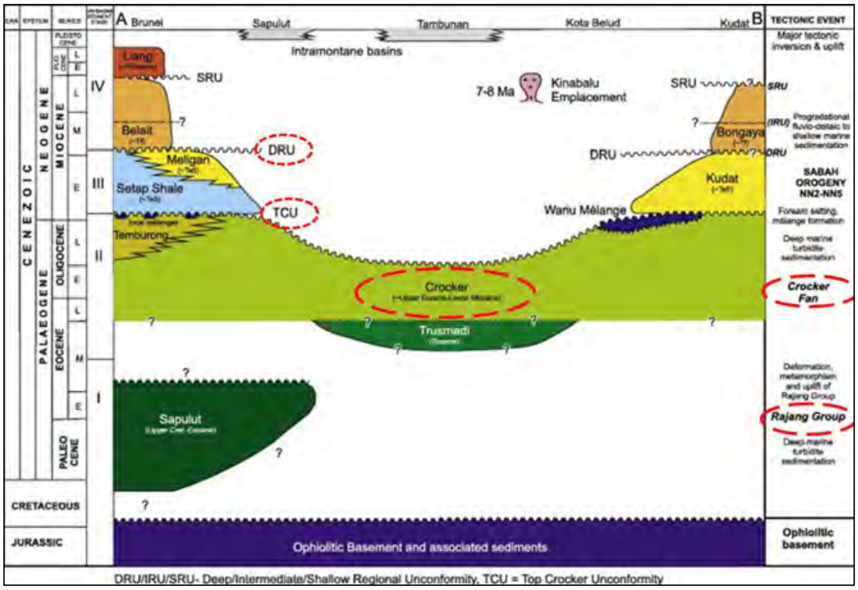

Figure 1: Stratigraphy of Sabah Basin as proposed by van Hattum *et al*., 2013. Sapulut Formation is separated from Trusmadi Formation by an unconformity and stratigraphic relation between Trusmadi and Crocker Formation is still unknown. Furthermore, no differentiation between East and West Crocker formations is reported while Temburong Formation is relatively younger than ''Crocker Formation'' and lower contact of Temburong Formation is marked from late Oligocene. Rajang Group only represented by Sapulut Formation overlain by younger Trusmadi Formation. Additionally, TCU marked the upper contact of Crocker Formation is relatively older than DRU while upper contact of Setap Shale is marked by DRU.

Table 1: Sedimentary facies and depositional environment of Paleogene deposits as reported by various scientists in their work on West Sabah.

Reference	Methodology/ Type of study	Sedimentary facies	Sedimentary structures/Texture	Architecture elements	Depositional environment/type of flow	Tectonics/ Provenance/age
Bakar et al., 2008	Field studies around Kingfisher Sulaman outcrop, Kota Kinabalu, and Inanam	Muddy and massive debrites, poorly sorted, structureless and amalgamated,	Load-cast, mud-clasts, flame structures, plant fragments, intraformational rip-up clasts	Large blocks of massive debrites floating in muddy matrix (Slump) and fining and thinning upward trend (channel)	Submarine debris flow, deep ocean currents,	tectonically active areas, deformation, uplift and erosion of Rajang fold and thrust belt during Oligocene-Early Miocene were related to opening of South China Sea resulting in deposition of West Crocker Formation
Jackson et al., 2009	Kingfisher, Taman Viewpoint, Low Kawi, **NW** Sabah, sedimentary facies,	Mud poor massive sandstone turbidites which gradationally changes into debrite as moving upward succession termed as linked debrite.	Water escape sheets, Flute marks, current ripple lamination, climbing ripple, planar-parallel lamination, clastic injections	Linked debrites are commonly developed in non-channelized part of fan system while they are less in proximal channel levee and distal plain facies	Single flow event having two phases: Fully turbulent flow phase creating turbidites and weakly turbulent to laminar-debris flow developing debrites, high density turbidites,	West Crocker Formation of Oligocene to Early Miocene
Lambiase et al., 2008	Bukit Melinsung, Jalan Sulaiman, Maju around Kota Kinabalu	Three sedimentary facies: Thick sandstones, interbedded sandstone with shale and shale facies	Load structures, massive base with upward parallel laminated beds, convolute bedding, amalgamated units. Flute casts, climbing ripples	Progradational lobes due to thickening and coarsening upward succession	High density turbidity currents, Ta, Tb, Td: Ta and Td, Ta and Tc, Ta and Te or just Ta, West Crocker deposited in deep water depositional system having depth more than 1000m.	Mostly Subarkose with some sublitharenite sandstone. Provenance of first-cycle product of an eroded orogenic belt, immature texture, poorly sorted, mostly angular to subangular, and short distance transport of West Crocker sediments.
Leong et al., 2018	Weston-Sipitang areas, **SW** of Sabah. Facies analysis and studies for renewed stratigraphic position of Paleogene units		Cross lamination,	**Middle fan facies**: Channel facies (Ta), Channel-levee (Td). Channel (Ta)-Lobe (Tb). Lobe-Lobe migration (Tb-Tc). **Outer fan**:Distal lobe (Tc with cross lamination), and migration lobe (Tc with cross lamination)	Ta to Te. High density turbidite, deep marine environment	Lower Miocene aged Crocker formation, rare trace fossils and no microfossils found in the study area
Mohamed et al., 2016	Tuaran area, North Kota Kinabalu, **NW** Sabah	Sand dominated facies, mixed sand and mud facies and mudstone facies	Flute casts, Ripple cross lamination, convolute lamination, parallel lamination	**Inner fan** channel- levee complex, **Middle fan**: channel- lobes, **outer fan:** distal lobe	Low density turbidity currents, high density turbidity currents, debrite facies	Oligocene to early Miocene age of West Crocker
Shafie and Madoon, 2008	Kota Kinabalu	Amalgamation, poorly sorted, massive sands	Scour, dewatering and soft sediment structure (convolute laminae), load structures, floating mud-clasts, rip-up clasts, clast injections		Mostly High density turbidite (Thick bedded), debrite-turbidite couplet, muddy debrite facies. Deep water depositional system.	Oligocene-Miocene
Tjia, 2015	Kota Kinabalu, and Kaung village, Mount Kinabalu		Sole marks, groove casts, flute casts, load casts, spiral grove casts, drag casts, chevron casts		bathyal abyssal depth of deposition,	Trace fossils including Nereites zoophycos, Eocene to Early Miocene age of Crocker formation,
Zakaria et al., 2013	Kota Kinabalu **SW** Sabah, Taman View, Lok Kawi, Inanam,	Sand dominated, thick bedded, massive, amalgamated, fine to coarse grained, medium to thick bedded sandstone, (70%) by channelized and non-channelized lobes of basin floor settings)	Dewatering structures (Ta), flute marks, Parallel lamination (Tb), current ripple lamination, tool marks, convolute lamination, climbing current ripples (Tc), ripple cross lamination, sand and mud injections	**Inner Fan:** Channel-levee complex (thinning and fining upward succession), **Middle fan:** channelized lobes (coarsening upward and fining upward succession), non-channelized lobes (coarsening upward), **Outer fan:** distal lobes (mudstone facies)	High (thick bedded and amalgamated) to low density (very fine to medium grained thin bedded) turbidites, co-genetic turbidite- debrite (mudstone facies), debris flow or MTD (ungraded, massive chaotic beds, muddy debrites), Ta only, Ta, Tb, & Tc, Tc and Td,	Poorly sorted, structureless sandstone deposited in tectonically active and structurally controlled basin. Paleocurrent data shows direction SW (proximal) to NE (distal) trend.

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A021

The sedimentology and depositional environment of the Late Jurassic – Cretaceous Pedawan Formation, Serian Area, West Sarawak

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INTRODUCTION

This paper reports on a detailed sedimentary facies analysis conducted on the Pedawan Formation currently exposed in the Serian district (southern part of Kuching). The objectives of this paper are: (i) to evaluate the sedimentary facies and facies associations of the Pedawan Formation; and (ii) to determine the depositional environment of this stratigraphic unit. A total of fourteen (14) well-exposed outcrops were evaluated and reported here for the first time.

GEOLOGICAL SETTING

Earlier studies in this area has identified the Pedawan Formation to be deposited during Late Jurassic-Cretaceous (Tan, 1993) based on the presence of radiolaria (Jasin, 2000). Tate (1991) and Breitfeld *et al.* (2017) reported that this formation consists of alternations of graded sandstones, laminated sandstone and mudstones deposited as turbidites. These rock units are interbedded with limestone and thin tuff and dacite layers. The stratigraphic organization suggests the occurrence of contemporaneous volcanic material and indicate a switch from a calcareous shallow marine setting to a deep marine clastic depositional environment.

METHODOLOGY

The study area stretches from longitude E 109° 45' to E 110° 57' and latitude N 1° 45' to N 1° present an opportunity to carry out detailed sedimentology studies (Figure 1). We evaluated the: (i) lithology; (ii) geometry; (iii) sedimentary and; (iv) biogenic structures of fourteen (14) stratigraphic sections measuring in total about 390 m.

RESULT AND DISCUSSION

a. Sedimentary Description

Sedimentary successions mainly comprised interbedded sandstone and mudstone; the northern part of the Serian district display thick bedded sandstone and mud-rich successions towards the southern part. Few outcrops display slumped and hybrid event units. The trace fossil *Ophiomorpha nadosa* occur in several locations.

b. Sedimentary Facies

The deposits of the Pedawan Formation are classified into seven (7) individual facies. Table 1 summarizes the sedimentary facies and key characteristics of the different facies identified in the Serian area.

i. S1: Thin-to-medium bedded structureless-to-faintly laminated sandstone facies

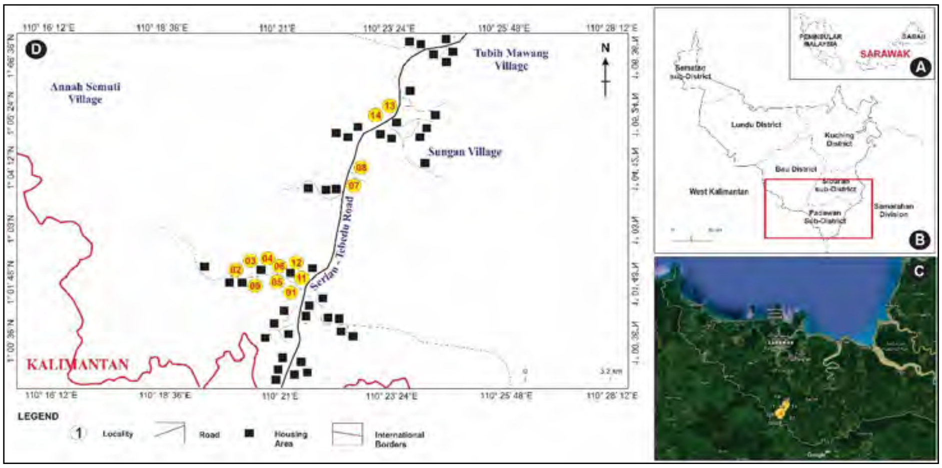

Figure 1: (A-B) The research area is located in Serian Area, West Sarawak, Malaysia, (C) Satellite image of the research are from Google Earth, (D) The localities map of the research area from the current exposed outcrops.

ii. S2: Thin-to-thick bedded normal graded parallel laminated sandstone facies

iii. S3: Thin-to-medium bedded normal graded parallel-to-ripple laminated sandstone facies

iv. S4: Thin-to-thick bedded laminated sandstone with mudstone interbedded facies

v. S5: Medium-to-thick bedded structureless-to-laminated sandstone with mud chips and/or clasts capped facies

vi. S6: Thick bedded deformed sandstone facies

vii. M1: Thin-to-thick bedded structureless-to-laminated silty mudstone facies

c. Facies Association

Sedimentary facies of the Pedawan Formation are grouped into five (5) environmentally diagnostic facies associations (Figure 2).

i. FA1: Deep Marine Slope

The main component of facies association 1 is S6. This facies association is interpreted as the results of mass transported deposits (MTD). The finer grain material assists soft sediment deformation and worked as the lubricant that moved the well-deposited upper beds down the slope. This unit is also linked to near-seafloor geohazards. Therefore, we interpreted this succession to be deposited in deep marine slope environment.

ii. FA2: Deep Marine Upper Fan

Facies association 2 comprises of S1, S2 and S3. The dominance of clean, structureless sand with excessively high sand:mud ratio has been interpreted as rapid emplacement from high density turbulence flow (Bouma, 1962; Mutti, 1992). This group of facies is interpreted to be deposited at the deep marine upper fan environment.

iii. FA3: Deep Marine Middle Fan

FA3 is composed of S1, S2, S3 and M1. This group has high mud content and thinner sandstone beds. The repetitive occurrence of turbidites within the succession indicate the active migration of the lobes in the deep marine middle fan setting.

iv. FA4: Deep Marine Lower Fan

Facies association 4 comprises S4, S2 and S3. A regular thin-bedded turbidites with good lateral continuity and high contents of relative thick mudstone facies supported interpretation of FA4 as deep marine lower fan.

v. FA5: Deep Marine Basin Plain

FA5 consists of M1. This unit is dominated the southern part of Serian. Facies Association 5 is interpreted to represent deposition dominated by hemipelagic sediments and sediments deposited by dilute turbidity current in a basin plain or distal area of an outer fan.

Table 1: Summary of sedimentary facies, which display characteristics of gravity flow to the Pedawan Formation.

CODE	SEDIMENTARY FACIES	LITHOLOGY & SEDIMENTARY STRUCTURE	BIOFACIES/ TRACE FOSSIL	DEPOSITIONAL PROCESS	FIELD PHOTOGRAPH
S1	**Thin-to-medium bedded structureless-to-fainty laminated sandstone facies**	• Light grey-to-light yellow, moderately sorted, fine-to-medium grained sand. • Structureless-to-faint lamination sandstone, dish-and-pillar, with flame and load cast structures • 20 cm to 1.8 m thick, tabular bed geometry and often sharp basal contacts • Showing Bouma characteristics type Ta	N/A	High-density turbidity current	
S2	**Thin-to-thick bedded normal graded parallel laminated sandstone facies**	• Light grey-to-light yellow, moderately sorted, fine-to-medium grained sand • Structureless (lower part), parallel-to-wavy lamination (upper part), with flame and load cast structures • 10 cm to 3.6 m, tabular bed geometry and sharp basal contacts • Showing Bouma characteristics Ta and Tb	Ophiomorpha nadosa (burrow)	High-density turbidity current	
S3	**Thin-to-medium bedded normal graded parallel-to-ripple laminated sandstone facies**	• Light yellow, moderate-to-well sorted, fine-to-medium grained sand • Parallel-to-wavy lamination (lower part), current ripple lamination (upper part), with flame and load cast structures • 10 cm to 1.8 m, tabular bed geometry and sharp basal contacts • Showing Bouma characteristics Tb and Tc with/out Ta	N/A	Low-to-high density turbidity current	
S4	**Thin-to-thick bedded laminated sandstone with mudstone interbedded facies**	• Light grey-to-light yellow, well sorted, fine grained sand Dark grey mudstone • Parallel-to-wavy laminations (few are carbonaceous) • 30 cm to 7.5 m, tabular bed geometry and sharp basal contacts • Showing Bouma characteristics Ta, Tb and Tc	N/A	Low-density turbidity current	
S5	**Medium-to-thick bedded structureless-to-laminated sandstone with mud chips and/or clasts capped facies**	• Light grey-to-light yellow, moderately sorted, fine-to-medium grained sand. • Structureless-to-laminated sandstone, dewatering structure, with flame and load cast structures • 30 cm to 3.4 m thick, tabular bed geometry and often sharp basal contacts • Rich with mud chips and clasts at the top	N/A	Hybrid event bed (proximal)	
S6	**Thick bedded deformed sandstone facies**	• Highly deformed contorted and disturbed bed and/or block of formerly S1, S2, S3 and S4 sandstone and silty mudstone as the background matrix • 1.7 to 17.2 m, tabular and lenticular bed geometry and sharp basal contacts	N/A	Results of unstable slope (slumps)	
M1	**Thin-to-thick bedded structureless-to-laminated silty mudstone facies**	• Light-to-dark grey • Structureless, parallel-to-wavy lamination (few are carbonaceous) • 1 cm to 30 m, tabular bed geometry and sharp basal contacts	N/A	Hemipelagic	

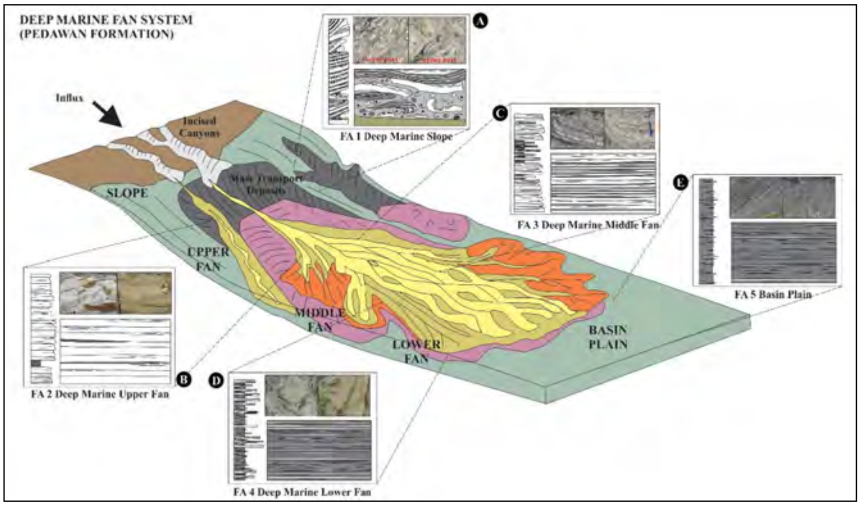

Figure 2: Conceptual depositional model of a deep marine fan system which represent the Pedawan Formation. Stratigraphic log and field photograph of interpreted deep marine; (A) slope; (B) upper fan; (C) middle fan; (D) lower fan; and (E) basin plain.

CONCLUSION

Based on detail facies analysis of the Pedawan Formation in Serian area, we identified seven (7) facies displaying the characteristics of deep marine deposits. These sedimentary facies are grouped into five (5) environmentally diagnostic facies association; (i) deep marine slope; (ii) upper fan, (iii) middle fan; (iv) lower fan; and (v) basin plain system. This study will be further updated using data from petrography analysis.

ACKNOWLEDGEMENT

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A096

Evaluating the stratigraphic trapping mechanism in X-Block, Penyu Basin

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INTRODUCTION

The study area is located in X-Block, Penyu Basin, east of offshore Peninsular Malaysia (Figure 1). This block covers 890 km^2. This study focuses on delineating and evaluating channel features, in order to identify the stratigraphic traps in X-Block of Penyu Basin. Several seismic attributes were tested in this study, including root mean square (RMS) amplitude, relative acoustic impedance (RAI) and sweetness. Results from the attributes indicate that most of the channel infills show low responses to all these three attributes. Therefore, the channels are interpreted to be filled with mud. Nevertheless, some medium-high amplitude responses were identified at the bend of meandering channel, while other high-amplitude and medium-high sweetness zones are spotted outside the confines of the channels. These indicate that they were filled by sand and these bright spots might be hydrocarbon-bearing. The bright areas can be channels overbank sediment, which were deposited as the channels developed. It is important to assess if these overbank sediments and point bar deposits could be potential stratigraphic trap targets, to determine the prospectively of this study area.

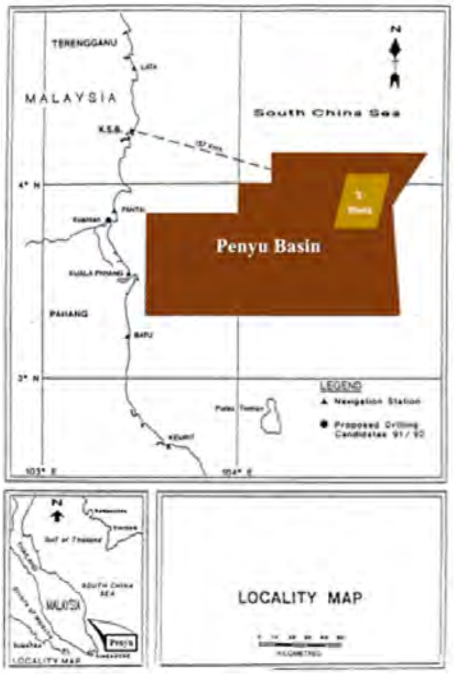

Figure 1: Location of X-Block, Penyu Basin (modified from [1]).

METHODOLOGY

Results obtained from seismic attributes and spectral decomposition were analysed and interpreted, in order to know the types of channel, direction of sediment flows and types of overbank sediment, whereby bright spots are detected, with potential stratigraphic trap configuration. Co-rendering of attributes (RMS amplitude and variance) allows the highlighting of high- amplitude areas (bright spots), while at the same time, the visualization of channel edges and faults in surrounding area. The chance of finding stratigraphic traps in the area of interest is recognized through detecting possible lateral and vertical trapping mechanisms by analysing the target areas by time-slices and 3D seismic cross-sections, to look for lithologic contrast and faults occurrence.

RESULTS

Several bright spots were identified, and may be deposits of hydrocarbon-bearing sand. These high-amplitude zones are associated with channels. They could have deposited within the channel (point bar), or due to breach of levees resulting in overbank sediments (crevasse splay). According to [2], fluvial overbank can be defined as gross-scale composite architectural element that comprises any part of a fluvial system, that accumulates sediment outside the confines of the river channel. Areas of interest located at time-slice of -240 ms, -286 ms, -580 ms and -982 ms.

At -240 ms time-slice, a point bar deposit is identified, that shows up as high-amplitude body, which associated with the meandering channel. A subsequent crevasse splay with very high-amplitude (bright spot) was deposited beside the meander channel at -286 ms time-slice (Figure 2). Crevasse splay is a fan-shaped wedge of coarse sediment, deposited downstream of levee breaks during floods [3]. High-amplitude, possibly hydrocarbon bearing sand was deposited inside the channel at time-slice of -580 ms. As sediment flow moved from NW-SE, high- amplitude zone possibly formed as a result of overbank sediment of the channel at -982 ms time-slice (Figure 3), which is identified as crevasse splay deposit.

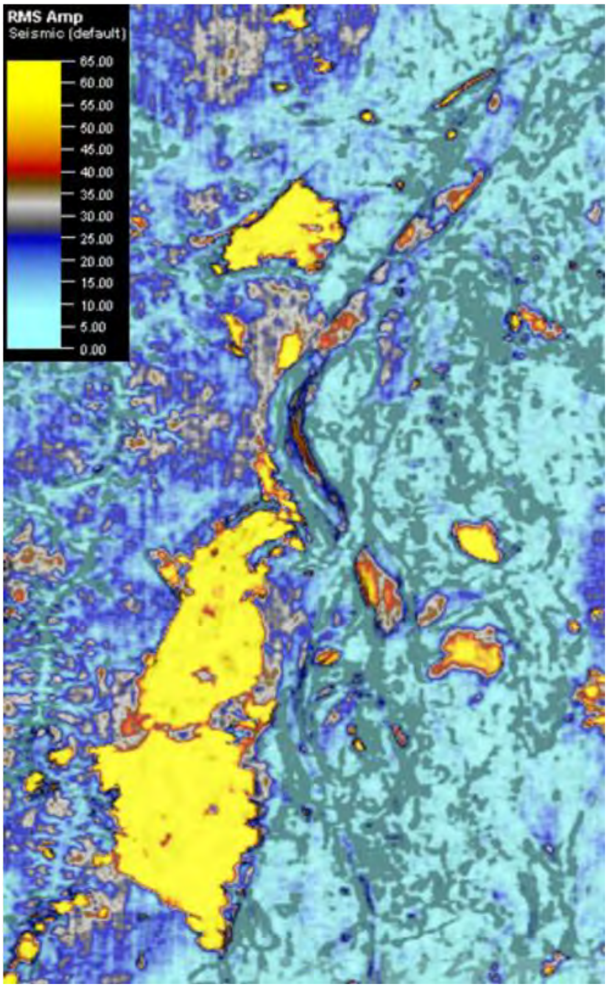

Figure 2: Bright spot beside channel at time-slice of -286 ms, interpreted as crevasse splay.

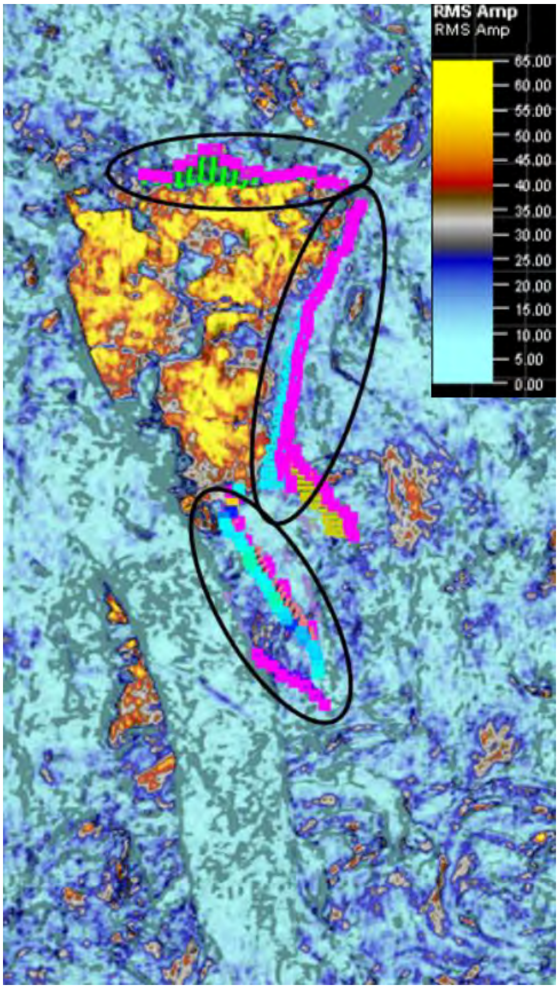

Figure 3: Bright spot (high-amplitude area) at -982 ms time-slice, recognized as crevasse splay and surrounded by interpreted faults (in black ovals).

CONCLUSIONS

Attributes such as RMS amplitude and spectral decomposition helped in identifying channels, as well as, several high-amplitude areas that might be possible hydrocarbon-bearing sand in the study area. The observations on the sediment distribution in the zone of interest (high- amplitude areas) suggests that these may be fluvial overbank deposits (crevasse splays). Another possible origin of bright spots is in- channel point bar sand within a muddy meander belt. The trapping mechanism depends on both top seal (caprock) and lateral seal.

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A099

The Holocene development of Perak River and coastal-deltaic plain

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Abstract: The Perak River is the second longest river in Peninsular Malaysia, after the Pahang River in Pahang, Malaysia. The river is sourced from the highlands in Upper Perak region, bordering Thailand. It flows from the north southward through the regions two largest towns of Gerik and Lenggong, before meeting with the Kangsar River at the royal seat of Kuala Kangsar. The river enters the Perak Tengah region, flowing through the towns of Parit, Pasir Salak and Kampung Gajah, before emptying into the Straits of Malacca just outside Teluk Intan – Bagan Datok area in the Hilir Perak (Lower Perak) region. The river shows no obvious delta development. We evaluated more than 70 boreholes data from seventeen locations, from Bruas and Parit in the north, and Teluk Intan and Bagan Datoh in the south. The Holocene sediments in the northern areas are generally thin (10-30 m) and dominated by terrestrial sediments – coarse fluvial sands and conglomerate. In the middle and southern part, near Teluk Intan-Bagan Datok, the Holocene succession may reach 100 m, comprising a lower terrestrial unit, a middle marine unit and an upper brackish-coastal unit marked by the development of thick peat (Figure 1).

We simulated the development of the Perak coastal-deltaic plain using DEM maps (Figure 2). By "flooding" the coastal-deltaic plain with 20 m, 15 m, 10 m and 5 m of "marine waters". The 'simulated' maps were able to track the southward progradation of the Perak delta, from the Bruas-Parit area in the north to Bagan Datoh area in the south. These maps show that the Perak River was filling a marine embayment, and building out a delta which progrades southerly. Other minor rivers flowing west from the foothills of the Main Range granite could have also contributed sediments into the embayment, which eventually developed into an extensive coastal-deltaic plain.

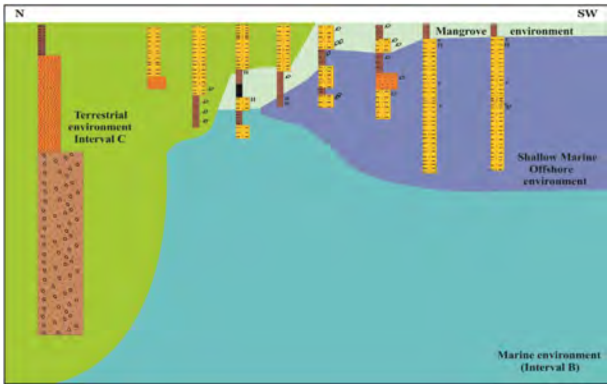

Figure 1: The interpreted Holocene succession of southern Perak coastal plain, which may reach 100 m, comprising a lower terrestrial unit, a middle marine unit and an upper brackish-coastal unit marked by the development of thick peat.

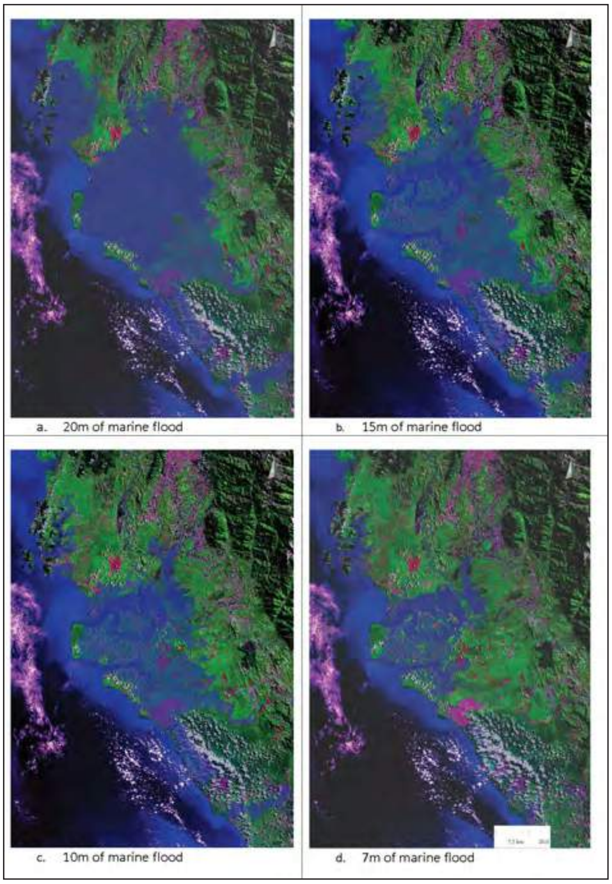

Figure 2: DEM maps of the study area, simulating marine flooding of the Perak coastal plain by - a. 20 m, b. 15 m, c. 10 m and d. 7 m of water.

A105

West Crocker subdivisions: West Crocker, East Crocker, North Crocker and South Crocker Formations

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The West Crocker Formation of Oligocene to Early Miocene (Figure 1) age which is a sand-rich turbidite formation deposited in an accretionary fore-deep basin of accretionary belt. As shown in Figure 1, this deep-water succession is well exposed over a large part of the coastal ranges of NW Sabah area can be up to 10 km in thickness (Stauffer, 1967). This siliciclastic succession developed along the subduction zone along NW Sabah margin, and has been interpreted as flysch, turbidite submarine fans, and/or Mass Transport Deposits (MTDs).

Paleogene West Crocker Formation represents a large submarine fan depositional system within part of the previously NW Borneo's complex and tectonically active margin. Comprehensive interpretation of the Crocker fan depositional system by (Zakaria A., Johnson, Jackson, & Tongkul, 2013) described seven facies (F1-F7) (Figure 2) which constitute three major facies groups: (1) sand-dominated facies (F1-F3), comprise high-to-low density turbidites and develop the main part of West Crocker Formation, (2) debris flow dominated facies (F4-F6) comprises mud- and sand-dominant debris flow and mass transport deposits (MTD), which form a highly distinctive secondary part of the West Crocker Formation, and (3) mudstone dominated facies (F7), represent the minor component of West Crocker Formation. The three main facies are divided into: F1 – graded sandstone (massive to planar laminated), F2 – thick amalgamated sandstone, F3 - ripple-cross laminated, wavy and convolute lamination sandstone, F4 – climbing cross-climbing cross-ripple laminated very fine-grained sandstone, F5 – Chaotic Bed of Mixed Sandstone- Mudstone Blocks and Clasts, F6 – lenticular bedded sandstone, and F7 – finely laminated siltstone and mudstone.

The five facies associations (Figure 3) represent depositional environment, from proximal to distal as: (1) channel-levee complex in an inner fan environment, (2) mid- fan channelized lobes, and (3) outer fan distal lobes. The West Crocker Formation consists of a large submarine fan consists of large (>20,000 km^2) submarine fan deposited as part of an accretionary complex (Jackson C. A.-L. *et al.*, 2009). Vertical facies succession observed are interpreted and organized in facies associations that

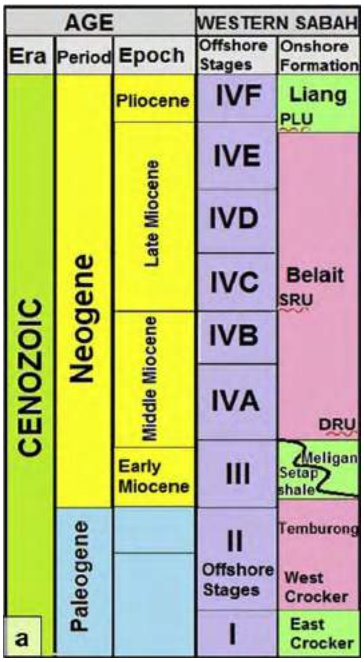

Figure 1: Generalized stratigraphy of the offshore and onshore Western Sabah (Abdullah *et al.*, 2017).

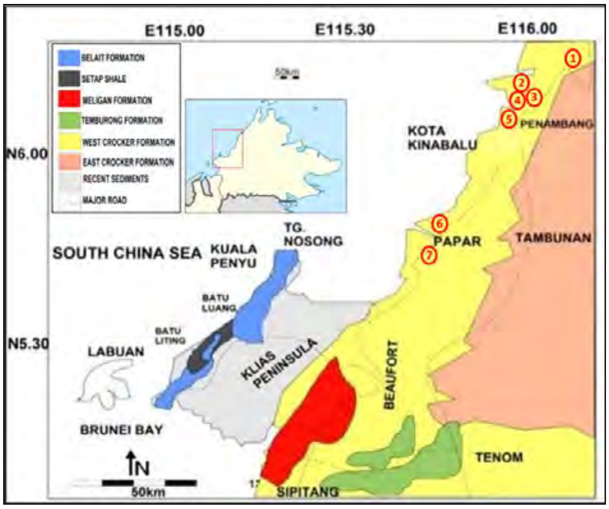

Figure 2: Geological map of NW Sabah. Locations of West Crocker Formation outcrops in Tuaran, Kota Kinabalu and Papar (Modified after Abdullah *et al.*, 2017).

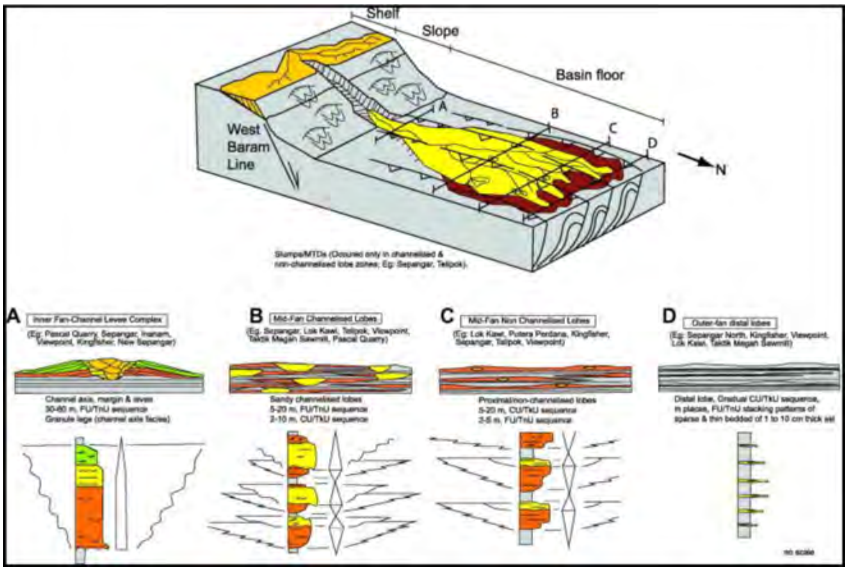

Figure3: Conceptual depositional model of the West Crocker basin floor fan system incorporating all the five discussed facies successions from proximal to distal parts of the fan (Zakaria *et al*., 2013).

represents different deposits of the laterally continuous submarine fan system (from proximal to distal). The depositional environment of West Crocker Formation submarine fan is interpreted as multiple source, and shelf fed, Type II, low-efficiency, sand rich submarine (Zakaria A. *et al*., 2013).

The aim of this study is to correlate petrographic and petrophysical properties of turbidite sandstones of West Crocker Formation in Sabah in order to understand their impact in the reservoir quality of the rock.

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A123

Impact of sandstone mineralogy on reservoir quality of sandstones: A case study of the Miri Formation, Sarawak, Malaysia

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INTRODUCTION

Miri Formation is the middle Miocene; swallow marine sandstone which is composed of upper and lower formation [1]. The upper Miri Formation exposes around Miri city likely which starts from Canada Hill stretches along Hospital Road and airport road extending from Tanjung Lobang to Pujut [2]. It is very crucial to study the properties of the outcrop of upper Miri formation due to providing information as an analog for subsurface sediment of the offshore west Baram delta [3]. The Upper Miri formation is more arenaceous. Sandstone and shale alteration occur quickly and irregular with the sandstone bodies merge more gradually into argillaceous sandstone and sandy or silty shale [4]. Knowledge about the properties of sandstone is very important in assessing its reservoir quality. For instance, grain shape, grain size, and composition especially clay mineralogy in the reservoir have a significant impact on the porosity and permeability. These two factors will affect the oil extraction from the reservoir. It has been reported that coarser grain sizes and better grain sorting have a positive impact on porosity and permeability, whereas a significant amount of clay content affects reservoir quality negatively [5], [6]. Apart from reservoir quality, the properties of the sandstone will also determine the best surfactant to be used for enhanced oil recovery (EOR) from the reservoir. Therefore, the objective of this paper is to evaluate the mineralogy of sandstone samples from a few selected outcrops of the Miri Formation and its impact on reservoir properties.

METHODOLOGY

Six sandstone samples were collected from Canada Hill outcrop in Miri during fieldwork. Porosity and permeability were determined on core plugs using Helium porosimetry. Scanning Electron Microscopy (SEM) with Energy Dispersive X-Ray Analysis (EDX) was performed to study the surface morphology and elemental composition of the reservoir. Thin sections were analyzed using an optical microscope for texture, mineralogy and pore characteristics. For this analysis, samples were impregnated with blue resin before thin sections in order to make the porosity more visible. X-ray Diffraction (XRD) was used to determine the composition of minerals present quantitatively.

RESULT AND DISCUSSION

From the field observation, Canada Hill outcrop consisted of pale white and yellowish-brown of fine grains with a minimum amount of medium grains and coarse grains. These grains were moderately sorted, sub-angular to sub-rounded, and less matrix support. In view of the grains size and organized sorting, the field is of good permeability and porosity. These results were supported by the porosity and permeability measurement. The porosity and permeability measurement from Canada hill outcrop obtained from Helium porosimetry analysis ranged between 25.01% to 29.30%. While the permeability measurement between 648.5262 Md to 2145.52 Md. Figure 4.1 shows the regression between porosity versus permeability. From the figure, positive regression was found as the permeability increased with porosity for fine-grain sandstone. The type of porosity in the reservoir based on the thin section analysis was mostly inter-granular and followed by dissolution porosity, as shown in Figure 4.2 (B). Bioturbation also presents in this outcrop. Presence of bioturbation in the sediment might reduce or increase the porosity and permeability depending on the vertical or horizontal activity of burrowing organisms [7], [8].

Furthermore, the type of minerals present in the outcrop has an impact on the porosity and the permeability. From the SEM analysis, the outcrop contained clay minerals such as kaolinite and chlorite. Kaolinite was present as booklets and plates, while chlorite was smooth plates in the SEM figure (Figure 4.2 (A)). The presence of these minerals acts as pore filling, pore blocking, and coating, which subsequently reduce the porosity and permeability of the reservoir. kaolinite was formed from the alteration of feldspar and muscovite [9], [10], shown as booklet kaolinite (Figure 4.2.A). Clay mineral gave negative regression toward porosity and permeability which mean it controls the porosity and the permeability. Apart from clay mineral, feldspar mineral was found in a minimum amount of approximately 2% from XRD analysis which is some mineral already dissolution and creates secondary porosity as resulted in helping to increase the porosity and permeability. According to the researcher said that dissolution of feldspar and lithic during digenesis could help to increase the porosity and the permeability [11]. Quartz mineral was also present in the sample. It presents as monocrystalline and polycrystalline from the study of the thin section. The results also showed that the quartz was overgrowth with a cement content of 2.42% with minimum iron oxide. Mineral content observation in samples was based on thin section analysis. Identified minerals were quartz, lithic, feldspar, mica, and clay minerals. The XRD results showed the clay minerals consisted of kaolinite, chlorite and smectite, Feldspar mineral consist of plagioclase (Figure 4.2.B) and k-feldspar, and jarosite mineral. From both analyses, it showed that Quartz present in a higher amount of 80% in Canada hills. The quartz cement shows negative regression toward porosity and permeability which mean that increase the quartz cement decrease the porosity and permeability.

CONCLUSION

From the results, it can be concluded that texture Canada hills outcrop composed of mainly fine grain with sub-angular to sub-rounded shape. These grains were moderately sorted, less compact, and therefore the outcrop has high porosity and permeability. Quartz is generally dominant and composes of polycrystalline and monocrystalline. Other minerals present include lithic, feldspars (plagioclase and microcline), muscovite and biotite. Clay minerals also present include kaolinite and chlorite. Feldspar and lithic mineral undergo dissolution then formed secondary porosity during digenesis which this stage maintained or increased the porosity and permeability. Quartz cement seems to reduce the porosity and the permeability. However, the presence of clay mineral decreased the porosity and permeability due to pore blocking and pore-filling.

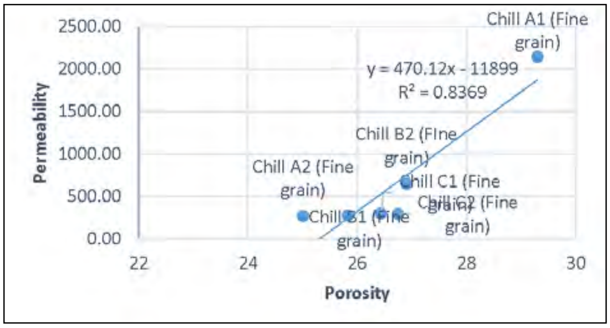

Figure 4.1: Porosity vs. permeability.

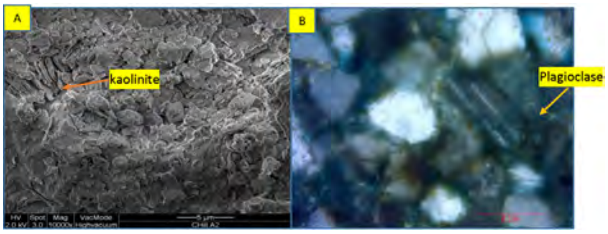

Figure 4.2: (A) SEM photomicrographs of booklet kaolinite, (B) Thin section of plagioclase.

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A127

Analisis fasies sekitaran paralik Formasi Kalumpang di Pulau Sebatik, Sabah

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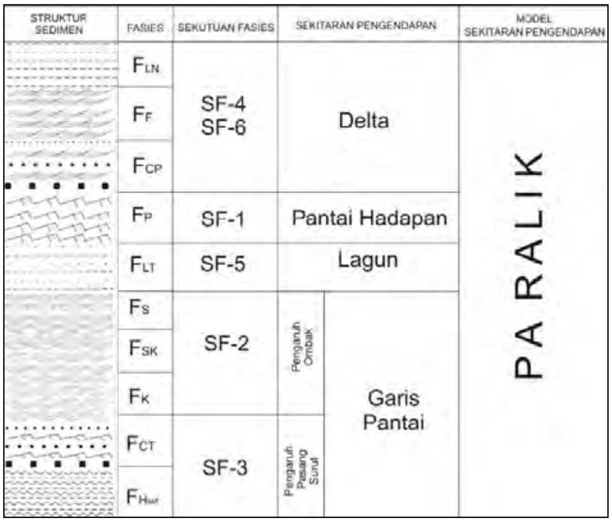
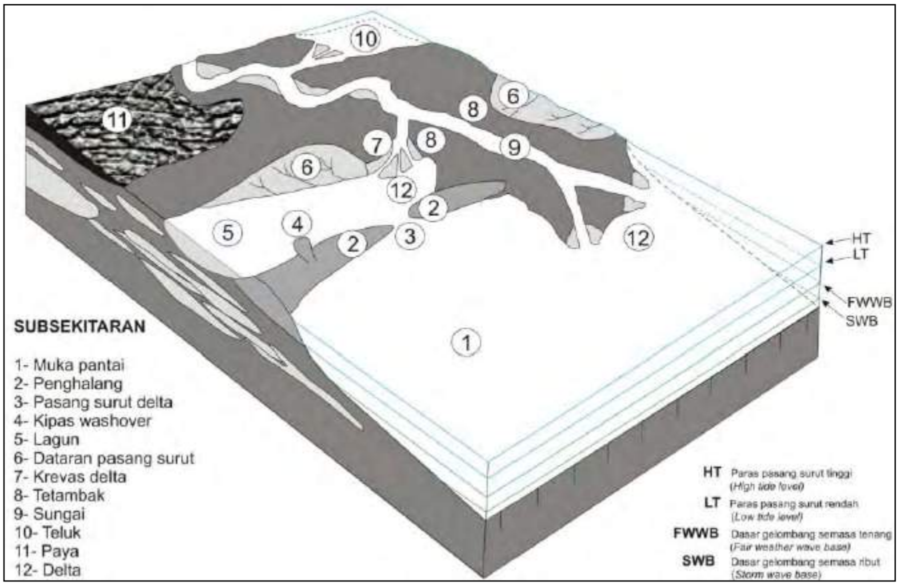
Abstrak: Kawasan kajian terletak di Pulau Sebatik, Sabah Malaysia yang meliputi keluasan kira-kira 200 kilometer persegi. Kawasan kajian terdiri daripada Ahli Batu Pasir-Syal Sebatik Formasi Kalumpang; merupakan sebahagian daripada jujukan Miosen yang terletak di bahagian utara Lembangan Tarakan (Sanudin Hj. Tahir & Baba Musta, 2007). Objektif utama kajian ini adalah untuk menganalisis fasies-fasies sedimen dan mentafsirkan sekitaran pengendapan kuno di kawasan kajian. Kajian ini dilaksanakan berasaskan litologi melalui pencirian sistematik terhadap parameter struktur sedimen pada singkapan batuan di lapangan berpandukan kaedah-kaedah sedimentologi (Selley, 1985; Tucker, 2003). Dalam kajian ini, struktur sedimen dipilih sebagai parameter bagi membezakan di antara satu fasies dengan fasies yang lain; kerana paramater ini merupakan penunjuk persekitaran paling penting di dalam menggambarkan keadaan dan proses pengendapan di suatu persekitaran pengendapan. Bagi iknofosil, indeks iknofabrik yang digunakan adalah,



Rajah 1: Ringkasan stratigrafi berasaskan fasies bagi Pulau Sebatik, Sabah.



Rajah 2: Model sekitaran pengendapan bagi Pulau Sebatik, Sabah.

berdasarkan Droser & Bottjer (1986) dalam Norzita Mat Fiah & Lambiase (2014). Terdapat sebanyak 72 singkapan batuan yang telah dicerap. Berasaskan pencirian lapangan didapati sebanyak sepuluh (10) fasies telah dikenalpasti, iaitu: heterolithic (FH), konglomerat menyatah (FCT), lapisan silang hummocky (FK), lapisan silang swaley-hummocky (FSK), lapisan silang swaley (FS), lumpur tebal (FLT), lapisan silang menyatah (FP), konglomerat palung (FCP), lapisan silang palung (FF) dan lumpur nipis (FLN). Fasies-fasies ini digabung dan dihubungkan menjadi enam (6) sekutuan fasies yang menggambarkan beberapa subsekitaran, iaitu: pantai hadapan, muka pantai, dataran pasang surut, fluvium, lagun dan delta (Rajah 1). Sekutuan-sekutuan fasies tersebut merupakan subsekitaran-subsekitaran yang bergabung dan berhubung di antara satu dengan yang lain membina sekitaran pengendapan paralik (Kotas & Malczyk, 1972). Model sekitaran paralik yang dicadangkan dalam Formasi Kalumpang di kawasan Pulau Sebatik ditunjukkan dalam Rajah 2. Sekitaran ini terbentuk melalui proses-proses seretan dan ampaian yang didominasi oleh pengaruh ombak dan pasang surut.

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A048

Sedimentology of turbidites-bearing Pedawan Formation (Jurassic-Cretaceous), Sarawak. Observation from outcrops in Batu Kawa area

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Pedawan Formation of west Sarawak is delineated as Jurassic to Createaceous shelf deposits, molasses and related non-marine deposits on the edge of West Borneo Basement Complex and were deposited in an environment which initially, shallow marine basin before long subsided deeper during Late Cretaceous, based on the evidence assemblage of the pelagic foraminifers. Observations of facies at three available outcrops exposed at Batu Kawa was conducted to describe specific characteristics of the sedimentary rocks and show the condition under which it was formed. Eleven facies were categorized and from that, three main facies association have been established and described, which are: FAI - Channeled portion of suprafan lobes facies association; FAII - Basin plain and lower fan facies association and FAIII - Distal submarine fan plain facies association. Facies associations suggest that the deposits prograded into the distal part of the submarine fan which is the basin from the adjacent highlands and discharged very coarse sediments on to a steep submarine slope.

Keywords: Submarine fan, turbidites, debris flow, suprafan lobes, Pedawan Formation

INTRODUCTION

Commonly described as thick sequence of moderately to steeply dripping predominantly argillaceous rocks, dominated by black shales with rare sandstone radiolarite beds and typically with abundant carbonaceous matter indicating proximity to a vegetated landmass. Besides, the age of Pedawan Formation ranges between Late Jurassic to Late Cretaceous which was determined based on its intertonguing relationship of the Late Jurassic part of the Bau Limestone and the presence of the Late Jurassic to Early Cretaceous Radiolaria (Hutchinson, 2005). This study documents the understanding of deep-marine turbidites sedimentation and specifically on the Pedawan Formation. Several outcrops were found and appraised around Batu Kawa vicinity to characterize the main features present in the light of submarine fan.

METHODOLOGY

Facies Analysis

Observations of facies at Batu Kawa exposed outcrops was conducted to describe specific characteristics of the sedimentary rocks and shows the condition under which it was formed. This include its geometry, lithology, texture, sedimentary structure, fossil content, trace fossil (bioturbation) and paleocurrent. It will help to achieve the aim of facies analysis, which is to determine the depositional process and environment (Fossum, 2012).

RESULT

Facies and facies associations

The Batu Kawa exposures comprise of eleven individual facies. These facies can be observed at all three outcrops that are available and accessible at the area.

- Facies 1- Thick coarse-grained sandstone
- Facies 2- Pebbly Sandstone
- Facies 3- Sandstone with mudclast
- Facies 4- Sandstone with organic matter
- Facies 5- Graded sandstone with conglomerate at the basal part
- Facies 6- Parallel laminated sandstone
- Facies 7- Cross laminated sandstone
- Facies 8- Fine to silty-grained sandstone
- Facies 9- Sandstone with boulder-sized clast
- Facies 10- Thin interbedded sandstone and mudstone
- Facies 11- Massive mudstone

Three major facies associations can be recognized and ascertained in the Batu Kawa area sediments. The facies associations and their predominant physical characteristic are:

1.1 Channeled portion of suprafan lobes facies association

The massive sandstone of the Pedawan Formation is deduced as channelled portion of suprafan lobes deposits. Arguably deposited on the smooth lobe farther downslope stated by Walker (1978) with the indication of massive and pebbly sandstone. The mechanism of this turbidites occurred as these sediments accumulated on the slope until a critical stress value exceeded, that leads to they move down slope as debris flows or turbidity currents (Middleton,1973).

1.2 Basin plain and lower fan facies association

Specifically, at the smooth portion of the suprafan lobes. These topographically smooth, low gradient areas are recognized by slow hemipelagic deposition, interrupted periodically by turbidity currents (Walker,1978). Furthermore, Deposition on the smooth, featureless bed results in very regularly and parallel-bedded on the basin plain however, gradually become thicker bedded toward the middle fan.

1.3 Distal submarine fan plain facies association

The massive and structureless mudstones are interpreted as outer submarine fan deposits. The mudstones facies records suspension-dominated deposition and large in thickness arguably indicate that large volumes of mud were supplied to the system with minimal to no intervening bedload deposition (Walker,1978).

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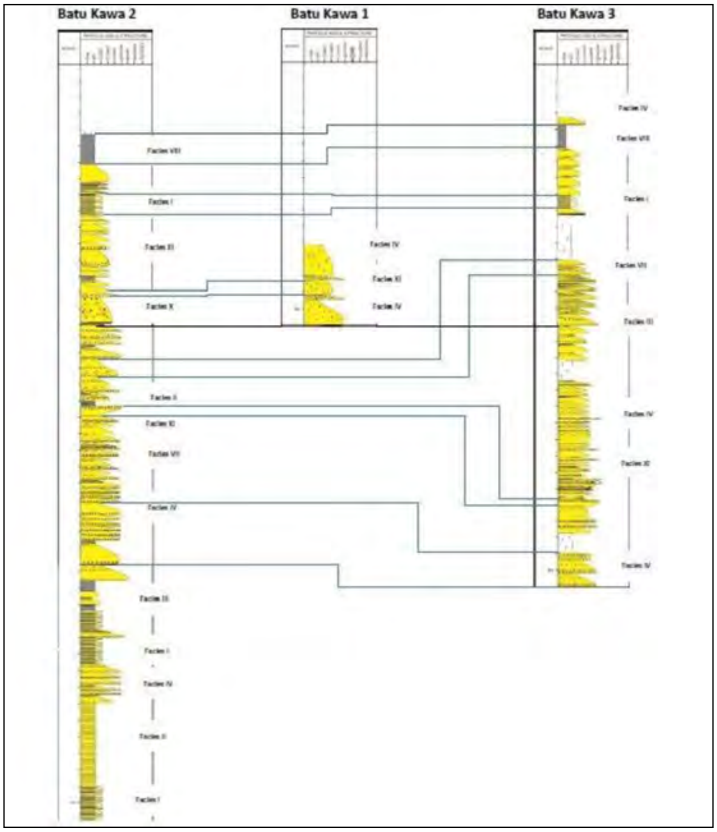

Figure 1: Sedimentological logs of exposed outcrops (Batu Kawa 1, Batu Kawa 2 and Batu Kawa 3) within the vicinity of Batu Kawa area.

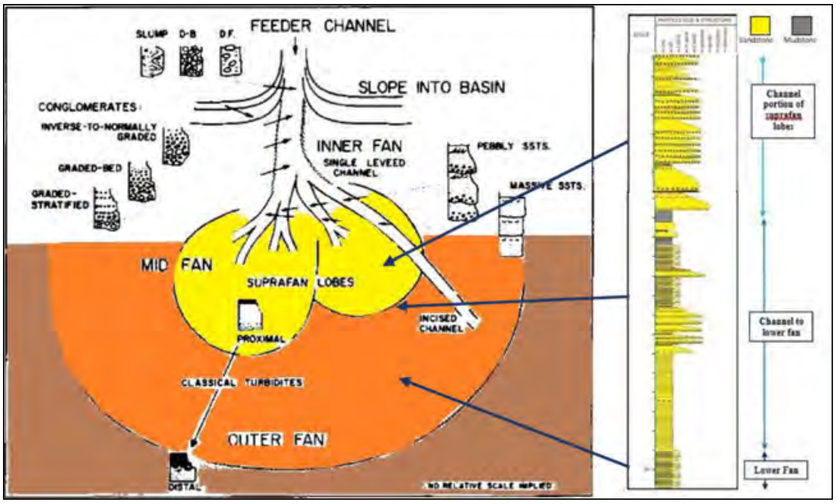

Figure 2: Model of submarine fan deposition, relating facies fan morphology, and depositional environment, modified after (Walker, 1978) and Sedimentological log of BTK02 which the most suitable log to be corelate with stratigraphic sequence proposed by Walker (1978) the represent each of the facies with the sub-environment of submarine fan.

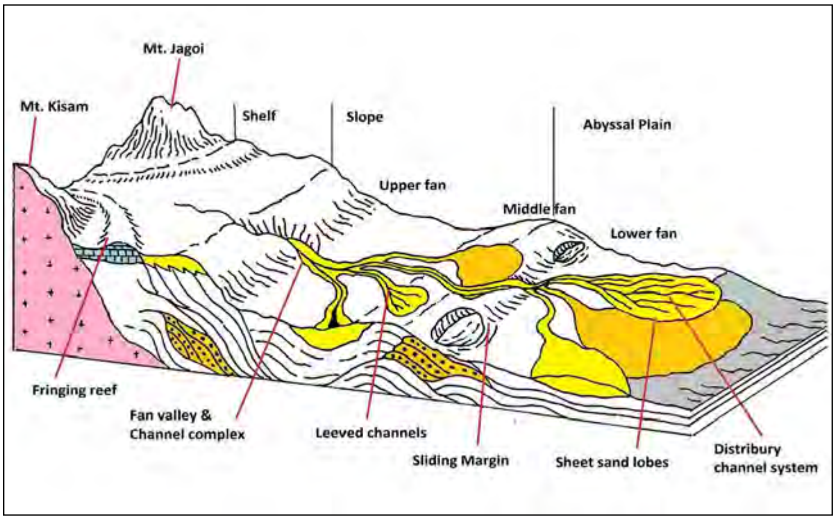

Figure 3: Proposed diagrammatic depiction of depositional environment of Batu Kawa area in relations with submarine fan understanding.

A059

Deepwater sediment fill in Sabah Trough and beyond

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Reservoir delineation has always been challenging in Sabah deep water. Spatiotemporal changes in reservoir presence and quality have imposed challenges in hydrocarbon exploration and development programs. In the SE part of Sabah trough, sediment dispersal is predominantly from Borneo mainland, i.e., from South to North. However, new multi-client seismic data reveals northerly sediment inputs for the North West Sabah outboard (NW Sabah platform). This paper demonstrates some of the deepwater geomorphic features associated with the Neogene deposits overlying the older rift sediments of Paleogene period. A regional seismic section demonstrating the regional structural architecture as well as sediment fill in the study area is shown in Figure 1.

Sediment fill in the study area is dominantly contributed by, turbidites, mass transport complexes (MTC) and pelagic and hemipelagic sediments. For clarity purpose, we have subdivided the study area into two segments, namely, (i) area-A and (ii) area-B. Figure 2 (a) represents a generalized map showing spatial distribution of identified features.

Area-A: Seismic data through the fold and thrust belt of area-A, shows the presence of numerous MTCs of varying thickness and size. A Mega MTC, covering hundreds of sq. Kilometers and having thickness more than 100 m has been identified in the SW part of area-A (Figure 2 (b)). Some of the prominent kinematic indicators of MTC demonstrates flow direction from west to east. Kinematic indicators are geological features which are useful in defining direction and mode of transport of any sediment flow (Bull *et al.*, 2009). The identified features possibly are correlatable to the similar MTCs identified in Brunei deep water (Hoggmascall *et al.*, 2012). These findings, in turn, suggest South Westerly sediment input, which is critical in chasing potential reservoir dispersal from Baram delta into the deep water Sabah. Seismic attribute maps superposed on structure map delineates several channels and fan features flowing from south to north (Figure 2(c)), which are in accordance with the regional sediment flow direction. Previous authors have tried to identify and correlate sediment fairway from SW Baram delta to western edge of the Area -1 (Khair *et al.*, 2018).

Area-B: The newly acquired 3D seismic over the Sabah platform reveals exciting geomorphic features, showing sediment influx from the localized paleo highs situated at the north of the study area (part of the dangerous ground). A prominent deepwater turbidite channel and associated fan have been identified using spectral decomposition followed by RGB blending. Horizon slicing of the blended cube reveals complete evolution cycle of a turbidite system (Figure 2(d)). The flow direction of these features confirms sediment dispersal from the north. Prominent channel and fan features oriented in NW-SE direction have been identified through complex trace seismic attribute analysis (Figure 2 (e) and (f)).

The recent findings regarding multi-directional sediment dispersal in the study area are vital in chasing reservoirs for hydrocarbon exploration. Specifically, deep water channels and fans sourced from northern highs open up new potential in terms of reservoir presence within Sabah Platform and Sabah Trough area.

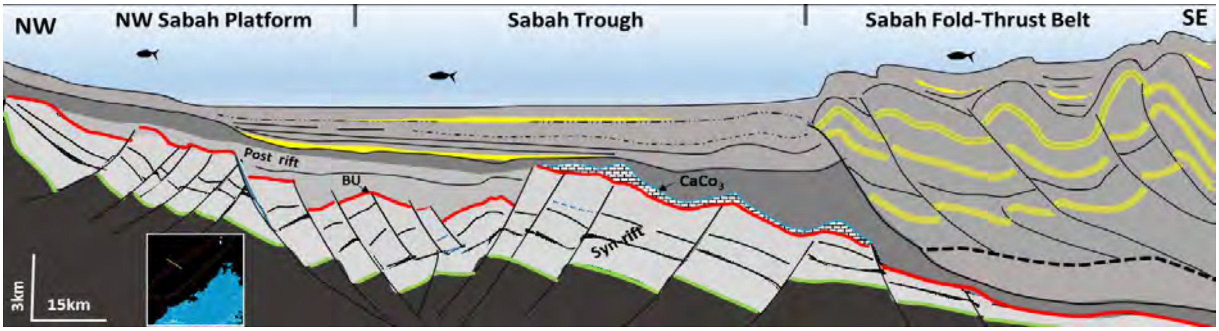

Figure 1: Regional geoseismic section across Sabah Trough.

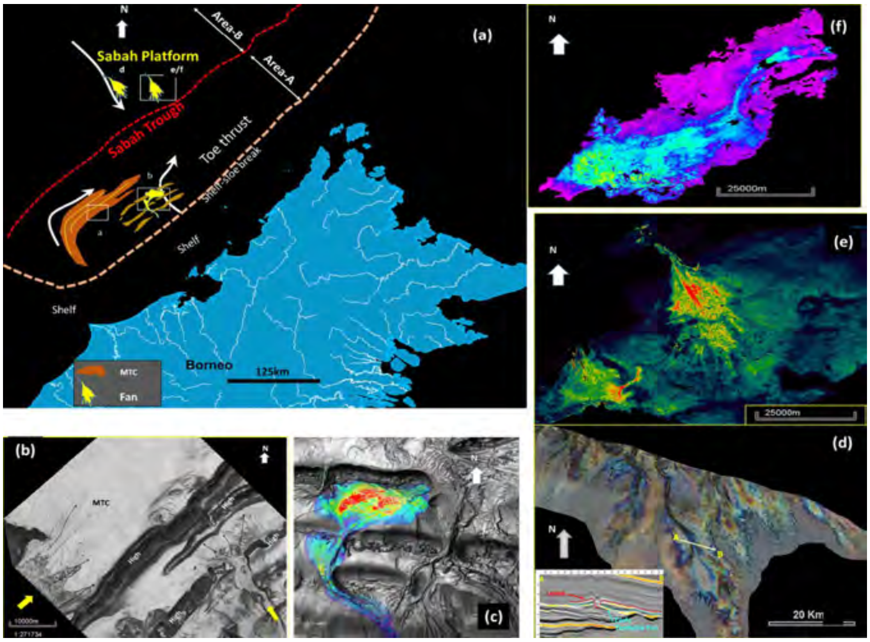

Figure 2: Seismic geomorphic features identified in the study area.

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A063

Sedimentology and diagenesis of the Early Miocene Nyalau Formation, Bintulu area, Sarawak, Malaysia

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Abstract: This paper presents sedimentary facies and their relationship to diagenetic alterations of exposed Nyalau Formation in areas around Bintulu town, Sarawak, Malaysia. Bintulu is situated in the NW Sarawak and geologically it is included in the Miri Zone (Figure 1). This zone is underlined by crustal terrains (Hutchison, 1996). The Early Miocene exposures of Nyalau Formation provide a unique prospect to study the sedimentology at reservoir scale in order to understand the depositional and post depositional changes. This formation, and its hydrocarbon-bearing offshore equivalents (Cycles I and II) which belongs to west Balingian Province (Jia & Rahman, 2009) is comprised of a thick succession of Lower Miocene clastic in the Balingian Province of central Sarawak (Almond *et al*., 1990). It is estimated to be 1000–2000 m thick in the Bintulu area. The Nyalau Formation conformably rests on the Buan Formation (Figure 1A) and unconformably on the Belaga Formation (Jia & Rahman, 2009). The Nyalau Formation is considered as the major transgression over the Eocene land mass. It is a succession of fine grained calcareous often argillaceous sands alternating with all gradation to clay and shales. It is sandy towards west and becomes muddier eastwards where it is known as the Setap Shales (Liechti *et al*., 1960). The Lower Miocene Nyalau Formation rocks are exposed along the shoreline and coastal areas in Bintulu, Sarawak. The exposed section around Bintulu town comprises massive sandstones intervals, laminated clays, and brackish-shales and lignite (Madon & Rahman, 2007). Materials and methods involve in the study include seventy rock samples from nine outcrop sections (Figure 1B), petrographic thin sections, X-ray diffraction, and FESEM-EDS-imaging. Five main types of samples are identified in the stratigraphic sections: sandstones, shales, coal, siltstones, and mudstones. These rock types further can be divided into fifteen lithofacies based on sedimentary structures and other characteristics. The hummocky cross-stratified sandstones, flaser wavy to lenticular bedded facies, herringbone cross bedded facies and tabular to low angle cross bedded facies are common facies in the area. Overall, the facies associations vary from mangrove, tidal flat, tidal bar, subtidal flat, lower shoreface, upper shoreface, tidal influenced channels, tidal dominated channels, offshore settings depending on the location of studied sections. Lithofacies type LFT 1 (heterolithic silty mudstone) is relatively tight, with clays filling in the pores and porosity is about 1%. LFT 2 (wavy bioturbated sandstone) is similar to LFT1 in petrography with tight fabric, clay and quartz overgrowth cementation, the porosity is less than 1%. LFT 5 (planar to trough cross-bedded sandstone with thin mud drapes) show quartz arenite with intergranular porosity of about 12%, with very little quartz overgrowth cements. LFT 4 (cross laminated sandstone with iron concretions) presents quartz arenite with 95% quartz, 5% feldspars and clay fractions, with porosity of about 5%. LFT 10 (channelized thick bedded sandstone) is quite similar with LFT 5, with relatively larger pores; however the pores are not well connected. Hence, we can conclude that the variations in compositional trends suggest strong lithological and diagenetic controls on the pore and cement types of the samples. Overall, the petrography and chemical analysis of samples indicate that the majority of the samples are dominated by quartz, feldspars, and clay minerals. The early diagenesis could have been controlled by the rise and fall in sea level, with later stages of diagenesis could be controlled by burial and later exposure of the rock unit in the Sarawak basin.

Keywords: Early Miocene, sandstone, diagenesis, facies, cements

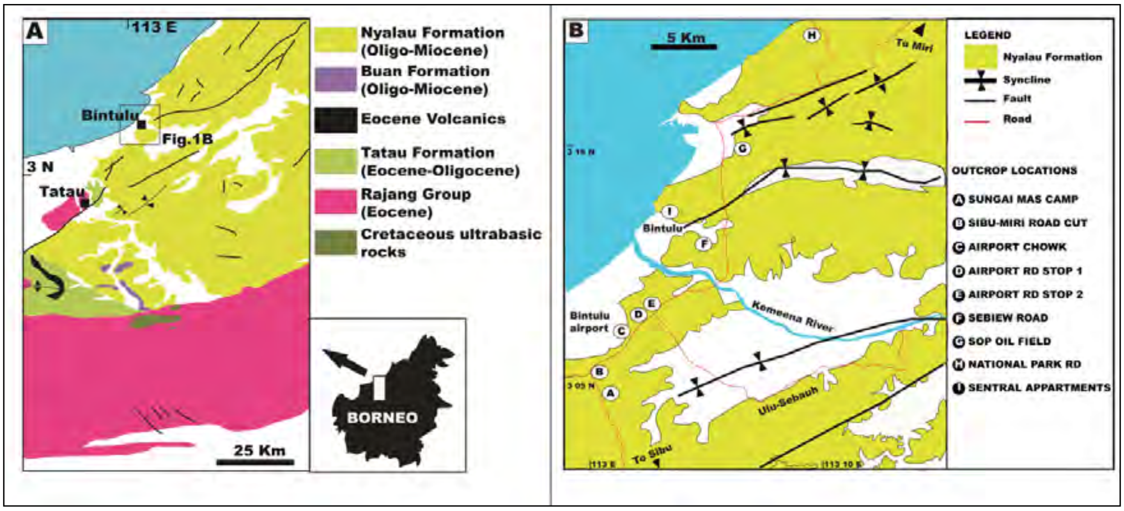

Figure 1: A) Geological map of Bintulu area, Sarawak, B) Location map of outcrops section studied near Bintulu area, with distribution of Nyalau Formation, Sarawak Malaysia, modified after (Hassan *et al.*, 2013).

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A087

Sedimentary fabrics, depositional environment, and provenance of the Late Neoproterozoic Hazara Formation, Lesser Himalayas, North Pakistan

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Abstract: In the present study, the Late Neoproterozoic Hazara Formation is studied from its exposure at Lora Maqsood road near Haripur, Lesser Himalayas, Northern Pakistan where it comprises of 2400 m thick metasedimentary succession of siliciclastic and carbonate lithologies. The Hazara Formation is the oldest sedimentary sequence exposed in the area. The Late Neoproterozoic Hazara Formation shows the cyclic pattern of thick sedimentation alternating between sandstone, siltstone, shale, slate, mudstone, and limestone. The formation is characterized by particular lithofacies, distinct bedding style and sedimentary structures. Eleven types of lithofacies were identified within the sequence which includes Thin Bedded Sandstone (HF1), Dark Grey Shale (HF2), Thick Bedded Sandstone (HF3), Massive Sandstone (HF4), Parallel Laminated Siltstone (HF5), Cross Stratified Sandstone (HF6), Mudstone Claystone (HF7), Thin Bedded Limestone (HF8), Thick Bedded Algal Limestone (HF9), Medium to Thick Bedded Algal Limestone (HF10) and Thick Bedded Algal Limestone (HF11). The sedimentary characteristics suggests that the Hazara Formation is a deep marine sedimentary sequence of submarine fan deposits in which inner fan, middle fan and outer fan facies were identified.

Petrographic analysis of limestone reveals that the limestone is micritic in nature and presence of stylolites and pressure solution structures. Furthermore, petrographic analysis of sandstone categorized as Feldspathic Greywacke in the QFR diagram. The quartz content is higher in sandstone and may reaches to 70% which indicate a weathered felsic source. Additionally, the chemical index of weathering CIA values of sandstone are 71% and 73% for shale suggests a moderate to high weathering conditions of a moderate relief terrain with warm and humid climatic conditions in the source area. The geochemical data of sandstone on K_2O/Na_2O–SiO_2 diagram falls within an active continental margin tectonic setting. The comprehensive studies of the Late Neoproterozoic Hazara Formation support a submarine fan environment of deposition on the basis of lithofacies assemblage combined with sedimentary structures. Moreover, combined petrographic, geochemical and paleocurrent data indicate a felsic source which is possibly central Indian Craton, Aravali Orogeny and Bundelkhand Craton and Dharwar Craton of Southern India.

Keywords: Sedimentary facies, depositional environment, provenance, Late Neoproterozoic, Hazara

A089

Sedimentary facies and depositional environment of Neogene Deposits; case study in Majalengka Sub-basin, Indonesia

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The research area is located in Cimanintin Village and its surroundings, Majalengka District, West Java Province. Geologically, the study area is part of the Majalengka Sub-Basin, which is mostly filled with submarine turbidite deposits. Turbidite deposits are sedimentary streams produced by turbidite currents and usually occur in submarine fans. Turbidite facies are divided into seven groups, namely A, B, C, D, E, F, and G with slope deposition environment; fan which is divided into upper fan, middle fan, lower fan; and basin plain. This study focused on Cinambo Formation which is divided into two parts, namely Cinambo Formation of Sandstone Members (Fm. Tomcl) and Cinambo Formation of Shalestone Members (Fm. Tomcu). Both of Cinambo Formation were deposited conformity through a turbidity flow mechanism at Early Miocene-Middle Miocene. The research aimed at analyzing facies and modelling depositional environments. The research methods used including field geological mapping, measuring stratigraphy, lithofacies analysis, and biofacies analysis. Geological mapping of the field includes observing the appearance of rocks megascopically. Measuring stratigraphy is done to collect data on layer geometry, layer thickness, rock texture, and sedimentary structure. Lithofacies analysis supported by petrographic analysis is used to correlate and identify the lithological characteristics of each rock layer. Meanwhile, Biofacies analysis was obtained from micro foraminifera analysis to determine the age and depositional environment. Based on geological mapping data, Cinambo Formation of Sandstone Members was obtained consisting of interbedded between sandstones and shalestones with the presence of more dominant sandstones around 60-70%. Sedimentary structures found are massive, parallel lamination, cross lamination, and wavy lamination which is included in the Ta-Tc sequences in the bouma sequence. The presence of these structures indicates that this formation is deposited through a turbidite flow process. Meanwhile, the results of the petrographic analysis showed that the sandstones and shalestone formed in this formation were included in the feldspartic greywacke and wackestone classifications. In addition, there were also large fossils of foraminifera in the form of *Lepidocylina* sp., *Miogypsina* sp., and *Miogypsinoides* sp. which showed the relative ages of the Early Miocene-Middle Miocene (Te.5-Tf.1) with bathymetry in the upper batial zone. Cinambo Formation of Shalestone Members was obtained consisting of interbedded between shalestones and sandstones. The presence of shale lithology is more dominant than sandstone with a ratio of 3:1. Based on petrographic analysis, rocks found in this formation are included in the classification of mudrock and sub-litharenite. Found the presence of sedimentary structures in the form of wavy lamination, cross lamination, parallel lamination, and convolute bedding which indicated that this formation was deposited through the turbidite process and included in Tb-Tc in the bouma sequence. Meanwhile, fossils of planktonic and benthonic foraminifera were found, namely *Globorotalia obesa*, *Globorotalia peripheroranda*, *Globigerinoides trilobus*, *Orbulina universa*, *Orbulina bilobata*, and *Filiform phytochemicals*. The presence of these fossils shows that, this formation relative ages was in Middle Miocene (N9) with an upper batial zone bathymetry. Based on facies analysis and depositional environment, Cinambo Formation of Sandstone Members are included in facies C which is characterized by the interbedded between sandstones and shalestone, while being deposited with a high density turbidity current flow mechanism. This formation is deposited in the lower to middle fan environment in the submarine fan system. Cinambo Formation of Shalestone Members are included in facies E which is characterized by interbedded between shalestones and sandstones and they are formed by the mechanism of low density turbidity current, so that it is deposited in the fan environment of the middle part of submarine fan system.

Keywords: Cinambo Formation, depositional environment, facies, Majalengka, turbidite

A035

Facies characterization and stable isotope application on EX Field, Central Luconia, offshore of Sarawak

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INTRODUCTION

Central Luconia area was characterized by the extensive development of shallow-water carbonate during late Oligocene and Miocene period (Ting *et al.*, 2012). The study area, EX Field is located in the southwest of Central Luconia (Figure 1.A), 80 km north of Bintulu town. EX age is from Middle Miocene until Late Miocene (Epting, 1980) for over 5 Ma years of deposition (Warrlich *et al.*, 2010). The architecture of the platform can be subdivided into two, "Megabank" structure with a thickness of approximately 170 m and pinnacles structure with thickness 340 m and was divided by thick deep marine deposits (Warrlich *et al.*, 2010) (Figure 1.B). A detailed facies investigation needed to be conducted in order to understand and delineate the facies response to a geological event using data integration to have more precision on qualitative and quantitative of carbonate sediments. This paper focused on Cycle V sequence from EX-3 well to investigate its depositional environment and diagenetic alteration using well logs, core description, and microfacies analysis stable isotope application.

METHODOLOGY

A. Lithofacies division

The density log has been used to create the zonation for this study. Density log has been divided into three category, low, intermediate and high density. Core description has been used to identify the lithology, texture and skeletal assemblages. The length of core for EX-3 is 286 m. 68 thin section has been used to describe the from microscopic scale. Thin section study has been utilized to extract more information on texture, benthic foraminifera assemblages and porosity. Carbonate depositional texture has been described based on Dunham's Classification (1962) and Embry & Klovan (1971).

B. Lithofacies Association

The facies that has been divided and analyzed, was then grouped into 5 facies. These facies association were made, considering its lithology, texture, fossil assemblages and depositional environment.

C. Stable isotope

60 samples have been chosen to be analyzed for stable isotope, $\delta^{13}C$ and $\delta^{18}O$. The stable isotope data are presented in δ notation, relative to VPDB standard, and was normalized against NBS18 and NBS19. The samples were analyzed at Melbourne Isotope Geoscience laboratory at Melbourne University, Australia. Carbonate samples were grinded to powder form. Subsequently, the powders were digested in 105°C phosphoric acid overnight. Mass spectrometric measurement were done on evolved CO_2 gas, using GV Instruments GV2003.

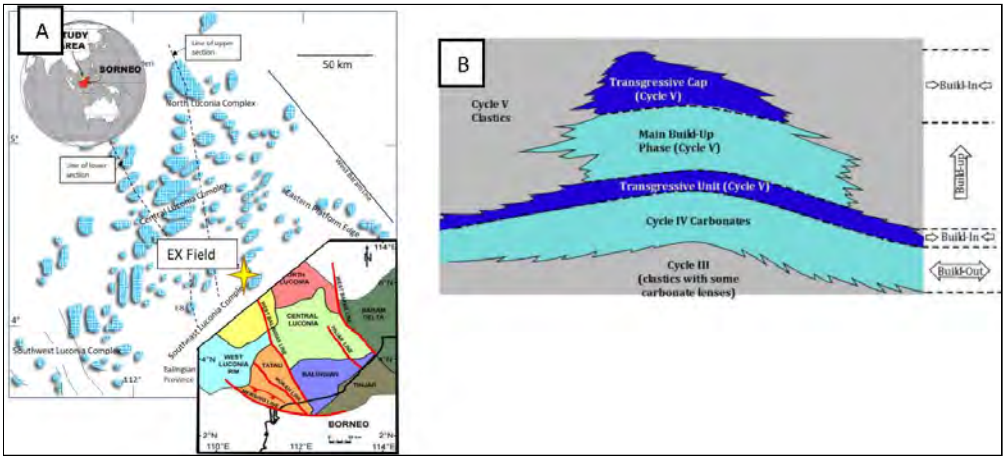

Figure 1: [A] EX Field located in southwestern region of Central Luconia, offshore of Borneo (Modified from Madon, 2005). [B] The architecture of EX Field has been divided into two, Megabank and pinnacle (Rankey *et al.*, 2019).

RESULTS AND DISCUSSION

The facies have been regrouped into 4, namely FA1, FA2, FA3, and FA4. The facies division are numbered according to their deposition with depth/ time. The facies repeated after one full cycle of facies completed. The details on the facies association are in Table 1.

$\delta^{13}C$ and $\delta^{18}O$ cross plot shows that facies in EX-3 was influenced by meteoric water overprinting the depositional signal, with all facies showing a positive correlation between $\delta^{13}C$ and $\delta^{18}O$ cross plots. However, FA 1 and FA 2 from megabank has less influence compared to other facies (r2 less than 0.5). The highest correlation can be found in FA1 and FA3 from the pinnacle section. Judging from the microfacies study, the presence of pendant cement (microstalactitic cement) from FA3 indicated that the facies has been diagenetically altered in the freshwater vadose zone. This zone can be classified as a mixing zone, where the marine water mixed with meteoric water. Mixing zones normally is a region that promotes dolomitization, as the fluids were undersaturated relative to calcite and supersaturated relative to dolomite (Swart, 2015), where the FA3 in EX-3 could actually be classified as a mixing zone, considering dolomite unit in strata, cements type and signal from the stable isotope.

CONCLUSION

These isotope patterns could be useful to prove the diagenetic alteration in carbonate rocks. The result can be added to the understanding of the regional process, influenced by sea-level fluctuation and subsidence processes.

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Table 1: Facies characterization for FA1, FA2, FA3 and FA4.

	Depositional Env.	Main Skeletal				
FA2			$\bar{X}\ \delta^{13}C$	-0.96	$\bar{X}\ \delta^{18}O$	-5.27
			Min $\delta^{13}C$	-1.47	Min $\delta^{18}O$	-5.70
			Max $\delta^{13}C$	-0.39	Max $\delta^{18}O$	-4.51
			Ranges	1.08	Ranges	1.19
FA1			$\bar{X}\ \delta^{13}C$	-0.38	$\bar{X}\ \delta^{18}O$	-4.82
			Min $\delta^{13}C$	-0.82	Min $\delta^{18}O$	-5.77
			Max $\delta^{13}C$	0.75	Max $\delta^{18}O$	-2.08
			Ranges	1.57	Ranges	3.69
FA4	shallow open marine	bryozoan, brachiopod, massive coral, *Operculina* sp., *Amphitesgina* sp., encrusting red algae,	$\bar{X}\ \delta^{13}C$	-0.37	$\bar{X}\ \delta^{18}O$	-4.86
			Min $\delta^{13}C$	-1.13	Min $\delta^{18}O$	-5.90
			Max $\delta^{13}C$	0.26	Max $\delta^{18}O$	-3.11
			Ranges	1.39	Ranges	2.79
		Miogypsina sp., uniserial foraminifera.				
FA3	lagoonal facies with dolomite interval	by red algae, *Operculina* sp., uniserial foraminifera, bryozoan and skeletal fragments	$\bar{X}\ \delta^{13}C$	0.10	$\bar{X}\ \delta^{18}O$	-3.52
			Min $\delta^{13}C$	-0.60	Min $\delta^{18}O$	-6.71
			Max $\delta^{13}C$	0.76	Max $\delta^{18}O$	-0.29
			Ranges	1.35	Ranges	6.42
FA2	deeper marine	benthic foraminifera (*Operculina* sp., *Miogypsina* sp., *Sorites* sp., *Amphitesgina* sp., *Lepidocyclina* sp. and *Cycloclypeus* sp.), miliolids, red algae and planktonic foraminifera.	$\bar{X}\ \delta^{13}C$	0.17	$\bar{X}\ \delta^{18}O$	-4.42
			Min $\delta^{13}C$	-0.14	Min $\delta^{18}O$	-5.68
			Max $\delta^{13}C$	0.76	Max $\delta^{18}O$	-3.06
			Ranges	0.90	Ranges	2.62
FA1	Lagoonal/protected environment	*Sorites* sp., *Operculina sp.*, *Miogypsina* sp., red algae and echinoid plate.	$\bar{X}\ \delta^{13}C$	0.09	$\bar{X}\ \delta^{18}O$	-6.56
			Min $\delta^{13}C$	-0.53	Min $\delta^{18}O$	-7.19
			Max $\delta^{13}C$	0.44	Max $\delta^{18}O$	-6.09
			Ranges	0.97	Ranges	1.10

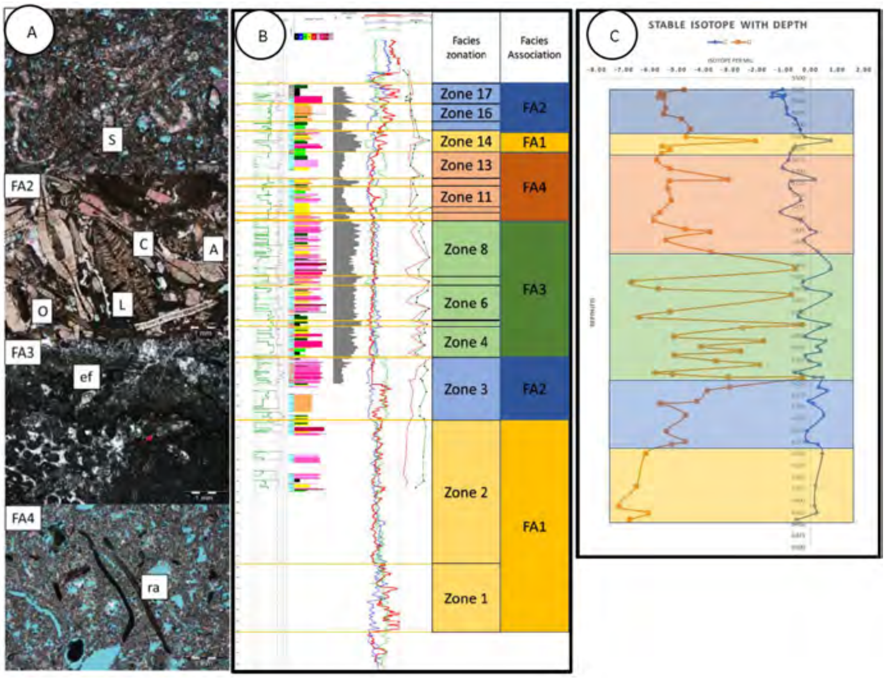

Figure 2: [A] microphotograph from different facies association. FA1 has a high number of *Sorites* sp. [S] indicating a protected lagoon environment. FA2 has the highest number of benthic foraminifera compared to other facies, with no porosity [A: *Amphitesgina* sp; C: *Cycloclypeus* sp.; L: *Lepidocyclina* sp; O: *Opercculina* sp.]. FA3 shows pendant cement surrounding the grains (marked with red arrow) and has more micrite compared to sparite. [ef: encrusting foraminifera]. FA4 shows a dolomitic microfacies, with high intercrystalline porosity, and mostly dominated by red algae [ra] skeletal. [B] Facies association created based on the description from Table 1. [C] $\delta^{13}C$ and $\delta^{18}O$ with depth, which has been grouped according to the facies association. The graph shows each facies have a different isotope trend. FA1 from both Megabank and pinnacle show positive isotope excursion for both $\delta^{13}C$ and $\delta^{18}O$. FA2 from Megabanks shows a constant increase to positive $\delta^{18}O$. $\delta^{13}C$ seemed to have a slight change for FA2 and FA3. FA3 has an extreme up and down signal for $\delta^{18}O$. FA4 seems to have more controlled $\delta^{18}O$ fluctuation and dropped in $\delta^{13}C$ value, compared to overlying facies.

A092

Stratigraphic zonation for the carbonate distribution of Field E6-3, Cycle V in Central Luconia

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The aim of this research is to divide the stratigraphic zones of Well E6-3 based on the biostratigraphy, seismic and well data. The stratigraphy for Central Luconia Province is mainly recorded based on the "Cycles" which only shows the major events of unconformities in this province. The development of these cycles rely on the seismic interpretation, and little dependency on the fossils dating. This thesis first examines the petrography characteristics of thin sections, then proceed with seismic 2D interpretation and well log analysis. The *Miogypsina* sp. and the Austrotrillina large benthic foraminifera have helped with the determination of age boundary and thus locate the separation of stratigraphic cycles. *Miogypsina* sp. indicates Middle Miocene age while the foraminiferal assemblages suggest that the depositional environment was a warm tropical shallow-marine at the fore-reef shelf zone. Seismic data and well log data also reconfirm that the top of carbonate is at 1688.51 metres.

A147

Characterization of Lower J reservoirs, Malay Basin by using well logs, petrography, XRD, LPSA and core analysis result

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5 cored well have been chosen from X Field of Malay Basin to accomplish the petrophysical evaluation of Lower J reservoir (J20, J25, J30) by integrating logs data, petrography, XRD, LPSA and routine core analysis result. Total 5 lithofacies S1, S2, S3, S41 and S42 were distinguish from core study with S1 is the best quality while S42 is the poorest. Due to abundance of silt volume, sand silt clay lithology model was used by utilizing Neutron Porosity (NPHI) and Bulk Density (RHOB) reading. At J20, the highest sand volume is at middle interval while clay volume increasing towards the bottom. Average total porosity is 20 percent with maximum permeability of 1 darcy. Average water saturation is 50 percent with the lowest is 20 percent. For J25, the lithology behavior is almost the same with J20 with clay volume increasing towards the bottom. Average porosity is 18 percent with maximum permeability of 1 darcy. Lowest water saturation is 30 percent suggesting that the reservoir is more shalier compared to J20. For J30, the sand thickness is thicker compared to J20 and J25. Average porosity is 20 percent with maximum permeability of 1 darcy. Average water saturation is 30 percent with the lowest is 20 percent. Based from petrographic result, the sandstones are mainly subarkosic and sublitharenitic in composition upper very fine to lower medium size grained, poor to well sorted and texturally immature to mature with porosity ranging from negligible to very good. Seven diagenetic events were observed and they are compaction, pyrite precipitation and glauconitisation, siderite precipitation, dissolution of unstable grains, clay authigenesis, quartz overgrowths and calcite precipitation. From LPSA result, most of the reservoir contain more than 25 percent of silt volume with less than 15 percent of clay. XRD report showed that kaolinite, chlorite, Illite and smectite present as clay type in the reservoir.

A022

Facies analysis of the Pedawan Formation in Kota Padawan - Siburan Area, Kuching, Sarawak

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INTRODUCTION

Sarawak is situated in the northwestern Borneo and can be separated into three tectonostratigraphic zones, which are the Kuching Zone, Sibu Zone and Miri Zone. The main focus of this research is the Pedawan Formation in the Borneo Heights - Siburan area of Kuching Zone [1º22'0.01" N, 110º24'0" E], as seen in Figure 1. The Pedawan Formation ranges from Jurassic to Cretaceous in age, and it overlies conformably on Bau Limestone (Ting, 1992). It is made up of a thick sequence of predominantly argillaceous rocks, mostly black shales with rare sandstone and radiolarite beds (Ting, 1992).

The Pedawan Formation in the Siburan area have not been studied in detail in terms of sedimentology, stratigraphy, and biostratigraphy. Thus, this research aims to evaluate and generate a sedimentological, stratigraphic and biostratigraphic framework of Pedawan Formation. In this paper, we present the preliminary results obtained through stratigraphic and facies analysis conducted on four (4) outcrops of Pedawan Formation in Siburan.

RESULTS AND DISCUSSION

The four (4) outcrops of Pedawan Formation along Jalan Borneo Heights in Siburan are named as BH1, BH2, BH3, and BH4 respectively. There are seven (7) lithofacies and five (5) facies associations recognized at the four outcrops.

LITHOFACIES IDENTIFICATION

The following is the identified lithofacies (Table 1).

a. S1: Massive, ungraded medium-grained sandstone

b. S2: Graded, coarse to fine-grained sandstone (turbidite sequence, Ta-Tb)

c. S3: Thick, medium to fine-grained sandstone with mudstone interbeds

d. S4: Thick, laminated medium to fine-grained sandstone with floating mud clasts

e. S5: Massive slump structures of medium-grained sandstones with thin mudstone layers

f. M1: Massive, laminated thin mudstone with medium to fine-grained sandstone interbeds g. M2: Thick mudstone with thin, fine to medium-grained sandstone interbeds

FACIES ASSOCIATION

a. FA1: Slope Area

FA1 facies can be distinguished by the presence of a massive sandstone beds with slumps, laminations, mud clasts, or with no structure at all. Massive bed of sandstones is transported by high density flow or grain

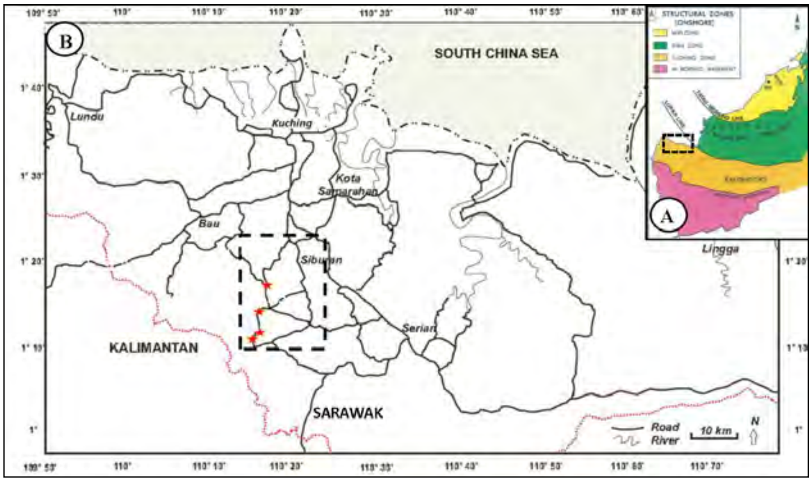

Figure 1: (A) Location of study area in Kuching, Sarawak (Madon, 1999). (B) Four outcrops are identified along Jalan Borneo Heights, which are BH1, BH2, BH3 and BH4.

Table 1: Description of lithofacies.

Lithofacies	Description
S1: Massive, ungraded medium grained sandstone	Some laminations and mud clasts observed along lamination. The base is sharp and irregular.
S2: Graded, coarse to fine grained sandstone (turbidite sequence, Ta-Tb)	Fining upwards sandstone bed, with Bouma's turbiditic sequence – from Ta (massive or graded bed) to Tb (horizontal and ripple laminations).
S3: Thick, medium to fine grained sandstone with mudstone interbeds	Laminated sandstone bed, with mud clasts on top and along laminations. It is interbedded with thin and thick mudstones (0.03 to 0.2 m thick).
S4: Thick, laminated medium to fine grained sandstone with floating mud clasts	Parallel laminated sandstone bed (0.3 m to 1.3 m thick), distributed with mud clasts on the upper and middle part.
S5: Massive slump structures of medium grained sandstones with thin mudstone layers	2 m thick slump, consists of medium grained sandstone beds and mudstones inter-layers of 0.01 to 0.02 m m thickness.
M1: Massive, laminated thin mudstone with medium to fine sandstone interbeds	Dark grey mudstone beds, with parallel laminations (0.02 to 0.2 m thick), interbedded with thin and thick sandstone beds (0.02 to 0.3 m thick). They overlies a thick sandstone bed.
M2: Thick mudstone with thin, fine to medium grained sandstone interbeds	Laminated mudstone (0.1 m to 0.5 m thick), interbedded by thin sandstone (0.02 to 0.08 m thick). Some mud clasts are observed.

Table 2: Summary of facies association (FAI -FA5).

Facies Association (FA)	Lithofacies	Description	Interpretation
FA1 Slope Area	S1, S2, S4, S5, M1	Massive sandstone with laminations, mud clasts, mud layers or with no structures. The base is erosional or sharp. Fining upwards sandstone (turbidite). Slump structure is available.	High density flow or liquefied grain flow. Slump is formed by gravity flow that deformed the soft sediments. Turbidite sequence indicates that density flow has become turbulent at the basin floor (Shanmugam, 1997).
FA2 Proximal Fan	S1, S2, S3, S4, M1, M2	Massive and thick sandstone beds. Fining upwards sandstone (turbidite). Parallel and wavy lamination, with mud clasts.	High density turbidity current and liquefied flow. Laminated sandstone beds indicate traction mechanism during high turbidity current (Shanmugam, 1997).
FA3 Middle Fan Channel / Distributary Channel	S2, S3, S4, M1	Fining upwards sandstone and thin mud layer. Thick, medium-fine sandstone beds and thin mudstone interbeds. Laminations and some mud clasts are observed.	Turbidity current decreases and sediments are transported and deposited by traction mechanism. Finer mud sediments are transported in suspension and deposited by falling out mechanism (Shanmugam & Moiola, 1988).
FA4 Frontal Fringe	M1, M2, S3, S4	Dominant laminated mudstone with fine sandstone interbeds. Presence of a thick sandstone bed in between a set of interbeds. Thickness of one set: 0.5-2.5 m.	Low turbidity current. Low energy leads to more mudstone beds to be deposited by the suspension fall-out mechanism (Shanmugam & Moiola, 1988).
FA5 Distal Fan	M1, M2, S3	Thin, laminated mudstone interbedded with fine-medium grained sandstone beds. Thin mudstone and sandstone interbeds are alternately overlain by a thick sandstone bed. Thickness of one set of interbeds: 1-3 m.	Low density turbidity current deposited mud by suspension fall-out mechanism (Shanmugam, 1997). It can be a pelagic sedimentation if biogenic materials like pollen or spores are present in the rock.

flow, which is supported by the cohesive forces between the grains (Shanmugam, 1997). Slump structures represent the slope area. Due to gravity, the sedimentary layer above the soft sandstone interbeds moves downslope, and deformed the sandstone into slumps. Graded beds are deposited by the waning flow which has a gradually decreasing energy (Shanmugam, 1997).

b. FA2: Proximal Fan

FA2 can be recognized by the thick sandstone beds and fining-upwards sandstone. FA2 is interpreted as a proximal fan deposit that was transported by high density turbidity current. Within proximal fan area, the transport of sediments can also be due to liquefied flow (Shanmugam, 1997), which deposited the thick sandstone beds.

c. FA3: Middle Fan Channel / Distributary Channel

In FA3, the medium-grained sand gradually fine upwards followed by a thin mud layer. There are also thick sandstone beds and thin mudstone interbeds. Away from the proximal fan area, the turbidity current decreases and the sediments are deposited by traction mechanism. Finer mud sediments are transported as suspension and deposited by falling out as the energy decreases (Shanmugam, 1997).

d. FA4: Frontal Fringe

This facies association is dominated by laminated mud with fine sandstone interbeds. There are also some thick sandstone beds in between the interbeds. There are also thinner interbeds of sandstone and mudstone which is fining upwards. This facies association reflects a low turbidity flow which produced the well stratified beds (Shanmugam, 1997). The frontal fringe area has low energy which deposit more mud sediments.

e. FA5: Basin Plain

Basin plain is marked by mudstone beds, interbedded with fine-grained sandstone beds. The basin plain is located further the slope area, and turbidity current is lower compared to other facies associations. The thinly bedded muddy units were deposited by suspension fall-out mechanism and is interbedded with the thin sandstone interbeds (Shanmugam, 1997).

CONCLUSION

Detailed facies analysis work carried out at four different outcrops in Siburan has resulted in the identification of seven (7) lithofacies and five (5) main facies associations. The outcrops are interpreted to be deposited in the deep marine environment, specifically the fan lobe setting. The high density flow and turbidity current along the slope area decrease as the sediments reach the fan lobe and basin plain area. Hence, more sand sediments are deposited near the slope area, while more mud sediments are deposited at the fan and basin plain area.

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A057

Facies analysis of deep marine channel to lobe deposits of Maastrichtian Layar member of the Belaga Formation, Rajang Group, Sarawak

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Belaga Formation is the most widespread and a better-known formation of Rajang Group (covering up to 95%) in the lower Rajang area (central Sarawak). The thick deep marine sediments of Rajang Group represent a major submarine fan and/or to some extent an accretionary prism (Hutchison, 1996; Moss, 1998) and is one of the world's largest ancient submarine fans. The Belaga Formation is believed to reach great thickness between 4.5 km and 7.5 km (Hutchison, 2005), excluding the repetitive sequences through folding and thrusting. It was subdivided into five members mostly based on palaeontological distinctions along with little sedimentological variations. These members are (in ascending order) Layar, Kapit, Pelagus, Metah and Bawang, younging northwards away from the Lupar Line (Liechti *et al.*, 1960; Wolfenden, 1960). The Layar member is the oldest unit of the Belaga Formation but is the least studied with respective to detailed turbidite facies analysis and sedimentology. The main objective of this research is to develop a depositional model for the Layar member based on comprehensive investigations of recent road-cut exposures around Betong, Saratok and Roban areas, Sarawak, Malaysia (Figure 1).

The description and classification of the sedimentary successions is primarily based on lithology, primary sedimentary structures and textures. In this study, forty sections were measured. Section measurements were done using columnar logs of different scales (based on bed thickness variations in individual outcrops), together with line drawings on the notebooks and photomosaics.

Eleven facies (F1-F11) or bed type associations can be identified in Layar member, based on bed type assemblages, bed geometry, degree of bed amalgamation, vertical grain size, and bed thickness trends (Figures 1-2). These includes; Structure less massive sandstone facies (F1), Thick graded sandstone (F2), Conglomerate Sandstone Facies (F3), Parallel Laminated Sandstone Facies (F4), Fine grained turbidite facies (F5), Mudstone facies (F6), Interbedded sandstone, siltstone and mudstone facies (rhythmite) (F7), Hybrid event beds or Mud-clast rich facies (F8), Sand Injectites Facies (F9), Double Mud Layer (DML) facies (F10) and Mass-transport deposits (MTD)- slumps (F11a) and debrites (F11b). These facies and bed type associations were than grouped into facies associations; for example, channel axis, channel margin, levee, lobe axis, lobe off-axis, lobe fringe, inter-channel, crevasse splay and slump. Sand injectites are restricted to inter-channel-crevasse splay and fan fringe association. Hybrid event are not restricted only to the lobe fringe but are also a common element of the lobe axis sub-environment in the "Belaga turbidite system". Their common occurrence in a proximal location in the lobes is probably due to enhanced seafloor erosion and rapid deceleration due to loss of confinement at the channel lobe transition further up-dip. Evidence such as bidirectional ripple cross-lamination in thin-bedded turbidites and variable paleocurrent orientations suggest a complex depositional topography, which also suppressed flow turbulence and promoted deposition of hybrid event beds in proximal locations through deflection and deceleration of incoming flows by confining counter slopes. Similar bed type assemblages within the slump and lobe deposits indicate a local origin for the slumps. Localized failures can form on low gradient slopes in tectonically active basins with complex topography.

Fine grained thin bed turbidites (silt/mud), hybrid event beds (HEBs) and sand injectites are the prominent facies that are being reported for the first time in this study.

Keywords: Belaga Formation, Layar Member, debrites, depositional lobes, sand injectites, hybrid event beds, channel-levee complex

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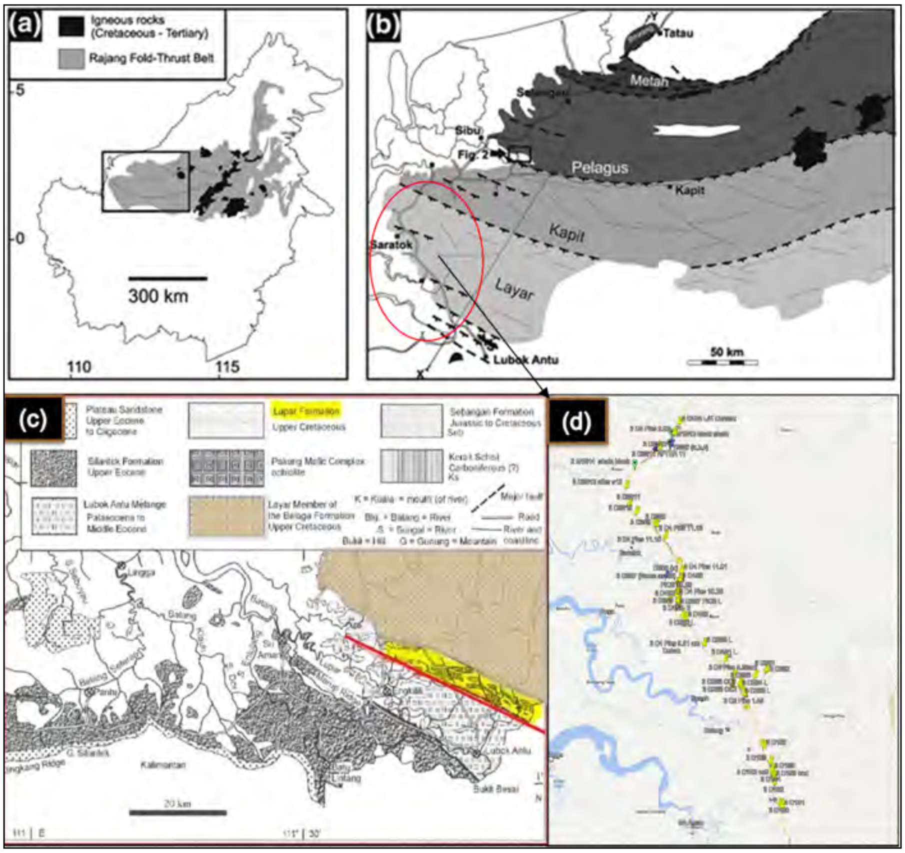

Figure 1: Map showing the location of (a) Sarawak and Rajang Group on Borneo. b) Geological map of the Sabu Zone of central Sarawak. Showing the divisions of Belaga Formations as well as major tectonic elements in the study area. Red circle is the location of study area. c) Geological map of areas around Lupar line (red colour line) (Modified from Tongkul, 1997). d) Google map image showing the locations of the points of visited outcrops.

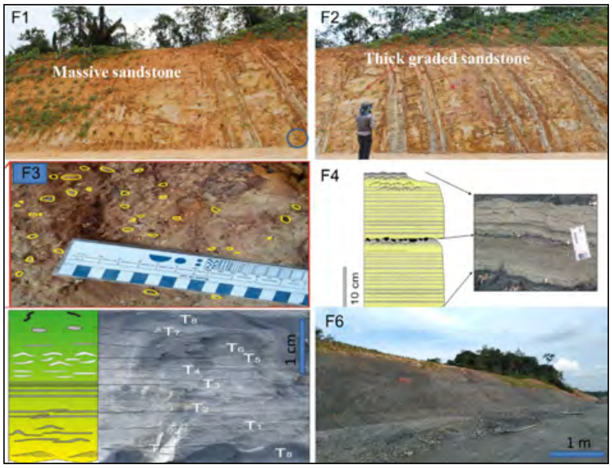

Figure 2: Field photo graphs and stiches of facies; Structure less massive sandstone facies (F1), Thick graded sandstone (F2), Conglomerate Sandstone Facies (F3), Parallel Laminated Sandstone Facies (F4), Fine grained turbidite facies (F5), Mudstone facies (F6).

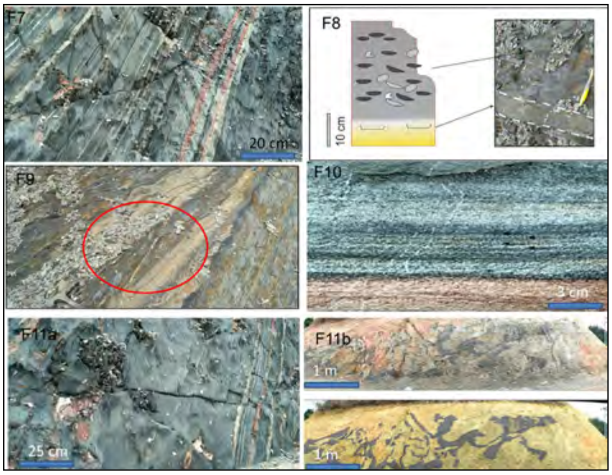

Figure 3: Field photo graphs and stiches of facies; Interbedded sandstone, siltstone and mudstone facies (rhythmite) (F7), Hybrid event beds or Mud-clast rich facies (F8), Sand Injectites Facies (F9), Double Mud Layer (DML) facies (F10) and Mass-transport deposits (MTD)- slumps (F11a) and debrites (F11b).

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Depth distribution of optimally preserved larger benthic foraminiferal tests in the sublittoral and uppermost bathyl zones northwest of Okinawa Island, Japan

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Models of depth distribution of modern benthic foraminifera are needed in predicting depth ranges of their fossil counterparts in palaeobathymetry estimation. Depth distributions of *Amphistegina lessonii* and *Calcarina hispida* showed asymmetric pattern with right-side skewness. Depth distributions of *A. bicirculata, A. radiata, A. papillosa, Operculina complanata* and *Planostegina longisepta* showed bimodal pattern that have been broken into two unimodal normal distributions. Dependence on coarse sand was demonstrated by *A. bicirculata, A. radiata* and *C. hispida*. Dependence on fine sand was demonstrated by *A. lessonii*. Dependence on very fine sand was demonstrated by *O. complanata* and *P. longisepta. A. papillosa* did not show dependence on any particular substrate type. Depth distribution of the optimally preserved tests showed agreements with living individuals from previous studies, hinting at its potential in determining benthic foraminiferal distribution.

Keywords: Large foraminifera, bathymetric distribution, depth, substrate type, depth transport

INTRODUCTION

Pioneering depth distribution investigations were performed by Hallock (1984) and Hohenegger (1994). They were the first workers that quantitatively investigating the depth distribution of living large foraminifera, with illumination and hydrodynamics as key environmental factors (Hohenegger, 2000a; Hohenegger *et al*., 1999). Depth is the composite factor influencing illumination rate, water movement and sediment distribution in the marine environment.

MATERIALS AND METHOD

Location and environmental setting

Okinawa is the largest island of the Ryukyu Island Arc. The Ryukyus are located in the southwest of mainland Japan and consist of hundreds of islands and islets. The Ryukyus extend from Tanega Island (30°44' N, 131°0' E) in the northeast to Yonaguni Island (24°27' N, 123°0' E) in the southwest. The area is bounded by the East China Sea on the northwest and by the Pacific Ocean on the northeast. The Okinawa Trough of 2000 m depth in the south separates the Ryukyu Arc from the East China Sea shelf (Kimura *et al*., 1991). The northern transects of the investigation area are located to the northwest of Okinawa with sampling stations located around the south of Izena Island (Figure 1). The southern transect is located to the west of Motobu Peninsula with sampling stations located in the south of Ie Island.

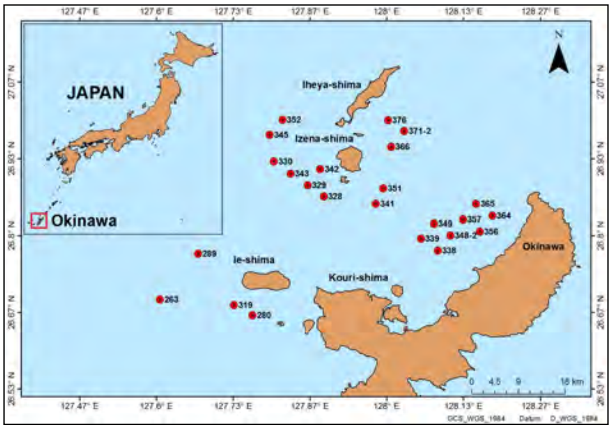

Figure 1: Map of the investigation area showing locations of sampling stations.

Sampling and preparation

Samples were collected using a grab sampler during a cruise (GH09) of a Japanese research vessel investigating the seafloor around Okinawa. Parts of the surface sediments were stored in plastic jars, filled with seawater and formalin to fix the protoplasm of living organism. A set of sieves with mesh sizes of 63 µm, 125 µm and 250 µm were used to wash and sieve the samples. Samples were dried at 60°C. A universal sample splitter was used to split samples of 250 µm fraction. Microsplitter was used to split samples of 125 µm fraction. Only optimally preserved foraminiferal specimens were picked and identified using Motic SMZ-168 Series microscope. Taxonomic identification was performed following Parker (2009), Hohenegger (2011), Hatta & Ujiie (1992), Loeblich & Tappan (1994) and Akimoto *et al*. (2002).

RESULTS AND DISCUSSION

Depth distribution of *Amphistegina lessonii* (Figure 2) was located in the middle sublittoral with an optimum at 73 m. Preference on fine sand was shown by 33 % of the samples (Figure 3). Depth distribution of *Amphistegina bicirculata* in the middle sublittoral showed an optimum at 89 m (Figure 2). Depth distribution of *A. bicirculata* showed a bimodal pattern demonstrating transport at 210 m. Frequency distribution in coarse sand was demonstrated by 32% of the samples (Figure 3). Depth distribution of *Amphistegina radiata* in the middle sublittoral showed that an optimum is attained at 83 m (Figure 2). *A. radiata* showed preferred distribution in coarse sand as demonstrated by 45% of the samples (Figure 3). Depth distribution of *Amphistegina papillosa* in the middle sublittoral showed an optimum at 89 m (Figure 2). *A. papillosa* did not show preferred distribution in any grain size classes (Figure 3). Depth distribution of *Operculina complanata* in the middle sublittoral showed an optimum at 85 m (Figure 2). Preferred distribution of *O. complanata* was shown in very fine sand class (Figure 3). Depth distribution of *Planostegina longisepta* showed an optimum at 105 m (Figure 2). Preference of *P. longisepta* was shown on very fine sand as demonstrated by 45% of the samples (Figure 3). Depth distribution of *Calcarina hispida* showed an optimum at 67 m (Figure 2). Abundant distribution of *C. hispida* was shown in coarse sand with 46% of the samples (Figure 3).

CONCLUSION

Depth distributions of *Amphistegina lessonii* and *Calcarina hispida* showed asymmetric pattern with right-side skewness. Depth distributions of *A. bicirculata, A. radiata, A. papillosa, Operculina complanata* and *Planostegina longisepta* showed bimodal pattern that have been broken into two unimodal normal distributions. Optima of the depth distributions of optimally preserved tests were in agreement with the optima of living individuals. Preference on substrate type shown by the tests was in agreement with substrate preference of the living larger benthic foraminifera. Agreements on optimal depth distribution and preference on substrate type with the living larger foraminifera signalised the potential use of

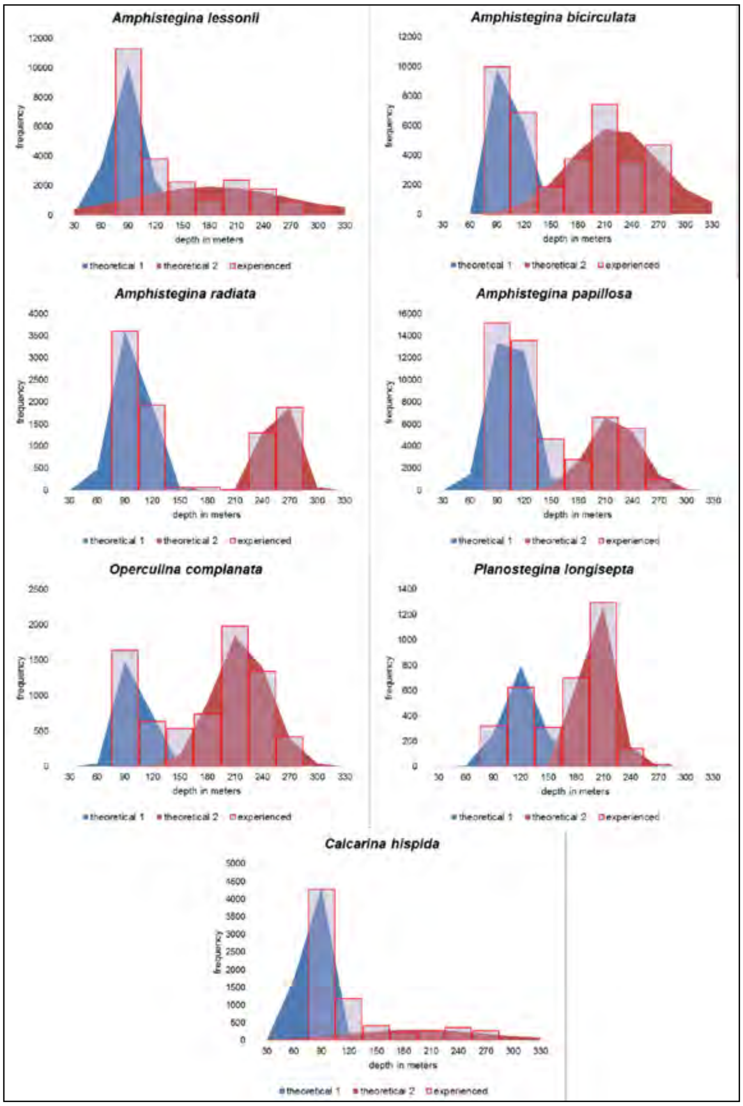

Figure 2: Experienced depth distributions (column) fitted by power transformed normal distributions. Abundances of *Amphistegina lessonii, A. bicirculata, A. radiata, A. papillosa, Operculina complanata, Planostegina longisepta* and *Calcarina hispida* are shown in frequency distribution.

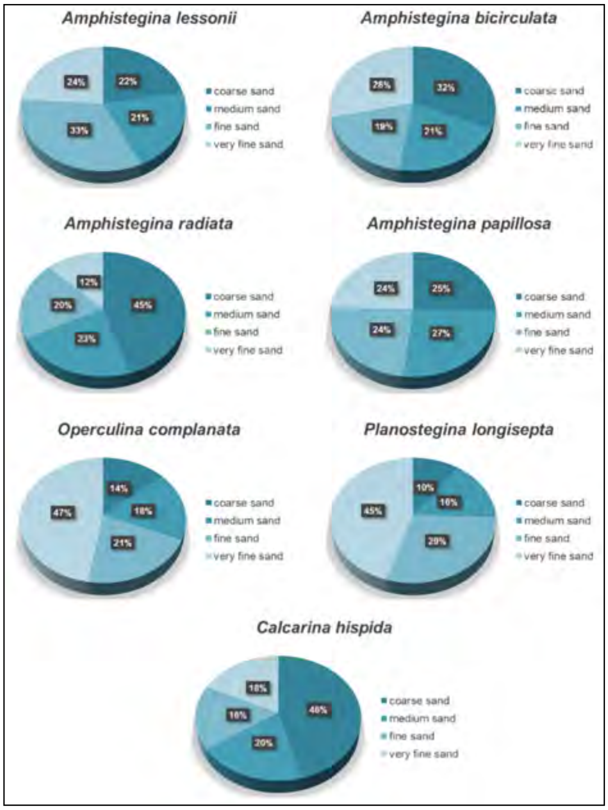

Figure 3: Frequency distribution of *Amphistegina lessonii, A. bicirculata, A. radiata, A. papillosa, Operculina complanata, Planostegina longisepta* and *Calcarina hispida* in grain size classes.

optimally preserved tests in understanding the distribution of benthic foraminifera thus providing us models in predicting depth ranges of their fossil counterparts.

ACKNOWLEDGEMENTS

The study was carried out as a part of my PhD thesis. It would be impossible for me to carry out the investigation without the financial support from the Ministry of Higher Education in Malaysia and Universiti Malaysia Terengganu. I would also like to thank Prof. Dr. Kazuhika Fujita from the University of the Ryukyus for sending the samples to Vienna, colleagues in the Department of Palaeontology, University of Vienna and AO. Univ. Prof. Dr. Johann Hohenegger for his supervision since beginning towards the end. Abstracts from this study have been published in conference proceedings (TMS Summer Meeting June 2015 and MIKRO Workshop September 2015).

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A154

Reservoir properties prediction using Stochastic Inversion

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OBJECTIVES

Petroleum systems in offshore are often very complex and subtle. Reservoir description based on conventional seismic and well-log stratigraphic analysis may be very uncertain in such depositional environments. There is a need to employ advance reservoir modeling techniques on seismic amplitude data to reveal reservoir units in these complex systems. The objective of this study is development of a new concept in reservoir modeling using tools of stochastic inversion and petrophysics. The results are expected to improve the understanding of subsurface for better lithology and fluid prediction and to investigate further prospectivity.

METHODS PROCEDURES, PROCESS

For a better understanding of reservoir properties prediction, first rock physics modeling for each defined litho facies has been performed separately through well log analysis. Next, seismic stochastic inversion incorporates all available subsurface information in a Bayesian engine and provides output simulations of elastic properties as well as their probabilities. In this way, uncertainty information is also captured and can be used in intelligent manner. The next crucial step is to convert these elastic properties to petrophysical properties of main reservoir. This study intends to propose solving an inverse problem through an efficient optimization algorithm for properties estimation improvement.

RESULTS

Petroleum industry is focusing more on offshore exploration because these sedimentary environments represent major hydrocarbon targets in numerous areas of the world. Reservoir modeling is a significant step for a successful performance, development and production of oil and gas fields. The methodology has been applied to characterize a field in Malaysian offshore. Structural interpretation shows an E-W dipping compressional anticline play. Strong and continuous reflectors present in reservoir section can be attributed to hydrocarbon and coal. Numerous high amplitude events can be seen in shallow section. Poor imaging in crestal areas due to gas wipeout. The petrophysical evaluation results indicate that the reservoirs are fine to very fine sand reservoirs. Apart from the obvious massive thick sands, the high surface-to-volume ratio at the inter-granular level could have attributed to a large extent and thus explain the high apparent water saturation in the wells. H and I units of

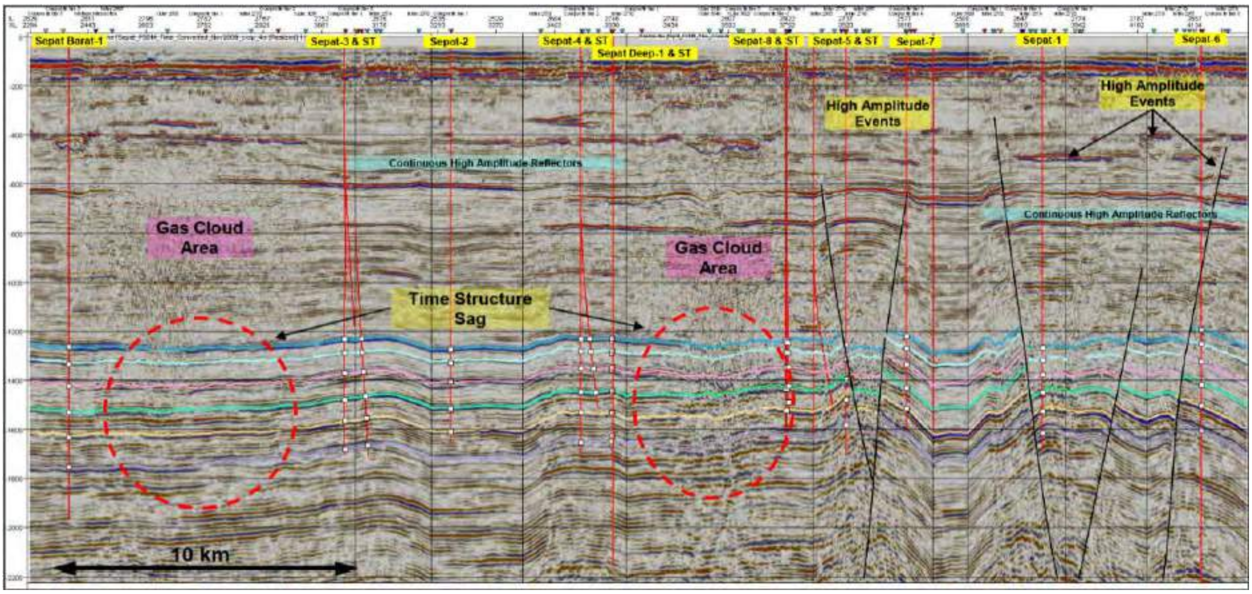

Figure 1: Composite seismic section through all available wells.

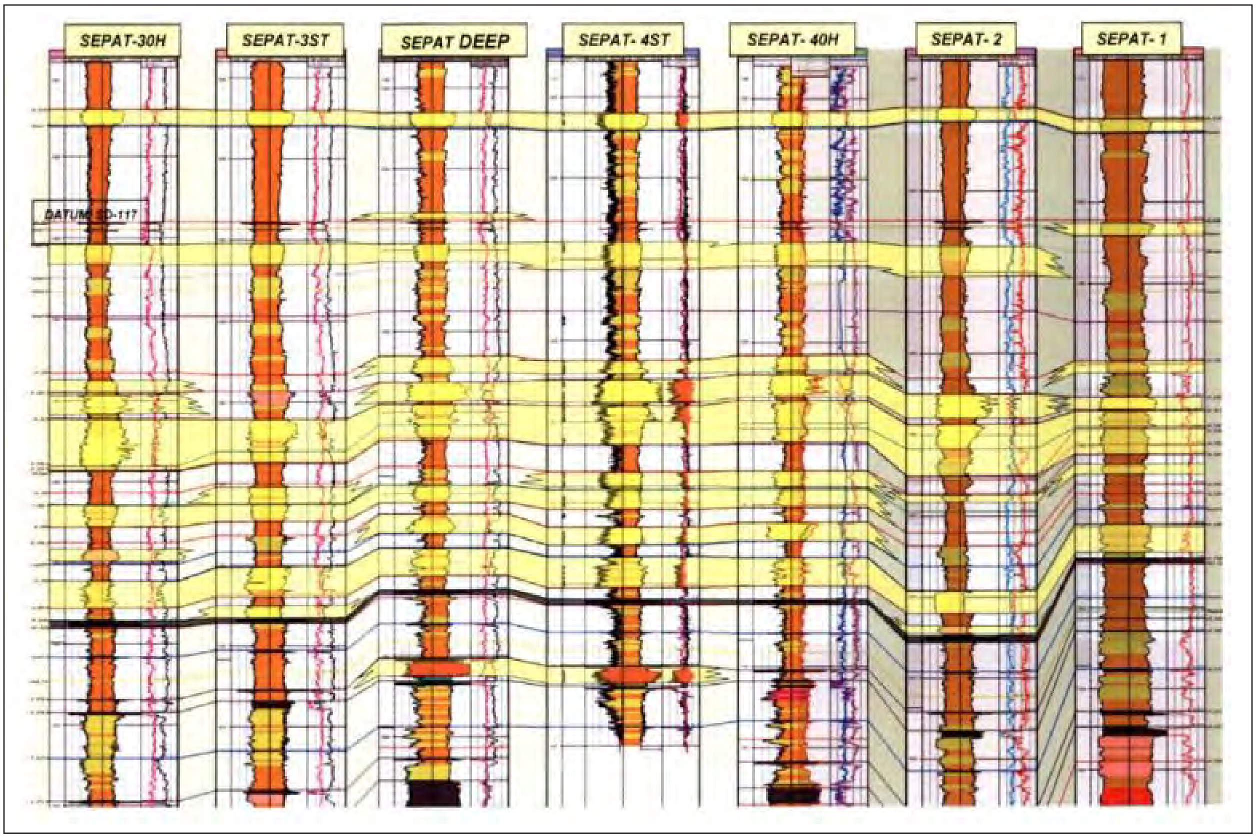

Figure 2: The field stratigraphic correlation.

lower Miocene age act as source whereas A, D and E units of upper Miocene age act as reservoir.

NOVELTY

The methodology can detect thin beds up to 5-7 meters by providing high resolution results. High resolution seismic approaching to well log resolution effectively eliminates the need of upscaling.

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ORAL PRESENTATIONS

CONSERVATION GEOLOGY, GEOARCHAEOLOGY & GEOTOURISM

A078

Archaeo-geotourism: Potential Palaeolithic site in eastern Sabah

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Abstract: Sabah is located on the island of Borneo, which is a part of the Sunda mainland during the Pleistocene epoch. This allowed the migration of early humans from mainland Southeast Asia to this area (Figure 1). It is is proved by the discoveries of Palaeolithic sites which mainly in eastern Sabah with the evidence of early settlements that began in Mansuli Valley 235,000 years ago (Figure 2) (Abdullah, 2013; 2015; Abdullah *et al.*, 2015). This valley revealed the evidence of stone tool-making workshops at open sites and also habitation sites in the cave. The Palaeolithic people choose Tapadong limestone hill as a habitation site and exploited raw material from Chert-Spilit Formation to make stone tools (Figure 3) (Bellwood, 1988; Harrisson, 1964; Harrison & Harrison, 1971). These discoveries are very important for geoheritage in Sabah because this valley shows evidence of the relationship between prehistoric people with geological sources. The evaluation is done by identifying three main components, which are cultural significance,

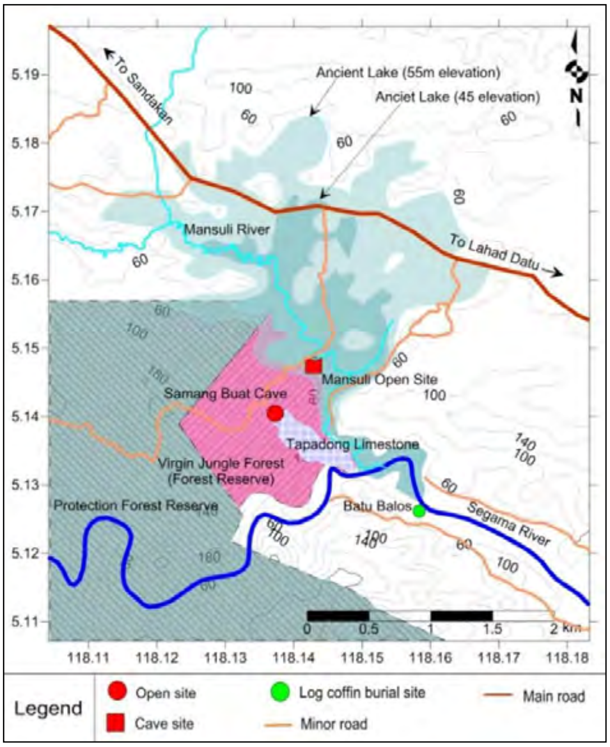

Figure 2: Location of archaeological sites in Mansuli Valley (Abdullah, 2013;2015; Department of Sabah Forest, 2015).

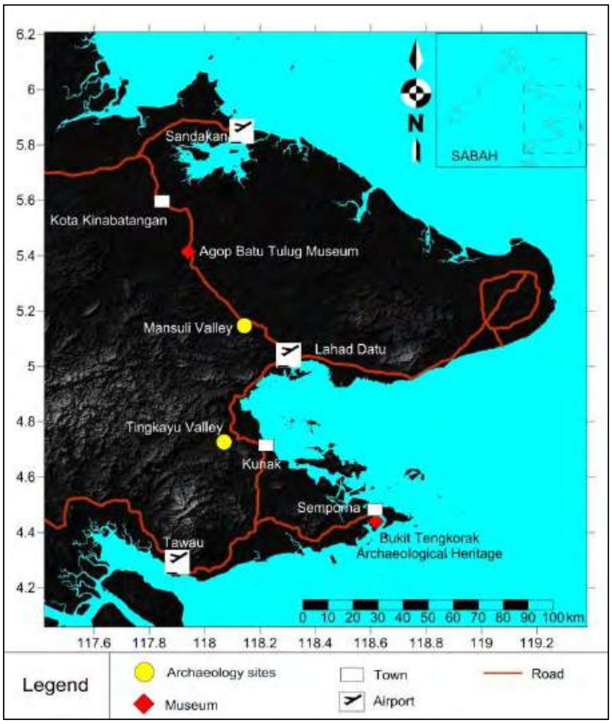

Figure 1: Location of archaeo-geotourism sites and major Palaeolithic sites in eastern Sabah.

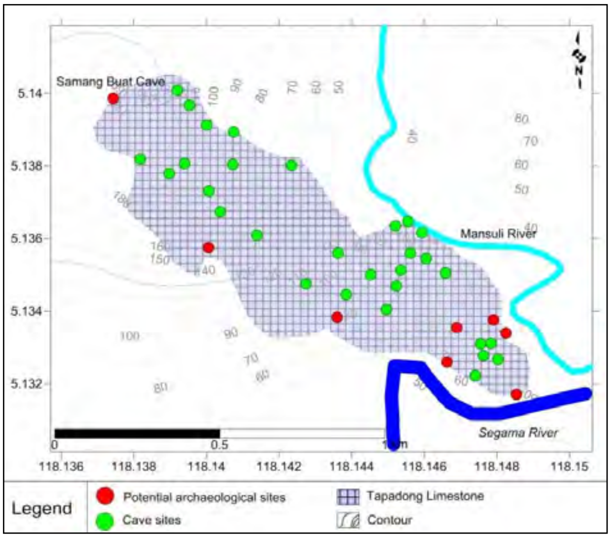

Figure 3: Archaeological cave sites in Tapadong Limestone Hill (Harrisson & Harrisson, 1971; Abdullah, 2013; 2015).

site vulnerability and market appeal to assess the potential of the Mansuli Valley as an Archaeo-geotourism site. The result of the assessment indicate that cultural significance is even higher, followed by market appeal and site vulnerability. Thus, site vulnerability criteria need to be focused once it starts to be developed as an Archaeo-geotourism. From this research, it proves that the archaeological site has the potential to be developed as Archaeo-geotourism destination. The diversity in cultural, habitation, geomorphology and aesthetic values together define the valuable potential of this area.

Keywords: Archaeo-geotourism, Sabah, Palaeolithic, stone tool, archaeological

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A104

Potential geoheritage values of Gua Sireh, Baling Kedah

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Abstract: Baling is a district in the state of Kedah, Malaysia consist a variety of unique and beautiful geological features with geoheritage values, as well as exclusive geological phenomenon, attractive geological landform and also treasurable earth materials. Gua Sireh, which is located at Baling Kedah was currently preserved by Kg. Padang Che Mas committee members as one of their tourism sites. However, this cave has not been explored by researcher to formally evaluate the potential geoheritage values. In this paper, we aim to follow the systematic studies which consist of five phases - inventory, characterization, classification, assessment and evaluation to formally evaluate the unique characteristics of Gua Sireh as part as geoheritage resources. With this initiative, we hope that Gua Sireh, Baling Kedah can be preserved from any threats and continues to develop in order to sustain and protect the geological features though supporting the geotourism development in the state of Kedah.

Keywords: Geodiversitv, Kg. Padang Che Mas, qualitative assessment, SWOT analysis

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Database and conservation of limestone hills in Malaysia

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In a world of limited resources and so many species and habitats in need of protection, informed prioritization is essential. However, we cannot prioritize effectively if historical and current information regarding a particular habitat or species remains scattered. Several good platforms have been created to help users find, use and create biodiversity information. However, good platforms for sharing habitat information for threatened ecosystems are still lacking. Limestone hills are an example of threatened ecosystems that harbor unique biodiversity, but are facing intensifying anthropogenic disturbances. As limestone is a vital resource for the construction industry, it is not possible to completely halt forest degradation and quarrying in developing countries such as Malaysia, where 899 and 485 limestone hills have been recorded in the West and East Malaysia to date. As such, there is an urgent need to identify which hills must be prioritized for conservation. To make decisions based on sound science, collating spatial and biological information on limestone hills into a publicly accessible database is critical. Here, we compile Malaysia's first limestone hill GIS map for 1384 limestone hills based on information from field surveys, geological reports and scientific literature. To assist in conservation prioritization efforts, we quantified characteristics of limestone hills in terms of size, degree of isolation, and spatial distribution patterns. We also assessed the degree of habitat disturbance in each limestone hill in terms of buffer area forest degradation and quarrying activity. These data are stored in a KMZ file and can be accessed through the Google Earth interface. Rather than being viewed as a final output containing basic limestone hill information, this database should be regarded as a foundational platform for users to collect, store, update and manipulate spatial and biological data from limestone hills to better inform decisions regarding their management.

Keywords: spatial analysis, forest degradation, species extinction, Keyhole Markup Language, caves, QGIS, SAGA GIS, mykarst

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Geokarst education potential of the Merapoh caves: Lipis Aspiring Geopark, Malaysia

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Abstract: The element of geoeducation is very important in a geoheritage site. Here we present some of the caves that are still it its natural states in Merapoh, Pahang, that could be used as a geokarst education center. Merapoh is largely a limestone region and is part of the proposed Lipis Aspiring Geopark. Several sources reported that the number of explored caves is around 200 – 300, and this number could be higher. For geokarst education, we propose three caves, namely; the Jinjang Pelamin, Tahi Bintang, and Sisik Naga. The selection is based on the dimension of the cave, number of speleothems, uniqueness of speleothem, size of speleothems, integrity, and level of accessibility. Apart from these, the abundance of other geological features such as geological structure and fossils are also taken into consideration. The dimension of the caves is around 240 to 400 m, with width of 20 – 40 m, and the height is around 10 - 22 m. There are around 35 types of speleothem found from these caves. Fossils such as cephalopod, brachiopod, bivalve, and coral are found abundance in the Sisik Naga and Tahi Bintang Caves. Each cave has its own uniqueness; for example, the ceiling of Sisik Naga Cave is decorated with mega-scallop, and the local called this as the dragon scale; the Tahi Bintang Cave is famous for its mammillaries and rimstone; and the Jinjang Pelamin cave is known for its series of column supporting the cave roof and multilevel notches. In terms of integrity, speleothems are still intact and preserved well. They are still in good condition due to the location in the protected forest reserve. Both the Sisik Naga and Tahi Bintang Caves are easily accessible, while some climbing is needed to get to the entrance of the Jinjang Pelamin Cave. All the information on the recorded speleothems and their names are manifested in the geo-storymap that can be accessed through https://arcg.is/1GbHLK0, this was made for the purpose of geokarst education in this area.

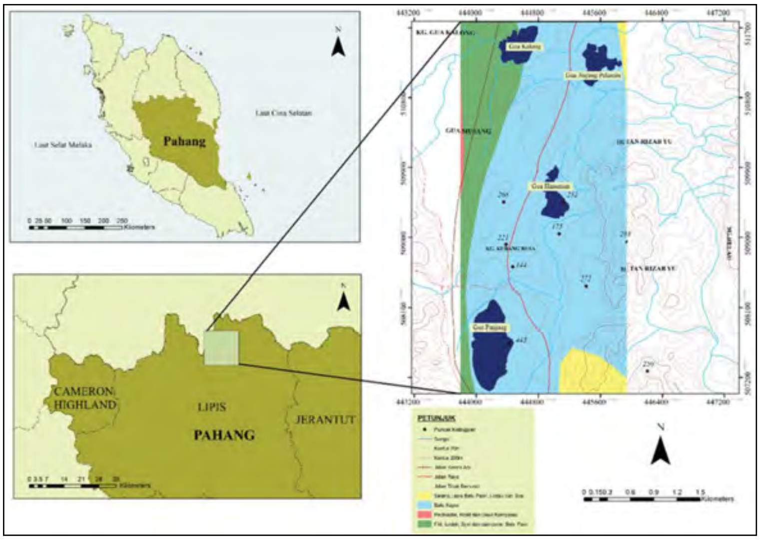

Figure 1: The location of proposed caves for geoeducation.

Figure 2: Some unique speleothems in each of the proposed caves. For examples, (a) mammilaries and rimstone dam in the Tahi Bintang cave; (b) cave popcorn/cave pearl in the Jinjang Pelamin cave; and (c) mega-scallop in the Sisik Naga cave.

INTRODUCTION

There are many well-known caves in Malaysia that are frequently visited by tourist from local and overseas. These caves are usually tourist caves such as the Gua Tempurung in Perak and Gua Kelam in Perlis. However, little are known there are caves located in Pahang that are far away from development and are suitable for geoeducation due to their variety of speleothems. This paper presents several caves that were explored in the Merapoh area of Pahang that can be developed as geoeducation site.

STUDY AREA

The study area are caves located in the forest reserve of Merapoh Pahang. These proposed caves are known as the Jinjang Pelamin, Tahi Bintang, and Sisik Naga Caves. In terms of geology, these limestone caves are included in the Gua Musang Formation with age from late-mid Permian to mid-Triassic (Kamal Roslan, 1990).

METHOD

The inventory of speleothems and other features were carried out by mapping in those three caves. The mapping activity includes identifying the speleothems and other features such as fossils; dimension of the caves; structure mapping; integrity; and vulnerability to damages. This is a preliminary work done before valuation of the caves for geosite suitability. For the purpose of this paper, only the types of speleothems that were identified are presented.

RESULT AND DISCUSSION

From the inventory mapping that was carried out at the three proposed caves, there are 22 speleothems in the Jinjang Pelamin cave; 20 in the Sisik Naga cave; and 15 in the Tahi Bintang cave. Fossils such as brachiopod can be found in the Sisik Naga cave and corals in the Tahi Bintang cave. Table 1 shows the type of speleothem that were identified from the mapping activity. Each cave has its own uniqueness, for example the Tahi Bintang cave has large rimstone dam and mammillaries; Jinjang Pelamin has waterfall terraces, spring, and cave popcorn/pearl; and Sisik Naga has mega-scallop (Figure 2).

Table 1: Group of speleothems found in each of the proposed caves.

Speleothems	Caves		
	Jinjang Pelamin	Sisik Naga	Tahi Bintang
Notches	✓	✓	✓
Microgours/rimstone (e.g. dam, lotus like)	✓	-	✓
Rimstone dam	✓	-	-
Column	✓	✓	✓
Cave Pearls/ popcorn (collaroids)	✓	-	✓
Stalactite	✓	✓	✓
Spring	✓	-	-
Flow stone	✓	✓	✓
Waterfall terraces	✓	-	-
Gallery	✓	-	-
Wet cave	✓	-	-
Wall pockets	✓	✓	-
Roof pendant	✓	✓	-
Micro-rills	✓	✓	-
Sawtooth	✓	-	-
Cupolas/scallop	✓	✓	-
Flute	✓	✓	✓
Chamber	✓	✓	✓
Soda straw	✓	-	✓
Pressure Tube	✓	-	✓
Stalagmite	✓	-	-
Rockhead	✓	-	-
Rock breakdown	-	✓	✓
Blade	-	✓	-
Bench	-	✓	-
Nodules	-	✓	-
Canopy (e.g. baldachino, bell)	-	✓	-
Doline	-	✓	-
Shawl	-	✓	-
Spongework	-	✓	-
Bell hole	-	✓	-
Moonmilk	-	✓	-
Mammilaries	-	-	✓
Volcano cone	-	-	✓
Canyon	-	-	✓
Helictite	-	-	✓

CONCLUSION

From the preliminary finding, all three caves exhibit potential to be a geoeducation site for limestone cave education. Although some speleothems are common in all three caves, each cave has their own unique speleothem that may show different type of geological processes that formed them.

ACKNOWLEDGEMENT

This study would like to acknowledge the funding provided by the Universiti Kebangsaan Malaysia under the university research grant GUP-2017-83.

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ORAL PRESENTATIONS

HYDROGEOLOGY, ENVIRONMENTAL GEOLOGY & GEOCHEMISTRY

A013

Biogeochemical behavior of nutrients in soil-plants from oil palm estate, Tawau, Sabah

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Abstract: Nutrient concentration in soil is one of the major factors that determined the performance of oil palm growth and yield. A detailed information on soil and leaf nutrients is required for nutrient management and greater fertilizer-used efficiency. This paper highlights the nutrient status of soil and leaf from three different blocks of PJ Moutai Estate, Tawau. Fifteen samples of soil and leaf were collected from each block. The nutrient elements were determined using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) and Ultraviolet-Visible Spectroscopy (UV-VIS) Spectrometer. Based on the result, the soil was acidic with pH range from 4.3 to 4.5. The soil in each block mostly classified as loamy sand and sandy loam soil, therefore affecting the low cation exchange capacity (CEC) and less nutrients retain. The most important macro nutrients: Nitrogen (N), Phosphorus (P) and Potassium (K) were not balance as P content was too low for both soil and leaf while K was found extremely high in leaf. The result of soil and leaf provided information for fertilizer application use on the soil. Therefore, a continuous monitoring is highly recommended to ensure balance fertilization.

Keywords: Oil palm, soil nutrient, leaf nutrient

A018

Geophysical survey and lineament study for groundwater exploration at Pulau Mengalum, Sabah

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Geophysical technique plays important role in groundwater exploration in order to map the aquifer within the bedrock or alluvium. A 2-D Electrical Resistivity Imaging (ERI) and Induced Polarization (I.P) survey had been conducted at Mengalum Island, Sabah to locate the fresh groundwater zone for future development on of this Island. From the geophysical results, the subsurface materials are classified into four materials according to the resistivity values ranges; which are freshwater zones (10Ωm - 50Ωm), salt water intrusion zone (0.2Ωm - 1Ωm), alluvium layer (50Ωm - 300Ωm) and bedrock (300Ωm - 800Ωm). Lineament analysis indicate that the shape of the island itself is largely controlled by five sets major lineaments; NW - SE, N - S, NE - SW, ENE - SSW and E - W trends. The extent of salt water intrusion and percolation might be influenced by these sets of major lineaments. There are four (4) proposed drilling locations (PDL) were suggested for fresh groundwater potential zone.

Keywords: Groundwater exploration, electrical resistivity imaging, induced polarization, lineament, saltwater intrusion

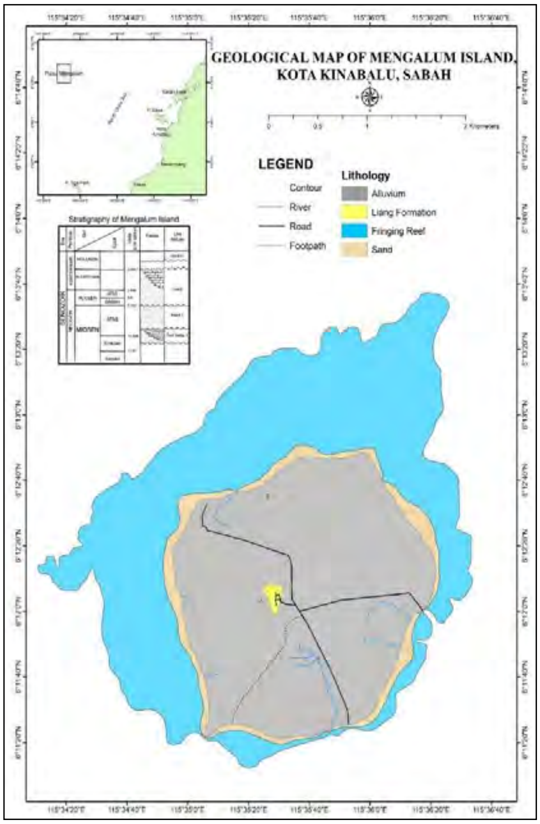

Figure 1. Geological map of Mengalum Island, Kota Kinabalu, Sabah.

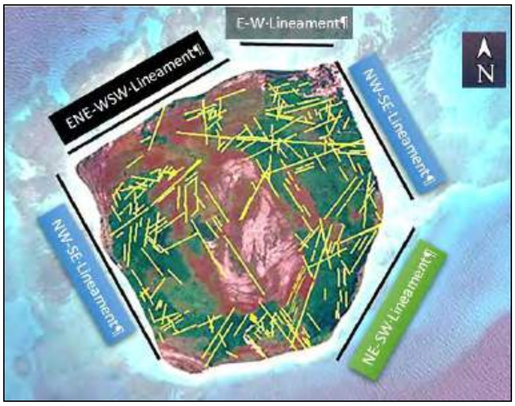

Figure 2: The shape of Mengalum Island is largely controlled by five set of major lineaments.

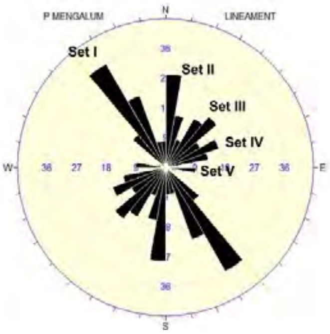

Figure 3: Rose diagram of five set of major lineaments orientation of Mengalum Island.

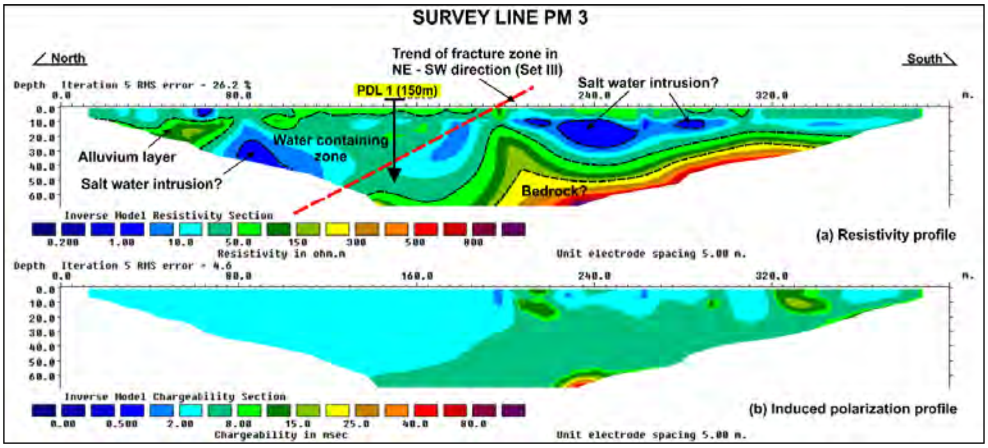

Figure 4: Interpreted resistivity and induced polarization profiles of survey line PM 3.

Figure 5: Four proposed drilling locations (PDL) were suggested at Mengalum Island, Sabah plotted on Google Earth image overlay with land lots for future development.

A001

Cased hole formation resistivity contribution in water management and production enhancement of mature reservoirs

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Abstract: Due to continuous demand of oil market, it is increasingly important to improve production and increase proven reserves in the most efficient way possible. Hydrocarbon detection and saturation evaluation have long been a problem in cased holes. Determining hydrocarbon and water saturation behind casing plays a major role in reservoir management. Saturation measurements over time are useful for tracking reservoir depletion, enhancing recovery strategies and diagnosing production problems such as water production that is one of the main challenges facing oil and gas producers. It is necessary to manage water production to enhance oil production. In order to identify watered out zones, traditionally thermal decay time logging (TDT) and carbon/oxygen (C/O) logging are used, these tools have shallow depths of investigation and their effective application is limited in low porosity and salinity. With the introduction of cased hole formation resistivity technology (CHFR) a new dimension has been added to cased hole evaluation. A deep reading formation resistivity can now be obtained through steel casing, that means no effect of borehole fluid invasion on measurements as it has been the case with pulsed neutron tools.

In cased hole evaluation, cased hole resistivity finds it utility in two circumstances; as a first resistivity measurement in old and new wells to assess the formation in present conditions, or as a time-lapse technique to describe temporal behaviour of reservoir dynamic and reservoir fluids movements to mainly detect bypassed oil zones and water invaded zones. Six field examples of mature reservoirs suffer from water production problems attributed to different geological and reservoir conditions. In all cases, the remedial workover operations based on the cased hole resistivity results have allowed a significant enhancement of the oil production and the implementation of an optimum field management strategy.

Keywords: Water Management; bypassed oil, CHFR, TDT, workover

A054

Analysis of rare earth elements in soil, rock and concentrate samples by LA-ICP-MS from JMG's experience

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Today, the Inductively Coupled Plasma Mass Spectra (ICP-MS) is one of the standard instruments for rare earth element (REE) analysis in the geosciences. Combination between Laser Ablation (LA) and Inductively Coupled Plasma Mass Spectrometry have become an important trace element microprobe technique, which is widely applied for determination of REE concentrations in geoscientific laboratories. The rare earth element is still a new topic in Malaysia. Department of Mineral and Geoscience Malaysia is the only laboratory that has a modern facility to analyse REE. In the past, the determination of REE in geological samples was a time consuming and expensive task: sample digestion and separation of the REE via ion exchange was required prior to analysis by ICP-AES or ICP-MS. More recently, the methodology has developed whereby REE can be determined in the same whole-rock fusion glass beads which are used for X-ray fluorescence (XRF) analyses and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). Different type of CRM was used to prepare a calibration curve. The samples and standards were introduced as a fusion bead 18 mm in diameter by mixing 0.15 gm sample or standard with 1.50 gm flux (Lithium Metaborate, Lithium Tetraborate and Ammonium Iodide) and fused in an automatic fusion machine.

A024

Petrography of andesite ignimbrite in Temangan, Kelantan

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Volcanic rocks within the area of interest were deposits have been formed in different currents and different concentration of materials. Normally, pyroclastic rock (ignimbrite) is formed through column collapse mechanism which mean by explosive eruption process. The volcanic rocks composed mainly of the matrix part of the outcrop and it composes of ignimbrite as fragments and andesite as matrix. It is very rare for ignimbrite to have andesite as its matrix. This study tries to compare characteristic and analyses petrography of volcanic rock in the Temangan, Kelantan. The objective of this paper is to determine the mineralogical composition of andesite ignimbrite characteristics.

Keywords: structural geology, pyroclastic, petrography

INTRODUCTION

Temangan was located in the northwest part of the Kelantan state. The research study is underlain by metamorphic rocks comprise the Taku Shist, as well as intrusive rock comprise as shown in Figure 1.1. Temangan ignimbrite was exposed in the Temangan area. Based on Aw (1967), the Temangan Ignimbrite forms a prominent ridge trending approximately N-S in central Kelantan. Normally, pyroclastic rock (ignimbrite) is formed through column collapse mechanism which mean by explosive eruption process (Branney *et al*., 2002). Volcanoclastic rocks or pyroclastic deposits can be divided into three types such as fragments of new lava, individual crystal and lithic fragments. Fragments of new lava are range between solid un-vesiculated material to fragments of highly vesiculated lava, individual crystal present of the phenocrysts and lithic fragments are for older rock in the deposit (Jerram & Petford, 2011). However, the andesite ignimbrite showing the ignimbrite exists as the fragments and andesite as the matrix. It is very rare for ignimbrite to have andesite as its matrix. In this study, we present the results of the petrography analyses for andesite ignimbrite characteristics and discuss about the textures of volcanic rocks in Temangan, Kelantan.

METHODOLOGY

The methodology is divided into two part. The primary method is geological mapping (structure geology, geomorphology mapping and stratigraphy) and the result was applied by using the Arc GIS software. Second method is petrography analysis. The petrographic analysis was conducted for mineral identification. XRD will be used for allows an estimate of the relative mineral phase composition of type of rock and the result was interpreted in software Diffrac.EVA.

RESULT AND DISCUSSION

STRUCTURAL ANALYSIS

According to the result of the lineament analysis, joint analysis and fault analysis, suggesting the thrust fault occurred in the study area. The tectonic activity resulting from the compression forces. The direction of the principle's forces is at the maximum $\sigma1$, relatively trending North- West to South West. This activity caused the existing folds minor and change the structure to the drag folds.

PETROGRAPHY ANALYSIS

Using the X-Ray Diffraction (XRD) analysis, the mineral albite, quartz, pyroxene, muscovite, sanidine, berlinite, orthoclase as well as volcanic glass were observed in andesite samples. Viewing of a thin section of the sample through the optical microscope led to identification of plagioclase, quartz, pyroxene, mica and hornblende as shown in Figure 1.2. Meanwhile, albite, ankangite, orthoclase, sanidine, muscovite, berlinite, biotite, graphite, microcline were observed in ignimbrite sample in XRD analysis. From the petrography analyses, quartz, alkali feldspar, biotite, heavy minerals and iron oxide had been identified as shown in Figure 1.3.

CONCLUSION

Volcanic rock is identified by hand specimen based on characteristic of the rock and petrography analysis are been analyses. There are consists many different of mineral composition of volcanic rock due to the phase of crystallise and formation. Based on the hand specimen

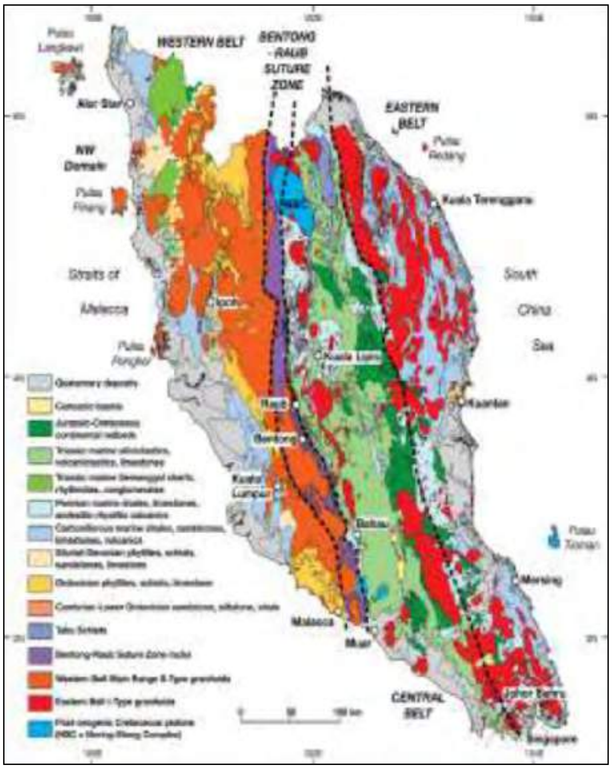

Figure 1.1: Simplified geological map of the Malay Peninsula, modified by (Metcalfe, 2013).

of the volcanic rock in Temangan area, the name of the volcanic rocks is andesitic ignimbrite. However, based on petrography, the volcanic rock is found and are identify as naming of ignimbrite and andesite.

ACKNOWLEDGEMENTS

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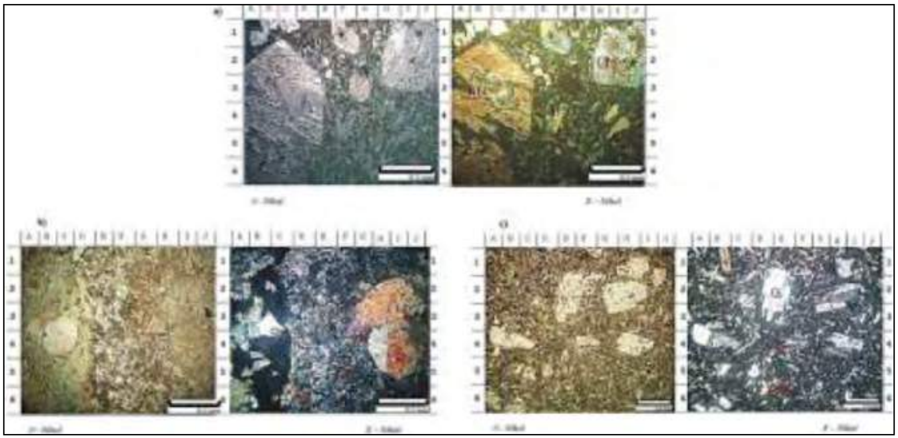

Figure 1.2: Photomicrographs image (a), (b) and (c) shows the aphanitic and porphyritic textures of andesite. (a) Sample 1 contain Quartz 10%, Alkali Feldspar 7% and Plagioclase 83%, (b) Sample 2 contain Quartz 10.38%, Alkali Feldspar 0.56% and Plagioclase 89.05%, (c) Sample 3 contain Quartz 8%, Alkali Feldspar 5% and Plagioclase 86% (XPL, Pl = plagioclase, Cpx = Clinopyroxene, B = Biotite , Hbl = Hornblende, Q = Quartz, A = Alkali Feldspar, M = Matrix).

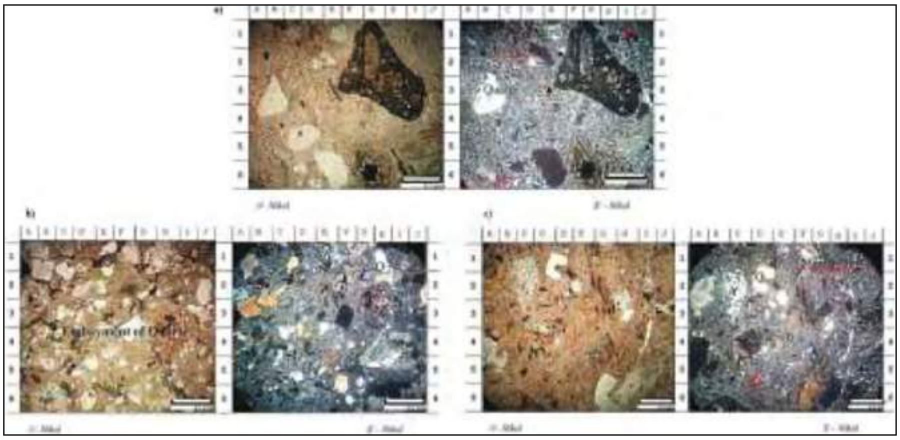

Figure 1.3: Photomicrographs image (a), (b) and (c) show the aphanitic and phenocryst of ignimbrite (Q = quartz, A= Alkali Fledspar, B = Biotite, M = Matrix).

A030

Geochemistry of granites in Gua Musang

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Abstract: Granitoid and some extrusive volcanic rocks are widely exposed in Malaysia, including in Kelantan territory. In Gua Musang area, two different granites are exposed; these are the grey granite with slightly feldsparhyric and the pink granite. One of the groups of elements found to be deposited in association with granitic rocks is rare earth minerals. However, there is no detailed geochemical study on these two type granites in that area. The objective of the study is to investigate the distribution of chemical elements in different types of granitoid rocks in Gua Musang, Kelantan. In order to investigate this observation further and determine the types of granitoid rock in Gua Musang, 12 selected samples of granites (grey and pink) were analysed using X-ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) respectively. The XRF and ICP-MS showed a variation in distribution of elements between two types of granites, grey and pink granites. As granitoid rocks are widely exposed in Malaysia, result of this study would give a basic knowledge to develop a more detail study especially in Rare Earth Elements (REE) potential in different types of granitoid rocks in Malaysia.

A047

Comparative evaluation of microwave assisted acid digestion and Li-borate fusion method for determination of REEs in Malaysian monazite using ICP-MS

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The increasing demand of rare earth elements (REEs) for the wide range of its applications has stimulated a tremendous interest among researchers in the scientific and technological perspective. A detailed knowledge of their distribution and association with the other elements in the natural environment is vital for any geochemical and petrogenetic investigations. However, the similarities in the physio-chemical behavior of REEs tend to make their determination unusually difficult and complicated. The most common analytical techniques used in the determination of REE are ICP-MS, ICP-OES, XRF and NAA. Of all the techniques ICP-MS has become one of the most powerful techniques in REE determinations due to their simpler spectra and lower detection limits than ICP-OES, allowing REE determination by avoiding matrix separation (Zawisza *et al*., 2011). Despite spectral interferences being one of the problems in ICP-MS analysis, they can be resolved by several means, including high resolution, reaction or collision cells, and separation as well as by mathematical correction (Date & Gray, 1985).

Sample preparation and development of newer methods have now widened as a prospective area of research interest. Despite a considerable number of new studies on sample introduction techniques in ICP-MS applications, especially in the analysis of geological samples, solution nebulization remains the preferred method. Hence, for the majority of geochemical samples, dissolution is a prerequisite for routine analysis. The methods that are commonly used for dissolving samples for metals analysis are digestion in an open flask, digestion in a pressurized, sealed container, and microwave assisted decomposition (Mitra, 2004). Recently, however, methods employing microwave energy as a means of heating for effective decomposition, especially for geological samples have been explored (Navarro *et al*., 2008, Balaram & Rao, 2003).

In this study, an attempt has been made to explore microwave assisted acid digestion process as a potential sample preparation method for ICP-MS analysis of determining the REEs in Malaysian monazite. In the microwave digestion method, the sample of monazite is digested in a combination of acids such as H_2SO_4, HNO_3, and HF using a microwave digester (MARS 6 Microwave Digestion System, CEM) programmed to run at 270ºC for 30 minutes. Boric acid was added to complex with the residual HF as a neutralizer. Then the resulting sample was diluted prior to analysis using ICP-MS (Perkin Elmer ICP-MS Nexion 300). For reasons of comparative evaluation, the standard Lithium metaborate/ tetraborate flux fusion digestion method was also performed in this study, wherein digested samples were prepared using a flux of lithium metaborate and lithium tetraborate and fused in an induction furnace. The molten melt is immediately poured into a solution of 5% nitric acid containing an internal standard and mixed continuously until completely dissolved (~30 minutes), and the dissolved solution is diluted prior to analysis.

From ICP-MS analysis in Figure 1, the ICP-MS for the microwave digested sample and Lithium tetraborate/ metaborate fused sample exhibit parallel trends of composition. Overall, Malaysian monazite composed of about 70 wt. % of REEs and traces of other elements. On evaluating the two methods of dissolution of monazite for the ICP analysis, the $Li_2B_4O_7$ technique was usually considered to be a more reliable for REE based mineral geochemistry studies as a purely acid based microwave digestion would only be a partial analysis. From Figure 1, it can be noticed that the weight percent of the major REE's are close to each other for both the methods, except for element P and Nd, which could be due to matrix effects. Based on ICP results of both the results, trace elements were detected, however, to obtain accurate results for trace elements in samples, different dissolution methods need to be employed according to the element required. While the major REEs had varying success for the analysis of Malaysian monazite in this study for both of the dissolution procedures, trace elements were exhibiting a positive and negative bias. A major problem for trace element determinations could be due to the contamination of chemicals and contamination during sample preparation. A noteworthy contradiction of the

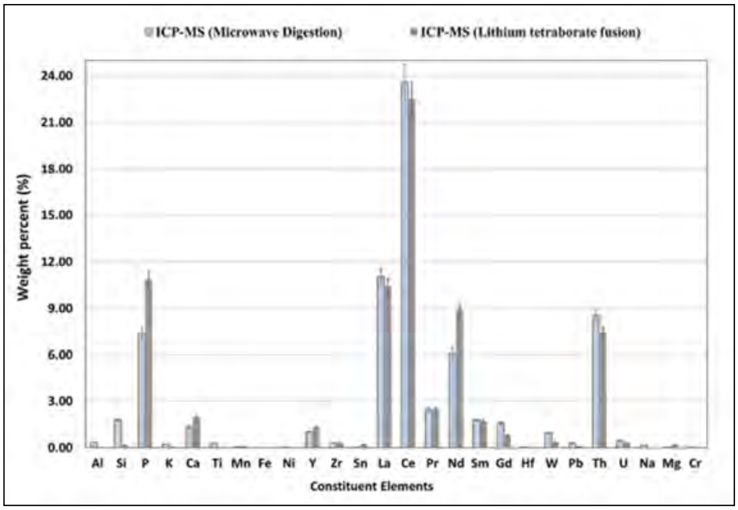

Figure 1: Comparison of wet chemical analysis (ICP-MS) for microwave digested and Lithium tetraborate fused-digested Malaysian monazite.

Table 1: Comparison of chemical composition of monazite using different sample preparation and characterization methods. (N.D-not detected).

Elements	Weight percent of elements (%)	
	ICP-MS (Microwave Digestion)	ICP-MS (Lithium tetraborate fusion)
Al	0.34	0.03
Si	1.82	0.15
P	7.41	10.81
K	0.23	0.02
Ca	1.35	1.96
Ti	0.27	0.01
Mn	0.07	0.07
Fe	0.00	0.00
Ni	0.01	0.00
Y	1.04	1.34
Zr	0.31	0.30
Sn	0.00	0.20
La	11.03	10.40
Ce	23.55	22.50
Pr	2.45	2.44
Nd	6.15	8.88
Sm	1.82	1.69
Gd	1.58	0.80
Hf	0.00	0.01
W	0.97	0.34
Pb	0.29	0.06
Th	8.55	7.43
U	0.46	0.29
Na	0.18	0.00
Mg	0.03	0.21
Trace elements (*Cu, Ag, Ba, Bi, Eu, Tb, Dy, Ho, Er, Tm, Yb, Lu, Ta, Tl, Rh, Pd*)	N.D	~0.8

composition of P, Si and Nd among the two methods could also be noticed in Table 1.

In overall, for analytical purposes, flux fusions were recommended over acid digestions for quick rapid analyses because acid digestions do not allow for the analysis of Si, due to the volatilization of Si in the presence of HF and may not yield usable results for refractory elements (e.g., Ti, Cr, and Zr) hosted in minerals that are difficult to dissolve (respectively, rutile, chromite, and zircon). On the other hand, because of the addition of matrix, flux fusion also possibly trades off the analysis of some key trace metals (e.g., Ni, V, Cr, Zn, and REEs) due to the consequent arbitrary increase in procedural detection limit.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support from Universiti Sains Malaysia (USM) Fellowship Award. This work was financially supported by USM and Ministry of Higher Education (MOHE) of Malaysia through the following research grants: Fundamental Research Grant Schemes (FRGS) (No. 203/PBAHAN/6071364) and (No. 203/PBAHAN/6071402).

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A061

Hydrogeochemical characteristics of groundwater in coastal zone of Terengganu River Basin

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INTRODUCTION

Saltwater intrusion is one of the main threating factors for the quality of groundwater resources in the coastal aquifer. The coastal aquifer is a dynamic closed-system that depends on various factors such as water recharge, tides, coastal morphology and the hydrodynamics of the coastal area (Pulido-Velazquez *et al.*, 2018; Mahmoodzadeh & Karamouz, 2019; Xiao *et al.*, 2019). The combined factors of water recharge and coastal hydrodynamic can induce hydraulic gradient that may change freshwater and saltwater interfaces. Therefore, hydrogeochemical characteristics of groundwater in different aquifers in the coastal zone are crucial to determine the potential saltwater intrusion occurrences.

MATERIAL AND METHOD

Water samples were collected from a shallow and deep aquifer in Terengganu River Basin. All samples were collected using acid-washed low-density polyethylene (LDPE) bottles. In the laboratory, the acidified samples were filtered through a 0.2 µm cellulose filter and then analyzed for cationic species. Chemical elements such as Magnesium, Lead, Zink and Aluminium were measured using the Inductively Coupled Plasma Optical Emission Spectrometer (ICP–OES, PerkinElmer) at the Universiti Malaysia Terengganu. Ion Chromatography was used to measure anion species such as Nitrate, Phosphorous, Chloride, and Fluoride.

RESULT AND DISCUSSION

Based on the WQI classification the majority of the samples are falling under excellent to good water category and suitable for drinking water purposes. The order of the distribution of the major cation and anion is as follows $Na^{+}>Mg^{2+}>Ca^{2+}>K^{+} = Cl^{-}>HCO_3^{-} >CO_3^{-} >SO_4^{2-}$

The result reveals that the groundwater is characterized by fresh to brackish water type. The piper diagram shows that groundwater in the study area is Na–HCO and mixed Ca-HCO type. In addition, the result shows that the coastal aquifer is characterized by high salinity and brackish water type. A high salinity content was observed in the shallow aquifer at Pulau Ketam which located 2 km from the shoreline. In addition, the deep aquifer is designated as $Na\text{-}HCO_3$ water type and classifies as good water.

CONCLUSION

In summary, the coastal aquifer in Kuala Terengganu River Basin is influenced by saltwater water intrusion phenomenon. The study of hydrogeochemical of

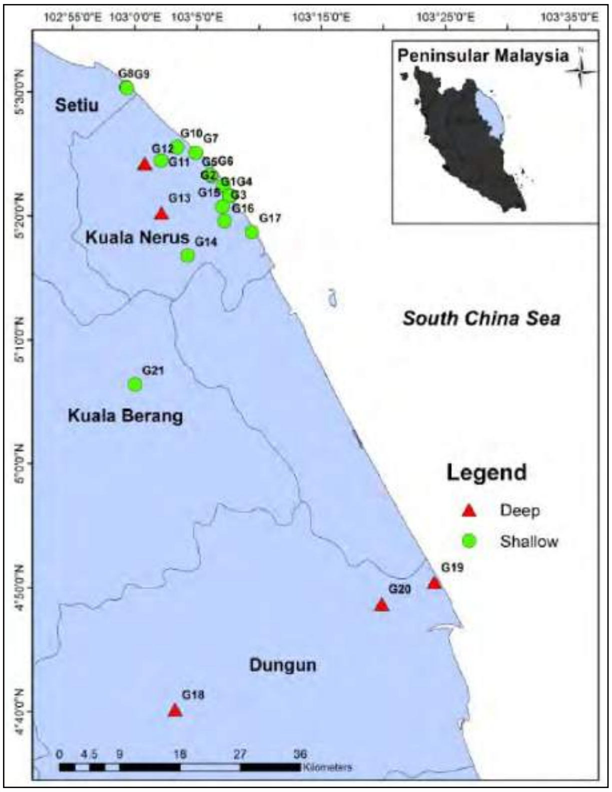

Figure 3.1: Location of the sampling stations around Terengganu.

groundwater in the coastal area provides a good indicator of saltwater intrusion phenomenon. Mitigation plan of saltwater intrusion is needed to ensure the sustainability freshwater resources in Terengganu.

ACKNOWLEDGMENTS

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A065

Zircon U-Pb and Hf isotope constraints on the Neogene Semporna Peninsula volcanic rocks and its tectonic implications

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The Semporna Peninsula volcanic rocks is part of volcanic activity that generated during the Miocene subduction. Here we report a study of zircon U-Pb geochronology and Lu-Hf zircon LA-MS-ICP-MS isotope geochemistry of intermediate and felsic volcanic rocks from Semporna Peninsula, Sabah. Zircon U-Pb geochronology from Semporna dacite and Tawau dacite yielded weighted mean $^{206}Pb/238U$ ages of 12.46 ± 0.28 Ma and 9.26 ± 0.26 Ma, respectively. Semporna andesite yielded weighted mean $^{206}Pb/^{238}U$ ages of 10.49 ± 0.11 Ma. Initial $\varepsilon_{Hf}(t)$ value exhibit positive to highly negative (+16.7 to -54.8) value for the zircons indicating heterogeneous sources for the magmatic fluid. Zircon U-Pb and Lu-Hf data suggest that episodic of depleted mantle with crustal growth from Precambrian until Cenozoic were involved during formation of Semporna Peninsula volcanic rocks.

Keywords: Semporna Peninsula, zircon U-Pb geochronology, Hf isotope, magma source, volcanic rocks

INTRODUCTION

The subduction generated volcanic activity along the Sulu Ridge from Zamboanga Peninsula to southern Sabah in Early Miocene to Late Miocene (Rangin and Silver, 1991; Ali *et al.*, 2018) and its extended until Pleistocene in southern Sabah (Kirk, 1962; Leong, 1987; Takashima *et al.*, 2005). In this study, we present the new in situ zircon U-Pb geochronology and Lu-Hf isotope zircon geochemistry from Semporna Peninsula andesitic and dacitic rocks in order to constrain the timing of formation and the source rocks.

METHODS

Sixty nine zircon grains were analyzed for U-Pb studies and 30 zircon grains for Lu- Hf isotopes from 3 samples of volcanic rocks (1 sample andesite, 11L3; 2 samples dacite, 8L6 and 11L1). Zircon U-Th-Pb geochronology was undertaken on LA-ICP-isotopic analysis utilized LA-MC-ICP-MS at the Institute of Earth Science, Academia Sinica, Taiwan.

RESULTS AND DISCUSSION

Th/U ratios from sample 8L6 (Tawau dacite) suggested a magmatic origin. The zircon grains yield a weighted mean $^{206}Pb/^{238}U$ age of 9.26 ± 0.26 Ma which representing the formation age of Tawau dacite. Zircon grains display positive $\varepsilon_{Hf}(t)$ value (5.7 to 9.5) and TDM2 model ages range from 0.4 Ga to 0.6 Ga, suggesting that their host magma was probably derived from Neoproterozoic to Middle Paleozoic juvenile crust.

The sample 11L1 (Semporna dacite) indicates a magmatic origin based on the Th/U ratios. A total of 17 analyses yield a weighted mean $^{206}Pb/^{238}U$ age of 12.46 ± 0.28 Ma which represents the formation age of Semporna dacite. Hf isotope analyses yielded highly positive εHf(t) value ranging from +9.1 to +16.7. TDM2 model ages range from 0.6 Ga to 16 Ma. This indicates that the parental magmas originated from a mixture of older and younger juvenile crust of Cambrian to Recent age.

Th/U ratios of Semporna andesite (sample 11L3) shows zircon grains are all magmatic in origin. Total of 15 analyses yield a weighted mean $^{206}Pb/^{238}U$ age of 10.49 ± 0.11 Ma which symbolized the formation age of Semporna andesite. Hf isotope results give yielded negative $\varepsilon_{Hf}(t)$ value values from -54.8 to -7.0 and the calculated TDM2 model ages range from 3.0 Ga to 4.3 Ga. This suggests that the host magma originated from the Hadean crustal (source) or Hadean crust by reworking of Mesoarchean crustal material.

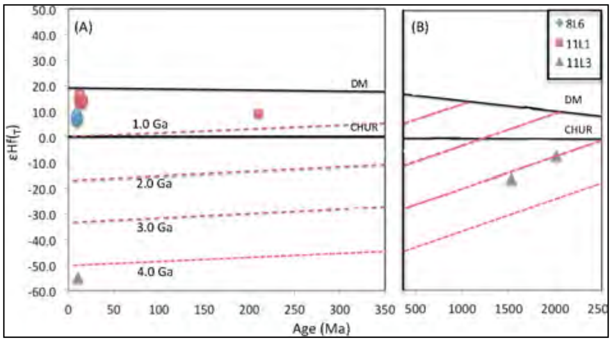

Figure 1: Plot of $\varepsilon_{Hf}(t)$ value versus U-Pb ages. (a) Miocene Semporna Peninsula volcanic rocks and Late Triassic inherited zircon of Semporna Peninsula volcanic rocks. (b) Cambrian to Proterozoic inherited zircon of Semporna Peninsula volcanic rocks. The red dash lines are representative of calculated TDM2 model ages using an average upper crustal value Lu/Hf ratio 0.015 (Griffin *et al.*, 2002).

CONCLUSION

1. Episodic magmatism of the intermediate and felsic volcanic rocks of Semporna Peninsula were formed during Middle Miocene to Late Miocene.

2. The negative to positive $\varepsilon_{Hf}(t)$ value of zircons in Semporna Peninsula volcanic rocks suggested the parental magma was derived from a mantle source and contaminated by crustal materials.

3. Highly negative $\varepsilon_{Hf}(t)$ value -54.8 with TDM2 model ages 4.3 Ga, all suggesting a Hadean felsic continental crust in Northeastern Borneo.

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A070

Combination of in tank aeration and ozonation groundwater treatment system in Kg. Melai, Tasik Chini, Pekan, Pahang

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Abstract: Effectiveness of two combination of groundwater treatment implemented at remote area of Kg. Melai, Tasik Chini, Pahang water treatment plant supplying two villages (Kg. Melai 1 and Kg. Melai 2) was being assessed. Aeration and ozonation coupled are the best technology and proven for more than a decade to remove iron, manganese and other unwanted insoluble material. This treatment system was generated by solar system with two steps of processes (pre and post treatment) in a 3,000-litre tank. Iron and manganese are the common mineral found in groundwater and can be removed by converting unfilterable ferrous iron to filterable ferric iron by mixing with air. Air is a powerful oxidizer of both iron and hydrogen sulphide. Aeration is usually used as a pre-treatment in the process of removing iron and hydrogen sulphide from water. Aeration is produced by injecting high pressure of water into tank that brings water and air in close contact in order to remove dissolved gases and oxidizes dissolved metals such as iron and other elements. Iron removal is based on the precipitation of dissolved iron (Fe^{2+}) into its oxidized form (Fe^{3+}), as $Fe(OH)_3$ or Fe_2O_3. In this study, ozone is being used to remove odour, colour and taste. Concentration of 30mg/L of ozone was applied into the tank. The post-treatment for the groundwater treatment is filtration. Ozone will oxidize iron and manganese to form insoluble particulates that can easily be filtered from the water. Iron and manganese will build up on the filter over time and must be removed. A back-washable filter is used and recommended for these purposes. Sand filters are used for iron and manganese removal for post-treatment. Iron and manganese reduced by almost 45% each. Ozone improve the unwanted odour and colour to fresh and clear water. The treatment process consumes low energy power and cost effective.

Keywords: Aeration, ozone, iron and manganese, filtration and groundwater

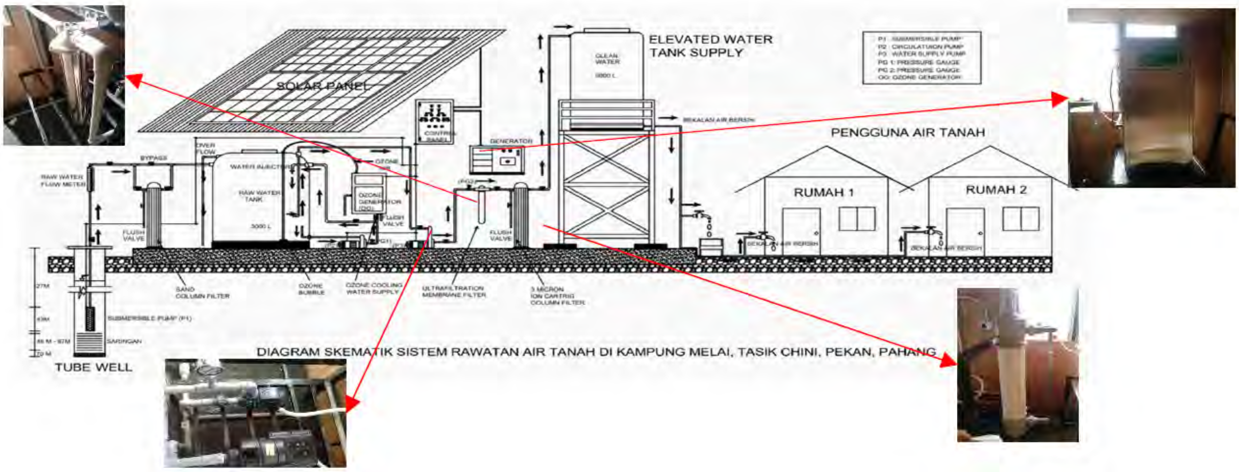

Figure 1: Schematic diagram of the groundwater treatment plant system including solar system and water transferring.

A072

Groundwater quality assessment in small island aquifer, Mabul Island, Sabah

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Abstract: Mabul Island depend mostly on groundwater as a major source of water supply for domestic and tourism industry purposes. There was no inflow from river and the highest level was 4.2 meter above mean sea level. Rainwater is the only source of recharging the groundwater to sustain the quality. Over-abstraction of fresh groundwater lens leads to saltwater intrusion and deterioration of its quality. This study aimed to assess and understand the groundwater characteristics in the fragile aquifer of the island. In order to assess this issue, a groundwater sampling was collected 3 times between March 2018 to March 2019 from 15 dug wells scatter in the island. The geochemistry concentration of chloride and electrical conductivity usually used to determine saltwater intrusion. This study focuses on the assessment of freshwater lens mixing and salinization. The mixing fresh groundwater lens situated from 2.5 to 2.9-meter depth below ground level (bill) which quality defer from 1,218 to 23,170 µS. Depth below than 4 meters from ground level is seawater. Most of the pumping came from the tourism industry and was not used for a drinking purpose. Most of the groundwater was identified as saline water and only a part of the island shows slightly saline water based on the ionic strength and chloride concentration. The groundwater lens indicated that the island's coastal aquifer has been encroached by seawater.

Keywords: Saltwater intrusion, groundwater lens, geochemistry, chloride, ionic strength

Hydrochemical evolution, from Ca to Na rich. Groundwater type, from Ca-HCO_3 to NaCl in Mabul Island (left). Assessment scheme for seawater intrusion based on ionic strength against Cl concentration (right).

A073

Using the down the borehole camera technology for groundwater inspection in Selangor, Malaysia

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Abstract: The understanding of the aquifer physical characteristics such as fractured rocks were very unique and challenges when attempting to characterize the movement of groundwater and transport of contaminants. Using the Down the borehole video Camera Technology were used to obtain from the upper surface to the bottom and to support environmental site investigations. The camera produced real-time recordable video as it was lowered into a borehole and was used to investigate borehole more than two inches in diameter and up to 300 m deep. The present study in Selangor, the video camera will be used to determine borehole casing integrity, to identify constructions or casing damage, to locate and observe groundwater producing intervals. During this study, down borehole camera helpful to determine the construction of borehole for which construction logs or records are not available. In conclusion, the camera was also useful for locating groundwater producing fractures zone in selected borehole in Selangor.

Keywords: Groundwater, down well camera, bore hole, well casing, and fractured zone

A076

Carboniferous ammonoids from the Kubang Pasu Formation, Hutan Aji, Perlis

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The Carboniferous age Chepor Member of the Kubang Pasu Formation exposed in Perlis comprises thick mudstone with interbedded laminated and cross-stratified sandstones and associated dropstones (Amir Hassan *et al*., 2014). The mudstone contains a rich marine invertebrate fossil assemblage, which includes rugose and tabulate corals, brachiopods, bivalves, gastropods, trilobites, crinoids and ammonoids. Many of brachiopod and trilobite taxa have been systematically described (e.g. Hamada, 1968, 1969; Kobayashi & Hamada, 1973). Except for Amir Hassan *et al*. (2014), there are no other detailed descriptions of the ammonoids present in the Chepor Member.

A recent fieldtrip to Hutan Aji, Perlis, has uncovered numerous ammonoid fossils, with well- preserved sutures, in the mudstone of the Chepor Member. The ammonoids are concentrated in cm- to dm- thick shelly horizons within the mudstone, which may represent periods of non-deposition and/or reworked storm or current deposits.

Based on the suture pattern, one new taxon previously not reported from the unit was identified: *Delepinoceras* sp. The taxon is an index genus for the Upper Serpukhovian (Mississippian). The ammonoids *Goniatites* sp. and *Praedaraelites tuntungensis* previously described in Amir Hassan *et al*. (2014) also give a Mississippian age. This is also consistent with interpreted ages from cyrtosymbolid trilobites (Kobayashi & Hamada, 1973).

Figure 1: Photograph and suture line drawing of *Delepinoceras* sp. from the Chepor Member, Kubang Pasu Formation of Hutan Aji, Perlis.

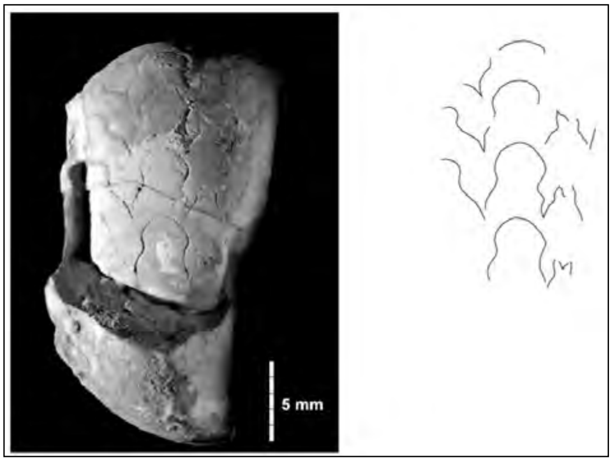

Figure 2: Photograph and suture line drawing of juvenile *Delepinoceras* sp. from the Chepor Member, Kubang Pasu Formation of Hutan Aji, Perlis.

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A084

Major and trace elemental analysis of the Belata black shales in Peninsular Malaysia

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INTRODUCTION

The Western Belt of Peninsular Malaysia (Figure 1) is known for its mineralization (Balamurugan, 1991). During the 19th century tin mining was one of the leading industries in Malaysia, which have contributed a lot in the socio-economic development of the country until the tin crisis of 1985 (Balamurugan, 1991). Owing to the new concerns on oil and gas production, search for economic metals have been lessened in the Peninsular. However, exploration and development of economic metals hosted in the vast distribution of Palaeozoic rocks scattered in Peninsular may contribute to the country's economy especially as the production of hydrocarbon declines

Metal concentrations within black shales are enriched because of accumulations of biogenous or hydrogenous material. Black shales are formed in an oxygen-deficient environment and preserve in this type of environment over certain geologic period to sustain preservation of the organic matter deposited in them. Organic rich black shales mostly serve as metallic ore deposits as they can act as traps for metal accumulation actively or through post- depositional alterations (Boggs, 2006). The Belata Formation occupies the southern part of Tanjung Malim and has black shale exposures with little information on their metal content.

The aim of this study is focused on determining the diversity, abundance and distribution of the metals in the black shale beds of the Belata Formation. It also discusses further on the environmental conditions that prevailed during deposition of the metals in the black shales.

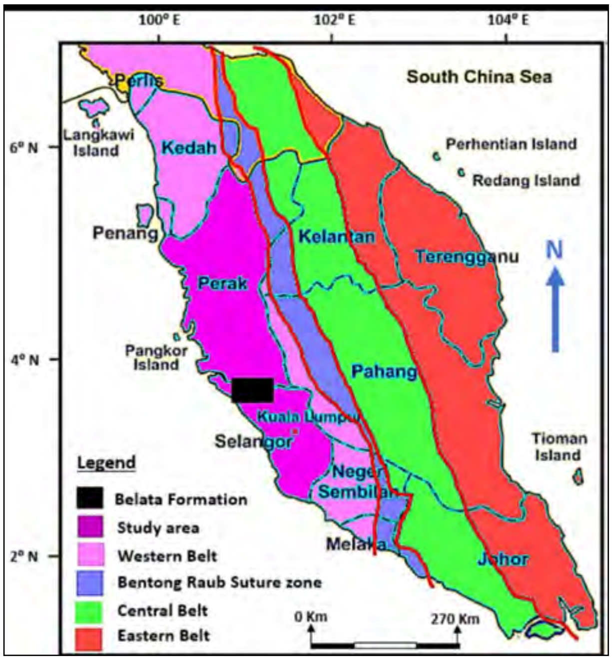

Figure 1: Location map of the study area in the Peninsular (modified after Metcalfe (2013)).

METHODS

XRF analysis of black shales samples was conducted to measure trace and major element composition of the black shales. These geochemical proxies are further employed to analyse the accumulation, enrichment, and the trend of distribution of the metals in order to evaluate and determine their potential for extraction. A detailed explanation of metals in outcrops distribution is provided in Figure 2.

RESULTS

Significant enrichment above 100ppm were observed for Ba, Rb, Zn, W, P, As, Ni, Co, Sr, Cr, Ga, Mo, V, Zr, Ge, Se, Pb and Nb with S showing the highest concentration of about 10,930ppm (Table 1). Anomalous values of enrichment are seen in the concentrations of copper, sulphur, barium and zirconium, which is above the concentration of the threshold values proposed by Green (1995). Metal enrichment ranges from outcrop to outcrop.

DISCUSSIONS

Elements such as Cu and S could be an economically explorable resource. The geochemical results show enrichment of elements in the black shale as compared

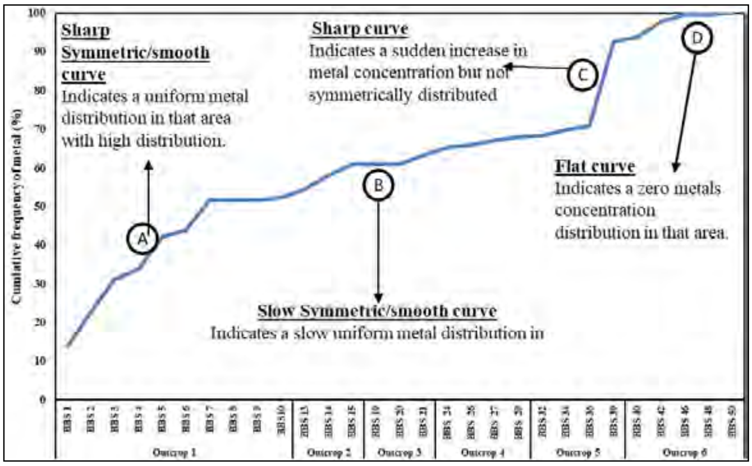

Figure 2: The structured trend of the distribution of metals as represented in each outcrop.

Table 1: Concentration of metals within the Belata Black Shale.

No of Sample		Cu (ppm)	S (ppm)	Ba (ppm)	Rb (ppm)	Zn (ppm)	W (ppm)	P (ppm)	As (ppm)	Ni (ppm)	Co (ppm)	Sr (ppm)	Cr (ppm)	Ga (ppm)	Mo (ppm)	V (ppm)	Zr (ppm)	Ge (ppm)	Se (ppm)	Pb (ppm)	Nb (ppm)
Max	29	600	69200	5500	1700	718	3600	14800	400	500	2600	939	647	300	300	3200	2900	18	200	300	200
Min	29	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg.	29	227.69	10930	2951.38	718.48	138.55	706.90	1782.76	116.38	143.72	103.45	196.00	153.34	64.70	18.14	499.72	1093.93	0.62	6.90	10.34	38.55
Total	29	6603	316970	85590	20836	4018	20500	51700	3375	4168	3000	5684	4447	1876	526	14492	31724	18	200	300	1118
UCC	29	25	-	550	112	71	2	700	1.5	44	17	350	83	17	1.5	107	190	16.	50	-	12
Green, 1959	29	70	900	640	280	80	2	900	2	100	18	350	117	26	1.7	90	170	2	0.01	16	20

*Min- Minimum, *Max- Maximum, *Avg- Average, *UCC- Upper Continental Crust

to threshold values. Generally, outcrops 4, 5 and 6 are more mineralised in the trace elements or metals as compared to outcrop 1, 2 and 3. The metals accumulated through precipitation from seawater and adsorption on the surfaces of suspended sediment particles. The trend of distribution of these metals shows their accumulation and viability to be a mineable product. Fieldwork on the exposed black shale outcrops of the Belata Formation exposed a water pond which was serving previously as a local dug-out mine. Various workers have found and explored metal concentrations in a lot of formations including shales (Lewan & Maynard, 1982; Brumsack, 2006). As such, the findings of this research demonstrate the high potential of metal exploration and mining for the Belata formation and in similar stratigraphic intervals of onshore Peninsular Malaysia.

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A090

Study of Ouw natural clay-TiO_2 composites synthesis method for application to Linear Alkylbenzene Sulfonat surfactant degradation reactions

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The study of the method of making Ouw natural clay-TiO_2 composites and photocatalytic applications on Linear Alkylbenzene Sulfonate surfactant degradation reactions has been done. The methods used are impregnation and pilarization. The study of calcination temperature was also carried out. The variations in temperature that are used are 200, 250 and 300°C. Characterization was done using X-ray diffraction. The characterization results showed that the pilarization method at a temperature of 250°C had the highest number of peak of montmorillonite-TiO_2 phase whereas the highest number of peak of impregnation phase method was obtained at the application of 200°C calcination temperature. The LAO-TiO_2 composite method of pilarization at calcination temperature of 250°C successfully degraded Linear Alkylbenzene Sulfonate surfactant by 89.2% with adsorption capacity of 0.357 mg/g while LAO-TiO_2 composite method of impregnation at calcination temperature of 200°C degraded Linear Alkylbenzene Sulfonate surfactant by 80.75% with adsorption capacity of 0.323 mg/g.

A094

Evaluation of water physicochemical parameters on acid mine drainage impact surrounding Tasik Puteri Area, Terengganu

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INTRODUCTION

Acid mine drainage (AMD) refers to effluent from the mine that is characterized by its low pH-value, acidic and high concentrations of heavy metals (Bwapwa, 2018). It is a serious environmental concern as a result of sulphide minerals such as pyrite (FeS_2) expose to air and water. High level of dissolved iron which exists in reduced form (Fe^{2+}) or in oxidized form (Fe^{3+}) is often associated with AMD. Sulphide minerals oxidize and discharge dissolved ferrous ion and acidity into water which consequently releases other metal ions such as Fe^{3+}, Al^{2+}, Mn^{+} and Cu^{2+} which are not biodegradable (Norinsafrina & Shamsul Kamal, 2014). This study aims to analyze the influence of water physicochemical parameters: pH, conductivity (EC) and temperature on heavy metals concentration surrounding Tasik Puteri at Bukit Besi, Dungun Terengganu. Tasik Puteri is a man-made lake created from the legacy of this former mining activities (Khairul Azlam & Sazali, 2018; Anon, 2016). This study provides an analysis of water quality and evaluate the severity of AMD problem throughout the study area. Variables such as pH, electrical conductivity (EC) and temperature have been classified so that appropriate available water treatment can be suggested to suit water quality standard and legislation compliance.

SAMPLING AND ANALYSIS

A total of 23 water samples surrounding Tasik Puteri were collected by grab sampling method. In-situ analysis was carried out using Thermo Scientific Orion Star A329 portable multiparameter meter and Hach TSS Portable Hand-held meter. Meanwhile, metal analysis was conducted using Perkin Elmer Inductively-Coupled Plasma-Optical Emission Spectrometry (ICP-OES) to measure concentration of selected metal elements. All the data were analyze using Statistical Package for the Social Sciences (SPSS V.16) Software.

RESULTS AND DISCUSSIONS

Data obtained from the analyses were analyzed using SPSS V.16 Software to classify range of pH, EC and temperature. Five (5) classes of pH, three (3) classes of EC and two (2) classes of temperature have been determined and correlated with 8 major heavy metals which are Fe, Ni, Al, Cd, Pb, Se, Cu and Zn. The pH classes are tabulated from acidic to neutral region (strongly acidic, acidic, moderate acidic, mildly acidic and low acidic-neutral), EC classes are tabulated from low to high region (low, moderate and high EC) while temperature classes are tabulated from low and high with the associated major heavy metals. The analysis results were compared with 3 parameters, i.e. pH, EC and temperature. Analysis result shows that there were 3 elements (Cu, Al and Fe) did not fulfil standard allowable limit of Schedule (Regulation 4), Parameter and Limit of Effluent, Mineral Development (Effluent) Regulations 2016, Mineral Development Act, 1994.

(a) pH

As shown in Figure 1(a), (b) and (c), maximum value linear line decreased steeply for Al and Fe, whereas the line increased gradually for Cu. Figure 1 also illustrates all minimum linear line were almost plateau although for Al, the line displays a small decrement. Graph of Al shows that the higher pH range lower the Al value. For Cu, the value increase at pH range 2.73-2.891. Then, it started to reduce at pH range 2.892 to 5.96.

However, it increased at pH more than 5.96. Meanwhile, the range for Fe shows the ununiformed of Fe value according to increment of pH range. Favas *et al.* (2016) stated that heavy metals are the important component as high concentrations of metals wills lead to AMD. They also mentioned that Al and Fe are considered as significant characteristic of AMD for numerous reasons such as a similar trend in creating oxy-hydroxides and oxy-hydroxy-sulphates in "acid-neutralized" environments. Furthermore, other metals concentrations could be affected by them and this could indirectly affect the pH of the effluent. Overall conditions show that in all pH range, concentration of Al, Cu and Fe could increase above the allowable standard limit of 10, 0.2 and 1 mg/L.

b) Temperature

During the whole analysis for EC as shown in Figure 2(a), (b) and (c), Al and Fe increased progressively with increasing of temperature. At low-temperature range (T = 25.0°C–26.5°C), Cu concentration range is 0.001–2.5295 mg/L, while Fe concentration range is 0.049–74.115 mg/L. At high temperature range (T = 26.6°C–37.1°C), Cu concentration range is 0.0015–2.61 mg/L, while Fe concentration range is 0.055–145.25 mg/L. A different behaviour compared with Al can be observed in Figure 3. At low temperature range, the maximum Al concentration is 49.05 mg/L and it decreased to 30.39 mg/L at high temperature range. In the meantime, the minimum Al concentration increased along with the temperature. Overall condition shows that in both temperature ranges, concentration of Al, Cu and Fe could increase above the allowable standard limit of 10, 0.2 and 1 mg/L. The results have shown the indication of different metals release rate at different temperature range and the correlation of metals and the temperature evolution (Li *et al*., 2013).

c) Electrical Conductivity (EC)

Referring to Figure 3(a), (b) and (c), Al and Fe increased gradually with increasing of EC except for Cu. In the meantime, Cu concentration was decreased at EC range of 77.93–784.32, but it increased according to high EC range. The results indicated high concentrations of heavy metals will lead to high EC, similar to study conducted by Favas *et al*. (2016). Overall condition shows that in all range of EC, concentration of Al, Cu and Fe could increase above the allowable standard limit of 10, 0.2 and 1 mg/L.

CONCLUSION

Analysis using SPSS Software has determined range of pH, EC and temperature and the ranges were corresponded with 8 major heavy metals which are Fe, Ni, Al, Cd, Pb, Se, Cu and Zn. The pH classes are tabulated from acidic to neutral region, EC classes are tabulated from low to high region while temperature classes are tabulated from low and high with the associated major heavy metals. There were 3 out of 8 elements did not fulfil the allowable standard limit for concentrations, which are Cu, Fe and Al. This classification could be improved by more data available for analysis. Overall, Tasik Puteri can be considered as a potential AMD generation area. Appropriate treatment could be suggested due to further investigation and analysis.

ACKNOWLEDGEMENTS

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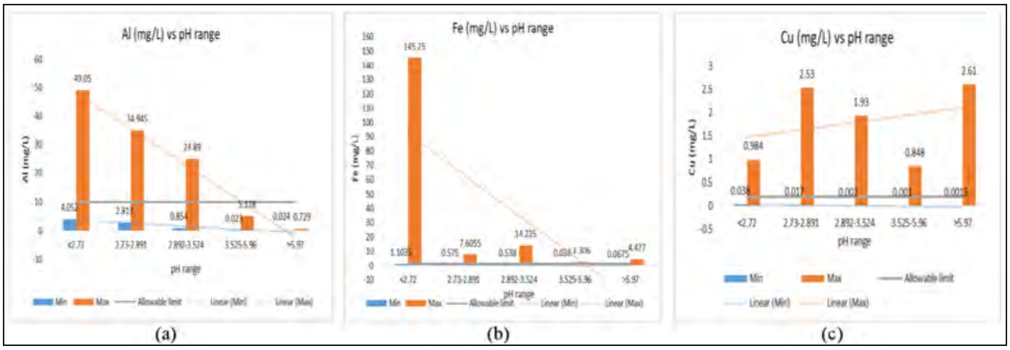

Figure 1(a), (b) and (c): Graphs of minimum and maximum values of Al, Cu and Fe vs. pH range.

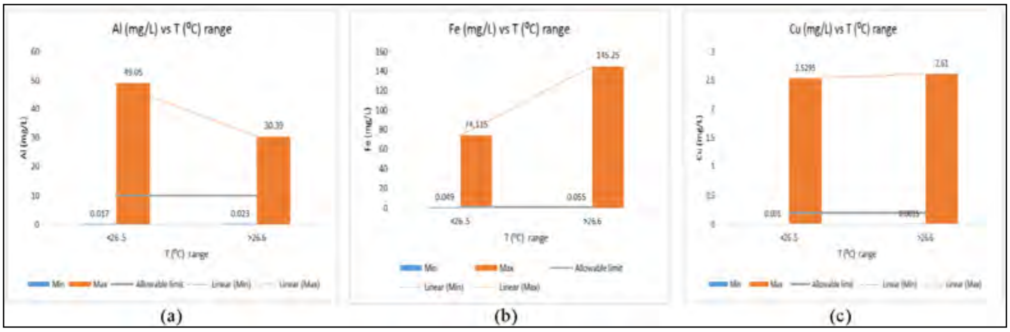

Figure 2(a), (b) and (c): Graphs of minimum and maximum values of Al, Cu and Fe vs. Temperature range.

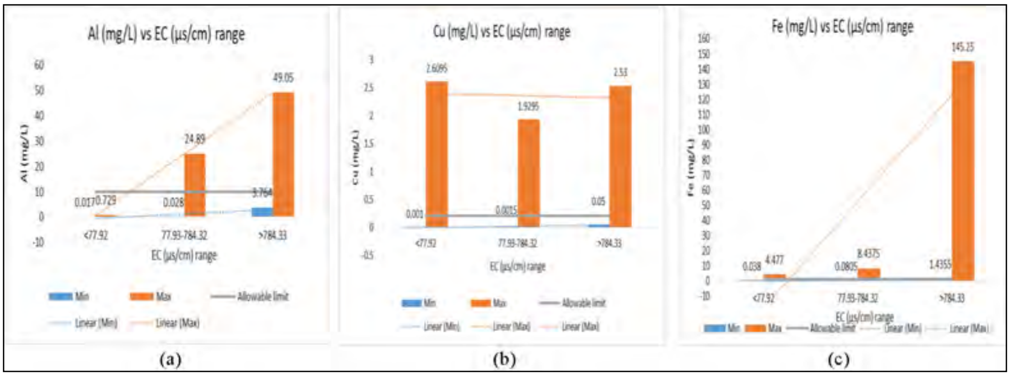

Figure 3(a), (b) and (c): Graphs of minimum and maximum values of Al, Cu and Fe vs. EC range.

A097

Groundwater hydrogeochemistry assessment in Langat River Basin, Malaysia

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Abstract: The industrial activity, population growth, urbanization, and extensive farming have led to increased demand for water to meet the needs of these sectors. This is because the industrial sector is a major contributor to Selangor's economic growth. In order to meet the increasing demands for the manufacturing sector, groundwater has been extensively and conjunctively used with surface water. This has led to increasing groundwater dependence day by day which raises concerns that it may contributing to the deterioration of water quality and negatively impact to the environment. This study was carried out to assess the groundwater hydrogeochemical characteristics in Langat River Basin. A total of 15 groundwater samples were collected and analyzed for various parameters. The results showed pH values ranging from 4.40-7.70 which slightly acidic to alkaline. The sequences of major cations and anions were $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ and $HCO_3^- > Cl^- > SO_4^{2-} > CO_3^{2-}$. The main facies are Na-HCO_3, and Na-Cl water types while the remaining are Ca-HCO_3, Mg-HCO_3 and Na-SO_4, respectively. The elevated values of electrical conductivity (EC) and chloride (Cl^-) in a few locations are believed to be due to remnant of ancient seawater intrusion. It can be concluded that groundwater quality in Langat River Basin is mainly controlled by natural processes and anthropogenic activities, respectively. The findings will help the local authorities and stakeholders to comprehend the groundwater system behaviour, and help managing groundwater resource sustainably.

Keywords: Hydrogeochemical, sequences of major ions, groundwater facies, seawater intrusion

A112

Molecular and trace element geochemistry of the shales of Patti Formation in the Southern Bida basin, Nigeria

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Abstract: A combined investigation of molecular and trace elements geochemistry was carried out on the Campano-Maastrichtian shales of Patti Formation in southern Bida basin, Nigeria to define organic source input, depositional environments and thermal maturity of the shales.

The dark grey shales with parallel lamination occur mostly in nodular form. The shales are associated with siltstones, claystones and concretionary ironstones. The biomarkers of the shales extracts are characterised by short to middle chain n-alkanes, CPI values of 0.38-1.47, Pr/nC_{17} and Ph/nC_{18} values of 0.34-0.62 and 0.32-0.51. Pr/Ph ratio of 0.53-2.84, C_{31}/C_{30} hopane values of 0.87-1.54, odd versus even carbon preference (OEP) values are less than 1 (0.12-0.74) and the sterane Isomerization ranged from 0.32-0.37. The averages of trace elements concentration in the shales are 431, 80.22, 75.78, 60.83, <20, 15.2, 15.2, 11.2, 11.1, 6.54, 6.34, 1.92 and 1.04 ppm for Ba, Y, Nb, V, Ni, Rb, Sn, Th, U, Cs, Sr, Be and Co respectively.

Biomarker data of n-alkanes isoprenoids, steranes and others indicate thermally immature organic matter derived from mixed marine and terrestrial sources. Pr/Ph ratio and C_{27}-C_{29} regular steranes indicated that the shales were deposited in estuarine to open marine environment under anoxic to dysoxic conditions characterised by mixed terrestrial and marine sources. Average trace elements ratios of V/Ni, Th/U and Ni/Co also depicted that the organic matter was deposited under oxic-dysoxic conditions.

Keywords: Patti Formation, biomarkers, trace elements, organic source input, thermal maturity

INTRODUCTION

The Bida basin in central Nigeria is a gently down-warped trough whose origin may be closely connected with the Santonian orogenic movements of southeastern Nigeria and the nearby Benue Valley (Obaje, 2009). It is frequently regarded as the northwestern extension of the Anambra basin, major depocentres during the third major transgressive cycle of southern Nigeria in Late Cretaceous times (Obaje, 2009). The basin is divided into two sub-basins which are the northern Bida basin and the southern Bida basin. Pioneer studies on stratigraphy, sedimentation and structural elements of Bida basin include those of Falconer (1911), Russ (1930), Adeleye, (1973, 1974) among others. The structural relationship between Bida and Anambra basins in the lower Benue Trough has suggested the possibility of hydrocarbon accumulation in Bida basin because organic rich sediments were deposited in adjacent Anambra basin. Campanio-Maastrichtian age was assigned to Patti Formation in the southern Bida basin using pollen and spores (Ojo & Akande, 2006; Ojo, 2010). Patti Formation has been regarded as a potential hydrocarbon source rock in the Bida basin considering the presence of abundant organic rich shale facies in southern part of the basin which has been interpreted to be deposited in continental to marginal marine and marsh paleoenvironments during Cretaceous (Akande *et al.*, 2005). Hydrocarbon resource potentials of the Patti Formation were assessed by Ehinola *et al.* (2006), Obaje *et al.* (2011). However, additional geochemical investigation is required to unravel the hydrocarbon generative potentials of the organic rich shales of Patti Formation in the southern Bida basin. This study aims at using combined molecular and trace elements geochemistry to assess the thermal maturity, organic source input and depositional environment of Patti Formation sediments.

MATERIALS AND METHODS

Surface samples of Patti Formation at two localities in Ahoko district around Lokoja township (Figure 3) were described and logged following standard procedures of examining the lithology, texture, colour sedimentary structures among others. Representative samples were subsequently collected and stored for geochemical analyses. The shale samples were finely pulverised, labeled, stored in vials, and subjected to total organic carbon (TOC) analysis using elementar Vario III, elemental analyser (Hanau, Germany). Following the TOC results, selected samples were ultrasonically extracted using dichloromethane (DCM) and methanol (CH_3OH) as the solvent mixture in the ratio of (10:0), (5:5) and (0:10). All extractions were repeated thrice and the extracts pooled together. The pooled extracts were reduced by rotavapor machine and separated into the aromatics and aliphatic fractions. The aliphatic fractions were analysed for biomarkers by Gas Chromatography Mass Spectrometry (GC-MS). Selected samples also demineralised following standard procedures. Specifically, 15-20 g of each sample was soaked in 1M HCl for 24 hours, decanted and rinsed with distilled water. The supernatants were treated with 1M HCl/10% HF for 5 days, decanted and rinsed with distilled water till the ph of the water is 7 (neutral). The samples were oven dried at 40ºC, stored and subjected to Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) for the trace elements.

RESULTS

The sediments of the Patti Formation exposed at the localities in Ahoko district comprised of shales, siltstones, ironstones and claystones. The shales are light grey in colour, mostly nodular with characteristics parallel lamination. The siltstones are medium to fine grained with parallel laminated beds. The ironstones are laminated parallel beds colour ranging from yellow, pink to red. The ironstones are intercalated by intermittent white to yellowish claystones. The TOC and biomarker (n-alkanes isoprenoids and steranes) results are presented in Table 1. Trace element concentrations of the Patti Formation showed that Zr Ba, Y, Nb, V, Ni, Rb, Sn, Th, and U contents are prominent with average values of 1685, 431, 80.22, 75.78, 60.83, <20, 15.2, 15.2, 11.2 and 11.1 ppm respectively while Cs, Sr, Be and Co has average values of 6.54, 6.34, 1.92 and 1.04 ppm respectively.

DISCUSSIONS

Organic source input and depositional environment

The distribution of n-alkanes in oil and extracted bitumen has been used to indicate the organic matter source (Duan & Ma, 2001). The distribution of n-alkanes in the shale samples reflected an organic matter derived from both marine and estuarine environment (Peters *et al.*, 2005). Pr/Ph ratios of the Patti Formation samples ranging from 0.53 to 2.84 (Table 1) with an average of 1.1 and close to 70% of the values being less than 0.8 suggested a saline anoxic environment (Peters & Moldowon, 1993; Peters *et al.*, 2005). The Pr/nC_{17} of the shales ranges from 0.34 to 0.51 while the Ph/nC_{18} ranges from 0.003 to 0.5 (Table 1). The cross plot of Pr/nC_{17} and Ph/nC_{18} can also be used to infer the depositional environment and the type of the organic matter (van Koeverden *et al.*, 2011; Peters *et al.*, 2005) The cross-plot of Pr/nC_{17} and Ph/nC_{18} (Figure 1) shows that the organic matter is derived from a mixed source (both terrigenous and marine) in an oxidizing environment. Also, the CPI values for the shale samples ranging from 0.38 to 1.47 (Table 1) indicates oxidizing environment. This assertion is further confirmed by the cross-plot of CPI against Pr/Ph (Meyers & Snowdon, 1993).

The occurrence of C_{27}-C_{29} steranes in high amounts in the shales indicates that the organic matter has been derived from both marine and terrestrial materials. A ternary diagram showing the distribution of the C_{27}, C_{28} and C_{29} regular sterane can be used to interprete the depositional environment of the shales (Peters *et al.*, 2005). The ternary diagram shows that the samples are deposited in estuarine to open marine environment. The V/Ni and Ni/Co ratios of the samples showed that the organic matter was deposited under oxic to dysoxic conditions respectively (Galarraga *et al.*, 2008). However, cross-plot of Vanadium and Nickel revealed organic matter deposited in a marine environment.

Thermal maturity

Alkane and isoprenoids distribution, Pristane/n-C_{17}, Phytane/n-C_{18}, Carbon Preference Index (CPI), and improved Odd-Even Preference (OEP) have been used as indicators of maturity (Peters *et al.*, 2005; Peters & Moldowan, 1993). Ph/nC_{18} ranges from 0.32 to 0.5 (Table 1) suggests a thermally immature to early mature source rock. The CPI values for the shale extracts ranged from 0.37 to 1.47 (Table 1) also this depicts a thermally immature shale. The OEP values ranging from 0.85 to 0.12 equally indicates thermally immature organic matter

Table 1: TOC and biomarker results of Patti Formation.

Sample	TOC	Pr/Ph	Pr/nC17	Pr/nC18	OEP	CPI	TAR	20S+20R C29 steranes	ββ/(ββ αα) C29 steranes
T1	1.20	2.84	0.34	0.51	0.12	0.38	1.69	0.35	0.5
T2	2.65	0.53	0.35	0.5	0.32	1.39	-	0.34	0.55
T3	2.29	0.63	0.41	0.48	0.85	1.47	0.22	0.34	0.53
T4	2.67	1.09	0.51	0.32	0.72	1.06	1.35	0.35	0.57
T5	2.22	0.62	0.62	0.35	0.25	0.99	3.44	0.37	0.52
T6	2.10	0.68	0.38	0.33	0.74	1.02	0.37	0.32	0.56

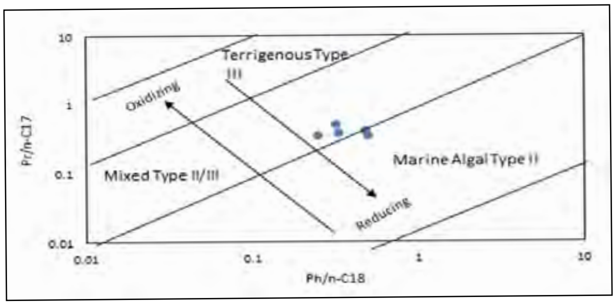

Figure 1: Plot of Pr/nC_{17} and Ph/C_{18} for the samples.

in Patti Formation shales. The βα-moretane/hopane-αβ and Ts/Ts+Tm-homohopane ratios for the shale extracts ranged from 0.09 to 0.79 and 0.31 to 0.47 respectively. These values indicate an immature organic matter. The ratios of the C_{29} 20S/(20S+20R) in the samples ranging from 0.32 to 0.37 (Table 1) suggests an immature source, while the ββ/(ββ + αα) ratio (0.5 to 0.57)(Table 3b) depicts that the shales are immature to marginally mature. However, the cross-plot of 20S/(20S+20R) and ββ/(ββ + αα) for C_{29} steranes indicates that the organic matter in the shales are marginally mature and the samples are in the early oil window (Figure 2).

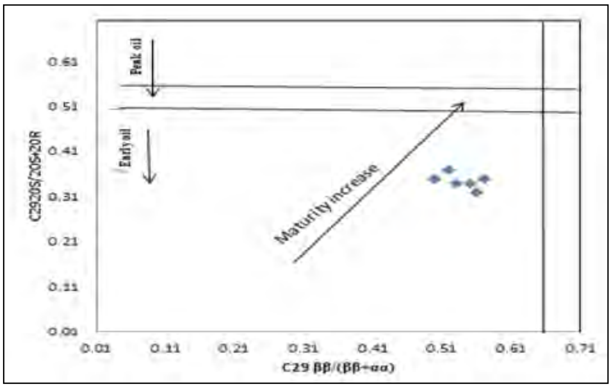

Figure 2: Cross plot of C_{29} steranes for the samples.

CONCLUSION

Shales in the Patti Formation of southern Bida basin are composed of organic matter sourced from marine and terrigenous materials. These sediments are deposited in estuarine to open marine environment under anoxic to strongly dysoxic conditions. The sediments are thermally immature to marginally mature in the early oil window.

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A114

Estimation of water surface level using digital terrain model in data sparse environment

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Flood vulnerability assessment is very important to prepare for a pre-flooding event and to reduce the impact of a post-flooding event. But in the absence of in-situ river bathymetry data, how the assessment could be possible? To address this issue, a methodology has been proposed in this study. The main objective of this study was to estimate river Water Surface Level (WSL) in the absence of in-situ river bathymetry data by using Digital Terrain Model (DTM). The study was conducted at a part of Sungai Lebir, Kelantan, Malaysia. River geometry was calculated using in DTM of 3 m resolution as a reference terrain in RAS Mapper. The proposed methodology was applied to improve the geometry obtained from the DTM. Hydrological modeling was conducted in HEC RAS by using DTM and improved DTM's geometries. The output of HEC RAS was compared and validated with in-situ WSL data. The study reveals that the standard deviation of WSL between in-situ and DTM river geometries was 1.6 m overestimation which is reduced by the proposed methodology up to 0.4 m overestimation. Overall, the proposed methodology predicts reasonably well the WSL in the absence of in-situ river bathymetry data.

A116

Trace elements concentration in Quaternary shallow aquifers of northern Kelantan, Malaysia

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Abstract: Groundwater is one of the commonly used sources of fresh water supply in northern Kelantan. Groundwater demand for domestic and agricultural usage increases day by day in the region. Return flow from agriculture and domestic water use have the potential for groundwater contamination. The aim of this study is to assess the degree of trace element concentration and the suitability of groundwater for drinking purpose. Trace element analysis for thirty-two groundwater and surface water samples were carried out. The groundwater samples were collected uniformly from domestic wells which are mainly confined/constituted in shallow aquifers in the northern part of Kelantan state. Total fifteen trace elements (As, Pb, Sr, Ba, Mn, Co, Ni, Cu, Cd, Fe, Zn, Cr, B, Se, and Al) were analyzed using Inductive Coupled Plasma Mass Spectrophotometer (ICP-MS) in Nuclear Agency Malaysia. The study shows that most groundwater samples contain low concentrations of trace elements. Majority of toxic elements concentrations are found to be in minute quantities and thus assumed to be harmless. The trace elements concentration from most of the domestic wells are shown below the permissible limit of WHO which points to the unpolluted source of water supply in the area and is thus suitable for drinking and other domestic purposes. Recommendations for the usage of groundwater must take into consideration, factors such as soil categories, type of crops, plantation management practices and proper drainage systems. Appropriate use of regulations and effective water management policies may help in further developing the available groundwater resources for agriculture and other domestic purposes.

Key words: Groundwater, trace element concentration, Kelantan, Malaysia

A120

Effect of rainfalls and air temperature on groundwater levels in Kedamaian Basin, Kota Belud, Sabah

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INTRODUCTION

Water is the most essential for human consumption as well as for daily uses. Groundwater is the main water supply for most of the people along the coastal area particularly in Kota Belud, Sabah. Most of them depend on the groundwater supply from shallow wells like dug wells and tube wells constructed by themselves or the government agencies. The biggest problem with shallow wells is the water levels tend to fluctuate and could be dry during the drought season.

The study area is located in Kedamaian Basin, Kota Belud (Figure 1). Six tube wells constructed in quaternary and recent alluvium and the water levels monitored monthly by the Department of Minerals and Geoscience Malaysia Sabah under the Groundwater Reserved Assessment Project (RMKe-11). This study evaluates the effects of rainfalls as well as the air temperature to the groundwater water levels using data collected from 2017 to 2019 in Kedamaian Basin, Kota Belud. This study is vital to understand the pattern of groundwater fluctuation for the purpose of groundwater extraction and future groundwater management.

LITERATURE REVIEW

The water levels in the aquifers depends on the groundwater discharge and recharge. Fluctuation is affected by many factors, such as rainfall intensity, rainfall quantity, the capability for water infiltration of rock and soil, groundwater depth above sea level, topography, evapotranspiration, and well discharge (Wilson, 1987). The water table fluctuation was influenced by the rainfall, runoff, and infiltration (Abdullahi, 1995).

The study area composed of quaternary and recent alluvium that restricted to the low lands towards the sea as well as along the river. It is mainly represented by unconsolidated alluvial sediments on river terraces and floodplains consisting of varying proportions of unsorted to well sorted gravel, sand, and silt with minor amounts of clay which were derived from the upstream bedrock.

METHODOLOGY

Six tube wells were constructed by Department of Minerals and Geoscience Malaysia Sabah with depth ranging from 8 – 26.5 m. All these wells constructed

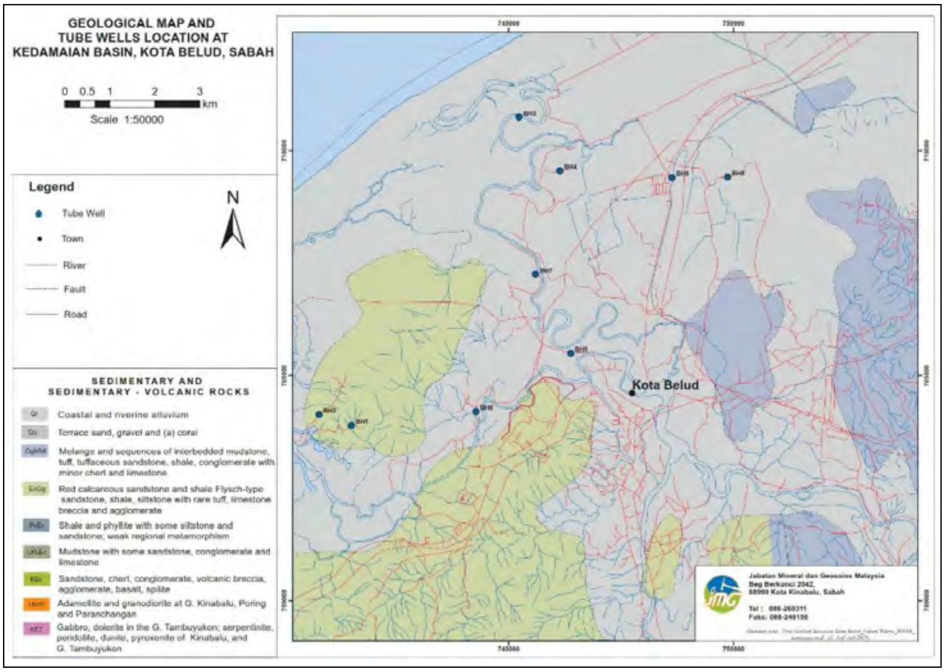

Figure 1: General geology and tube wells location of study area.

Table 1: Tube wells location and descriptions.

Tube well ID	Location	Elevation (msl), m	Tube well depth (m)	Description
BH-2	Kg. Suang Punggur	0	8.00	Away from river channel. Constructed in recent alluvium composed of sand and clay
BH-3	Kg. Lilud	5	25.50	Very near to the river channel. Constructed in recent and quaternary alluvium composed of sand, clay, gravels and boulders
BH-4	Kg. Marabau	9	26.50	Adjacent to river channel. Constructed in recent and quaternary alluvium composed of sand, clay, gravels and boulders
BH-5	Kg. Sembirai	15	18.00	Away from river channel. Constructed in recent and quaternary alluvium composed of sand, clay, gravels and boulders
BH-6	Kg. Lingkodon	13	21.50	Adjacent to river channel. Constructed in recent and quaternary alluvium composed of sand, clay, gravels and boulders
BH-7	Kg. Timbang Dayang	13	20.00	Adjacent to river channel. Constructed in recent and quaternary alluvium composed of sand, clay, gravels and boulders

in quaternary alluvium as well as in recent alluvium (Table 1).

The monthly groundwater levels data from six tube wells collected from July 2017 to June 2019 (except BH-4, which only available on October 2018). All the water levels measured below ground level (b.g.l) and taken on certain day of each month. The monthly rainfall data observed at Kota Belud Haiwan – Wariu Farm while the monthly air temperature data observed at Kota Kinabalu Airport. Those data were collected by the Department of Meteorological Kota Kinabalu, Sabah. The rainfall data represent the rainfall distribution at Kota Belud area. However, there is no air temperature data available for Kota Belud, hence the air temperature data observed at Kota Kinabalu Airport was used as reference.

RESULTS

BH2, BH5, BH6 and BH7 fluctuate and shows a significant drop of water levels from July 2017 to May 2019. Meanwhile, BH3 shows a minimal fluctuation in the same period. Generally, the groundwater levels drop on Feb 2018, June 2018 and Feb 2019. The groundwater levels increased significantly on Oct 2017, May 2018, Oct 2018 and June 2019. The BH3 and BH4 basically almost maintained the water levels along this period (Figure 2).

The rainfalls data observed from July 2017 to June 2019 shows that the amount of rainfall on Jan 2018 and June 2019 is the highest, while the lowest rainfall recorded on Aug 2017, Mar 2018 and Feb 2019. Rainfall distribution and the average air temperature on the study period shows that high rainfall will decrease the air temperature and vice versa (Figure 3). High rainfall increased the water levels through rainwater infiltration into the groundwater system and vice versa.

CONCLUSIONS AND DISCUSSIONS

The data was analysed to study the effect of rainfalls and air temperature to the water levels fluctuation. Analysis of data from July 2017 to June 2019 shows that there is a relationship between the rainfalls, air temperature and groundwater levels. During drought season, the rate of evapotranspiration in the soils and vegetation obviously increased particularly during hot season (high air temperature). Groundwater vaporised on

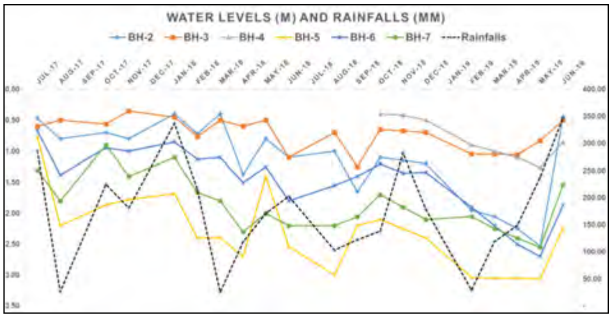

Figure 2: Groundwater levels of tube wells at Kedamaian Basin, Kota Belud (July 2017 – June 2019).

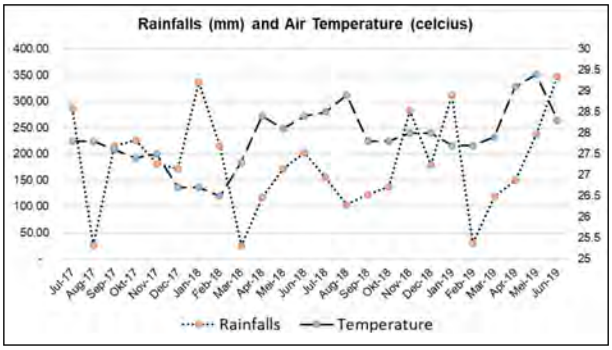

Figure 3: Monthly rainfalls and air temperature.

the air since vegetation depended mostly on the groundwater as source of water.

During rainy season, water levels is normally maintained or increase. However, during the drought season, water levels shows a significant drop except from BH3 and BH4. During drought season particularly on Feb to April, these tubewells normally used by the villagers as a main source of water supply. Due to high demand of water, it was used heavily and over extracted. The water levels drop to certain depth without replenishment by the rainwater infiltration. The water levels from BH3 mostly maintain along the period because it's rarely used by the villagers.

Other factor that contribute to the groundwater levels fluctuation is low recharge rate. Groundwater aquifers mostly recharged by the rainwater infiltration as well as recharged from the rivers. During drought season, rivers are shallower hence the rate of recharging is very low.

This study concluded that, rainfalls and air temperature contributing the groundwater levels fluctuation. Water levels decreased during low rainfalls with high temperature but increased during rainy season. Other factor might contribute to the groundwater fluctuation is the groundwater extraction as well as recharge from the river.

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A136

Heavy metals content in ultrabasic soil and plant around Ranau Sport Complex, Sabah, Malaysia

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Abstract: Heavy metals pose a considerable level of danger to the flora and fauna due to its high toxicity and the possibility of accumulation in the environment and soil. Heavy metals have been generally used as environmental monitoring factors and their toxicity in humans, animals, and plants are well known. Therefore, human and ecosystem health levels need to be assessed frequently by monitoring the concentration of heavy metals in the environment. The total heavy metal concentration has always been used as a contamination indicator. The soils derived from ultrabasic rock in tropical areas are exceptionally rich in Ni and Cr, suggesting that when these soils are used for agricultural crops there is a potential heavy metal risk for human health. A study has been carried out to determine heavy metals content in three species of plant namely *Centratherum punctatum* sp., *Odontosoria chinensis(L.) J. Sm. (Dennstaedtiaceae)* and *Imperata cylindrica* that were each taken in triplicates together with the soil within their rooting zones. Method of heavy metals extraction in soils and plants follows protocol 3050b of the US EPA.

Soil data showed a very high content of total Ni and Cr which is above the intervention/action values in The New Dutch List (2000) standard. When the metals content in soil occurs above the action/intervention values it indicates the functional properties of the soil for humans, plants and animals is seriously impaired or threatened. A case of environmental contamination is defined as 'serious' if >25 m^3 soils are contaminated above the intervention value. They are representative of the level of contamination above which a serious case of soil contamination is deemed to exist (The new Dutch list, 2000) and remediation is deemed necessary. The cobalt and Zn content are also above the target values.

Previous study by Sahibin *et al.* (1996) show that serpentinite soil in Ranau area is acidic, with pH between pH 5.2 to pH 6.4 and high in organic matter content. Serpentinite soils also contain high concentrations of Ni which ranges from 2244 to 9008 mg kg^{-1}, Cr concentration ranges from 2295 to 3791 mg kg^{-1}. Cobalt concentration is between 136 to163 mg kg^{-1}, and Zn concentration between 0 to 20 mg kg^{-1}. In this study the Ni, Cr, Mn, Co and Zn content in soils were 1622.00 ± 328.10 to 3728.21 ± 536.35 mg kg^{-1}, 2318.33 ± 942.80 to 7202.61 ± 1165.53 mg kg^{-1}, 1169.00 ± 144.25 to 2274.2 ± 331.52 mg kg^{-1}, 125.30 ± 9.19 to 315.57 ± 39.75 mg kg^{-1}, and 152.80 ± 51.30 to 345.50 ± 173.24 mg kg^{-1}, respectively. Heavy metals content in plants were 20.50 ± 13.42 mg kg^{-1} to 291.13 ± 5.79 mg kg^{-1}, 27.89 ± 0.42 mg kg^{-1} to 182.46 ± 97.07 mg kg^{-1}, 40.50 ± 3.53 mg kg^{-1} to 376.05 ± 97.86 mg kg^{-1}, 53.75 ± 2.57 mg kg^{-1} to 132.00 ± 14.14 mg kg^{-1} for Ni, Cr, Mn and Zn, respectively.

Heavy metals content in plant leaves were low compared to the metals content in soils. Metals content in plant leaves is above the normal values for Ni and Cr. The uptake of heavy metals in plant is shown by its Biological Accumulation Coefficient (BAC), and accumulation and contamination of heavy metals in soil are shown by its Geo-accumulation Index (Igeo), Contamination Factor (CF) and Pollution Load Index (PLi). The plants in Ranau Sport Complex showed a BAC values of less than 1, which meant that all metals do not have the potential to be accumulated in the plant. The Geo-accumulation Index (I-geo) showed that all heavy metals in Ranau Sport Complex fall in grade 1 for Zn and Mn, grade 3 for Co and grade 5 for Ni and Cr (Table 3). This suggests that the ultrabasic soils are heavily contaminated to extremely contaminated for Ni and Cr, moderately contaminated to heavily contaminated for Co and uncontaminated to moderately contaminated for Mn and Zn. The Pollution Load Index (PLI) was calculated from the Contamination Factors (CF). Results of the present study showed that the CF values of all of the metals in the study area were very high for Cr, Ni and Co (>6), and moderate CF for Zn and Mn (1<CF≤3). The contamination is dominated by Cr and Ni followed by Co, Mn and Zn. Pollution load index (PLi) value for all heavy metals in soil around the sport complex was high at 2.54 indicating that there is a steady increase of pollution in the specimen.

Keywords: Pollution, heavy metals, accumulation, potentially toxic, biological accumulation coefficient (BAC), Geo-accumulation Index (I-geo), Contamination Factor (CF), Pollution Load index (PLi)

A049

Geochemistry of volcanic rock in Pulai, Peninsular Malaysia, emphasis on tectonic implication

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Pulai is located at the Central Belt of Peninsular Malaysia. In the area, there are two different types of volcanic rocks, Pulai rhyolite and Pulai basaltic andesite, interlayered with the metasedimentary rock as part of Gua Musang Group. This paper presents an overview of the field relations, petrology, geochemistry and geotectonic of the Pulai volcanic rocks. The petrography of samples was examined by transmitted light microscope and the whole-rock major and trace element analyses were analyzed using the Inductive Coupled Plasma Emission Spectrometer (ICP-ES) and Inductive Coupled Plasma Mass Spectrometry (ICP-MS). Pulai rhyolite shows a porphyritic texture with euhedral to sub-euhedral K-feldspar and quartz as the main phenocryst surrounded by a microcrystalline-granular groundmass of quartz, feldspar, muscovite and sericite. Pulai basaltic andesite is characterized by its porphyritic texture with plagioclase, pyroxene and feldspar as the main phenocrysts, set in a groundmass of holocrystalline feldspar, plagioclase and opaque minerals. Pulai rhyolite (SiO_2: 71.2% to 75.64%) is a felsic I-type peraluminous with high calc-alkaline and shoshonite series of volcanism while Pulai basaltic andesite (SiO_2: 51.07% to 65.21%) is characterized as an intermediate rock with calc-alkaline of peraluminous rock. In terms of geochemistry, the rhyolite is slightly more enriched in most incompatible trace elements compared to basaltic andesite and shows positive anomalies and enrichment of U, Ta, Nb and Eu while negative anomalies for Ba, Sr, P and Ti. The rhyolite is also more evolved and undergoes fractionation of plagioclase and alkali feldspar. Pulai basaltic andesite is recognized with negative anomalies of Nb, Ta Sr, P and Ti, besides display negative trend oxides of Al, Mg, Ca, Ti, Fe and P as increasing SiO_2, mostly related with early crystallization, precipitation and fractionation phases of ferromagnesian minerals of pyroxene, plagioclase and biotite. This is also consistent with the significant negative Eu and Sr anomalies of the basaltic andesite, indicate the high partition coefficient for Eu and Sr in plagioclase. Both rhyolite and basaltic andesite volcanic rocks are generated from a different source of magma as they have different geochemical composition. Based on the geotectonic classification, the Pulai rhyolite is associated with the post-collisional setting while the Pulai basaltic andesite was formed at the active continental margin of volcanic arc setting. The source of magma for the Pulai rhyolite is related with the assimilation and fractional crystallization of mantle-derived magma while the Pulai basaltic andesite was formed from the partial melting and enriched with fluids derived from subducted slab. The variation of basaltic andesite to rhyolitic volcanism in Pulai may be related to the changes of andesitic volcanism during Permian to felsic volcanism

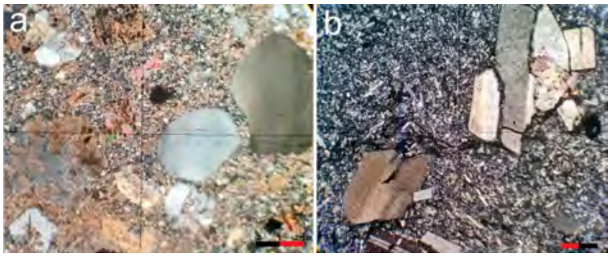

Figure 1: (a) Pulai rhyolite with phenocryst of k-feldspar in the matrix of quartz, sericite k-feldspar and carbonaceous materials. (b) Pulai basaltic andesite with phenocryst of k-feldspar in the matrix of plagioclase.

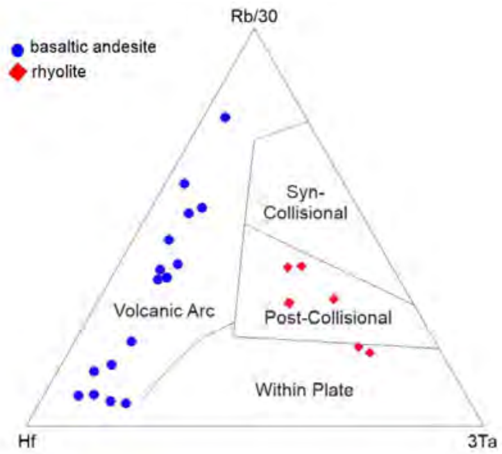

Figure 2: Tectonomagmatic classification diagrams of Hf-Rb/30-(Ta x 3) after Harris *et al.* (1986) for Pulai rhyolite and Pulai basaltic andesite.

in the Triassic at the Central Belt of Peninsular Malaysia. The basaltic-andesite could be interpreted as the Permian andesitic volcanism from the subduction of Paleo-Tethys beneath the Indochina/East Malaya plate and continue with the middle to early Upper Triassic felsic volcaniclastic rock accumulated in the Central Belt.

Keywords: Pulai, rhyolite, basaltic andesite, post-collisional, volcanic arc

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A027

The integration of GIS and AHP techniques for mapping of groundwater potential zones in Johor southern region, Malaysia

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Abstract: The sustainable of ecological environment and ecosystem is very important to develop and maintain groundwater resources in Malaysia. The decline of groundwater level data is a critical issue for water resources management in the Johor Southern Region. As demand of water still increases for domestic consumption, agriculture and industrial uses. Geographic Information System (GIS) and remote sensing based on studies have gained more benefits in groundwater exploration because it is rapid information on the resource for research and developments. Therefore, the present study has been conducted with an objective to map the groundwater potential zones in Johor state of Malaysia as an example and assess the contributing factors for exploration of potential groundwater resources. Remote sensing data and geographic information system will be used to locate potential zone for groundwater. The data is obtained from Mineral and Geoscience Departments Malaysia (JMG). The remote sensing and geographical information system are a component of geospatial techniques. It is a very powerful tool for processing, analysing and integrating spatial data sets compared by the conventional methods based on ground surveys. Thus, the integration of Remote Sensing (RS) and Geographic Information System (GIS) has been proven to be efficient, rapid and cost-effective technique producing valuable data on geology, geomorphology, lineaments and slope as well as a systematic integration of these data for exploration and map locate of groundwater potentials zones. Then, an integration between of geographical information system and analytical hierarchical process techniques (AHP) was used in the present study. A total of 12 various maps such as Geology, Geomorphology, Land Use/Land Cover, Lineament density, Drainage density, Rainfall, Soil, Slope, Roughness, Topographic Wetness Index, Topographic Position Index and Curvature were prepared and studied for groundwater potential zone. The groundwater availability of the area will qualitatively be classified into different classes based on its hydro-geo-morphological conditions. The land use/land cover map will be also prepared for the different seasons using a digital classification technique with a ground truth based on field investigation. Weights assigned to each class in all the thematic maps are based on their characteristics and water potential capacity through AHP method. The accuracy of the output was cross-validated with information on groundwater prospects of the area and the overall accuracy of the method comes to around 89%. The groundwater potential zone map thus obtained was categorized into five classes - very high, high, moderate, low and very low. The study reveals that about 59% of the area is covered under moderate groundwater potential zone. The low and high groundwater potential zones are observed in 35% and 12% respectively. Area under very high and very low potential zones are recorded only in very limited areas. Results obtained from this study can be useful for future planning of groundwater exploration, planning and development by related agencies in Malaysia which provide a rapid method and reduce cost as well as less time consuming. The results may be also transferable to other areas of similar hydrological characteristics.

Keywords: Groundwater potential zone, Geographic Information System, Analytical Hierarchical Process

A041

Liberation studies of Malaysian monazite concentrates: Effect of grinding and concentration processes

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Mineral processing, also known as mineral dressing or ore beneficiation, follows the primary mining process and prepares the ore for extraction of the valuable elements to produce a saleable product. Every mineralogical process essentially needs to go through two fundamental operations; liberation (release of the valuable minerals from the gangue) and concentration (the separation of these values from the gangue). Liberation of the desired minerals from the gangue is accomplished by means of size reduction or comminution, which involves the crushing and grinding to a size such that the product is a mixture of liberated or free ore minerals (Wills & Finch, 2015).

One of the major objectives of comminution processes it to achieve liberation at "the possible coarsest particle size". A good liberation is necessary for obtaining high grade solid mineral products for subsequent hydrometallurgical processes, such as leaching, it may only be necessary to expose the required mineral. Inadequate mineral liberation in itself leads to higher operating costs, as it demands finer grinding to achieve an adequate degree of liberation, and this can lead to the generation of ultra-fine slimes particles, which may be lost in the downstream process (Veasey & Wills, 1991).

Generally, hydrometallurgical processes only require a mere exposure of the surface of the mineral which comprises of the desired element of extraction. The presence of middlings in the concentrate is sometimes an indication that subsequent liberation through size reduction can result in an increase in the recovery (Xie *et al*., 2013). An intimate knowledge of the mineralogical assembly of the mineral ore ("texture") is essential to determine if subsequent liberation is required. In practice, complete liberation is seldom achievable, even if the ore is ground down to less than the grain size of the desired minerals. Therefore, a thorough understanding on the liberation characteristics using advanced mineral liberation analysis warrants the need for additional operations in the downstream processes (Fandrich *et al.*, 2007).

A comprehensive understanding on the liberation of mineral constituents of any complex ore body is important in order to select a feasible beneficiation methodology. This research study involves the assessment of different comminution processes on the possible highest degree of liberation of Malaysian monazite from their associated impurities like xenotime, zircon, ilmenite, quartz and other phospho-silicate minerals. The effect of grinding on the liberation characteristics of the monazite concentrate obtained from the tin tailings from Kinta Valley mines in eastern Malaysia, are evaluated in the study. Although the concentrates were rich in monazite following the initial comminution operations, liberation analysis supported by SEM-EDX showed that most of the REE- rich sites were still entrapped and locked within the gangue minerals as shown in Figures 1 and 2. The entrapment of REE- rich mineral within a chemically resistant gangue mineral may tend to affect the efficiency of the hydrometallurgical extraction processes. An additional grinding operation was carried out to break down the middlings and expose the monazite grains engulfed by the gangue minerals as well as zircon, xenotime and ilmenite. Figure 3 shows the liberated free grains of monazite after the grinding process. A customized concentration method was employed by taking representative samples of the ground concentrate which was sieved for different size fractions to analyse the ratio of REEs to impurities (gangue minerals) in every size fraction. This understanding will benefit the consequent metallurgical processes and the effects of different particle sizes on the recovery process can also be studied.

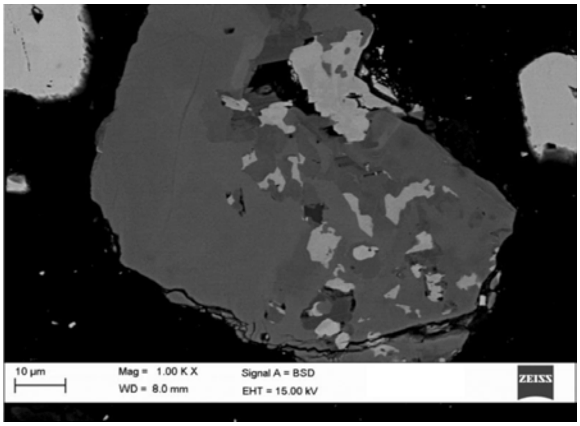

Figure 1: Backscattered SEM image of a single grain in the concentrate illustrating the different minerals entrapped in the zircon grain.

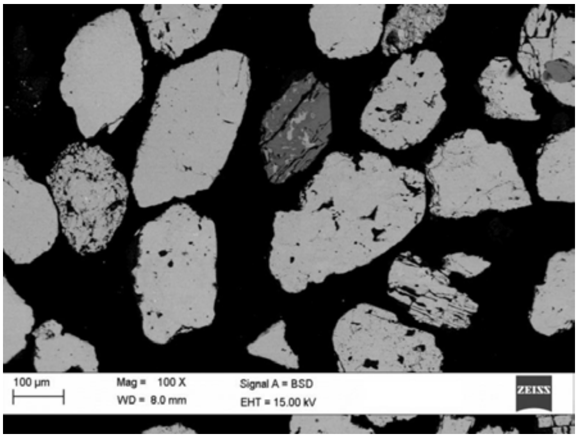

Figure 2: Backscattered images of Malaysian monazite concentrate (as received).

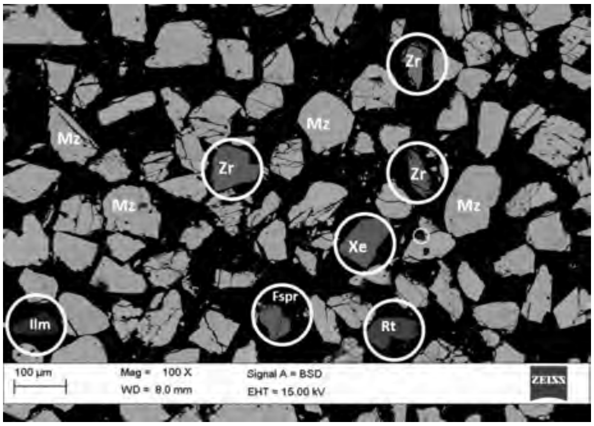

Figure 3: Liberated grains of monazite concentrate after the grinding process. Mz-monazite, Fspr-Feldspar, Xt-xenotimem Rt-Rutile, Ilm-ilmenite, Zr-Zircon.

ACKNOWLEDGEMENTS

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A135

Characterization and potential industrial application of gypsum rich waste

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NUF Gypsum rich waste which is by-product of REE processing plant was characterized and analysed. The industrial quality, suitability and potential utilisation of NUF Gypsum to natural-commercial gypsum for specific industrial application were thoroughly evaluated. The properties and industrial characteristics of the waste were thoroughly determined and analysed by standard X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Differential Scanning Calorimetric (DSC) / Thermo gravimetric Analysis (TGA) and X-ray Fluorescence (XRF) analysis. Other tests included pH, LOI, moisture content, specific gravity and plasticity were also determined. The presence of characteristic bond of water vibration at 3606-3558cm^{-1} and sulphate vibration at 1151cm^{-1} in FTIR test indicates the existence of gypsum anhydrite ($CaSO_4.2H_2O$) phase.

The SEM photomicrograph also revealed the presence of hexagonal crystal structure of gypsum including Calcium Oxide (CaO) and sulphite (SO_3) phases as indicated by XRF analysis that confirmed the formation of synthetic gypsum. The XRD results also indicate the presence of gypsum and calcite crystallinity phases. The gypsum rich waste is suggested suitable to be used in agriculture and for gypsum board manufacturing since it almost complies all the industrial specification. The high content of magnesium, Mg which is 5.87% is suitable for plant growth as it can act as soluble salt for the nutrient supply. It is also suitable for gypsum board manufacturing since the composition would not distract the hydration process of gypsum board. The presence of impurities such as silica (SiO_2) 0.62%, chlorine (Cl) 2.8% and Na (Sodium) 0.7% is still within the specification for gypsum board industry and many agriculture requirements. The iron content in the gypsum waste is fairly high for the high grade gypsum board manufacturing. One of the initiatives is to minimise the iron impurities via using organic acid leaching. Furthermore, the significant plasticity index value around 20 is considered favourable for manufacturing of high strength gypsum board.

Keywords: Gypsum, natural waste, recycling, gypsum board

ORAL PRESENTATIONS

APPLIED TECHNIQUES IN GEOSCIENCE

A028

Rock identification using seismic refraction method and electrical resistivity tomography

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There are multiple geophysical methods on analysing the subsurface of soil of the earth. One of the best methods is by using the seismic refraction method. The main reasons to use seismic refraction method in this study is to analyze and characterize the subsurface geologic conditions and geologic structures and the electrical resistivity method will help enhancing and verify the results from seismic refraction techniques by contrasting the different value of resistivity and IP of the different soil layer. In this study, the ABEM TERRAMETER LS 2 will be used for the resistivity and IP survey whilst the ABEM TERRALOC are used to conduct the seismic refraction method. From the testing, the bedrock is apparent at the elevation of 40 meter above sea level and from the Electrical resistivity method there seems to be a boulder at the elevation of 50 meter above sea level because of the high level of resistivity value around 5000 ohm.m

INTRODUCTIONS

There are multiple exploration methods which can helps in interpreting the conditions of the subsurface of the earth. One of the methods are by using Electrical Resistivity Tomography and also by using seismic refraction methods. Seismic refraction methods are used to detect the lateral and vertical variations in velocity while producing detailed imagery of the subsurface (Azwin, Saad, & Nordiana, 2013). Electrical resistivity tomography surveys the subsurface by applying the electrical current into the subsurface, and thus we obtain the subsurface imagery in term of electrical properties. One of the disadvantages of the seismic refraction technique is the velocity of the surveyed subsurface must increase with depth ("Seismic methods," 1966), which means the layer of the subsurface must increase with density the further down the wave travel until the wave hit bedrock. However, the subsurface is a vast unknown territory and usually is non- heterogenous. In the case of the presence of boulders, the seismic refraction technique will not be able to give out a precise result on the subsurface imagery because of the uneven velocity at different layers of the subsurface. To improve on this predicament, the Electrical resistivity tomography will be used to help improve the reading of the seismic refraction methods and give out better subsurface imagery data.

STUDY AREA

The study area was located in between Jalan Hutan Percha and Jalan Pekan Tebong, Alor Gajah Melaka.

METHODS

The electrical method (electrical resistivity and induced polarization) used in this study was performed using ABEM Terrameter LS 2 to obtain the electrical resistivity and induced polarization imaging on site. The Multiple gradient array was used with 200 meters survey line and 5 meters spacing in between electrode. For the seismic refraction methods, ABEM'S Terraloc Mark 6 was used with the sledge hammer and a metal plate as the wave source.

RESULTS AND FINDINGS

From Figure 1 the resistivity value was the highest at elevation of 50 meters above the sea level which is around 5000 ohm.m which indicates a possible boulder at the area.

CONCLUSION

Both of the electrical and seismic refraction survey was successfully performed on site. Based on the data obtained from both of the geophysical methods, the boulders are not apparent inside the seismic refraction data because of the way the behavior of wave and the Electrical resistivity tomography helps to identify the boulders inside the subsurface of the study area in which the seismic refraction methods cannot detect

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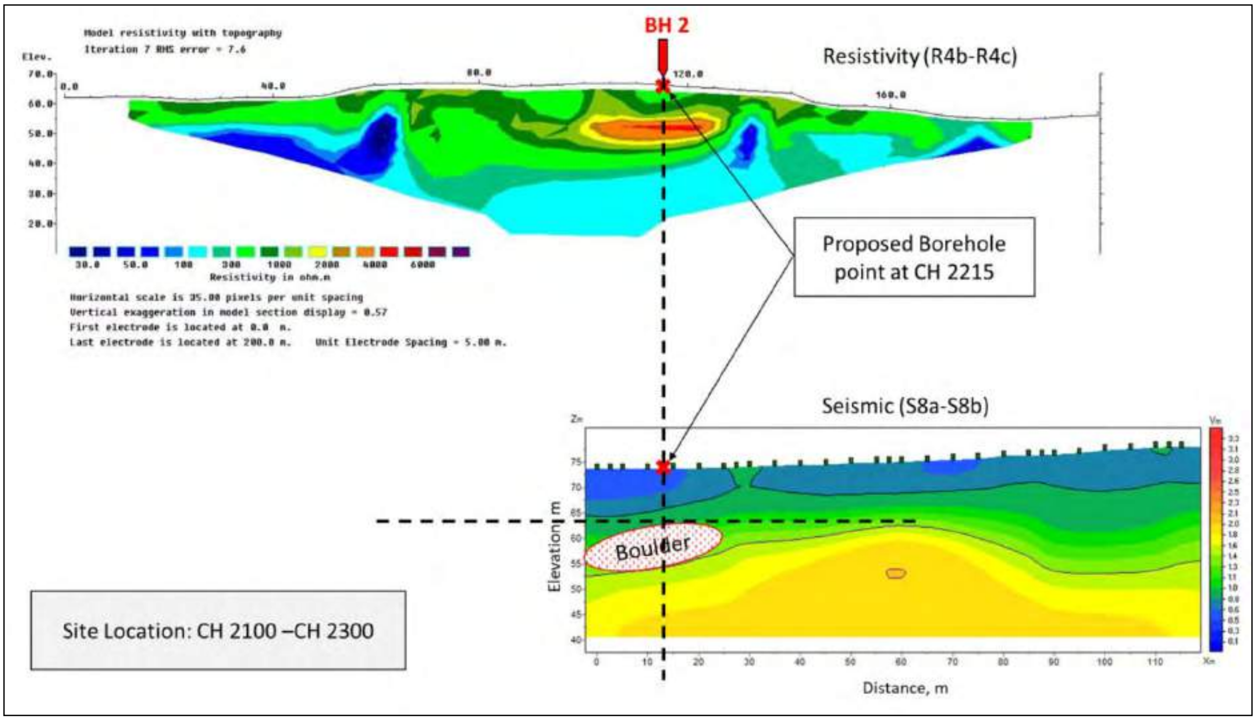
BH 2
Resistivity (R4b-R4c)
Model resistivity with topography
Iteration 7 RMS error = 7.6
Resistivity in ohm.m
Horizontal scale is 35.00 pixels per unit spacing
Vertical exaggeration in model section display = 0.57
First electrode is located at 0.0 m.
Last electrode is located at 200.0 m.
Unit Electrode Spacing = 5.00 m.
Proposed Borehole
point at CH 2215
Seismic (S8a-S8b)
Boulder
Elevation, m
Distance, m
Site Location: CH 2100 –CH 2300

Figure 1

A050

Geothermal studies in clay dominated area using 2-D resistivity imaging method

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Abstract: Manong, Perak has been chosen for geothermal studies using 2-D resistivity imaging method. The study area has clay rich soil in which gives almost the same resistivity value. Two resistivity lines were conducted together with induced polarization (IP) to characterize the type subsurface composition. Generally, the geothermal system is made up of four elements which are heat source, reservoir, fluid and recharge area. Based on the geothermal system, electrical methods that involve resistivity and induced polarization (IP) were conducted to elucidate the main objective of the study which is to investigate the deep geological structures that correspond to the geothermal bodies. The resistivity value (Ωm) will decrease with the increasing of temperature, fractional volume of rock occupied by water, permeability and free-ion content of connate water. A high (saturated) porosity and clay content will significantly increase the conductivity of a soil (Loke, 2004). The induced polarization is conducted to differentiate the resistivity value for clay and geothermal water because the clay minerals tend to decrease the resistivity value (Ωm). Clays have the capability to adsorb large amounts of ions, and even a small clay presence can lower the electrical resistivity of a soil significantly (Waxman, 1968). IP has higher sensitivity to noise and needs stronger currents than resistivity surveying but has seen increasing use due to upgraded instruments and its capability to notice certain minerals and contaminants that resistivity measurements cannot (Loke, 2004). ABEM Terrameter SAS4000 was used to record the resistivity and IP data with Schlumberger array configuration. Inversion of apparent resistivity data to a 2-D resistivity model section was done using a RES2DINV software. Based on the result, both two lines are associated with the fractured zones that act as geothermal veins for transporting hot fluids. Most of the fractures occurred at depth of 50 meters and above with size of approximately 20 meters. Resistivity values >800 Ωm may indicate the presence of granite bedrock based on the Table 1. Low resistivity value <50 Ωm and higher chargeability >15 msec indicate the fracture zone consist with geothermal fluid that mixed with the sulphur minerals as well. The summary of standard for induced polarization (IP) values is shown in Table 2. The presence of fractures is associated with the major fault which occurred along the study area. The 2-D resistivity imaging result were compared with the geological map of the selected study area to confirm the geophysical findings.

Keywords: Manong, 2-D resistivity, induced polarization

Table 1: Resistivity values of rocks and soil (Keller & Frischknecht, 1966).

Material	Resistivity (Ωm)
Alluvium	10 – 800
Sand	60 – 1000
Clay	1 – 100
Groundwater	10 – 100
Sandstone	$8 - 4x10^3$
Shale	$20 - 2x10^3$
Limestone	$50 - 4x10^3$
Granite	$5x10^3 - 1x10^6$

Table 2: Chargeability (IP) of various Earth materials (Telford *et al.*, 1990).

Material Type	Chargeability (msec)
Groundwater	0
Alluvium	1-4
Clay	3-7
Gravel	3-9
Schist	5-20
Granite	10-50

A009

Crustal modelling along the Port Dickson–Kuala Rompin transect

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This paper is the integration of geological and geophysical information to understand the subsurface. The main objective of the paper is to improve the understanding of regional geology of Peninsular Malaysia by incorporating gravity survey. According to Ryall (1982) and Loke *et al*. (1983) the main problem in the current regional geological model/section is the lack of subsurface information to support the model evidently. The study comprises geophysical acquisition using gravity at a regional scale to map the subsurface. The outcome of the acquisition is then correlated with surface geology. A conceptual crustal model of Peninsular Malaysia is constructed by integration of gravity and geological data acquired along the study area from Port Dickson at the west coast to Rompin at the east coast of Peninsular Malaysia. A total of 77 gravity stations established along the transect and gravity readings measured using Scintrex CG-5 Autograv gravimeter with 3 km spacing. Gravity data acquired were corrected for drift correction, latitude correction, free–air correction, Bouguer correction and terrain correction. Based on the corrected gravity values a gravity profile along the Port Dickson-Kuala Rompin transect is plotted. The gravity values obtain after correction reflects the lateral changes in density of the subsurface along the transect. Hence, the plot marks the boundaries of the main geological regions of the area such as the Western Belt, Main Range Granite, Central Belt and Eastern Belt. The granitic areas of the Main Range and the Eastern Belt have a gravity minimum whilst the Central Belt shows a gravity maximum (Ryall, 1982; Loke *et al*., 1983). In general, the granitic area such as Main Range and Eastern Belt shows gravity minimum. The metamorphic rocks and sedimentary rocks appeared to have a relatively positive anomaly. This information correlated to the surface geology of the respective areas to validate and understand geophysical data prior to modelling. Besides that, the lithological information along the transect is obtained to be able to justify the model. A crustal model constructed by matching the measured gravity values with the software calculated values to produce a relevant crustal model that confirms the surface geology. The lithology constituents of the model are schist, Main Range granite, metasediments (phyllite), tuffaceous sandstone (Semantan Fm.), Eastern Belt granite, volcanic rock and Cretaceous sandstone with density 2.60 g/cm^3, 2.55/2.60 g/cm^3, 2.50 g/cm^3, 2.40 g/cm^3, 2.60 g/cm^3, 2.50 g/cm^3 and 2.40 g/cm^3 respectively. The model is constructed up to 50 km using a best fit

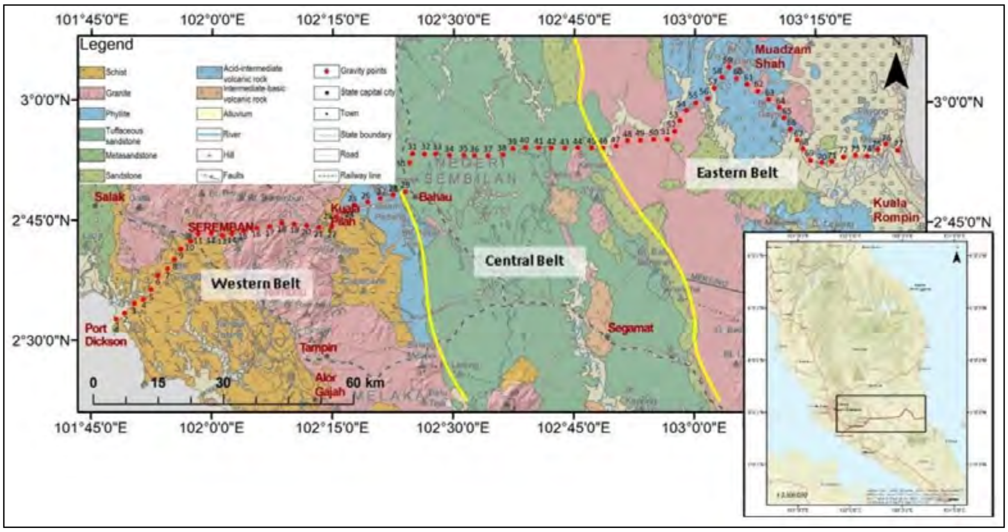

Figure 1: Gravity station overlying the geological map of the Port Dickson-Kuala Rompin transect.

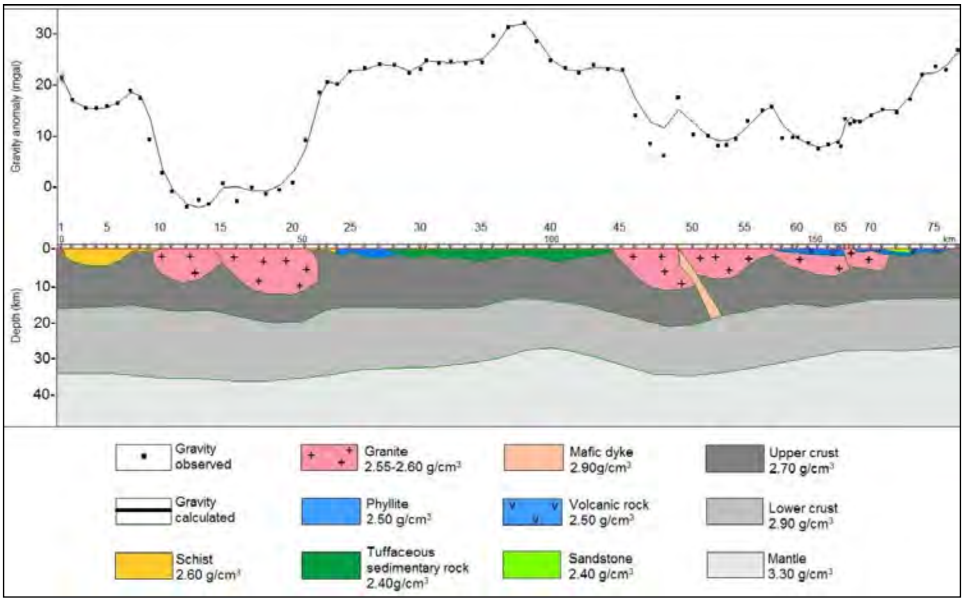

Figure 2: Crustal model of Port Dickson-Kuala Rompin transect constructed using GM-SYS.

of gravity observed to gravity calculated (Akhmal Sidek *et al.*, 2013). From the crustal modelling, the crust of granitic region is relatively thicker, where the Main Range area is ~32 km and Eastern Belt granite also has similar thickness but thinning to the east to 27 km. The crust of Central Belt shows an uneven thickness which ranges from 26-29 km. The thinner crust occurred at the station 36-39 (western part of Muadzam Shah), which inferred from the local strong positive anomaly. Eastern part of Eastern Belt shows an increasing trend of gravity anomaly, which may represent a thinner crust probably related to the onshore extension of Penyu Basin. The turbiditic sedimentary sequences (Semantan Formation) appeared to have 2-3km of vertical thickness in the model and thinning up to the edge of the basin. The uneven basement of the basin is due to detachment fault at different depth. Based on the gravity model, the turbiditic sedimentary sequences (Semantan Formation) appear to have a relatively complex basin geometry appeared.

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A014

Geothermal exploration using 2D resistivity imaging and geomagnetic method in North Sumatera, Indonesia

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Abstract: The research is done to determine the geothermal fluid flows beneath the ground by using 2D resistivity imaging and geomagenic method. The area of research is in Tinggi Raja district at North Sumatera. It is located at 02º36'- 03º18' N and 98º32'- 99º35' E. The purpose of the research is to detect fluid contour, its anomaly and also subsurface structure layer. The geomagnet method uses PPM (Proton precession magnetometer) Elsec 770 type, data retrieval is randomly by the number of points earned 40-point measurement, data is processed by using surfers 10 to obtain a contour map and Mag2DC for windows to get a cross-section of the magnetic anomaly. Geoelectric method using a tool Ares-G4 Version 4.7 (Automatic Resistivity System) and GPS (Global Position System) measurement geoelectric method performed by spreading the electrode and injecting the current through two electrodes and the potential difference that appears can be measured in order to get the apparent resistivity obtained of geoelectric tools. The data is processed using Res2Div to acquire 2D cross-sectional contours of the rock layers resistivity values. The results showed that the spread of the fluid contours using geomagnetic and geoelectric spread vertically, sectional geomagnetic anomaly method has the lowest value and the highest value 22.75 69.92 nT nT, of the foregoing anomalous values obtained susceptibility 0.00054, 0.0006, 0.0016 where the model subsurface layer structure composed of sandstone, clay and limestone. For geoelectric method has a resistivity values (0,00-100) Ωm and clay models of rock layers. Resistivity values (150-200) Ωm models silt rock layers. Value restivitas (350-500) Ωm sand layer model, and the value restivitas> 22250 Ωm limestone layer model. From the results of this study concluded that the area had potential as geothermal energy. The second aim is to identify the stones that compile the mineral by using XRD at geothermal. The results from XRD by using diffractometer Jeol-350 Shimadzu 6100 show that the intensity from x-ray diffraction has the geothermal fluid spreads laterally to the geothermal manifestation. XRD survey shows the mean mineral that compile the geothermal stones at Tinggi Raja are calcite ($CaCO_3$) with trigonal crystal system (hexagonal). This mineral is the mean mineral that compile the clay.

Keywords: resistivity method, geomagnetic XRD, geothermal

A060

The application of the Persistent Scatterer (PS) and Small Baseline (SBAS) interferometry techniques to detect surface deformation in Penang Island with PALSAR data

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Abstract: Landslide is a natural geohazard destroying infrastructures and claiming several lives across the globe (Mirzaee *et al.*, 2017). It crashes down without warnings and travels several miles. The failures of landslides are inevitable especially around steep slope areas and the consequences vary depending on the number of activities of the area (Di Martire *et al.*, 2016). In recent years, landslide activities have increased at an alarming rate and Malaysia has been ranked tenth of the top ten countries with the highest landslides occurrences in the world between 2007 and 2016 as compiled by NASA (Figure 1), with 171 occurrences (Leoi *et al.*, 2018). Penang Island is one of the three states in Peninsular Malaysia with records of landslide occurrences (Ahmad & Lateh, 2011) as shown in Figure 2 and Figure 3. The geographical coordinate of Penang Island lies between latitude 5° 35' N and longitude 100° 32' E. It is important to monitor this phenomenon to reduce disaster and there is a need to understand the nature of the landslides that fail, and where, when, how and why they fail to mitigate risks from similar events in the future. The complexity of landslides can be studied using the joint efforts of both geophysical and remote sensing frameworks to achieve the best results (Borghero, 2017). This study focuses on the effect of landslides using Interferometry Synthetic Aperture Radar (InSAR) technique. This technique allows the measuring of the minute ground movement to a millimeter scale. Persistent scatterer (PS) and small baseline (SBAS) interferometry techniques were applied to Phased Array L-band Synthetic Observing Satellite (ALOS-1) mission PALSAR data obtained from Japan's Advanced Land to detect the changes in ground movement in Penang Island. InSAR results show signs of subsidence in certain areas like Tanjung Bungah, Bandar Baru Ayer Itam and Paya Terubong. Besides a subsidence trend, a seasonal behavior is also detected, probably related to aquifer recharge or tides. The calculated displacement velocities are compared to those obtained from leveling operations. Possible causes for the discrepancy are presented in the paper.

Keywords: Natural geohazard, inevitable, steep slope, InSAR, persistent scatterer, PALSAR

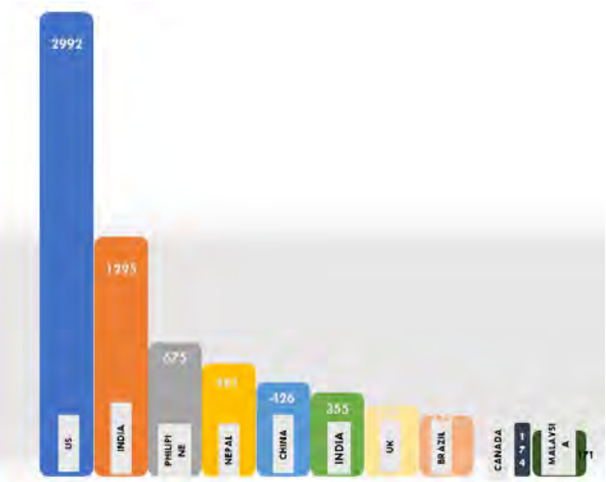

Figure 1: The ten countries with the highest landslides occurrence in the world

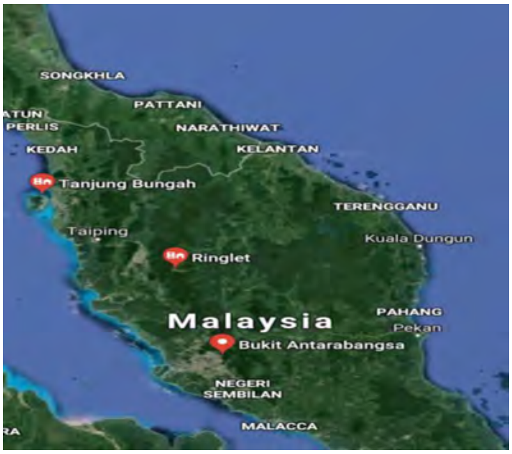

Figure 2: States with landslide occurences in Penisular Malaysia.

Tanjung Bungah Landslide, Penang, Malaysia on Saturday, 21st October 2017. Source: Malaymail website

The landslide along Jalan Persiaran Tanjung Bungah, George Town on Saturday 4th November 2017. Source New Straits Times website

The landslide along Jalan Bayan Lepas towards Balik Pulau, Penang on Thursday, 19th October 2018. Source The Star Online website

The landslides that caused more than 100 homes in Penang to be flooded on Friday 15th September 2017. Source: Malaymail Website

Figure 3: Various landslides occurrences in Penang Island.

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A071

Calibration of in-situ pressuremeter test using numerical simulation: A case study of Kenny Hill Formation

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The utilization of pressuremeter tests in geotechnical investigation gives advantages and drawbacks. Based on the determination of soil properties, in-situ testing is usually considered as the best method due its advantageous in determining the real soil behavior in representing the actual site conditions. For laboratory testing like triaxial test, undisturbed soil sample is required. However, the sampling process inevitably generate disturbance to soil samples. This situation is more significant when the sampling tools required to penetrate through soil with high resistance (i.e. stiff clay, hard sandy materials). Mechanical or physical behaviour of soil is unique and varies from site to site. Site in this study area is located in Kuala Lumpur, Malaysia and geological formation involved is Kenny Hill Formation. The finite element method for geotechnical problem required input from four main components, which are model geometry, soil parameters input, constitutive soil models and mesh elements. The model geometry determines the boundaries of the model, soil profile, depth of ground water level, and dimension of the structures. The input of soil parameters is often based on results from laboratory testing and in-situ testing. The selection of constitutive soil models often based on the characteristic of soil and the nature of the problem to be identified. Constitutive soil model is the formulations that determine the stress-strain- strength behaviour of soil. In the meshing process, the simulation model was discretised into smaller elements. However, soil characteristic and properties measured in laboratory or in-situ testing, is typically used pressuremeter test may not behave the similarly in the simulation with selected constitutive soil models. This is because that the simulation computes the stress and deformation based on measured soil parameters input under constitutive model. It is assumed that with the soil properties assign (e.g. soil stiffness and strength parameters), soil behave exactly as the framework of constitutive model. In practical, due to highly non-linear characteristic soil, the stress- strain behaviour of soil may deviate from simulation result even with the exactly soil properties input. It is crucial to ensure the simulation capture the real soil behaviour in practical. Regardless simple constitutive soil model nor second order advance soil constitutive model, calibration required on soil parameters to reduce the difference between measured and computation result (Calvello & Finno, 2004; Abed *et al*., 2014). The calibration of constitutive soil models

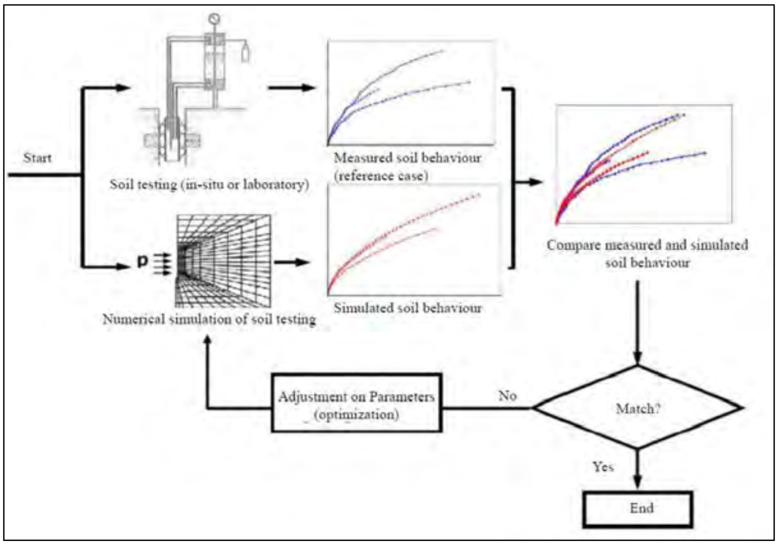

Figure 1: Work flow of constitutive soil model parameters calibration (Zhang *et al*., 2013).

parameters process often involved the data collection of soil properties, soil testing results, numerical simulation of soil testing, and fine-tuning on the constitutive soil properties to match the measured behaviour of soil as shown in Figure 1 (Azevedo *et al*., 2002; Calvello & Finno, 2004).

In detail, the preparation for constitutive soil models calibration should consist of identification of soil properties. Based on the soil characteristics and corresponding soil model, the required parameters should be identified. The measurement from in- situ testing (e.g. pressuremeter test) and / or laboratory testing were used as reference for calibration (Azevedo *et al*., 2002; Calvello & Finno, 2004; Surarak *et al*., 2012; Zhang *et al*., 2013). The numerical simulation required to reproduce the soil testing. The simulated stress-strain behaviour of soil was compared to the measured behaviour. The calibration process will be terminated if there is negligible difference between the simulated and measured soil behaviour. Else, adjustment on soil parameters required to reproduce the measured soil behaviour. This process shall repeat until the simulation match the measurement from soil testing. Calvello & Finno (2004) named this process as inverse analysis. The pressuremeter test measured stress- strain behaviour was used as reference case for constitutive soil model calibration in this study area. The calibration of constitutive soil models conducted by numerical simulation of pressuremeter test.

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A074

Enhancement of peat soil properties by applying Electrokinetic Stabilization (EKS) Method at Parit Kuari, Johor, West Malaysia

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Abstract: The aim of this study is to improve the properties of peat i.e. shear strength, moisture content, liquid limit and shear wave velocity. Peat is considered as weak foundation soil as they have low shear strength, high compressibility with high moisture content. One of the major problems for the construction industries in Malaysia is slope instability and bearing capacity failure or excessive settlement of peat foundation for the development of highways and buildings. Therefore, it's essential to find an appropriate way to enhance its properties. Malaysia contains peat about 3 million hectares which cover 8% of the total land. To ensure the reduction and solution of these problems can finally solve to apply electrokinetic stabilization (EKS) methods to the peat soil. The peat soil sample was collected from Parit Kuari, Batu Pahat, Johor, Malaysia. The voltage gradient of 110 V and 150 V was applied for the operational period of 6 hours. Some laboratory tests like shear strength (τ), moisture content (WN), liquid limit (WL), maximum dry density (MDD) and optimum moisture content (OMC) and bender element test were observed for pre-EK as well as for post-EK. It was observed that strength was found significantly improved from 11.66 to 70 kPa, MC was reduced from 613.989 to 270.294%, liquid limit was increased from 159.261 to 217.603%, MDD was decreased from 7.97 to 6.09 Mg/cm^3 while OMC was increased from 25.421 to 121.811%. The shear wave velocity was increased from 68.5 m/s to 110.5 m/s. The result shows the compaction properties of peat soil was improved with EK treatment and shear strength, moisture content, liquid limit of peats across the electrokinetic cell also altered depending on the applied voltage gradient, electrode and operational period.

Keywords: Peat soil, shear strength, electrokinetic stabilization

A083

Development of a 3D geological model for Kuala Lumpur (3DKL)

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Densely populated urban environments are subject to multiple competing land-use requirements and ever-growing populations that necessitate subsurface development to meet future needs. The subsurface presents a dichotomous environment of both resources for exploitation, and hazards that require mitigation. A better understanding of subsurface properties and processes is therefore critical to improving sustainable development and resilience of urban areas (Culshaw *et al*., 2009; De Mulder *et al*., 2001; Dearman, 1991; Legett, 1982; Tan, 2009; Tan & Rau, 1986). A significant step toward this understanding can be made through the development of 3D geological models that help inform the decision-making of geoscience stakeholders and practitioners involved in planning, design, construction, maintenance, demolition and remediation of buildings and infrastructure (Culshaw, 2005; Culshaw & Price, 2011; Campbell *et al*., 2010).

With the ambition of building the first 3D Geological Model of Kuala Lumpur (3DKL), a consortium was formed comprising a selection of geoscience stakeholders from across government, industry and academia. It includes Jabatan Mineral dan Geosains Malaysia (JMG), British Geological Survey (BGS), Dewan Bandaraya Kuala Lumpur (DBKL), Jabatan Kerja Raya (JKR), University of Malaya (UM), Universiti Tenaga Nasional (UNITEN), Universiti Kebangsaan Malaysia (UKM), Mass Rapid Transit Corporation (MRT). A workshop was held in November 2018 to share data, software, technical skills and geological knowledge and decide on the contents and methodology to be adopted for the creation of 3DKL, the details of which are presented here.

Due to the nature of the project (essentially a pilot study), the availability and quality of data (principally analogue data; limited data capture for superficial deposits and lithostratigraphy; and mostly derived from wash boring), it was decided that a 1:50,000 scale lithostratigraphical bedrock and superficial model would be constructed to a depth of 300 metres below ground level. The model would also incorporate major structural features, such as formation bounding faults.

The workflow adopted for 3DKL is a purely digital approach that can be broken down into four discrete stages: 1) development and population of a borehole database (Figure 1); 2) sourcing and digitising baseline topographic and geological data; 3) construction of multiple cross sections to produce a fence diagram (Figure 2); 4) combining cross sections, borehole data and baseline topographic and geological data to create a 3D geological model (Figure 3). This is a relatively conventional methodology that has been followed successfully by BGS, and others for many years (Culshaw *et al*., 2009; Ford *et al*., 2009; Kessler *et al*., 2008; Lelliot *et al*., 2006; Royse *et al*., 2008).

It is expected that numerous iterations of steps 3 and 4 will be required in order to improve the geological model. Examples of refinements that will be required include the formation of 'helper sections' between the main cross sections of the fence diagram in order to explicitly define geological features that elude implicit interpolation techniques – for example river channels and karst.

To date JMG have digitized over 800 hard copy borehole data logs sourced from various parties, mainly in the private sector and involved in civil engineering. These logs are digitized into a standard format accepted in current practice. Future industry practice should standardise borehole data and information presentation to authorities and stakeholders in a digital format, which in return will shorten the time taken to prepare 3D geological models and cross sections. This invaluable subsurface data and information will also be stored in a well-managed database system at JMG, which will be accessible to internal and external users.

With an improved understanding of the scale, distribution, and characteristics of the major geological units in the subsurface, geologists can now engage in constructive discussions with government authorities and industry professional to facilitate future subsurface development. A shared 'bigger picture' view of the subsurface will also allow ground investigation to be strategic, targeting aspects of the geology that pose the most risk in the critical volume of interest. Future

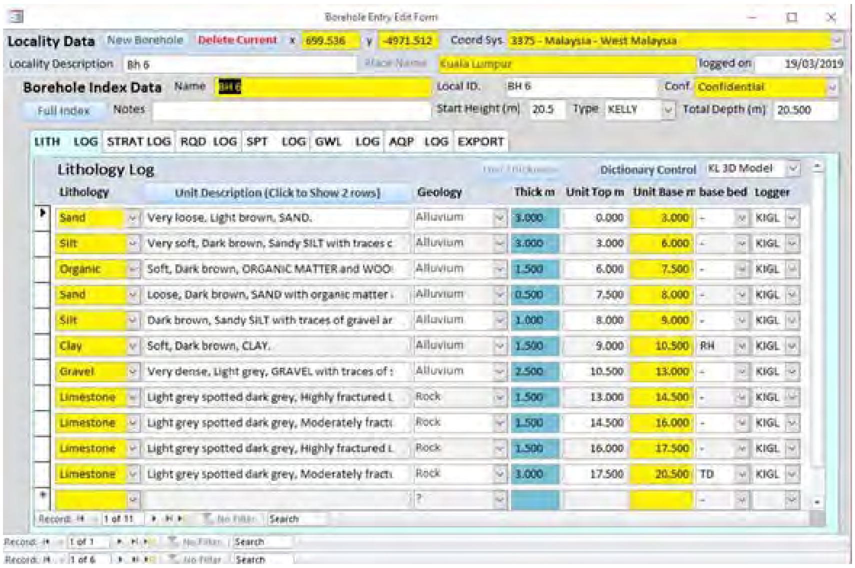

Figure 1: Borehole database interface.

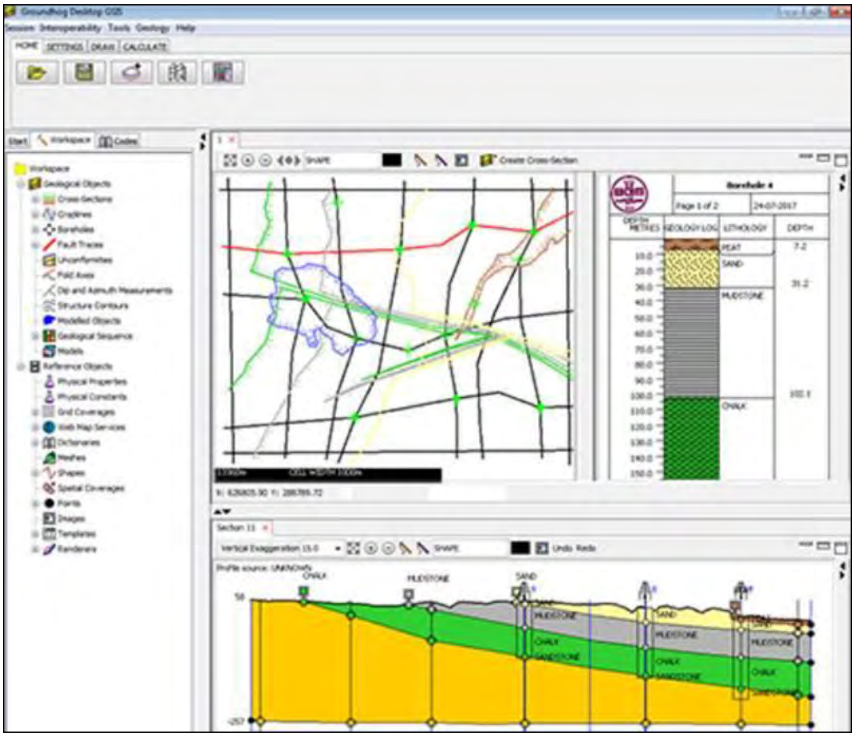

Figure 2: Groundhog software with windows displaying a cross section, fence diagram and borehole.

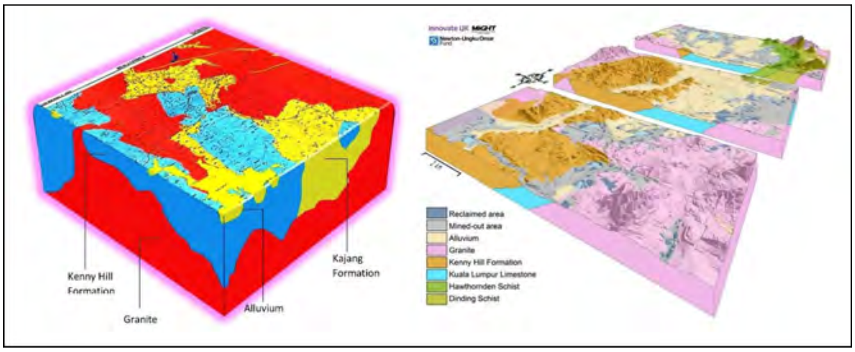

Figure 3: Example of conceptual 3D geological models of Kuala Lumpur.

integration of geological data and information into 3D information management and modelling platforms will also aid sustainable management of societal assets.

Good data management, particularly of sub-surface information, together with comprehensive data interpretation, helps industry practitioners in ensuring smooth development with the privilege of avoiding unforeseen and uncompromising geological ground conditions. This is critical to prevent stop work orders, change of project design, project delays and potentially huge additional financial costs.

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A085

Non stationariy training images from modern carbonate analogues for MPS modelling in Central Luconia Province

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INTRODUCTION

Over the past decade, Multiple-point geostatistical methods (MPS) are increasing in popularity in reservoir modelling since the work of Guardiano & Srivastava (1993) and further work developed in Strebelle's work in 2002 (Strebelle, 2002). Since then different approaches have been proposed (Arpat & Caers, 2007; Mariethoz G. & Renard, 2010; Parra & Ortiz, 2011; Straubhaar *et al*., 2011) and different algorithms have been developed, however not too many training images have been proposed to solve the geological issues to be widely used in carbonates environments. This study, therefore, aims to propose to optimize the workflow in using depositional modern analogs to construct Training images.

LOCATION

The modern analog for training images construction is located in Tun Sakaran Marine Park (Figure 1) and includes seven isolated carbonate platforms: Gaya, Selakan, Kapikan, Mantabuan, Church reef, Maiga and Sibuan. The area is situated 7.5 km east of Semporna, and it is surrounded by deep water ranging in depth between 60 m off the western edge of the study area, 90 m to the south, 120 m to the east and 90 m to the north (Chalabi, 2012).

METHODOLOGY

A. Training Images Generation

A training image is a two or three - dimensional numerical grids that quantify the heterogeneity from the properties of the reservoir (Mariethoz & Caers, 2014) and is one of the most important inputs in MPS technique. Thus, providing a representative TI, or a set of TIs, is the biggest challenge in the MPS applications.

For this case study 2D training image (TI) are built reflecting facies metrics and geometries using modern environments from small to large Church Reef, Maiga and Gaya platforms are chosen to observe the relationship between geometries (size, perimeter, shape) and facies distribution maps from previous studies (Chalabi, 2012) to confirm the non-stationarity in a carbonate platform for training images generation.

The training images are generating using BHGE's Jewel Suite which uses the Improved Parallel Multiple-point Algorithm Using a List Approach (IMPALA) algorithm (Straubhaar *et al.*, 2011) which is a further improvement to SNESIM algorithm (Strebelle, 2002) and proposed to replace the tree, which is a construction of the search tree by a list. This IMPALA list structure requires much less RAM which is a significant problem in SNESIM in dealing up with complex training images.

Figure 1: Satellite images showing the recent carbonates platforms in in Tun Sakaran Marine Park.

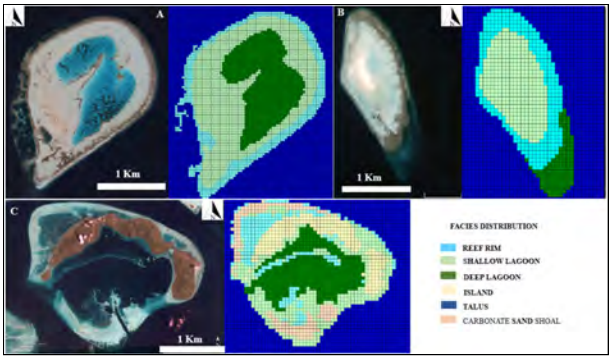

Figure 2: Training images in GLSIB format (A) Church Reef platform (B) Kapikan platform (C) Gaya platform.

RESULTS AND DISCUSSION

A library of training images in GLISB format describing common features in carbonates build-ups is being developed based on facies maps which represent

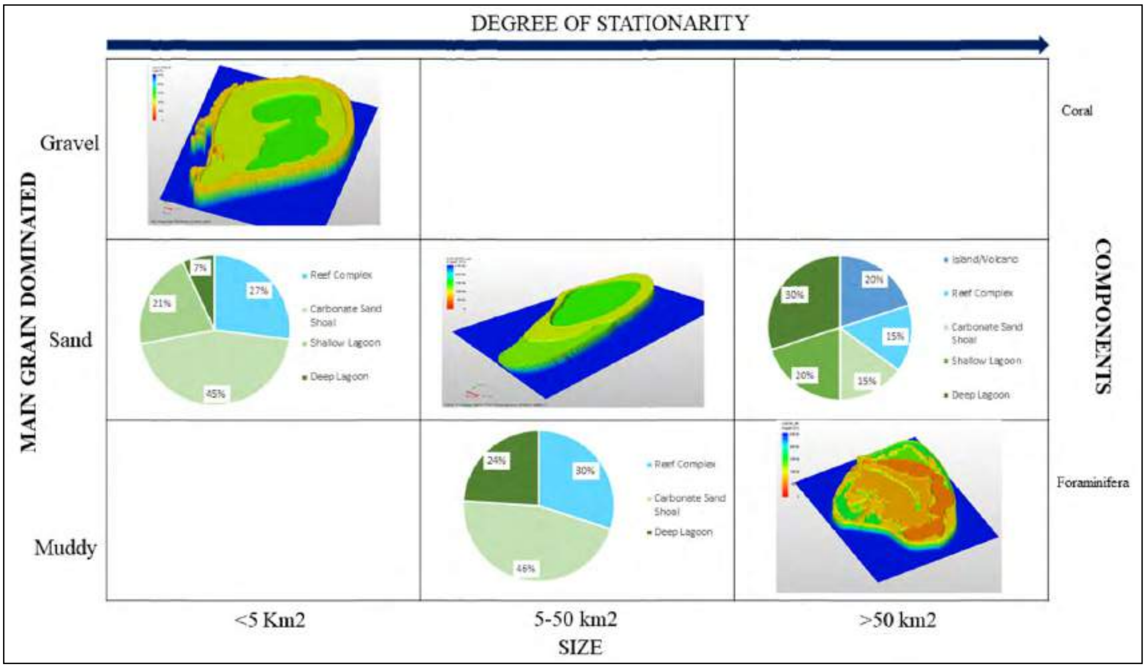

Figure 3: Degree of stationarity matrix using size, main grain dominant and facies distribution of (A) Church Reef platform (B) Kapikan platform (C) Gaya platform.

architectural analysis of carbonates build- ups analogs. In the MPS simulations, the main idea is not to reproduce almost identical patterns or geometries in the TI, but to generate similar features by inferring to the TI, while keeping an aspect of randomization to the simulation.

A. Metrics and Facies proportions

A previous remote sensing analysis of these modern carbonate platforms has led to the creation of maps of sedimentary facies and has highlighted the heterogeneity of distribution of sedimentary facies on some of the platforms (Pierson *et al.*, Chalabi, 2012). These facies maps allow exploring correlations and trends and relationships between facies distribution, size and reservoir quality to generate training images for a further MPS simulation (Figure 3).

B. Degree of Stationarity Vs Size of Platform

a) Lower (Church Reef Platform): This level corresponds to a small platform (<5 Km^2) coral factory dominated and homogenously distributed with a reduced number of facies.

b) Moderate (Kapikan Platform): Corresponding to a medium platform size between 5-50 Km^2, coral – foraminifera factory dominated, homogeneously distributed with a reduced number of facies.

c) High (Gaya Platform): Corresponds to a large platform >50 Km^2, foraminifera dominated and with a high degree of heterogeneity in surface, facies distribution and a high proportion of facies.

CONCLUSIONS

The training images (Figure 2) will be tested using IMPALA algorithm in JEWEL SUITE software and common issues during the workflow using MPS (search mask, multigrid's and others) which excessive runtime performance and handling nonstationary will be addressed.

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A091

Diving wave tomography: Forward modelling on synthetic data simulating shallow gas anomaly

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INTRODUCTION

In seismic imaging, near surface velocity model is said to be essential to image deeper structure [1]. Depending on the purpose of modelling, near surface constitutes depth of up to 100 m for uphole surveys and mining engineering while for hydrocarbon exploration, near surface may exceed 100 m in depth. In such cases, near surface modelling act as a mean to focus an image and to resolve traveltime anomalies [2]. Implementation of diving wave tomography (DWT) has been a routine procedure to minimize the effect of those anomalies, especially in area with complex geologic setting [1], [3].

Deeper hydrocarbon reservoirs that are the focus of prospect evaluation often obscured by shallow water environment and the overlying geological structures that introduce strong velocity variation, e.g. salt (Sigsbee), overthrust (Marmousi) and gas, which will be the focus of this paper. In contrast with DWT, reflection tomography used to illuminate deep reservoirs are often affected by the plunge in velocity caused by those gas pockets, thus making the velocity model of deep targets less reliable. Alternatively, first arrivals from diving wave carries valuable shallow structures information that are essential to complement and ultimately enhance the accuracy of velocity model generated from reflection tomography. The final outcome from the integrated workflow of DWT and reflection tomography are known to be used as input or initial velocity model for the high-fidelity modelling technique – full waveform inversion [4], [5].

METHODOLOGY

Based on the work done in [6], synthetic data is used to simulate the seismic traveltime of diving wave through a low velocity anomaly by means of forward modelling. Forward modelling refers to the process of predicting the result of measurement, given a complete description of a physical system, i.e. model parameter. It is a part of the overall integrated workflow of tomographic inversion, which seeks to minimize the difference between observed and modelled data through iterations (Figure 1).

1) True Velocity Model

A 2D velocity model with constant velocity gradient and Gaussian anomaly is generated specifically to imitate shallow gas cloud with velocity as low as 250m/s. The synthetic model is measured at 1000 m by 500 m dimension with sampling grid of 1 m (Figure 2A).

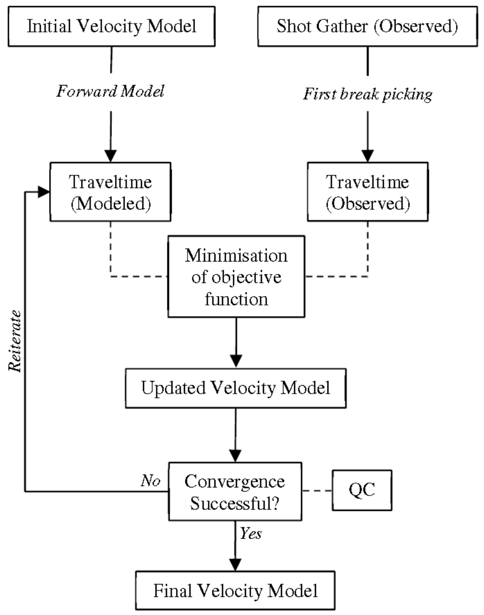

Figure 1: A simplified workflow of tomographic inversion.

2) Forward Modelling

The first forward modelling technique applied is ray tracing, in which a point on the wavefront rather than the complete wavefield is tracked along direction of propagation. It is a widely used method due to its simplicity and robust applicability in body wave tomography. The second method applied is the finite difference double-square-root (DSR) eikonal solver, expressed as the following:

$$\frac{\partial T}{\partial z} = \pm\sqrt{\frac{1}{v^2(z,s)} - \left(\frac{\partial T}{\partial s}\right)^2} \pm \sqrt{\frac{1}{v^2(z,r)} - \left(\frac{\partial T}{\partial r}\right)^2}$$

Where T is traveltime; z is depth; v is velocity; s is source and r is receiver.

CONCLUSION

Under ideal circumstances, such that a layer cake model or a simple geologic setting, the arrival times of a seismic shot gather would constitute first arrivals and

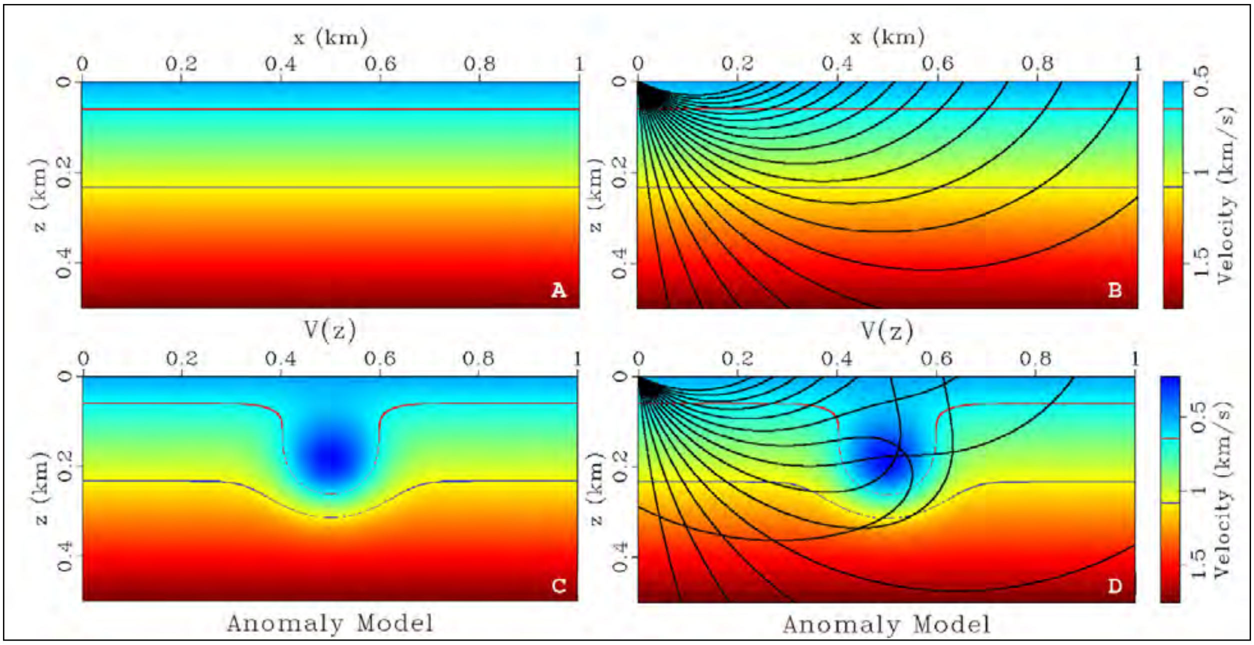

Figure 2: The initial velocity model (A) that shall be used as input in the tomographic inversion to image the Gaussian anomaly model (B). The ray traced from shot point (0,0) clearly demonstrates the effect of the low velocity anomaly (D) and how it introduces nonlinearity in arrival times versus offset as opposed to the constant velocity gradient in (C).

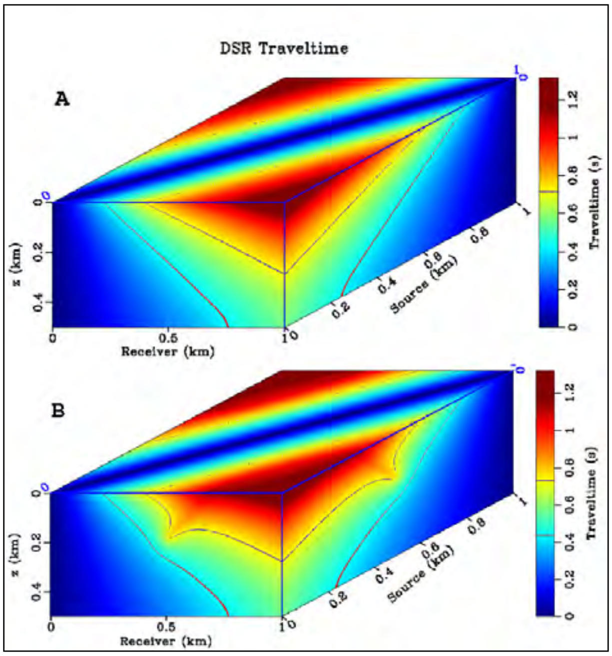

Figure 3: DSR first-break traveltimes of the Gaussian anomaly model. A clear delay can be observed in traveltimes of the diving wave travelling through the low velocity region (B), as opposed to the constant velocity model (A).

hyperbolic curves as reflective event. With the presence of low velocity anomaly in the shallow subsurface, the traveltimes recorded would carry non-linearities (Figure 2, Figure 3). These non-linearities would affect the seismic imaging of deeper region if not resolved, rendering the resulting seismic section less reliable for interpretation and analysis. DWT was therefore introduced to estimate shallow velocity model and minimize the effects of near-surface structures.

ACKNOWLEDGEMENT

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A100

Thought-provoking observations of the regional gravity fabrics of East Malaysia

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Abstract: The World Gravity Map (WGM) represents a set of high-resolution gravity anomaly maps and digital grids computed at global scale from available reference Earth's gravity and elevation models. The gravity anomalies are used to investigate the mass-distribution of the Earth interior to provide constrains on the geological structures from subsurface, crustal to upper mantle depths. The gravity features creates an interesting fabrics which can be used to understand regional tectonics as well as basin features around the world. This presentation present some of the interesting observation of WGM in the region of SEA with special emphasize around the Borneo island. These out-of–the box observations are hopefully will trigger some new way of looking at the geology of East Malaysia.

INTRODUCTION

World Gravity Map (WGM) is a map represent the first gravity anomaly maps computed in spherical geometry, that take into account a realistic Earth model. The gravity anomaly maps (surface free-air) are derived from available Earth gravity models (EGM2008, DTU10) and include high resolution terrain corrections that consider the contribution of most surface masses. New theoretical developments have been performed to achieve accurate computations at global scale using spherical harmonic approach (Balmino, G. *et al.*, 2011).

Tectonically, the Borneo Island is very complex (Hutchinson, 2005). Borneo has been divided into five zones: The SW Borneo, Kuching Zone, Sibu Zone, Miri Zone and East Borneo Zone separating by the Adang Fault, Lupar Line, Tatau-Mersing Line, Tinjar Line and Long Aran-Witti-Kinaya Fault,respectively. The presence of a complex Borneo Accretionary Prism (BAP) in the center of the Borneo holds the key to understand the tectonic evolution of the area. A number of tectonic models on BAP has been proposed, but none of the models perfectly match all of geological facts (Wang *at al.*, 2016).

OBJECTIVE

This paper has two main objectives. The first objective is to contribute to an important and current debate on the Borneo tectonic. In this context, we analyze the gravity fabric based on WGM of the Borneo and surrounding area. Our second objective is to link those regional gravity fabric to the tectonic understanding of the area.

THE ANALYSIS

The WGM demotes a set of high resolution gravity anomaly maps and digital grids computed at global scale from available Earth's gravity and elevation models and it provides homogeneous information on the earth static gravity fields at both regional and global scales. The analysis is done based on the regional gravity fabric coupled with the local geological maps published from various literatures. Based on the gravity fabrics, there are 6 zones (A, B, C, D, E, and F) clearly be seen (Figure 1). The zones are separated by semicircular or linear features

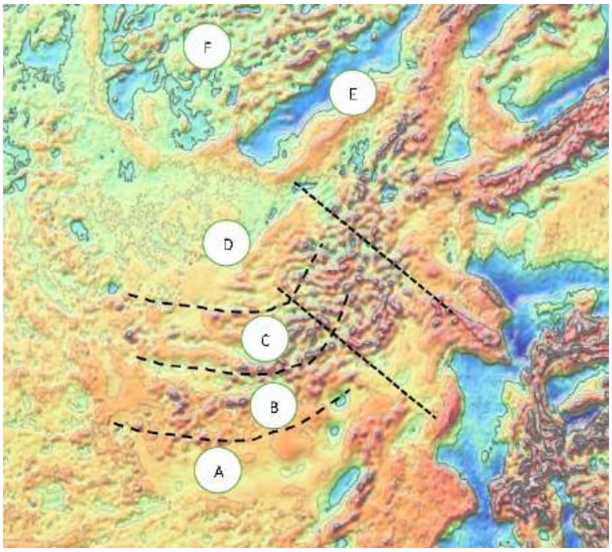

Figure 1: Gravity map of Borneo Island.

Table 1: Characteristic of the gravity zones and its equivalents.

Zones	Description	Geological zones
A	Low intensity gravity anomaly	SW Borneo
B	Intense semicircle arcute gravity lineaments	The Kuching Zone
C	Intense semicircle gravity lineaments	The Sibu Zone
D	Low intensity, broad gravity anomaly	The Miri Zone
E	Broad positive anomaly	Inboard Sabah
F	Intense linear SW-NE gravity anomaly	Dangerous Ground Zones

which may represent the fault lines. The characteristic of those zones as well as their respective geology equivalent zones are listed in Table 1.

CONCLUSION

Gravity fabrics shows another evident of the complex tectonic of the Borneo Island. WGM provides a thorough understanding of the Borneo Island tectonic which is crucial in exploration activities.

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A149

Effect of monsoonal clustering for PM_{10} concentration prediction in Keningau, Sabah using Principal Component Analysis

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Abstract: Particulate matter (PM) has caught scientific attention in scientific research due to its harmful effect on human health. While prediction is essential for future development in Keningau, temporal clustering in Keningau has yet to be studied. Thus, this research aims to determine whether monsoonal clustering is required for meteorological and pollutant concentration data collected in Keningau. Missing data is first imputed using Nearest Neighbour Method (NNM). Then, wind direction and wind speed are converted into northern (W_y) and eastern (W_x) component of wind speed. Data is then temporal clustered based on monsoonal season (NEM, IM_4, SWM, IM_{10}). Both clustered and unclustered data are analysed using principal component (PC) analysis (PCA). The findings revealed that humidity in PC1 with average EV (explained variation) of 93.92 ± 0.52 contribute the most variation of PM_{10}, followed by W_x in PC_2 with average EV of 3.51 ± 0.48. Regression analysis shows that humidity and PM_{10} are negatively moderate to strongly correlated except for IM_4 (intermonsoon April), which may be due to dry climate during the season. As for W_x, it has weak correlation with PM_{10}. This may be due to location of Keningau at western part of Crocker range. However, the spread of PM_{10} due to eastern wind causes weak to zero correlation. Due to consideration of dry climate as revealed by the findings from IM_4 cluster, there is need for data collected by Keningau to be clustered by monsoon.

Keywords: PM_{10}, nearest neighbour method, monsoonal cluster, principal component analysis, regression analysis

A150

Effect of exposure time of Near Infrared Light Radiation (NIR) on human's vein visualization

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INTRODUCTION

Human blood specimen contains information about health and possible diseases that help the physician identifying the appropriate medical diagnosis. Many studies have focused on the characteristics of NIR on human skin but the effects of exposure time as one of the design parameters in NIR exposure was not discovered.

OBJECTIVE

This research proposes studies that ease the handling operation and minimize the operating cost of NIR imaging in visualizing vein-structure. The study aims to measure and compare the effect of exposure time of the near infrared light emitting diodes on the vein visualization.

METHODOLOGY

An infrared camera is required to capture the vein digital images. This study will then process the overall quality of the images with different exposure time by highlighting the vein-morphological structure hessian and contrast method.

RESULT

The results revealed that increasing time of exposure do not increase the absorption of the NIR in both palm and arm area. Image processing further confirms this result by showing the extracted and highlighted vein. For all images, the numbers of vein appeared are the most significant factors that contribute to the vein visualization.

Keywords: Near Infrared Imaging, vein detection, image processing

A031

The integration of seismic refraction and multichannel analysis of surface wave (MASW) for subsurface characterization

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Abstract: Slope stability analysis and stabilization require an understanding and evaluation of the processes that govern the behaviour of the slopes (Ozcep *et al.*, 2010). The essential of a geological and seismological parameter related to the slope is crucial to understand as well as the methods used in slope analyses. Slope instability is a complex phenomenon that occur at many scales which has always brought to significant economic losses, human lives, infrastructures, and other facilities. Landslides occur during earthquake causing saturated soil to lose their strength with ground settlement, lateral spreading, mass movements of the ground and foundation failures (Chik & Islam, 2013). The strength of hill-slope scale associated with the strength of intact rock, the degree of weathering, and characteristic of bedrock fracture (Schmidt & Montgomery, 1995; Hoek & Brown, 1997; Jaeger *et al.*, 2007). Hence geophysical approaches were applied to study soil characteristic using seismic refraction method with cooperated surface waves. The method is used to analysis the stiffness of the soil with soil properties of shear modulus, G. 2-D seismic refraction method is commonly used in identifying subsurface geology and properties including depth; based on the travel time of refracted seismic compressional wave velocity, Vp at interfaces between subsurface of different velocity layers (Zainal *et al.*, 2012; Saad *et al.*, 2012; Kamaruddin *et al.*, 2015). Meanwhile shear wave velocity, Vs of near-surface materials is an important parameter in various geotechnical and engineering applications in assessing soil amplification and seismic site classification. The small-strain shear modulus of individual soil layers, G is directly proportional to the square of their characteristic shear wave velocity. Furthermore, the study of soil characteristic of slope stability was carried using seismic refraction and multichannel analysis of surface wave (MASW) and estimation shear modulus, G of soil using empirical formula. Five survey lines were designed at the slope area of Archaeology Building of Universiti Sains Malaysia and the data was acquired using the ABEM Terraloc MK8 system with 24 of 4.5 Hz and 28 Hz geophones. The raw data was transferred into the computer to commence processing using application software; FirstPix for picking first arrival time, Gremix15 for velocity analysis, SeisOpt@2D for generating 2-D seismic refraction profile. The data for surface wave was processed using Geopsy software to produce an inversion result of 1-D profile for S-wave velocity. The field data of time-space (t-x) domain is transformed into frequency-wave number (f-k) domain using F-K transform before the dispersion curve analysis. The result of 2-D seismic refraction shows the

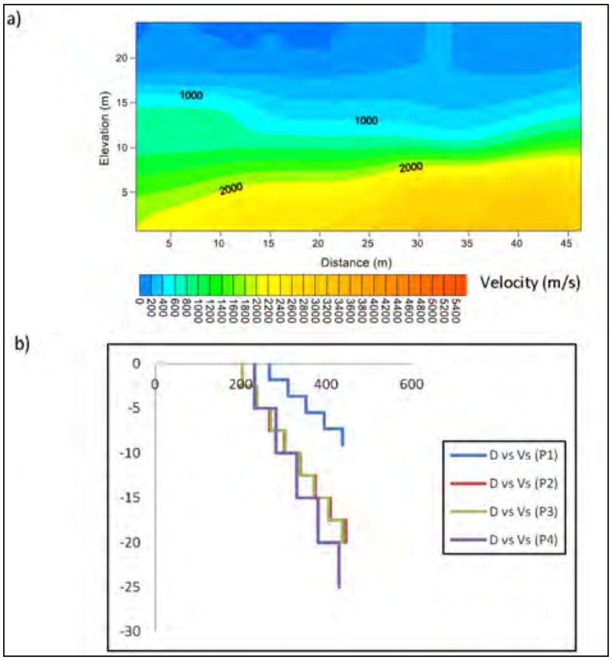

Figure 1: a) 2-D seismic refraction model b) 1-D velocity model of MASW.

velocity values, Vp is ranging from 200-5400 m/s with depth up to 25 m while average velocity of shear wave, Vs profiles of 195-445 m/s with investigation depth of 25-30 m as the values increase with depth (Figure 1). The estimated field shear modulus of soil for each line is ranging from values of 0.05-0.4 MPa as it varies with depth. The soil characteristic for this area shows the low show modulus values is dominated with silty sands while high shear modulus is representing the dense sand and gravels. The integration of the result shows the Vp and Vs velocity and shear modulus increases with depth as the soil are dense and stiff. This method of seismic refraction and MASW is successfully applied in analyses of the soil characteristic of the slope for this area.

Keywords: 2-D seismic refraction, MASW, shear modulus, slope stability

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A003

New approach for resistivity model building of shaly sand reservoirs using new seismic attributes

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INTRODUCTION

Archie's modelling is successfully used to estimate the empirical relationship between water saturation and resistivity of clean sand reservoirs. In such cases of shaly reservoirs, Archie's model overestimates water saturation value due to the extra conductivity contribution from shales or clays. In this paper Indonesia modelling was used to determine the water saturation and resistivity distributions more accurately by taking into account the volume and resistivity of the shales. We presented in the following equation:

$$R_t = \left(\frac{1}{Sw}\right)^n * \left[\left(\frac{V_{sh}{}^{2-V_{sh}}}{R_{sh}}\right)^{\frac{1}{2}} + \left(\frac{\phi_e{}^m}{R_w}\right)^{\frac{1}{2}}\right]^{-2} \quad \text{Equation 1}$$

Where m and n are cementation and saturation exponents, ϕ_e is effective porosity, V_{sh} is volume of shale, R_{sh} and R_w is resistivity of shale and water formation respectively. The resistivity calculation was done for different cases of hydrocarbon saturation ideally can be used as input for electromagnetic sensitivity studies.

The continuity of petrophysical volume predictions were controlled by incorporating with two new seismic attributes known as SQp and SQs. These attributes derived from attenuation property through rock physics approximation introduced by Mavko *et al.*, (2009). SQp and SQs attributes can be presented in the following equation (Hermana *et al.*, 2016):

$$SQ_p = \frac{5}{6}\frac{1}{\rho}\frac{\left(\frac{M}{G}-2\right)^2}{\left(\frac{M}{G}-1\right)} \quad \text{Equation 2}$$

$$SQ_s = \frac{10}{3}\frac{1}{\rho}\frac{\left(\frac{M}{G}\right)}{\left(\frac{3M}{G}-2\right)} \quad \text{Equation 3}$$

Where M/G is the ratio of bulk and shear modulus that can be approximated from P-wave and S-wave velocity ratio. SQp attribute has similar lithological response to gamma ray log while SQs attribute has similar response to resistivity log.

SQP AND SQS ATTRIBUTE VALIDATION AT WELL LOCATION

SQp and SQs attributes generated from Equation 2 and Equation 3 at well location using Vp/Vs ratio and density log. A similar response is between SQp attribute and gamma ray log and between SQs attribute and resistivity log accordingly. This is to validate the practicability of these attributes to be used as the main inputs for petrophysical volume prediction.

PRE-STACK SEISMIC INVERSION

Seismic inversion was carried out to provide Vp/Vs ratio and density volumes for SQp and SQs attributes generation. A partial seismic dataset consists of near, mid and far gathers data was used as inputs in simultaneous seismic inversion to obtain the P-impedance, S-impedance and density elastic properties. The generated SQp together with SQs volume attributes were analysed to characterize the shaly sand reservoir and gas distribution of the study area. A reservoir interval was seen from 690 to 750ms time interval indicating lower value of Vp/Vs ratio and SQp attribute. SQs attributes showed relatively higher values indicating the presence of hydrocarbon within reservoir interval.

PETROPHYSICAL VOLUME PREDICTION

The volume of shale, effective porosity and water saturation are the main parameters controlling the resistivity distribution of shaly sand reservoirs as presented in Equation 1. The reservoir petrophysical distributions in this study were predicted by using Multi-Attribute prediction method based on step-wise regression algorithm. It works by finding the best attribute from input attributes to predict the target log using a linear regression line. The multi-attributes were ranked based on their training and validation error values. SQs and SQp attributes were included with other internal seismic attributes to facilitate the prediction process to produce a good training and validation correlation respectively. The predicted petrophysical distribution showed a good consistency with higher response of SQs attribute in the southern area. This was supported by the presence of low volume of shale, high values of effective porosity and lower water saturation in the overlapping area.

RESISTIVITY MODELLING

The predicted petrophysical volumes were used as input to calculate the resistivity distribution of shaly sand reservoirs from Equation 1. The water saturation cut off values of less than 50% was used to delineate the producing gas sand distribution and substituted with 95% and 10% of water saturation to represent low and high case of hydrocarbon saturation respectively. The calculated resistivity distribution of different cases corresponded to the high SQs response in the southern part.

CONCLUSION

We presented a new approach to build a robust resistivity model for shaly sand reservoirs. The resulting resistivity distribution showed a good agreement with well log resistivity and seismic distribution. This work has also proven that when the new seismic attributes is amalgamated with other internal seismic attributes can lead to a better resistivity estimation.

ACKNOWLEDGEMENT

The authors thank UTP for funding this research work and PETRONAS for providing the data.

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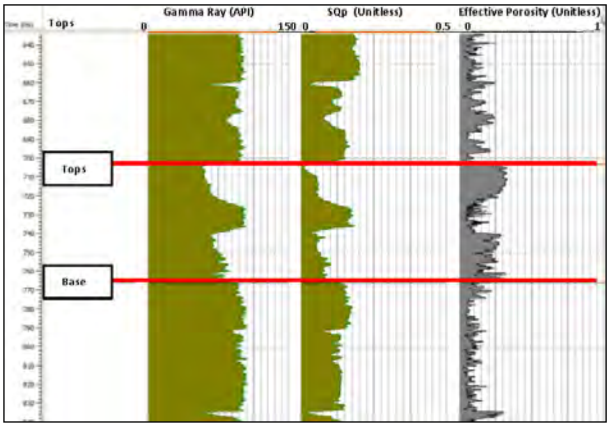

Figure 1: SQp response showed similar response to measured gamma ray and corresponded to effective porosity log.

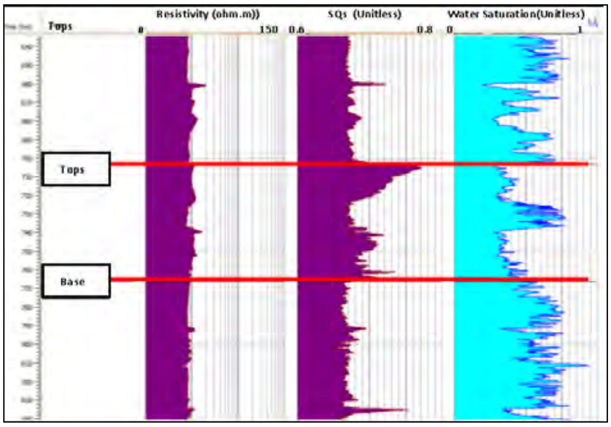

Figure 2: SQs response showed similar response to measured resistivity and corresponded to water saturation log.

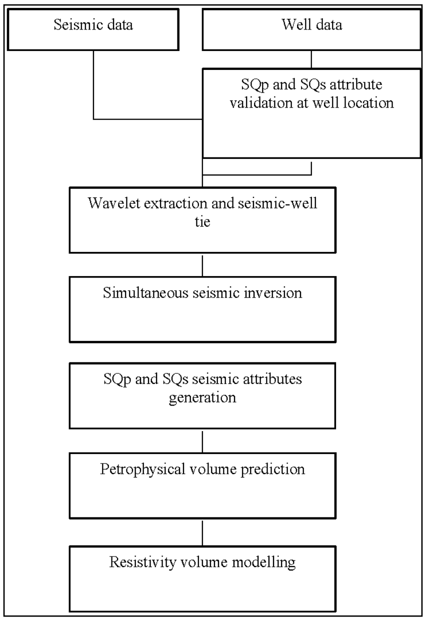

Figure 3: Workflow of 3D resistivity model building.

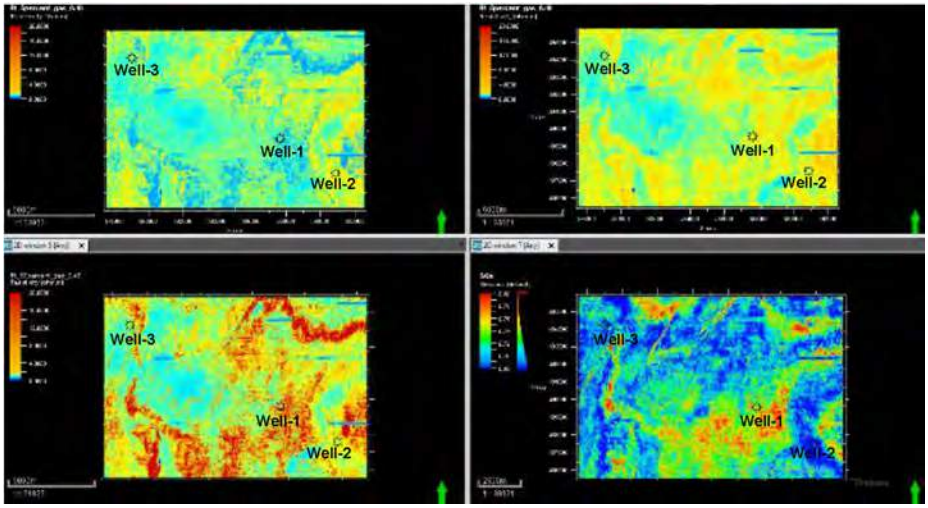

Figure 4: Resistivity modelling result for 5% hydrocarbon saturation (upper left), in-situ resistivity distribution predicted from seismic attributes (upper right), 90% hydrocarbon saturation (lower left) and SQs attribute (lower right).

AT079

Hybrid approach for Enhanced Seismic Imaging using inversion and imaging in Malaysian carbonate

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INTRODUCTION

Seismic inversion is a procedure which helps to extract the essential models of the physical characteristics of the subsurface rocks and fluids from seismic and well-log. In the absence of the well-log data, the properties can also be inferred from the inversion of seismic data alone (Krebs, J., 2009). In exploration and production oil and gas industries, seismic inversion considers as a tool of tracing hydrocarbon potential lithology's in subsurface using seismic data.

A mainstream of remaining proven Oil & Gas reserves is contained by Carbonate reservoir, and much more complicated to explore as imaging of the Carbonate rocks is poor. In case of Carbonate data, seismic diffraction imaging (Bashir, Ghosh, Janjuhah, & Sum, 2018; Bashir, Ghosh, & Sum, 2018) has contributed to an enhancement in the quality of seismic but there is still lack of understanding the lithology and impedance contrast which can be defined by the seismic inversion. In contrast, to the conventional process, an integration of seismic inversion methods is essential to understand the lithology and include the full band of frequency in our initial model to incorporate and detail study about the basin for prospect evaluation. In this paper, an integrated approach is developed for better delineation of subsurface structure and lithology's. Seismic post stack inversion technique is applied to the Carbonate field to study Electrifies and lithofacies of subsurface strata for better and detail study of the reservoir.

The Central Luconia province in offshore Sarawak Basin of Malaysia has witnessed prolific carbonate deposition during Miocene with high level of exploration success. The Miocene carbonate play is the primary target for hydrocarbon exploration in Central Luconia province with many commercial gas discoveries and upside exploration potential. A majority of remaining exploration potential in Sarawak Basin is contained in Carbonate reservoir, and much more difficult to explore and develop as imaging is complicated mainly due to heterogeneity. Identification of growth architecture, depositional Facies, and diagenetic imprints with special reference to Karstification events are important for field development and future exploration success in carbonates of Luconia platform.

DISCUSSIONS AND CONCLUSIONS

In this research, Petrel software has been used for data interpretation and further for seismic inversion Hampon-Russel software is used. Data with suitable format such as seismic and well-logging data of SEG-Y and LAS respectively is used in this study. Figure 1 shows the seismic interpretation window in which a top Carbonate with blue horizon and a base Carbonate with purple horizon was picked. These two horizons

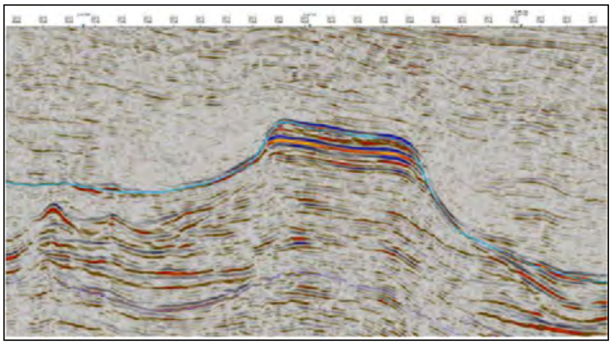

Figure 1: Interpreted seismic cross section with top Carbonate (Blue) and base Purple horizon.

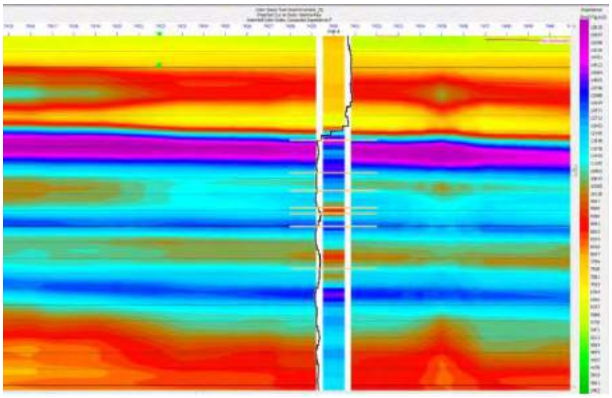

Figure 2: Inversted Impedance contrast using seismic postpostpostpost-stack inversion.

were selected to apply the seismic inversion with in the reservoir. The acoustic impedance log is calculated by multiplying sonic and density log in well location. In seismic inversion, the most significant step is wavelet extraction, a suitable seismic wavelet was extracted separately in the location of Well-A. The wavelet extraction and synthetic seismogram was repeated constantly until the correlation coefficient between the synthetic and the real seismogram become acceptable with minimal errors in the well location.

After selection of the model-based inversion method for seismic post-stack inversion process, the results show in Figure 2 the acoustic impedance contrast with interpretation of reservoir tops. Seismic inversion process has enabled to image the thin bed within the reservoir layer, that has been capture by the well-log but in the seismic impedance the layer strata is missing. This could be image by the re-processing of legacy data set with inverted Vp in which well-log frequencies are used.

Present study is useful to reduce the uncertainty of the key subsurface parameters that has strong bearing for field performance. Application of modern techniques in interpretation has greater impact to optimise the number of wells with proper placement in sweet zone to ensure better well deliverability and thus to reduce the project cost and enhance the chance of economic viability of the project.

Integration of geological and geophysical data indicates that relatively higher porosity is expected in the reefal build-up area towards the west, along the south & eastern margin than the depressed lagoonal area of the central part of the structure and northern part of the field which has an impact on hydrocarbon reserves and production behaviour in this field.

ACKNOWLEDGMENTS

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A093

Seismic forward modeling: Application of finite difference eikonal solver for traveltime computation

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INTRODUCTION

Seismic forward modeling can be described as the use of geological model of earth (normally velocity model) for numerical simulation algorithm which allow geoscientist to mathematically approximate how seismic waves propagate through it. In forward modeling, there are two main approaches that can be used to calculate the seismic wave's traveltime which are ray tracing method and finite difference approximation to the eikonal equation (Alashloo & Ghosh, 2017; Alkhalifah & Fomel, 2010; Perez & Bancroft, 2001). Ray tracing uses the assumption of wave traveling like a ray through shortest path in the model and change direction when encountering velocity and density difference. Although the result is accurate and regularly used, this method is computationally intensive, unable to solve shadow zones and sometimes overlook the shortest ray path (Perez & Bancroft, 2001; Vidale, 1990). Finite difference solution to the eikonal equation was proposed by Vidale in 1988. Instead of calculating wave propagation locally as in ray tracing, finite difference solves the problem over the whole earth model by dividing into grid points which is faster and more reliable.

OBJECTIVE

The main objective of this paper is to generate a synthetic seismic shot-gather that have more reliable traveltime of reflections events from a fast and stable algorithm which can be used further in velocity analysis such as seismic tomography.

THEORY

In this paper, we applied fast marching method (Sethian, 1996; Sethian & Popovici, 1999) as the eikonal solver in the forward modeling for isotropic condition. To compare with ray tracing and other finite difference methods, this method is more stable and remarkably efficient (Alashloo & Ghosh, 2017; Alkhalifah & Fomel, 2010).

We can solve traveltime problem by first referring to the basic equation to calculate time of a moving object:

$t = d/V$ (Equation 1)

where t is the time, d is distance and V is velocity. Since we use velocity (V_p) model, we can calculate the corresponding traveltime of the propagating wave at each point of distance.

Eikonal equation that describes wave propagation in three-dimension (3D) is described as follows:

$$\left(\frac{\partial t}{\partial x}\right)^2 + \left(\frac{\partial t}{\partial y}\right)^2 + \left(\frac{\partial t}{\partial z}\right)^2 = s^2(x,y,z) = \frac{1}{V^2(\theta)}$$

(Equation 2)

Where x, y, z are Cartesian coordinate axes, t is the traveltime, s is the wave slowness which is the inverse of velocity, V. V is a function of the angle of propagation, θ.

Illustration of fast marching method is referred to (Alashloo & Ghosh, 2017). In fast marching eikonal solver, the grid points are labelled is labelled as Alive (already calculated), NarrowBand (waiting to be calculated analytically) or FarAway (remain untouched, large traveltime value) as shown in Figure 2.

1. At the beginning of wave propagating (source location), the grid points are put as Alive, where time is set as zero.
2. The algorithm will find the point having minimum traveltime value among the NarrowBand points and then, set the point as Alive.
3. When all points in NarrowBand are set as Alive, the neighboring points of FarAway are updated as the next Narrowband.
4. Step 2 and 3 continue looping until all points are covered by the wavefront. The updating step of traveltime at point will use Equation 2.

CONCLUSION

Calculation of seismic traveltime is the vital part of Kirchhoff imaging. An accurate and reliable methods applied such as fast marching method is important for successful velocity analysis in the seismic imaging part. By having more accurate traveltime, better depth estimation toward subsurface layers can be achieved.

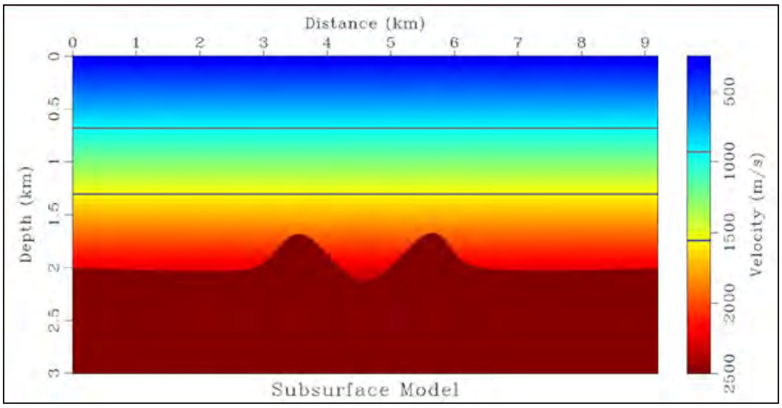

Figure 1: Geological model that will be used for application of fast marching method. The velocity gradient is set to increase gradually with depth by 250 m/s from 0 to 2 km and a syncline-anticline structure is set with 2500 m/s Vp.

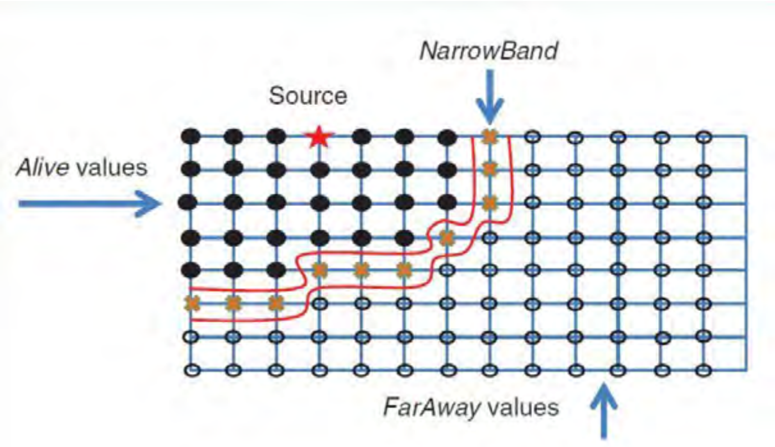

Figure 2: Fast marching method illustration describing the traveltime update calculation from source to whole grid points. Source: (Alashloo & Ghosh, 2017).

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A103

A preliminary study of seismic interpretation in the offshore Peninsular Malaysia

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Abstract: Seismic interpretation in the Miocene strata of the study area is located in the Peninsular Malaysia Offshore. The objective of this study was to investigate the seismic sequence from the seismic reflection data. A seismic interpretation was investigated using the 3-D high- resolution seismic data and profiles. In this study, the hydrocarbon potential reservoir of A- field was evaluated using seismic, well logs and check shot data. A seismic-well tie is formed by using well log (Well-A) and 3-D seismic data and the total vertical depth is approximately 2,200 m. The lithology log of Well-A is important to determine the reflector of seismic waves represent the boundary of the different rock. The reflection coefficient is from the sonic velocity recordings and density while the sequence boundaries are determined based on gamma-ray logs, density log, sonic and velocity log. There are few sequence boundaries in the study area including sandstone, clay, siltstone and thin layer of coal. The seismic interpretation will provide important data for determining the potential reservoir of oil and gas.

A002

Developed correlations between sound wave velocity and porosity, permeability and mechanical properties of sandstone core samples

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Abstract: In the evaluation of a petroleum reserve, it is necessary to accurately determine certain petrophysical properties such as porosity and permeability of the reservoir rocks and rock mechanical properties. Petrophysical properties are key factors in the reservoir performance and mechanical properties as they control drilling programs and affect stimulation programs and development plans for given reservoir. It is more convenient to use homogenous rock samples with nearly constant initial permeability, however, obtaining such cores is very difficult. In this paper a simulated natural and homogeneous compacted sandstone rock with known physical and petrophysical properties were used. Physical properties reservoir rocks including pore size distribution, grain size, cementing material concentration, and confining pressure affect rock porosity and permeability. This paper focuses on the correlation between seismic wave, permeability and porosity. Sound wave velocity was measured using an ultra sound tool on different sandstone core samples. Good correlation has been developed between sound wave velocity (V_P and V_S) the petrophysical properties mainly porosity and permeability. Significant correlations have been developed between seismic wave velocity (V_P, V_S and V_P/ V_S) and reservoir rock mechanical parameters namely Young's modulus, shear modulus, bulk modulus and Poison's ratio for sandstone core samples. This study has been carried out on dry core samples and core samples with different water saturations and results showed that there are changes in the correlation between seismic wave velocity and mechanical and petrophysical properties as the water saturation change from dry rock to wet rock.

Keywords: seismic wave, porosity, permeability, mechanical parameters, sand core samples, water saturation

A040

Extended discovery of prehistoric site at Gua Pelangi using ground penetrating radar

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Located in Felda Pasoh 4, Jelebu, Negeri Sembilan, Gua Pelangi is a potential first prehistoric site to be discovered in the southern part of peninsular Malaysia. Gua Pelangi was first discovered in 2014 and several archaeological and geophysical surveys were conducted. The first and second phase of excavation works were done in 2015 by archaeologist from Centre of Global Archaeological Research (CGAR) USM and discovered artefacts that provide evidence of human presence approximately 14000 years ago (Rasydan & Saidin, 2015). The discovery of relics such as stone tool and axes were similar to those found in other caves in previous time. The snail shells and other bone fragment of animals were also discovered in the first and second phases of excavation. Due to this efficacious discovery, the extension study of this prehistoric site was conducted using Ground Penetrating Radar (GPR) to identify the potential area for further archaeological excavation. The area was divided into two; Site A and Site B. There were 11 GPR survey lines (A1-A11) were conducted at Site A and 31 lines (B1-B31) at Site B respectively with 20 cm spacing between lines. Total length of 5 m were conducted at each line for site A and 4 m for Site B. The data acquisition was performed using high frequency 800 MHz shielded antenna. Using the concept of reflection of waves, the transmitter (Tx) emits a signal into the surface of investigation. The back reflected signal is detected and registered by a receiver (Rx). In contrast to seismic methods, GPR uses electromagnetic (EM) waves instead of acoustic waves. EM waves will not penetrate as deep as acoustic waves but will result in much higher resolution maps. Targets with a contrast in electrical impedance to the surrounding media will be detected (MALA, 2011). Therefore, GPR is the best geophysical tool used for detection and localization of any buried artefacts or cultural layers either metallic or non-metallic target down to several meters' depth, depending on the frequency used. The higher the frequency, the higher the resolution map (radargram). The data were further process to get the clear radargram by applying three basic filters; DC, time-gain and band pass filters. Based on results

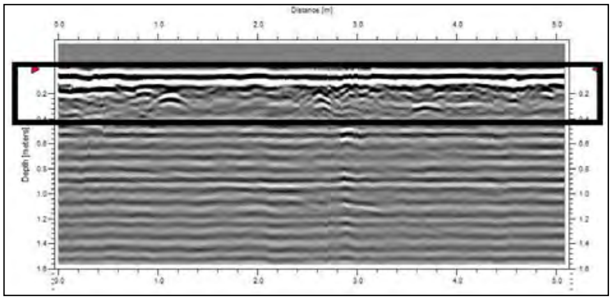

Figure 1: Several hyperbolas detected embedded in cultural layer at depth less than 0.4 m at line A1.

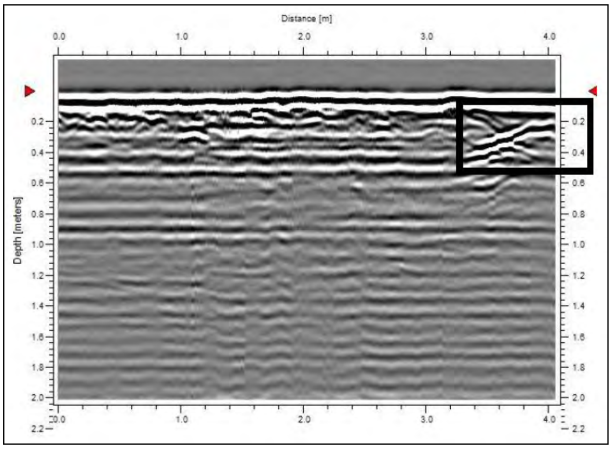

Figure 2: Strong reflection at line B7 at depth of 0.2 - 0.3 m.

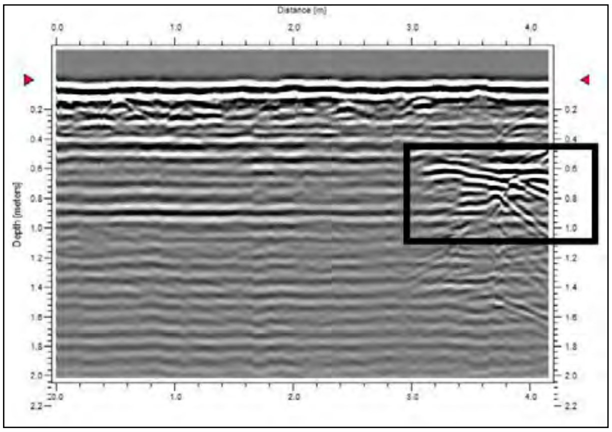

Figure 3: Strong reflection at line B11 at depth of 0.5 - 0.9 m.

obtained for Site A, several hyperbolas were detected at shallow depth, less than 0.4 m that can be interpreted as small rock/artefacts embedded in cultural layer (Figure 1). Strong planar reflection was also observed at depth of 0.5 m and 0.9 m which correspond to the change of different sediment/material layers. Therefore, three layers were observed from the radargram with first layer is from surface to 0.5 m, second layer is from 0.4 – 0.9 m and third layer is from 0.9 m and beyond. As for Site B, several hyperbolas were also observed with depth of less than 0.4 m. A sudden change in amplitude (strong reflection) were observed at distance of 3.4 – 4.0 m and depth of 0.2 - 0.3 m for survey line B6 and B7 which may indicate the disturbed soil layer at that area (Figure 2). A strong reflection also detected at distance 3.0 - 4.0 m for line B11-B14 at slightly deeper depth of 0.5 – 0.9 m (Figure 3). This anomaly shows the disturbed soil layer but most likely located at second layer of soil. Due to the very strong reflection, it can be suspected as potential burial area or cavity/void taking the fact that the EM wave travel about three time faster in air than in solid material. This velocity pull-up effect can result in high (strong) amplitude reflections at the interface between soil and air-filled cavity (Reynold, 1997).

Keywords: Gua Pelangi, prehistoric, ground penetrating radar, disturbed soil, cultural layer

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A062

Integration of resistivity and gravity methods for karstic void identification at Gua Serai-Gua Batu Boh, Gua Musang, Kelantan

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Karstic void is a very common feature within karst hill. The main objective of this survey is to identify the subsurface karstic void using combination of geophysics methods which is resistivity and gravity by the integration of resistivity pseudo-section with gravity contour map. The surveys were conducted at the palm oil estate between Gua Serai-Gua Batu Boh, Gua Musang, Kelantan. The ABEM Terrameter SAS 4000 was used in conducting 6 resistivity lines with 200 meter length and 5 meter intervals. The orientation of resistivity lines was arranged from northwest (start) to the southeast (end) using the dipole-dipole array. The results were processed with RES2DInv software. Total of 128 gravity stations were collected randomly within conducted resistivity survey area using CG-5 Gravimeter. But only 85 gravity stations were collected within the resistivity survey area. The gravity data were corrected using the polynomial fitting method before the gravity contour map was produced using ArcGIS software. Figure 1 shows the pseudo-sections of 6 resistivity lines with penetration reaching almost 43 meter in depth. The interpretation of pseudo-section was divided to three layers; which is the topmost layer (L1), the middle layer (L2) and bottom layer (L3) where by each pseudo-section provided different depth for each layers depending on resistivity values (Table 1). Generally, L1 shows the lowest resistivity value that range between 20 – 160 Ωm which was interpreted as loam or soil mixture of clay and silt (Angenheister, 1982). Normally they are unconsolidated material such as silt, highly – moderately weathered limestone, incompetent rock or clay water that normally filled cavity (Zulfadhli, 2015; Zeinab, 2013; Muhammad Farooq *et al.*, 2012; Loke, 2000). The L2 shows various resistivity range from 190 – 300 Ωm to between 750 – 1,500 Ωm among the resistivity lines. This layer was interpreted as transition layer which its composition ranges from soil (loam) to bedrock that has resistivity value between 105 – 900 Ωm (Ismail & Anderson, 2012), moderate – slightly weathered limestone (Zeinab, 2013), till fresh limestone (Ismail & Anderson, 2012; Reynolds, 2011; Stepišnik, 2008; Palacky, 1987). Most of L3 pseudo-section shows the highest resistivity value that indicate the fresh limestone and bedrock and an interesting anomaly which is related to the identification of possible karstic void. At the southeast of Line 1, the pseudo-section shows highest resistivity value with range from 750 – 3500 Ωm up to 10,000 Ωm at the depth between 14.0 – 43.0 m (Figure 1a). This anomaly shows very high resistivity compared to the surrounding.

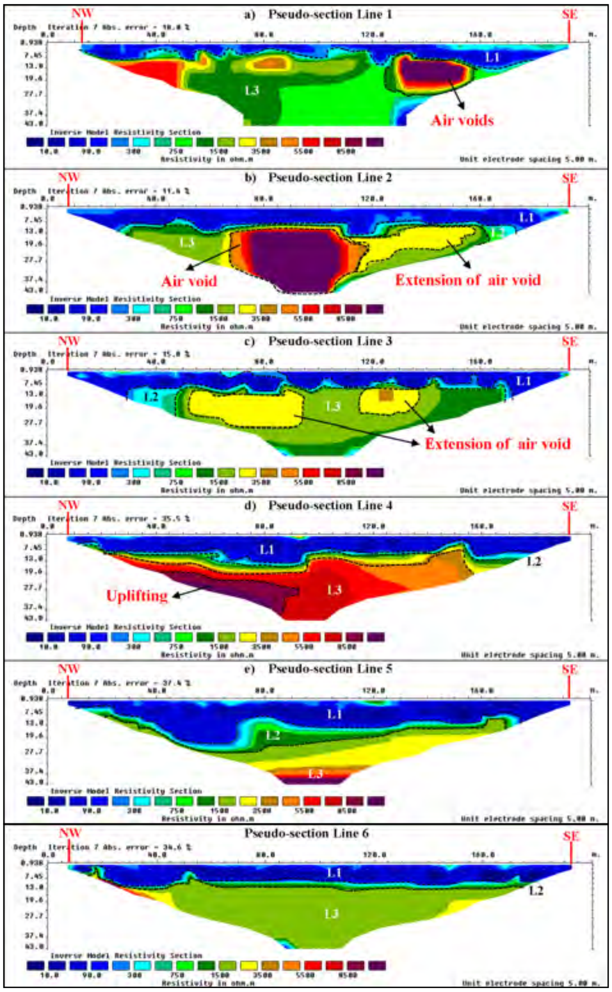

Figure 1: Pseudo-section Line 1 – 6.

Based on Gibson *et al.* (2004), Mitrofan *et al.* (2007), Chalikakis *et al.* (2011), Ismail & Anderson (2012), and Martínez-Moreno (2014), the near-infinite resistivity of air can display higher resistivity value compared to the surrounding. This anomaly can be interpreted as small air void as an open air void spaces or caves. At the southeast of Line 2 – 3, the pseudo-section still shows that the resistivity value is higher than the surroundings. This is due to the extension of air void from Line 1 (Figure 1b – 1c). A bigger air void was discovered at the centre of Line 2 and its extension can be seen at Line 1 and Line 3. The same identification is also shown in the gravity contour map, showing the connection of the air void extension between Line 1 and Line 3 (Figure 2). Based on Figure 1d, the bottom layer of Line 4, it shows a higher resistivity value compared to the surrounding. It was interpreted as an uplift due to faulting (Khalid, 2016). The bottom layer of Line 5 shows that most of the layer covered with high resistivity and being interpret as the transition from weathered limestone and bedrock to fresh limestone and bedrock as the resistivity value increased gradually till 10,000 Ωm. On other hand, pseudo-section Line 6 was interpreted as weathered limestone and bedrock based on resistivity value is more than 1,500 Ωm. The integration of resistivity data with gravity contour map shows that Line 1 and Line 2 have a medium density value (Figure 2). But towards the southeast of both lines, the density value become lower compared to the surrounding. Therefore, both result from resistivity pseudo-section and gravity contour map are indicative that an air void was discovered between Line 1 – 3.

Keywords: Resistivity, gravity, integration, karstic void

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Table 1: Resistivity pseudo-section interpretation.

Line	Layer	Depth (m)	Resistivity Ranges (Ω m)	Interpretation
1	Topmost	0 – 7.45	0 – 190	Low resistivity. Moist soil. Exposed to weathering and contain loam.
	Middle	7.45 – 14.0	190 – 750	Transition zone. Soil to the bedrock.
	Bottom	14.0 – 43.0	750 – 3,500	Highest resistivity. Showing obvious anomaly compared to surrounding. Interpreted as weathered limestone and bedrock with air voids.
2	Topmost	0 – 13.0	0 – 190	Low resistivity. Which is moist, exposed to weathering and contain loam.
	Middle	13.0 – 19.6	300 – 950	Transition zone. Soil to the bedrock. Contains mixed of loam and weathered bedrocks with resistivity values.
	Bottom	19.6 – 43.0	950 – 1,500	High resistivity. Interpreted as weathered limestone and bedrock. Anomalies detected at the centre that represent the air filed cavity and the second anomaly at the southeast is interpreted as the extended air void from line 1.
3	Topmost	0 – 13.0	0 – 190	Low resistivity. Which is moist, exposed to weathering and contain loam.
	Middle	13.0 – 15.0	190 – 750	Transition zone between soil at the upper part to the bedrocks.
	Bottom	15.0 – 43.0	750 – 3,000	High resistivity. Represent mixture of limestone and weathered bedrock. Anomaly showed represent small air void area at the line 3 due to the air void of line 1 and line 2.
4	Topmost	0 – 13.0	0 – 190	Low resistivity. Which is moist, exposed to weathering and contain loam; mixture of clay, sand and silt.
	Middle	13.0 – 19.6	190 – 750	Transition zone. From loam to the bedrock.
	Bottom	19.6 – 43.0	750 – 8,500	High resistivity. Due to the limestone (>10,000 Ωm) and the bedrock.
5	Topmost	0 – 13.0	0 – 190	Low resistivity. Due to damp soil or clay. At distance between 40 – 80 m (from first electrode), shows some overburden that occur causes the first layer to be lowered until depth of 27.7 m.
	Middle	13.0 – 19.6	300 – 1,500	Transition zone. Zone between soil to the bedrock.
	Bottom	19.6 – 43.0	1500 – 10,000	High resistivity. As resistivity increased gradually as the depth increased. It represent the transition zone from weathered limestone to fresh limestone bedrock.
6	Topmost	0 – 10.0	0 – 300	Low resistivity. Due to damp soil or clay.
	Middle	10.0 – 13.0	300 – 1,500	Transition zone. From soil to the bedrock.
	Bottom	13.0 – 43.0	>1500	High resistivity. Represent as weathered bedrock and fresh limestone bedrock.

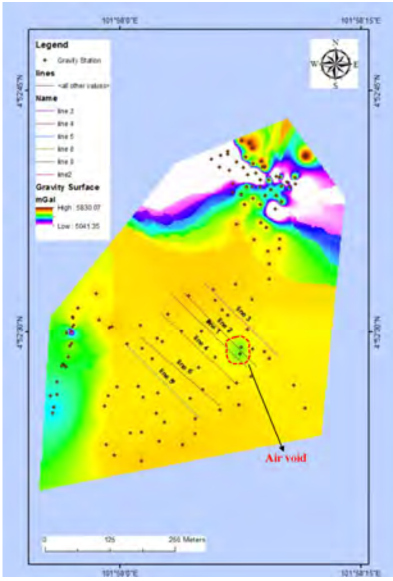

Figure 2: Gravity contour map of Gua Serai-Gua Batu Boh.

A017

Characterization of soft marine clay deposits using geophysical and geotechnical methods

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Engineering problems regarding soft soils call for urgent attention for ground remediations, now that suitable lands for developments in Malaysia are depleting. Soft soils induce many problems during constructions due to excessive settlement of the soil during or after construction phase as a result of insufficient bearing capacity, high compressibility and low shear strength of the soil (Mohamad *et al*., 2016). Nibong Tebal, Seberang Perai (Penang) is covered with soft marine clay deposits as a result from sea level transgression during Mid-Holocene, which simultaneously hinders high rise infrastructure developments in the area (bin Hassan, 1990; Raj, 1992). With regards to this, strong knowledge on the soil's properties such as soil shear strength and porosity are essential for cost-cutting in constructions via appropriate selection and application of optimum ground improvements and foundations techniques (Mamat, 2013). Therefore, physical properties of soft marine clay in Nibong Tebal are thoroughly studied using 2-dimensional resistivity method in conjunction with porosity measurements from soil samples and Standard Penetration Test (SPT) values from borehole record. A resistivity survey line of 160 m length using Schlumberger electrode configuration was designed to cut across an existing borehole to enhance data interpretation. The spatial distribution of clay depicted from resistivity section suggests three lithologies of different range of resistivity values; 10 – 87 Ωm reclaimed clayey topsoil followed by 0 – 10 Ωm of soft marine clay and 10 – 700 Ωm of sandy layer in the area (Figure 1). The soft clay extends up to 20 m in thickness where it overlies a sandy layer and could be correlated back to lithology profile from borehole record. 12 undisturbed soil samples were collected using hand-auger up to 4 m depth at three locations along the survey line for porosity measurements via saturation porosimetry method. The samples demonstrate that the soft clay soil has very large porosity range (55.39 – 75.17 %) and holds a tremendous volume of water as it occupies almost three quarters of the soil sample. This is worrisome as the soft soil could be largely compressed as this trapped water is released from its pores under load. Besides that, SPT-N values of the soft clay are also very low with a range of 0 – 6, thus could be classed as very soft to soft cohesive soil with very low shear strength as compared to a higher range of 10 – 16 SPT-N values of the sandy layer (Table 1). These results further indicate that the upper layer is not capable of bearing immense loads such as high-rise infrastructures. Based on the overall results, it is clear that the area is indeed covered with thick soft soil with high porosity and low shear strength with high probability of excessive compression due to large water volume stored in its pores. Hence, the area must undergo ground treatment methods prior to any infrastructure developments on the land such as soil chemical stabilizers or physically modify the soil via soft soil replacement, expedite pore water dissipation, insertions of prefabricated vertical drains and installation of stone column in order to avoid unwanted incidents that could lead to loss of lives (Mamat, 2013).

Table 1: Borehole and augured records on the study area's lithology profile which supports resistivity, shear strength and porosity results.

Depth (m)	Type of soil	SPT-N value	Resistivity (Ωm)	Porosity (%)
0 – 3	Medium stiff clay (reclaimed)	6	10 – 87	34.05 – 44.29
3 – 15	Very soft clay	0	0.04 - 10	55.39 – 75.17
15 – 30	Medium dense sand	10 – 16	10 – 700	No data

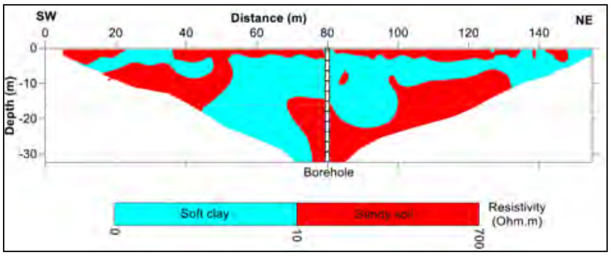

Figure 1: 2-D resistivity section portrays two types of lithologies; soft clay and sandy layer with respect to borehole record.

Keywords: soft soil, porosity, shear strength, excessive settlement, Nibong Tebal

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POSTER PRESENTATIONS

A005

Kesan suhu terhadap cirian mekanik bata sisa rawatan air mentah dan abu terbang

(Effect of temperature on mechanical properties of brick from raw water treatment sludge and fly ash)

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Abstrak: Perkembangan industri negara sejak dua dekad lalu telah meningkatkan permintaan air bersih dan tenaga. Ini sejajar dengan perkembangan infrastruktur bagi memenuhi keperluan penduduk. Proses perawatan air dan penjanaan tenaga mengakibatkan penghasilan sisa yang perlu diselenggara dengan baik bagi mengelakkan masalah pencemaran alam sekitar. Penggunaan semula sisa dapat mengurangkan masalah lambakan sisa dan bebanan yang diterima oleh tapak-tapak pelupusan. Berdasarkan kajian lampau, suhu pembakaran bata memberikan kesan terhadap kekuatan mampatan sesuatu bata. Oleh itu, kajian ini bertujuan melihat pengaruh suhu terhadap sifat mekanik bata yang dihasilkan dari sisa rawatan air mentah (RAM) dan abu terbang (AT) sebagai bahan tambah pada nisbah terpilih. Dua set sampel bata disediakan terdiri daripada bata 100% RAM dan bata campuran 80% RAM dan 20% AT, masing-masing dilabelkan sebagai 100SRA dan 80RAM. Kedua-dua set sampel bata ini dirawat pada suhu berbeza (30ºC, 500ºC dan 700ºC). Pencirian asas sisa-sisa yang digunakan menunjukkan SRA adalah berasid manakala AT pula beralkali, masing-masing pH4.44 dan pH8.44 dan bahan organik 6.8% dan 1.30%. SRA didominasi oleh mineral kaolinit manakala AT menunjukkan kehadiran mulit, aluminium dan kuarza. Luas permukaan tentu pula menunjukkan AT (42 m^2/g) lebih tinggi berbanding SRA (35.68 m^2/g). Peningkatan suhu menunjukkan pengurangan ketara bagi nilai luas permukaan tentu dan bahan organik bagi AT. Ujian toleransi dimensi menunjukkan peratusan perubahan isipadu bagi bata (100RAM dan 80RAM) masing-masing meningkat daripada 26.10% kepada 31.45% dan 25.37% kepada 32.40% namun nilai ketumpatan mengalami penyusutan akibat peningkatan suhu. Penyerapan air meningkat bagi kedua-dua set bata dengan peningkatan suhu dan peningkatan ini lebih ketara bagi set bata 80RAM. Kekuatan mampatan bata meningkat dengan peningkatan suhu dan set bata 100RAM corak peningkatan kekuatan mampatn yang lebih tinggi berbanding 80RAM. Kajian ini menunjukkan bahawa penambahan suhu telah meningkat kekuatan mampatan bagi kedua set bata yang dikaji.

Kata kunci: Bata, sisa rawatan air mentah, abu terbang, kekuatan mampatan

A007

Assessment of petroleum source rock potential and paleodepositional conditions of the Paleozoic carbonaceous shales of the Kubang Pasu and Timah Tasoh formations in central Perlis, Malaysia

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Abstract: Kubang Pasu and Timah Tasoh formations comprise part of the formation in Paleozoic succession in the northern area of Peninsular Malaysia. These carbonaceous shale samples were examined using organic geochemical and petrographical methods to determine the origin, kerogen type and also the paleo depositional environments of the sediments, and subsequently to interpret their petroleum source potential. The analysed shale samples have 0.1 to 5.3 wt% TOC indicating poor to very good hydrocarbon potential (Peters & Cassa, 1994). On the other hand, evaluation from bulk pyrolysis instruments shows that the Kubang Pasu and Timah Tasoh formations have very low hydrogen index (HI) ranging from 1 to 7 mg HC/g TOC which suggest the organic matter is dominated by Type IV kerogen. This is also supported by low hydrocarbon yields recovered from bitumen extraction (37-103 ppm) in the Kubang Pasu and Timah Tasoh formations thus supported the poor petroleum source rock potential. Petrographically, amorphous organic matter, inertinite and reworked organic matter were observed with primary vitrinite phytoclasts that recorded high reflectance values in the range of 1.22-1.93 %Ro. These values suggest the analysed samples are late mature to over-mature for the generation of liquid hydrocarbon. Biomarker study (with reference to Peters *et al*., 2005) indicates the samples consist of a mixed terrestrial-derived organic matter input with significant influences from lacustrine and marine-derived organic matter that was mainly deposited in a transitional environment (terrestrial to marine) under a subtoxic condition of deposition. The preserved organic matter within these shales are dominated by Type IV kerogen, thus this suggests they are gas prone and over mature (Hunt, 1996), consequently could not generate liquid hydrocarbons although may have the potential for gaseous hydrocarbons.

Keywords: Paleozoic, hydrocarbon source potential, thermal maturity, kerogen types, biomarker fingerprints

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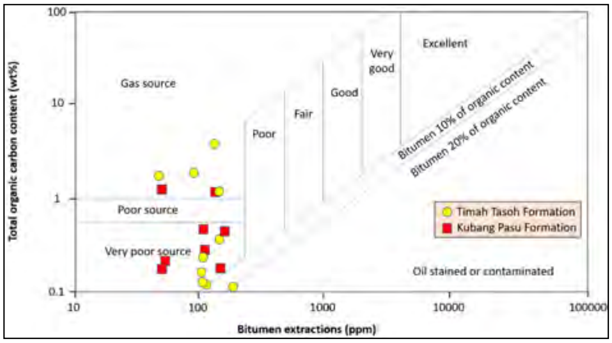

Figure 1: Cross plot between total organic carbon (TOC, wt%) and bitumen yields (ppm) showing hydrocarbon source potential of the analysed samples.

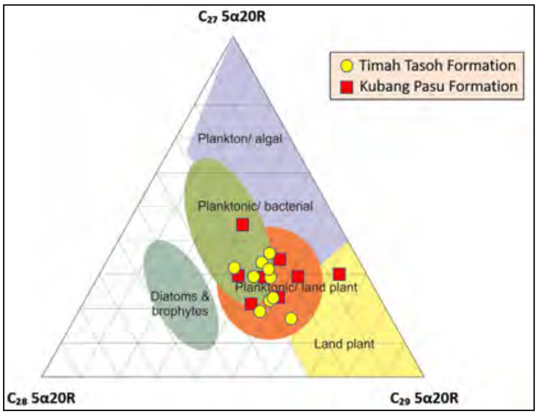

Figure 2: Ternary diagram of C27, C28 and C29 regular steranes indicating a mixed organic matter input in the analysed samples of the Kubang Pasu and Timah Tasoh formations.

A016

Spatial relationship quantification of mineralization factors and gold potential mapping in Kelantan, Malaysia

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Abstract: This study exhibits an effective method for measuring the impact of ore controlling factors of orogenic gold. In this study, ore genesis factors including heat source (intrusive rocks), migration pathways (NE-SW, NW-SE faults) and depositional environment (sedimentary and Metasediment rocks) were examined. The procedure successively used the weight of evidence model to weigh and quantify the spatial association between the ore factors and the known gold prospects (training data) in the area. The approach later summed up all the weighted evidence into a single potential map. The results show that factor such as the NE-SW faults, the intrusive rocks as well as the sedimentary rocks (and metasediment) have a strong pattern of correlation with mineralization. The NW-SE faults displayed a weak pattern of correlation with the deposits.

Keywords: Mineral, spatial, GIS, Kelantan

INTRODUCTION

The information of spatial relationships between geological factors and mineralization is not only significant for understanding the ore genesis of mineral deposits but in most cases also help to provide guides (potential maps) exploration programs. Lately, several authors had modelled spatial analysis to illuminate ore forming processes (Liu *et al.*, 2013), some even generated potential maps (Mamuse *et al.*, 2010). In spite of the gold mining activities in the central gold belt of Malaysia Peninsular, no single research has focus on the spatial analysis to generate a potential map of the area. Consequently, only a little is has been documented about the spatial relationship between the ore controlling factors and mineralization. It is in this regards that this current remote sensing and GIS-based research, aimed at quantifying the spatial relationships of controlling factors in Kelantan.

STUDY AREA

Kelantan is at the north-eastern corner of the Malaysian Peninsular. Typically, four rock types can be found in the region including sedimentary rocks, granitic rocks, unconsolidated sediments and extrusive rocks (volcanic rocks). While localized geological features such as faulting and jointing characterized the granitic rocks, folding, faulting and jointing characterized the sedimentary rocks. Granitic rocks are widely spread in the east borders (the Boundary Range granite) and west (the Main Range granite) of the state of Kelantan (Ghani, 2005; Yao *et al.*, 2017).

METHODOLOGY

The approach had created a conceptual framework model that linked the mineralization factors (critical element) to their mappable criteria and further linked them to the available datasets. The plausible evidence

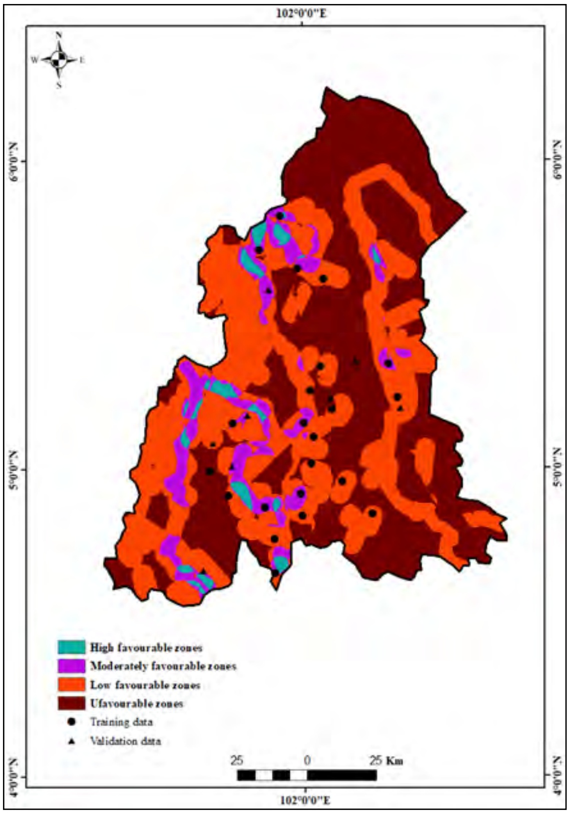

Figure 1: Generated potential map, highlighting the potential zones of mineralization.

maps were then quantified using the weights of evidence model, based on the known gold prospects (training data and testing data) in the area, and thereafter, combine the weights of each evidence into a single potential map based on Bayes' probability concepts and assumptions of conditional independence.

RESULTS AND DISCUSSION

The spatial quantification revealed a strong relationship between the mineralization and ore factors such as NE-SW faults, intrusive rocks, and sedimentary rocks. The NW-SE faults show a weak relationship with mineral deposits. All the evidence maps were combined to generate a gold predictive map.

CONCLUSION

These results conclude that igneous activities initiate the gold formation processes. Moreover, while the magmatism (igneous rocks) served as the heating chambers, the migration and trapping processes were accomplished due to the presence of structural features. Evidently, sedimentary rocks acted as a trap and the same time as host for the mineralization. These conclusions are the vital ingredients necessary for exploration. The created map potential map highlight both known and new location of mineralization.

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A029

Subsurface investigation for cocoa cluster - Ranau Highland Cluster Development Project, Ranau, Sabah

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Geophysical method is a great method that can be used for detailed characterization and delineation of the subsurface geology for various purpose. A subsurface investigation using Electrical Resistivity Imaging (ERI) and Seismic refraction method had been conducted at Ranau, Sabah to investigate the subsurface condition for Cocoa Cluster – Ranau Highland Cluster Development project. Three (3) resistivity survey lines and three (3) seismic survey lines was conducted at the proposed location. From the result and correlation between the resistivity and seismic, the first layer can be interpreted as completely weathered rock (0 Ωm to 100 Ωm and 400 m/s) with thickness ranging from 20 m to 30 m. The second layer was interpreted as highly weathered rock (100 Ωm -1500 Ωm and 1600 m/s to 2000 m/s) with thickness from 20 m to 25 m and the third layer, was interpreted as fractured zone (0 Ωm -100 Ωm).

Keywords: Subsurface investigation, electrical resistivity imaging, seismic refraction method

INTRODUCTION

Survey area is located approximately 122 km northeast from Kota Kinabalu city and the travel time takes about 3 hours by car. The topography of project area is classified as hilly area and overgrown with secondary forests and bushes. The elevation profile is ranging from 318 m to 358 m relative to mean sea level (MSL). The field data acquisition was conducted on 11th and 12th of October 2018. For Electrical Resistivity Imaging (ERI), the survey was conducted by using ABEM Terrameter SAS 4000 with the length of each survey line is 200 m and spacing between the electrode is 5 m. A 12V battery was used as the source. The expected depth of penetration for this survey is 70 m. The Seismic Refraction survey was conducted using ABEM Terraloc MK6 with the length of each survey line is 115 m and 5 m geophones spacing. A sledge hammer was used as the source for this survey with seven different sources location. The expected depth of penetration for this survey is 30 m.

Figure 1: Location of survey lines at project area.

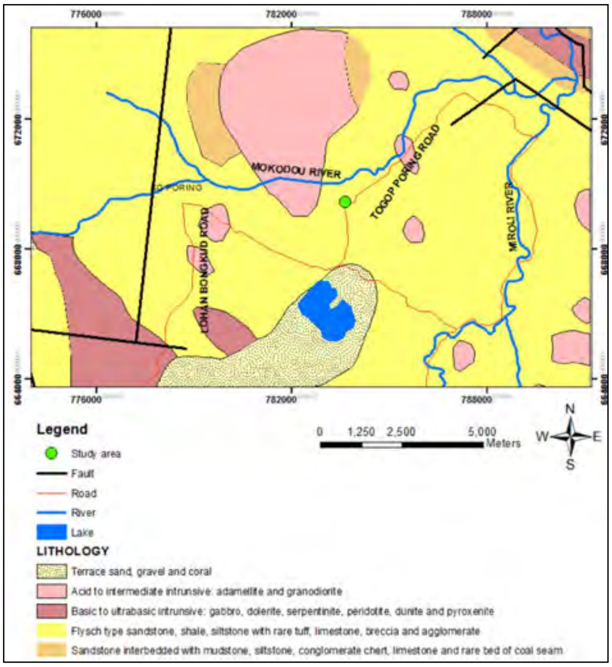

Figure 2: General geology map of study area and around Ranau area.

GEOLOGY OF THE SURVEY AREA

Based on field observation and borehole data, the geology of this area is consisting of sandstone and shale. Generally, from literature review, this area is located either in Trusmadi Formation or Crocker Formation. Jacobson (1970) stated Trusmadi Formation mostly consist of dark grey shales with thin-medium bedded sandstones, typical of a turbidite deposit. In certain areas, the unit has been subjected to mild metamorphism, producing slates, sub-phyllites and meta-sandstones, and intense tectonic deformation producing disrupted or brecciated beds. Quartz vein are quite widespread within the deformed sandstone beds. The shale is dark grey when fresh but changes to light grey when weathered. The sandstones interbeds are generally 1-100 cm thick. The sandstones consist predominantly of quartz grain with sutured grain boundaries. According to Jacobson (1970) also, the Crocker Formation consist mostly of interbedded grey sandstones and grey mudstones or shales. Sometimes red shale does occur. They are typically deep-water sediments, deposited as submarine fans. The sandstone beds range in thickness from a few cm to several meters thick.

METHODOLOGY

Electrical resistivity imaging

Electrical resistivity imaging system is mainly carried out with a multi-electrode resistivity meter system. A computer-controlled system is then used to automatically select the active electrodes for each measure. Throughout the survey conducted in the proposed site, the pole - dipole array has been used with the ABEM SAS4000 system. The data collected in the survey can be interpreted using an inexpensive microcomputer. The system is connected to 41 steel electrodes which lay out on a straight line with a constant spacing via multi-core cables. A microcomputer unit connected to the switcher unit then automatically selects four active electrodes used for each measurement. The data was checked to be of good quality. Partial correction was carried out to exterminate the bad data point. Processing software (RES2DINV) is used for the inversion to obtain the soil resistivity model.

Seismic refraction survey

The survey was conducted using a land streamer with 24 geophones at five-meter inter-distance and surface waves were recorded using ABEM Terraloc MK 6 seismograph. A sledge hammer was used as the source. The hammer was hit on steel plate to generate elastic waves. For this survey, the area is sampled using 7 source locations at -5.0, 2.5, 27.5, 57.5, 87.5, 112.5 and 120 meters. In the analysis, at first, the first arrival time, i.e. the travel time of seismic wave from shot point to each geophone, is decided. Then, the time-distance curve is plotted with the time for vertical axis and the distance for horizontal axis. By using Easy Refract software, the time distance curve was converted into seismic geological and velocity profile.

RESULT AND DISCUSSION

Electrical resistivity imaging

The result for the resistivity survey shows that the top layer was interpreted as completely weathered rock with the resistivity value from 0 Ωm to 100 Ωm. The thickness of this layer is about 20 m to 30 m. Second layer overlays beneath the first layer with resistivity value from 100 Ωm -1500 Ωm. This layer was interpreted as highly weathered rock and appear at the depth ranging from 20 m to 25 m at all survey lines. The third layer was interpreted as fractured zone as it shows a low resistivity value (0 Ωm -100 Ωm) and appears at the depth of 35 m-50 m.

Seismic refraction method

The layering is divided into three layers based on P-wave velocity. The first layer with P-wave velocity of 400 m/s interpreted as completely weathered rock. While the second layer with P-wave velocity of 600 m/s was interpreted as completely to highly weathered rock. The third layer with P-wave velocity of 1600 m/s to 2000 m/s was interpreted as highly weathered rock, located beneath the first layer and the second layer. The first layer thickness is about 20 meter-30 meter at all the

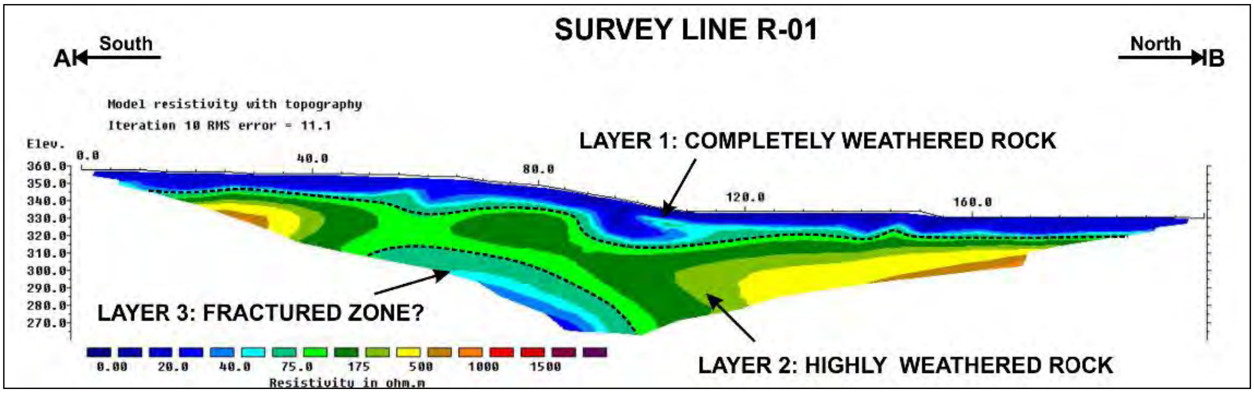

Figure 3: Resistivity tomography of survey line R-01.

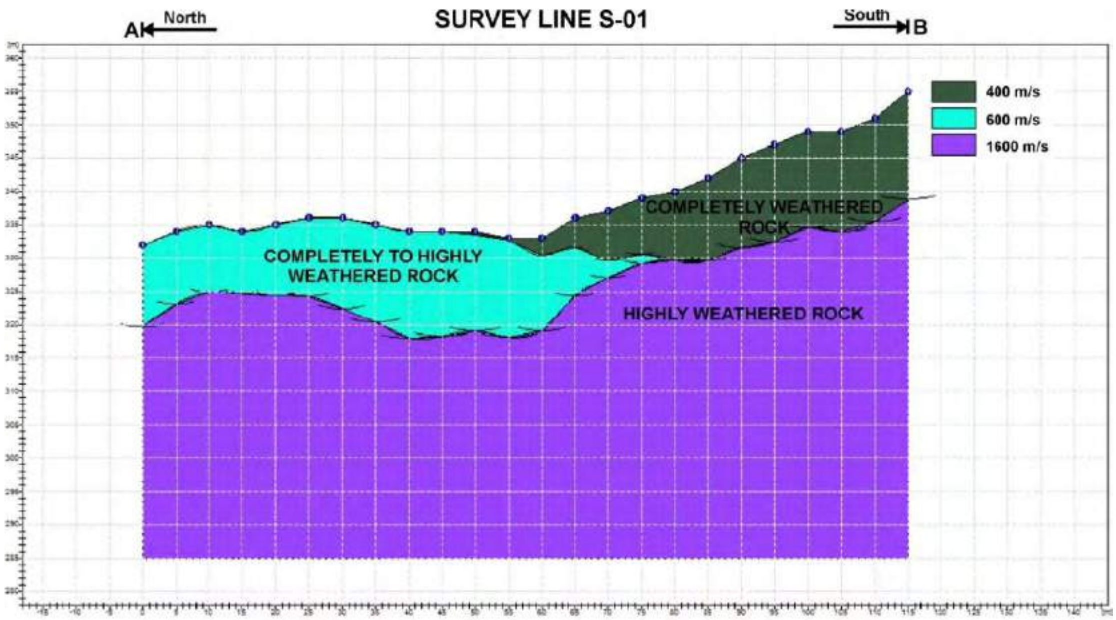

Figure 4: Morphology model of survey line S-01.

survey lines. The second layer for survey line S-01 can be classed as the same layer since the P-wave velocity of these two layers is not much different. At survey line S-02 the thickness of the second layer is about 5 to 10 meter and at survey line S-03 is up to 15 meters.

CONCLUSION

The result from both the resistivity imaging and seismic refraction survey gives out a good correlation on the subsurface layer beneath the study area. The thickness of the completely weathered bedrock at survey line appears to be 20 m to 30 m from the resistivity profile and 20 m from the seismic profile. This layer overlay on top of the highly weathered rock. The layer interpreted as completely weathered rock (400 m/s) and completely to highly weathered rock (500 m/s and 600 m/s) in the seismic morphological model can be class as one layer since the different of its P-wave velocity is not significant. From the resistivity result, the fractured zone appears at the depth above 35 m.

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A032

Closer look of the stratigraphy and structural patterns of the Neogene Basin in the offshore of Kudat Peninsula

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The onshore of northern Sabah is made up of mélange unit, Chert-Spilite, Crocker, Kudat, Bongaya, Timohing and South Banggi Formation (Tongkul, 1994; Sanudin *et al*., 2017; Ghaheri *et al*., 2017; Mohamed & Ali, 2007). The stratigraphic sequence and structural framework of offshore Kudat Peninsula remain conflicting owing to several issues which include the geological age, depositional environment, lithology and structuring of the units in the transition zone. This paper takes a closer look on the stratigraphy and structural patterns of the offshore Kudat Peninsula.

The stratigraphic analysis of the area was conducted based on detail field study, core well logging and structural analysis in respect to the seismic interpretation of the transition zone. Three 2D seismic lines in the offshore of Kudat Peninsula, and cores from well L1 and M1 were used to understand the geology in the offshore of Kudat.

Five geological units were identified in the offshore province of Kudat Peninsula. These geological units were labeled as Unit A, B, C, D and E (Figure 1). Unit A was interpreted as the basement rock known as the Chert-Spilite Formation, believed to be the basement rock for the offshore province. The age and lithological correlation had justified Unit B is equivalent to Kudat Formation. The distribution of Unit B is thinner and secluded in the offshore compared to its wide distribution in the Kudat Peninsula. Unit C and Unit E are more prominent and thicker in the offshore compared to the onshore, as the onshore extension of these units had experienced continuous erosion. Unit C and Unit E are well preserved in the northern part of the peninsula as Bongaya and Timohing Formations in Banggi and Balambangan Islands. Intruded mobile shale found in discrete areas are interpreted as Unit D. The seismic characteristics of Unit D assemble similar pattern with chaotic reflectors of the mélange unit, where it can also be found in Kudat Peninsula.

The faults interpreted in the transition zone seem to be extending from the onshore structures. The early phase faults are the deep-rooted faults responsible for the development of younger sedimentary basin in the offshore. The younger faults branching from the older faults were formed coetaneous to deposition of Unit C, D and E. The lithological boundaries between each geological unit appears to be an unconformity surface with observable hiatus. H5, H4, and H3 are interpreted as Unconformity I, Unconformity II and Unconformity III respectively (Figure 1).

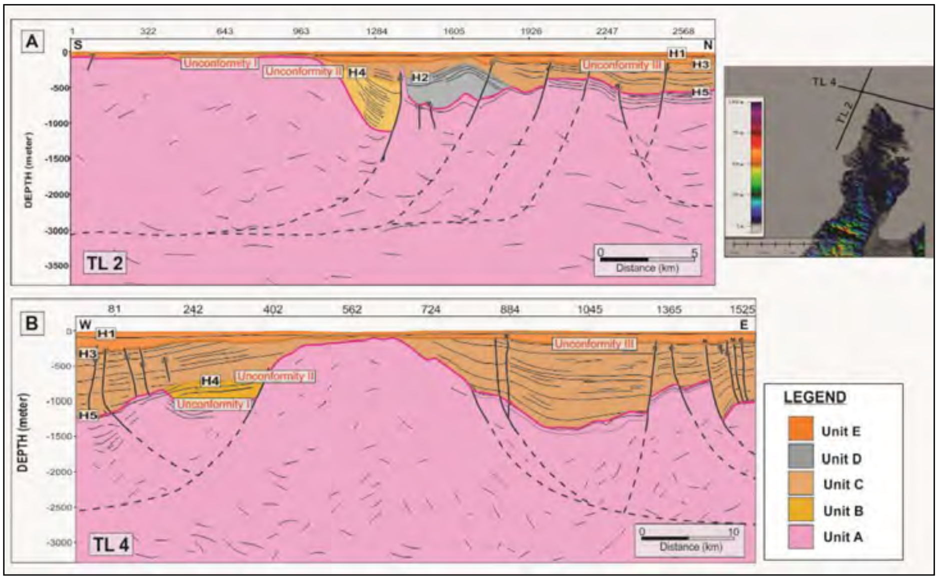

Figure 1: A) Seismic interpretation of offshore TL2 was acquired parallel to the coastline of the Kudat Peninsula. The sedimentary basin is thickening towards the north and become thinner in the south. Intrusion of Unit D from the hemipelagic sediments in the ophiolitic basement pushing the older unit upward. B) Seismic interpretation of offshore TL4 north to the Kudat Peninsula. The mounded basement rock is interpreted parallel to the Tip of Borneo. The Late Eocene to Pleistocene sedimentary basin formed on top of the basement rock in both East and West of the section.

CONCLUSIONS

The onshore rock formations and structural patterns are suggested to be extending the west, northwest and north offshore of Kudat Peninsula and have better preservation in the offshore. Unit A, B, C, D, and E are interpreted to be lying in these offshore regions where these units are stratigraphically correlated to the rock formations exposed in the northern Sabah. The lateral extension of the onshore formations is interpreted to be at least 20 km to the west and 10 km to the north. It is possible that these units extended further north as similar formations were observed exposing in Balambangan and Banggi Islands.

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A034

Subsurface structures and minerals identification using electrical method and geological analysis at Bojonegoro District, Indonesia

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Abstract: Subsurface structures reflect the impact on the landscape of the subsurface, determination of the degree of landslide hazard, discovery of hidden energy and act as host to economic minerals or metals such as gold silver. Mineral identification also plays an important role because through it the rock formation of an area can be identified in avoiding natural disaster that can occur. Awareness on the importance of subsurface structure and mineral identification has motivated this study to focus on the application of geophysical analysis involving combination of electrical method and geological analysis. One electrical method that has been carried out in this study is 2-resistivity survey. While for the geological analysis, the analysis that has been carried out in this survey are petrography analysis and XRD analysis. Generally, this study area is underlain by Kalibeng Formation that has been characterised by greenish or greyish white unstratified foraminiferal-rich marl (Susilohadi, 1995). The Kalibeng Formation was formerly termed the Kalibeng Beds by Duyfjes (1938) which were subdivided into the Lower (unstratified marl) and Upper (limestone and marl) Kalibeng Beds. De Genevraye & Samuel (1972) renamed them the Lower and Upper Kalibeng Formations. Six electrical survey lines were conducted with length of 400 meters for each line with 5 meters electrode spacing using pole-dipole array. There were three sites involved in this study which were Tondo Mulo, Kedung Lele and Bunten with total 2 lines for each site. The electrical survey lines that were conducted in this study were Tondomulo 1, Tondomulo 2, Kedung Lele 1, Kedung Lele 2, Bunten 1 and Bunten 2. For electrical method used in the surveys, the spacing between electrodes were standardized to ensure accurate application for all study areas to get the same depth of target. This survey was conducted with utilizing SAS4000 system for data acquisition. The resistivity data was processed using Res2DINV and Surfer8 software for inversion process and data imaging. The results of electrical survey have outlined the typical features of subsurface structures. Fault and fracture were identified from the high contrast in the resistivity values in the inversion result of resistivity. A region with resistivity value <3 Ωm was interpreted as conductive zone (silt/clay/silty clay/clay silt). While region with resistivity value of 50 –110 Ωm interpreted as limestone. For geological analysis, two rock sample were taken from the study area. The rock sample were undergoing petrography analysis and XRD analysis. From the XRD analysis, the mineral that had been identified in the rock were calcite, quartz, albite and muscovite. While from the thin section analysis, the mineral that has been identified were calcite, quartz, and k-feldspar. From all this mineral composition that were identified in the rock sample, rock formation at this study area was interpreted as limestone. Table 1 shows the summary of standard resistivity and chargeability for this study.

Keywords: Bojonegoro District, electrical method, geological analysis

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Table 1: Standard resistivity in Bojonegoro District.

Subsurface material / structure	Resistivity, ρ (Ωm)
Conductive zone (silt/clay/silty clay/clay silt).	<3
Limestone	50 – 110
Fracture / fault	High contrast value

A039

Survei geofizik menggunakan kaedah keberintangan elektrik dan pengutuban teraruh bagi profil bawah permukaan di Loji Rawatan Air Sungai Bilut, Raub, Pahang

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Abstrak: Pelaksanaan survei keberintangan elektrik (E.R.I) dan pengutuban teraruh (IP) secara 2 dimensi telah dijalankan di Loji Rawatan Air Sungai Bilut Raub, Pahang bagi mendapatkan profil bawah permukaan kawasan kajian. Kawasan kajian terletak bawah Kumpulan Bentong dan merupakan satu zon sutura di mana tempat berlakunya pertemuan dua kepingan tektonik iaitu Sibumasu dan kepingan Malaya Timur (Indochina). Seperti yang diketahui, kaedah pengimejan keberintangan elektrik merupakan kaedah yang mampu menentukan kedudukan struktur-struktur geologi di bawah permukaan (Griffith & Barker, 1993). Ini termasuk mendapatkan maklumat litologi terutamanya dalam membezakan zon potensi air tanah, zon retakan, batuan dasar serta struktur-struktur subpermukaan yang lain. Analisis terhadap profil keberintangan elektrik dan pengutuban teraruh ini telah memberikan enam ciri subpermukaan seperti zon potensi air tanah, zon retakan, batu dasar, tanah baki, tanah terkonsolidat dan tanah tidak terkonsolidat.

Kata kunci: Eksplorasi air tanah, pengimejan keberintangan elektrik, pengutuban teraruh

PENGENALAN

Loji Rawatan Air Sungai Bilut, Raub Pahang di kelilingi dengan kawasan hutan tebal yang bertopografi tinggi serta bentuk muka bumi seperti terdapatnya kawasan tebing yang curam, tanah runtuh dan air terjun. Pencerapan data di lapangan adalah mengikut kesesuaian luas kawasan dan objektif yang dikehendaki. Berdasarkan pemerhatian di lapangan, terdapat beberapa singkapan yang dijumpai seperti unit batuan filit, syis, batu pasir, batu kapur dan batu lumpur.

METODOLOGI

Survei keberintangan elektrik ini memerlukan sebanyak 61 elektrod keluli disambung kepada 4 kabel multi–teras pada sela yang telah ditetapkan dan direntangkan pada satu garis lurus. Satu unit mikro-komputer disambungkan kepada satu unit penukar (pemilih elektrod) yang kemudiannya akan memilih empat elektrod aktif secara automatik untuk pengukuran. Tatasusun elektrod yang telah digunakan adalah Kutub-Dwikutub. Data yang telah dicerap dipindahkan ke dalam komputer dan ditukarkan ke format yang serasi dengan perisian pemprosesan RES2DINV dengan menggunakan perisian SAS 4000 utilities. Profil grafik dihasilkan bagi memperolehi imej keberintangan bahan dalam bentuk 2-D (Loke & Baker, 1996) dan seterusnya tafsiran dibuat berdasarkan sokongan maklumat seperti log lubang gerudi, singakapan di lapangan dan geologi am kawasan kajian.

KEPUTUSAN DAN HASIL PERBINCANGAN

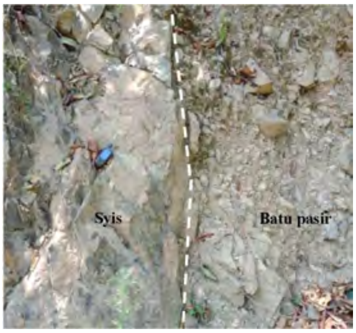
Secara umumnya, terdapat zon potensi air tanah bagi ketiga-tiga garis survei ini menunjukkan nilai keberintangan sekitar 0 Ωm-100 Ωm dan nilai kebolehcasan yang rendah iaitu sekitar 0ms – 7ms. Sifat fizikal air yang sangat konduktif namun tidak mampu untuk menyimpan cas turut mempengaruhi nilai tersebut.

Selain itu, nilai keberintangan elektrik yang tinggi iaitu sekitar 300 Ωm – 1500 Ωm ditafsirkan sebagai batuan dasar. Satu ciri subpermukaan jenis ketidaklarasan bersudut (angular unconfirmity) ditunjukkan seperti dalam Rajah 4. Struktur tanah yang dilihat seakan-akan

Rajah 1: Peralatan geofizik yang digunakan dalam pencerapan data di lapangan.

berselang lapis antara unit batuan juga ditunjukkan seperti dalam Rajah 4.

Seterusnya, satu zon retakan batuan dasar ditunjukkan dalam Rajah 5. Potensi air tanah dilihat berhampiran dengan zon retakan ini. Pada asasnya, zon retakan merupakan medium yang sesuai untuk pengaliran punca sumber air tanah terutamanya bagi kawasan yang berbukit. Rajah 7 menerangkan gambaran keadaan topografi kawasan kajian yang dijelaskan melalui gambar rajah berpagar profil keberintangan elektrik. Secaranya umunya, arah kemiringan diterangkan seperti dalam rajah 7 dan sekaligus menunjukkan pengaliran arah sungai dari barat ke timur.

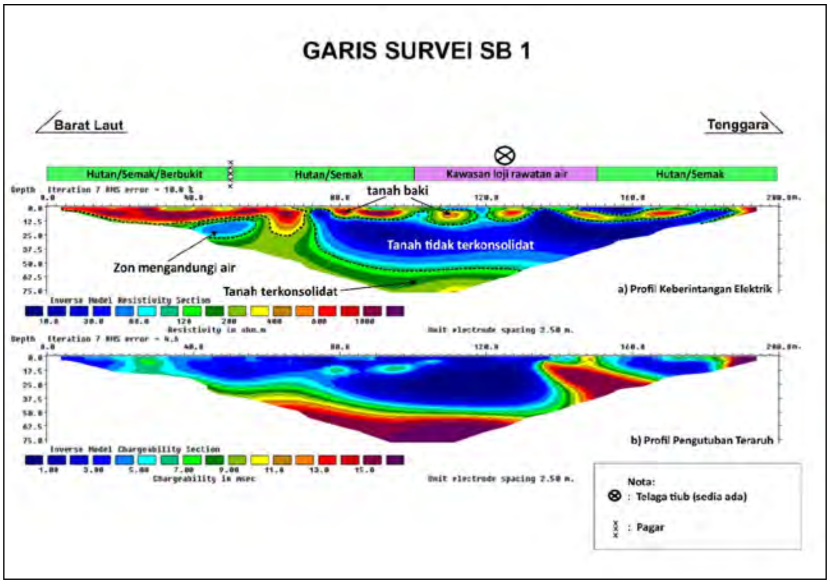


Rajah 2: Dua unit batuan di lapangan iaitu batu pasir dan syis yang dikelaskan di bawah siri arenit tua dan dipisahkan secara sentuh (contact).

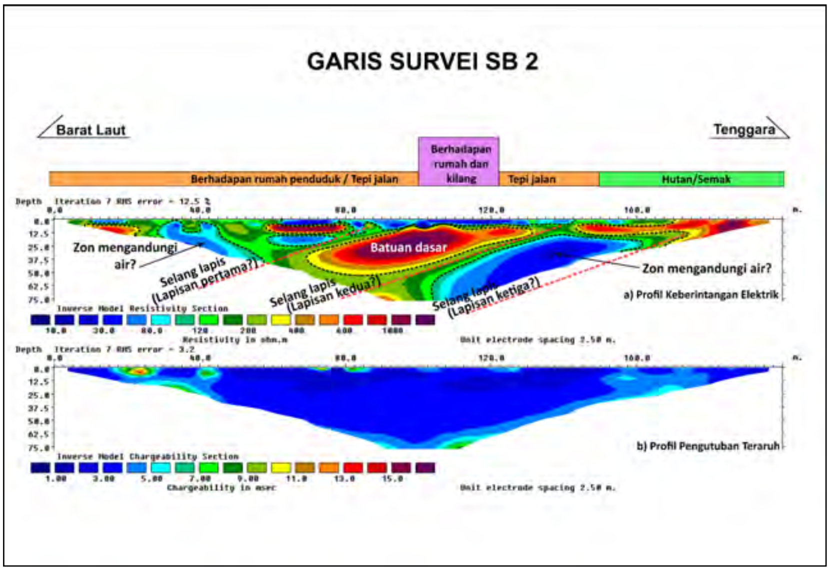
KESIMPULAN

1. Zon potensi air tanah atau akuifer telah dikenalpasti bagi ketiga-tiga garis survei yang dijalankan di Loji Rawatan Air Sungai Bilut, Raub, Pahang. Terdapat lima (5) lokasi yang ditafsirkan berpotensi mengandungi air tanah.

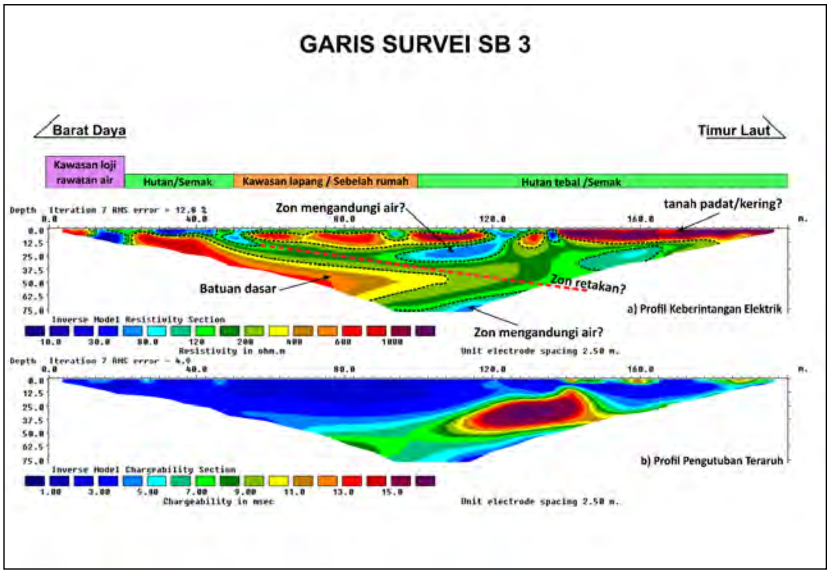
2. Selain itu, terdapat garis survei yang menunjukkan ciri-ciri subpermukaan zon retakan atau sesar. Berdasarkan



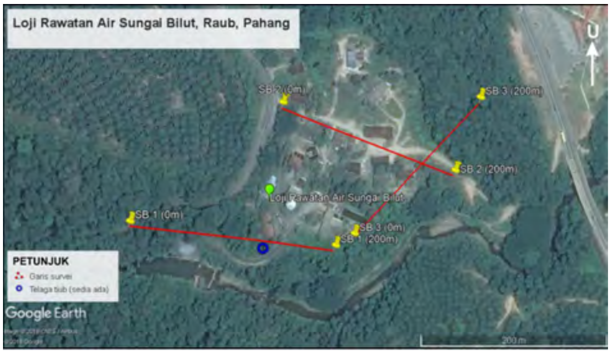
Rajah 3: Profil keberintangan elektrik dan pengutuban teraruh bagi garisan survei SB 1.



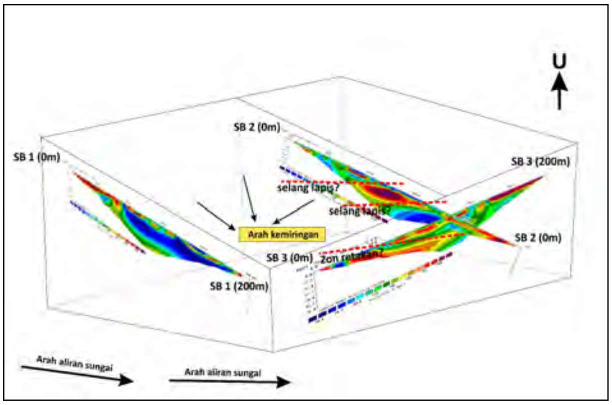
Rajah 4: Profil keberintangan elektrik dan pengutuban teraruh bagi garisan survei SB 2.



Rajah 5: Profil keberintangan elektrik dan pengutuban teraruh bagi garisan survei SB 3.



Rajah 6: Lokasi garis survei keberintangan elektrik sekitar Loji Rawatan Air Sungai Bilut, Raub.



Rajah 7: Gambar rajah berpagar bagi garis survei SB 1, SB 2 dan SB 3 yang dikolerasi secara amnya mengikut bentuk muka bumi (toporafi) kawasan kajian.

profil keberintangan elektrik, potensi air tanah dilihat berhampiran dengan zon retakan ini. Pada asasnya, zon retakan merupakan medium yang sesuai untuk pengaliran punca sumber air tanah terutamanya bagi kawasan yang berbukit.

3. Satu ciri subpermukaan jenis ketidaklarasan bersudut (angular unconfirmity) juga dikenalpasti di kawasan kajian. Struktur tanah yang dilihat seakan – akan berselang lapis antara unit batuan dan bahan jelas ditunjukkan melalui profil yang diperolehi.

4. Kedah keberintangan elektrik 2-dimensi ini telah membantu dalam penafsiran geologi bawah permukaan dan struktur-struktur bawah permukaan yang terdapat di kawasan kajian.

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A042

Kesan penggunaan bahan perapi tanah organik bagi merawat tanah di kawasan penanaman padi, Alor Senibong, Kedah

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Tanah jerlus dicirikan oleh nilai kekuatan struktur lapisan tanah atas yang rendah menyebabkan tanah tersebut tidak mampu menahan beban berat jentera yang bekerja di atasnya. Kajian yang dijalankan ini adalah bertujuan untuk mengkaji kesan penggunaan bahan perapi tanah organik bagi membaik pulih tanah jerlus di kawasan penanaman padi di Alor Senibung, Kedah. Sebanyak empat plot kajian telah dipilih iaitu plot kawalan, AS1, AS2 dan AS3. Sampel tanah jerlus diambil sebelum rawatan menggunakan bahan perapi tanah organik, selepas rawatan dan sebelum tanaman padi dituai, manakala nilai kekuatan tanah diukur pada kedalaman 0-100 cm yang diambil daripada setiap titik tanah jerlus dalam plot kajian sebelum dan selepas dirawat mengunakan bahan perapi tanah organik dijalankan. Hasil kajian menunjukkan peningkatan kualiti tanah jerlus yang dirawat iaitu melebihi aras normal (>0.4 MPa). Parameter kualiti tanah yang turut didapati meningkat selepas rawatan dijalankan adalah kandungan bahan organik, pH, kapasiti pertukaran kation, kekonduksian hidraulik, ketumpatan pukal, kestabilan agregat tanah, kandungan nutrien tersedia (K, Ca, Mg dan P) dan kepekatan mikronutrien (Fe, Mn, Zn, Cu). Selain itu, penambahan bahan perapi tanah organik telah menurunkan kandungan air dan kepekatan natrium dalam tanah. Indeks pengkelasan kekuatan tanah di semua plot rawatan dikategorikan kelas 3 iaitu sederhana keras hingga kelas 5 iaitu sangat keras, manakala bagi plot kawalan dikategorikan tanah lembut iaitu kelas 2. Kajian ini menunjukkan bahan perapi tanah organik berpotensi digunakan sebagai pembaik pulih tanah jerlus dengan meningkat indeks kekuatan tanah jerlus dan kesuburan tanah.

Kata kunci: Tanah jerlus, bahan perapi tanah organik, kualiti tanah

A043

Rock slope discontinuity sets extraction from photogrammetric point cloud using CloudCompare and DSE

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Discontinuities play a key role in the mechanical, hydraulic and deformational behaviour of rock masses, frequently having a considerable influence on the stability of rock slopes. The influence of discontinuities on the mechanical behaviour of rock masses, demands a detailed knowledge about the geometrical properties of the existing discontinuity network. Traditional measurement techniques provide a rough knowledge about a discontinuity network but are also prone to bias. They can be characterized by several geometric parameters as the orientation, persistence, and spacing. Although orientation has been traditionally measured through well-known techniques as a compass, more recent remote sensing techniques such as 3D laser scanning allow deriving both strike and dip direction of discontinuities. The novel SfM (Structure from Motion) technique, which is much less expensive than 3D laser scanning, is becoming mainstream within the research community. This paper examines the generation of 3D point clouds of a rock slope obtained from SfM techniques, and their application to the extraction of the orientations of the main discontinuity sets. To this aim, a selected sector from a cretaceous sedimentary rock cut slope located at Timah Tasoh, Perlis is analysed using both photogrammetric point clouds. This paper proposes a method to identify discontinuity sets in a point cloud and calculate the spacing of the sets. The discontinuity sets are semi-automatically identified with the open-source software DSE (Discontinuity Set Extractor) and CloudCompare.

A preliminary observation of the rock slope shows that most of the discontinuities are smoothed by weathering. In order to extract the discontinuity sets of the rock mass, a representative sector has been selected to minimize these mentioned effects that can mask the discontinuity surfaces. The rock slope which was excavated for Projek Lencongan Banjir Barat Timah Tasoh is situated at Kampung Wai, Kuala Perlis, Perlis where it is located at the northwest of Peninsular Malaysia. The rock slope which is made up of limestone was excavated to channel the water from Timah Tasoh Dam to the sea. The exact location of the rock slope is at latitude of 6.428794 and longitude of 100.143884. UAV with a mounted camera is used for slope mapping by taking aerial or side images of the slope based on the purpose of the project. All the images are geo-tagged with the coordinates by the built-in GPS in the UAV. However, the coordinates received are not corrected and might have random errors. Hence, GCP is set up on the study area to measure the exact coordinates of the location using RTK-GNSS instrument in which the coordinates are auto-corrected by the nearest RTK base station.

Agisoft Photoscan Professional software was utilized to process the acquired data images. A total of 234 images were used for bundle adjustment and producing a high-quality dense point cloud and 3D model. Besides dense cloud and 3D textured model, the photogrammetry process can produce high quality orthophoto and Digital Surface Model (DSM). The high accuracy dense point cloud generated based on GCP was imported into the open-source software, CloudCompare, using the FACET plugin and DSE to extract the geological planes in the rock outcrop.

Keywords: Discontinuity, SfM, CloudCompare, Discontinuity Set Extractor

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A044

A study on influence of twin tunnel configuration in Kenny Hill Formation using numerical approaches

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Underground development gives great options in contrast to surface development in terms of disturbance to public, utilization of space and environmental impacts. However, the construction of tunnels must consider surrounding buildings, utility cables and services, transport systems and others. Due to congested structures in an urban area, the construction of twin tunnels must be constructed horizontally, vertically and an inclined manner as shown in Figure 1. The configuration of the tunnel will influence the distribution of tunnel load and the deformation induced from soil and tunnel interaction due to a particular tunnel configuration. In the situation of horizontal tunnels, the distribution of tunnel load will be more in the lateral direction (W. Channabasavaraj & B.Vishwanath, 2013). This paper will discuss the influence of tunnel interaction in soil especially concentrate on the geometric arrangement of the tunnel by using numerical analysis. The location of the study area was Kuala Lumpur Kenny Hill Formation which basically based on Sungai Buloh to Kajang line project data of Klang Valley Mass Rapid Transit (KVMRT) system. The location of the study area is shown in Figure 2. Although two major types of geological formation are found in the study area, this research gives priority to the Kenny Hill Formation. Kenny Hill Formation includes interbedded clastic sedimentary rocks such as sandstone, siltstone and shale.

Hardening Soil model has been considered as the soil model for the numerical analysis. Hardening Soil model has advantage compared to Mohr Coulomb model in terms of stiffness parameter. The three-stiffness parameter that take in the Hardening Soil model is triaxial secant stiffness (E_{50}), oedometer stiffness (E_{oed}) and unloading- reloading stiffness (E_{ur}). Soil behave differently at a different stage of loading condition (Ti *et al*., 2009). So, to represent this behaviour Hardening Soil model is necessary compared to Mohr Coulomb model which is based on linear elastic and perfectly plastic theory. Settlement analysis has been carried out with the help of stress reduction method (Likitlersuang *et al*., 2014). The stress reduction method is the simplified 2D technique to estimate tunnelling-induced settlements. This method includes three calculation phases in the simulation process. This research was essentially split into three main components. The first component is the characterization of the subsurface. This is done based on all the soil investigation data. Secondly, for the Hardening Soil model, the empirical correlations of stiffness parameters and determination of soil properties. This correlation for Hardening Soil model determined based on 1.5 SPT-N as proposed by Law *et al.* (2014). Finally, the third component is the twin tunnel simulation using stress reduction method for different tunnel configurations. Using PLAXIS 2D the simulation of tunnel excavation is analysed in detail to determine the settlement curves. The findings are provided for distinct tunnel configuration in the form of ground settlement and stresses in the tunnel lining.

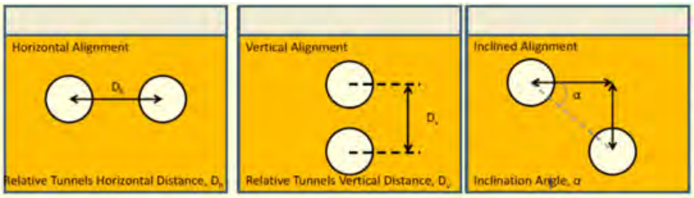

Figure 1: Tunnel configurations for analysis.

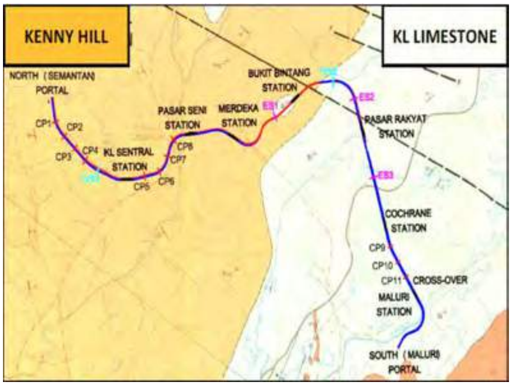

Figure 2: Study area and geological formation along Sungai Buloh to Kajang line.

This study will help to determine the type of tunnel configurations when there are underground congestions and constraints.

Keywords: Hardening Soil model, Finite Element Method, stress reduction method, tunnel configuration

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A058

Prediction of Unload-Reload Pressuremeter Modulus (E_{ur}) using GMDH-Neural Network: A case study of Kenny Hill Formation

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The soil investigation (SI) work is a process of collecting subsurface ground profile information for the purpose of evaluating soil engineering properties in a construction project. Standard penetration method (SPT) is widely accepted worldwide as simply and relatively inexpensive method compared to other SI methods. The limitation of SPT is this method unable to capture the real behavior of the soil deformation under loading condition. It also causes the high disturbance to the soil samples. Nevertheless, soil deformation which evaluate from soil stiffness parameter is very useful in settlement analysis. According to Schanz *et al*. (1999), a reliable stiffness parameter is very limited in soil testing, but having good data on soil strength is common. Simple laboratory tests may not be reliable in the most cases to evaluate stress-strain in soil, while sophisticated laboratory testing can be time consuming and costly (Mair & Wood, 1987). Hereof, pressuremeter test (PMT) was utilized to overcome this limitation. PMT is more popular in-situ method that used in interpreting soil deformation behavior. PMT output is pressuremeter modulus (E_0) and unload reload modulus (E_{ur}). E_0 is the initial modulus and potentially affected by the disturbances from surrounding and difficult to control. Meanwhile, the E_{ur} is unload reload modulus that conducted with the proper supervision and under controlled condition. The unload reload modulus that typically interpreted from the stress strain curve is highly important in settlement analysis especially in geotechnical project such as tunnelling and embankment. This parameter is reasonably obtained from field test, PMT. However, this test is relatively expensive than SPT. Considering the SPT is almost feasible for every project, establishment of correlations between PMT and SPT will be an advantageous to local practitioners. In a scope of Malaysia, correlation developed between both methods, SPT and PMT is useful for local practice especially for the project area that underlain by Kenny Hill Formation in Kuala Lumpur. In addition, the correlation could be improved by considering the result from geotechnical laboratory. Beside of N_{60} blows that obtained from SPT, physical properties of soil which extruded from boreholes and tested in geotechnical laboratory to determine the soil parameters such as particle size distribution, liquid limit and plastic limit also should be considered. These parameters are potentially contributed to the prediction of Eur. The analysis was conducted using group method of data handling (GMDH) neural network. A database containing of 47 data sets were adopted in the development of training and testing model.

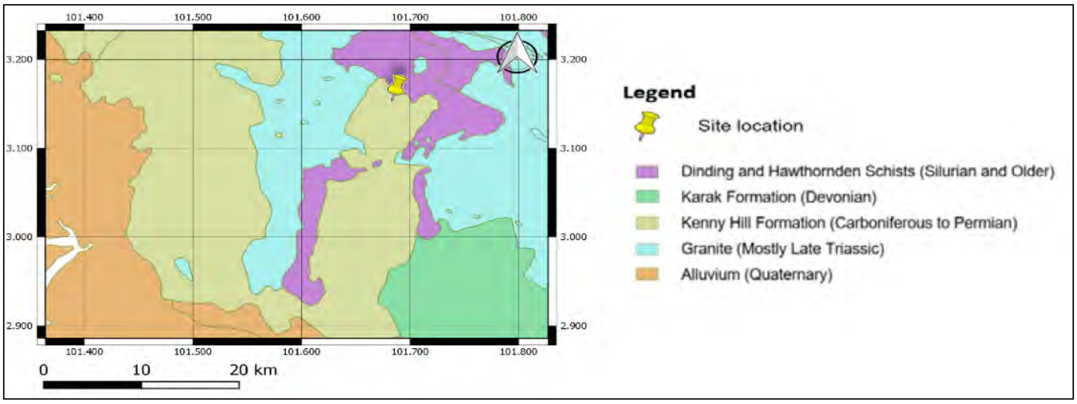

Figure 1: Distribution of Kenny Hill Formation in Geological Map of Selangor (redrawn from Geological map of Peninsular Malaysia [1:300,000]).

The detail of the study area is located in the central area of the west coast of peninsula Malaysia. It is the nation's fastest growing capital city, largest and metropolitan city in Malaysia. The Klang Valley is an area comprising Kuala Lumpur and adjacent cities and towns in Selangor. Underneath Klang Valley, it is also well-known of the existence of Kenny Hill Formation and Kuala Lumpur Limestone Formation. These two formations have their own characteristics as shown in Figure 1.

The formation of Kenny Hill has homogenous residual soil and weathered sedimentary rocks while Kuala Lumpur Limestone is well-known for its karstic limestone. According to Hutchison & Tan (2009) and Kong & Komoo (1990) the formation of Kenny Hill is the formation of meta-sedimentary rocks. It is largely composed of interbedded sandstone, mudstone and shale. It lies unconformably over Kuala Lumpur Limestone (Mohamed *et al*., 2007). Therefore, these problematic soil and complex geological condition should be identified and the correlation developed between SPT and PMT conducted for this area can be used as a reference in the preliminary design for the future project.

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A082

Geochemistry of Permo-Triassic meta-sedimentary rocks of southern part Ulu Sokor Gold Mine deposit, Kelantan, Peninsular Malaysia: Emphasizing on source area, provenance, recycling and depositional tectonic setting

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Ulu Sokor Gold Mine deposit located at the north of Kelantan state which lies within Central Belt of Peninsular Malaysia. This research is focusing on the meta-sedimentary rocks, emphasize in composition, source rocks and implication on the tectonic setting of southern part Ulu Sokor deposit. This particular part of deposit consists three pits known as New Found, New Discovery and Ketubong. Whole-rock geochemical data of major oxide, trace and rare earth elements (REEs) were identified using the Inductively Coupled Plasma Mass Spectrometry (ICPMS). The large ion lithophile (LILEs) in this studied samples show enrichment on Cs and Rb but depleted on Ba for all samples. The strong negative anomaly of Sr indicates that all the samples are typical for old recycled environments. The pattern of high field strength elements (HFSEs) reflects the sediments are no preferential accumulation of zircon addition and titanium minerals. The chondrite-normalized of REEs study shows the light rare earth elements (LREEs) are slightly enriched compared to the heavy rare earth elements (HREEs) with slightly negative Eu anomaly. Value ratio on La/Yb is 5.77, unveil the moderate REEs fractionation. The range value ratio on Th/U from these studied show slight varies, which is 0.9-6.4. Intense weathering occurs when the value ratio is more than 4.0. Plotting of data on the SiO_2 vs. Al_2O_3/TiO_2, show meta-sedimentary rock from this mine fall in the field between intermediate to felsic sources. Trace element ratios of La/Sc=0.77-2.47, Th/Sc=0.10-0.88, Cr/Th=2.97-11.80 and Eu/Eu*=0.58-0.82 reveal that these meta-sedimentary rocks are derived

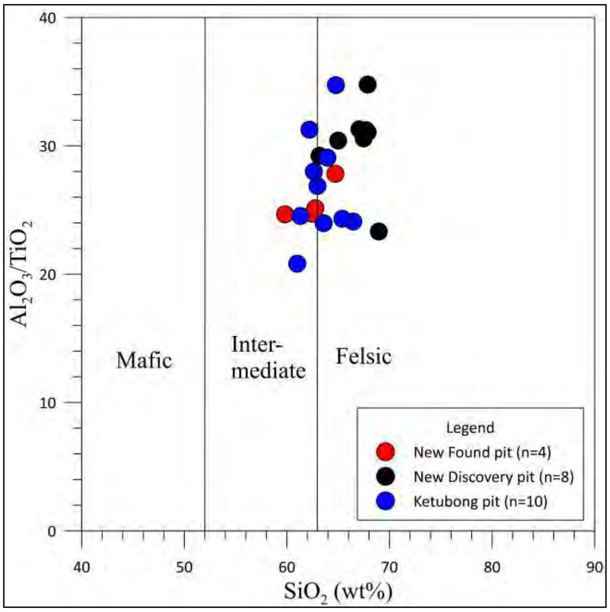

Figure 1: The SiO_2 vs Al_2O_3/TiO_2 relationship meta-sedimentary rock samples from southern part of Ulu Sokor Gold Mine deposit. The fields are from Le Bas *et al*., 1986.

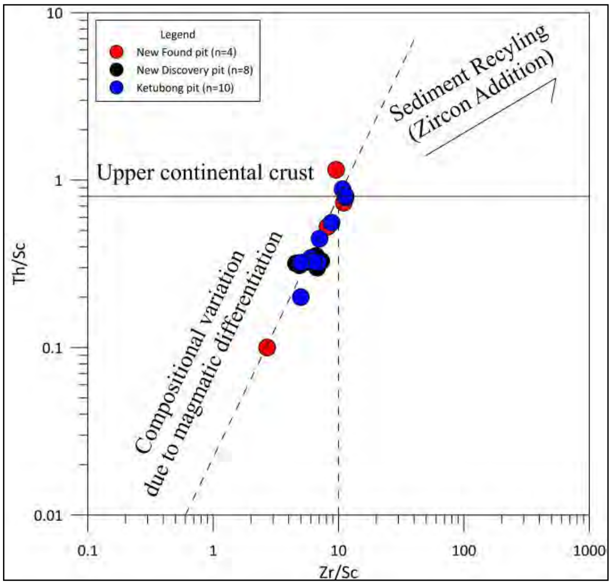

Figure 2: Zr/Sc vs Th/Sc plot (McLennan *et al*., 1993) for meta-sedimentary rock samples from southern part of Ulu Sokor Gold Mine deposit.

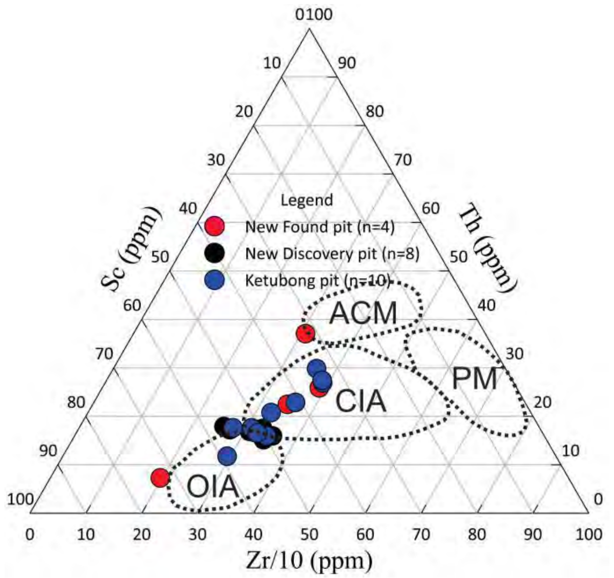

Figure 3: Tectonic setting discrimination diagrams Sc vs Th vs Zr/10 for the meta-sedimentary rock samples from southern part of Ulu Sokor Gold Mine deposit (Bhatia & Crook, 1986).

from felsic sources. The SiO_2 vs. Al_2O_3 values ratio for three pits studied samples in this mine show ranging from 3 to 5, which indicate it is close to the source and immature nature. The discrimination ratio of $TiO_2/Zr\times100$ shows that meta-sedimentary rock samples of deposit derived from pelitic sediments with the average value of >0.33. The average Zr contents in the samples are ≈138, which reflecting the less degree of recycling. The distribution pattern Zr/Sc vs. Th/Sc followed the magmatic differentiation trend with slightly toward >10 value ratio of Zr/Sc. The discriminatory tectonic plot Sc-Th-Zr/10 for the studied samples shown in the fields of continental island arc and oceanic island arc.

Keywords: Geochemistry, meta-sedimentary rock, source rock, provenance, depositional tectonic setting

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A102

Application of electrical resistivity tomography to identify suitable location of shallow tube well for irrigation

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Abstract: Agricultural drought becomes more appearance due to climate change and uncertain weather pattern. The current and continuing drought in many parts of the world, combined with ever increasing demands from both traditional and new water users, including municipal, industrial, agricultural and environmental needs, has impacted groundwater resources. Supplementary irrigation becomes important to overcome short term drought ensuring successful cultivation. Apart from obtaining the irrigation water from the traditional water sources (surface run off and rainfall) for irrigation, other alternative water source needs to be explored. The most feasible water source and relatively abundance is the ground water. Identify suitable location for shallow tube well development using electrical resistivity method has been extensively used. This method once of the surface geophysical methods can reduce risk and unnecessary costs by assisting in the siting of wells location. Technique based on resistivity can be used to interpret the characteristics of aquifer and thus to identify suitable location for tube well. The surveys were conducted at three different locations in Perak and Kelantan situated in Peninsular Malaysia which was mainly alluvial deposits lithology. The shallow tube well in quaternary aquifer into the ground will consider for groundwater identification. The resistivity values of highly discharge of groundwater approximately in ranges of 4.4Ωm to 20 Ωm with flowrate at range 45 m^3/h to 47 m^3/h. The depths of tube well were in between 9 to 24 m. The groundwater aquifers are found in saturated sand, coarse sand with some gravelly sand.

Keywords: Geophysical method, tube well, irrigation

A113

Mapping of major fault structures by gravity technique in Peninsular Malaysia

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Interpretation of major fault structures in Peninsular Malaysia was carried out by analyzing the satellite gravity data. Aims of study are to map the major fault and joints as well as to determine their subsurface depth and dip directions. The satellite gravity data were conventionally analyzed by Oasis Montaj computer software to produce the Bouguer anomaly map as well as calculating the total horizontal derivatives (THD), the total vertical derivatives (TVD), tilt angle (TDR) and horizontal tilt angle (TDX) derivatives. The resulting Bouguer and all of the derivatives maps produced were successfully been used in determining the location of many major fault structures and the boundary of main range granite and central belt metasedimentary rocks of Peninsular Malaysia. The major faults determined are namely the N-S trending Bok Bak, Lepar and Lebir faults. While the NW-SE trending faults of Kuala Lumpur, Bukit Tinggi, Seremban and Mersing were also successfully mapped. The most outstanding finding of this study is the determination of Bentong-Raub Suture, which is separating the Eastern and Western Geological Tectonic Belts of the Peninsular Malaysia. The presence of eastern, western and central geological tectonic belts, are clearly observed in the derivatives anomaly maps represented by their abrupt changes in the gravity values. The range of Bouguer gravity values representing the N-S trending Main Range Granite and the eastern range granite batholiths were in between -72 mGal to 2 mGal. While the southern range granite body particularly in Johore shows higher values ranging from 9 mGal to 25 mGal due to possibly higher density value as compared to the main range granite body. These major fault locations including Bok Bak, Kuala Lumpur, Mersing, Lepar, Ruok, Galas and part of Bentong-Raub Suture zone derived from gravity analysis were almost overlapped on the fault locations determined by geological mapping and RADARSAT image. The Bouguer anomaly values were further inversed by using 3D Euler Deconvolution technique with selected windows ranging from 10-20 and Structural Index (SI) of 1 especially meant for fault analysis. The resulting 3D Euler analysis produced coordinates of point source anomalies in X-Y direction or horizontal plane which can be used for mapping as well as coordinates of point source anomalies in vertical X-Z direction which can be used in establishing cross sections and consequently estimating the dips and depths of all these major faults. 3D Euler cross sections of point source anomalies established along six E-W profiles show faults dipping towards east, west and southeast forming grabens and half grabens within the sedimentary and granitic rocks. The range of dips and depths based on the arrangement of point source anomalies are approximately 14º-80º and 10 km to 14 km respectively. The similarity of both results shows the satellite gravity data analysis can be potentially used to support geological mapping especially in fault determination in rugged and hilly areas.

Keywords: satellite gravity, Bouguer anomaly, total derivatives, 3D Euler Deconvolution, fault structures

A125

What lies beneath: Deep-marine trace fossils in the West Crocker Formation and their palaeoenvironmental significance

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The deep marine environment is relatively "quiet", dominated by pelagic/hemipelagic deposition of clay-rich sediments. This "background" sedimentation is punctuated by the intermittent terrestrial sediment influx via sediment gravity flows (turbidity and debris flows). The resulting "event beds" are of interest to sedimentologist for their academic and economic value. The fine-grained muddy intervals also contain a wealth of information but are paid less attention. During the quiet "non-event" periods, tracks and trails are produced by organisms on the deep sea floor but the occurrence of trace fossils is usually mentioned only in passing. Careful study of the traces and the host sediment would shed light into the organism-sediment interactions and the paleoenvironmental conditions during the non-turbiditic "background" intervals, which are equally as important as those of the event beds themselves.

In the West Crocker Formation (Eocene-Oligocene), Kota Kinabalu, Sabah, trace fossils are not ubiquitous, although fairly common in the thinly bedded heterolithic sandstone-mudstone facies in these "flysch" sequences. The trace fossils commonly occur on the sole of thin sandstone beds, which are mainly the Bouma Tc divisions, and often with ripple cross-laminated sandstone, as hypichnial semi- or full reliefs. The abundance of trace fossils in the thinly bedded facies suggests preferential production and preservation in the "distal", fine-grained parts of the submarine fan system. Although their presence is not widespread, when present in abundance, the diversity is low; some bedding surfaces appear to be dominated by one or two specific ichnofacies.

The assemblage of traces is characteristic of the *Nereites* ichnofacies, widely recognized as indicative of bathyal to abyssal water depths (>2000 m). Many forms belonging to this ichnofacies (Seilacher, 2007) were recognised. The ichnofacies is dominated by horizontal grazing, farming and feeding traces, ranging from solitary to branching tubular burrows (*Ophiomorpha*, *Palaeophycus* and *Planolites*) to meandering trails and tunnels (*Nereites*, *Cosmorhaphe*, *Helminthopsis*), as well as the distinctive, pretzel or doughnut-shaped, spiriform burrows, *Spirophycus* (Figure 1).

Graphoglyptids, most diagnostic of the *Nereites* ichnofacies, are common in some parts of the West Crocker Formation. These are complex spiral and meandering traces, believed to be produced by sediment grazers and farmers (agrichnia) and often display intricate networks of mainly horizontal tunnels preserved as full or semi-relief beneath turbidite beds. Most of the common pre-depositional graptoglyptids described by Uchman & Wetzel (2012) are present. They include the delicate spiral traces of *Spirorhaphe*, as well as the enigmatic hexagonal network burrows, *Paleodictyon* (Figure 2).

The various species of the *Nereites* ichnofacies represent mainly "post-turbidite" traces, left by a community of burrowing orgasisms that fed on the turbiditic muds during the quiescent period between turbidity flow or mass transport events. Besides these key deep-water traces, other traces include e.g., *Planolites*, *Thalassinoides* and *Ophiomorpha*, known to be facies-crossing and, generally, not environmentally diagnostic. *Ophiomorpha* appears to be more common in sandy facies and tend to penetrate deeply into pre-existing turbidite beds.

With detailed observations on the degree of bioturbation, it may be possible to further subdivide the *Nereites* ichonofacies in "sub-ichnofacies" to distinguish different parts of the submarine fan system (Seilacher, 1974; Buatois & Mángano, 2011). The *Paleodictyon* sub-ichnofacies, for example, is characteristic of lobe fringe and fan fringe, whereas the distal basin floor has the same sub-ichnofacies but with high abundance of fodichnia components (Heard & Pickering, 2008). Channel axis and proximal fan has the characteristic *Ophiomorpha rudis* sub-ichnofacies, while off-axis proximal areas are characterized by mixture of both *Ophiomorpha rudis* and *Paleodictyon* sub-ichnofacies. The presence of *Ophiomorpha* in these types of proximal turbidite facies may also indicative of a well-oxygenated newly deposited turbidite (e.g., Nielsen *et al.*, 2012).

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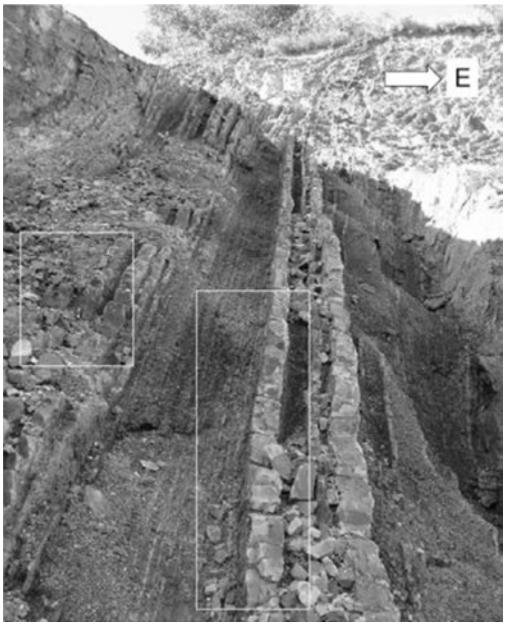

Figure 1: Example of thinly bedded turbidites and mudstones of the West Crocker Formation where abundant trace fossils were found.

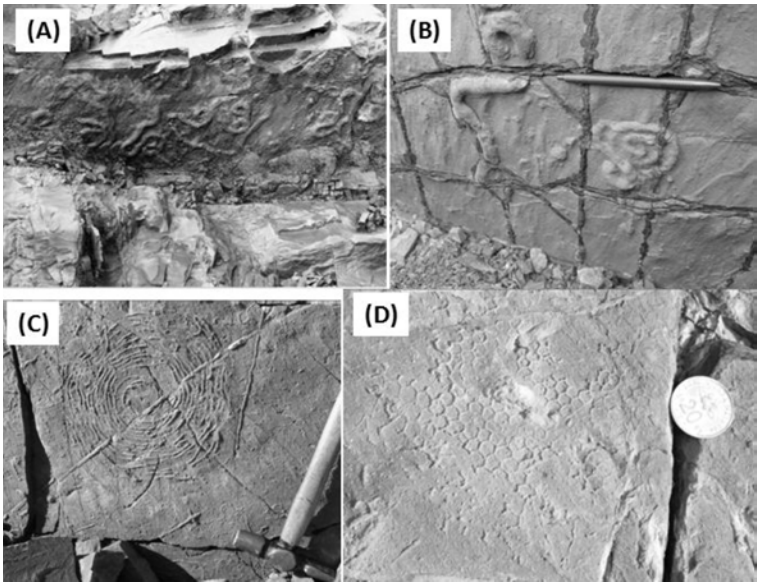

Figure 2: Some examples of the trace fossils in the West Crocker Formation, Kota Kinabalu area. (A) *Spirophycus*, (B) *Spirophycus*, (C) *Spiroraphe*, (D) *Paleodictyon*.

A133

Trace element fractionation behaviour of soil from Benta Alkali Syenite

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Benta is situated in the state of Pahang, located at the western part of the Benom Complex. It belongs to the Benom Plutonic Complex which has been a prolific equivalent to the Benta alkali series, comprising of Gunung Benom Granite that consist of calc alkali affinities and the Benta intermediate to mafic rocks of the alkali series. Weathering of the syenitic rock produced a Ba-rich bearing soil. A soil profile (2.0 m height) was selected and 7 rock soils have been analysed from this profile at the interval of ~0.5m (Figure 1). The host rock is taken at another nearby area which is the representative parent rock of the soil profile in the same area. The enrichment of Ba increases significantly with increasing SiO_2, from mafic to felsic. As it mostly occurs in K-feldspar (orthoclase) and mica through the substitution of Ba^{2+} that replaces K^+ due to similar ionic radii between the two ions which are 135pm and 138pm respectively. This is also supported with the presence of Barite mineral in the XRD analysis. Hence, Ba concentration is prominent in both syenitic rock and soil samples in Benta that ranges between 5884ppm-3323ppm and 4297ppm-2233ppm respectively. The LREE fractionation $(La/Pr)_n$ and HREE fractionation $(Lu/Ho)_n$ both unveils moderate enrichment that increases towards the surface of the profile with increasing weathering.

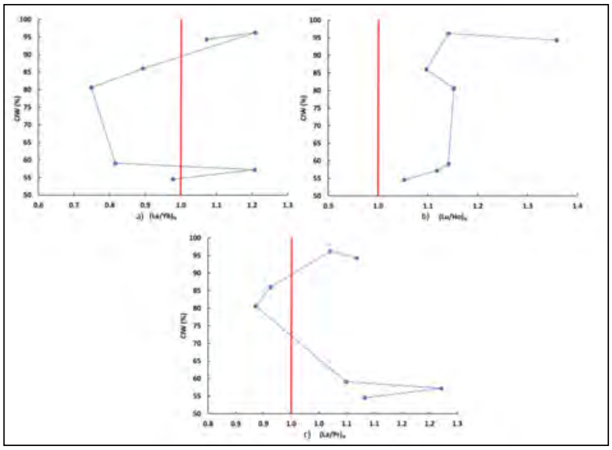

Figure 1: Variation of REE ratios with chemical index weathering (CIW) for comparison. a) LREE/HREE values represented by $(La/Yb)_n$. b) Fractionation within HREE group represented by $(Lu/Ho)_n$. c) Fractionation within LREE group represented by $(La/Pr)_n$.

The LREE/HREE ratio that is represented by $(La/Yb)_n$ portray a significant increment results in a higher LREE fractionation compared to HREE. Mass transfer coefficient ($\tau_{j,Nb}$) of REE > 1 which indicates the enrichment of REE in the soil. However, Ce behaves slightly different as compared to the elements and unveils a positive Ce anomaly. Hence, the soil is known to have undergone the oxidizing condition and retains the Ce element in it. This results in the enrichment of the Ce concentration in the soil that ranges between (288.3 – 325.3 ppm).

Keywords: Geochemistry, alkali syenite, igneous rock, fractionation, element behaviour

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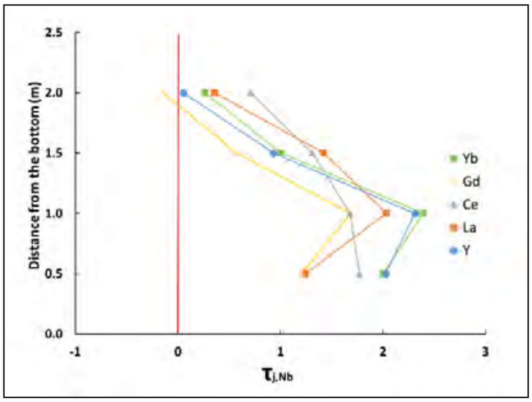

Figure 2: Mass transfer coefficient ($\tau_{j,Nb}$) of selected REEs in the syenitic profile. For a given element j, $\tau_{j,Nb} > 1$ indicates enrichment, $\tau_{j,Nb} < 1$ indicates depletion and $\tau_{j,Nb} = 1$.

A141

Risk of biotic degradation on structural wood

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Wood is and will remain to be the most abundant renewable resources for structural construction. Since the 1980s, an expansion of wood usage in construction such as timber panels have steadily grown in prominent countries such as the United Kingdom and Italy. Due to the increasing technical innovations of engineered wood products (EWP), it is easily presumed that there will be a magnification of exercise in wood-based constructions in the near future. In spite of the perquisite, building materials still faces complications during natural disasters as a building is only as strong as its building materials. Unlike other construction materials such as steel and concrete that are majorly affected by the abiotic agents, wood-based materials are affected by both biotic and abiotic agents that deteriorates the wood quality. This paper summarizes the effect of biotic agents on the structure and composition of wood as a building material. It will focus on the types of biotic agents such as fungi and insects, and the type of damage it bestows upon the attacked materials. Furthermore, prevention and remediation procedures were also included to prevent onslaught damages if exposed to the agents.

Keywords: Wood, construction, biotic, natural disaster

A151

Slow onset and emerging hazards in the coastal zone of Kuala Selangor, Malaysia

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There is growing evidence that human influence has contributed substantially to surface warming of continents, affected the global water cycle, caused glaciers to retreat as well as increased surface melting of the Greenland ice cap, loss of Arctic sea-ice, and raised the upper oceanic heat content and global mean sea levels. Recent findings indicate that human activities have caused around 1°C of global warming since pre-industrial times. The prognosis for climate change over the 21st century is not very favourable under all assessed emission scenarios, even without addition of green-house gasses due to natural sources. Surface temperature is expected rise, more frequent and longer lasting heat waves are anticipated, extreme precipitation events will be more intense and frequent, the ocean will continue to warm and acidify while global mean sea level is projected to rise albeit unevenly across regions.

Coastal hazards such as storms and floods as well as slow onset sea level rise, inundation and erosion are expected to impact communities that live in susceptible coastlines with high exposure. Recent geoscience findings indicate that a small rise of 0.5 m in sea level have the potential to double the frequency and the intensity of tsunami-induced flooding of the coasts due to earthquakes along the Manila Trench. Sea level rise also threatens coastal aquifers and exposes infrastructure such as waste disposal sites that could emerge as future pollution sources. Geomorphological features are an important factor in the development of decision-support tools that deal with coastal disaster risk reduction and multi-hazard risk of social-ecological systems. Geoscientists have the capacity to advance disaster preparedness in a variety of sea level scenarios, to build the resilience of coastal communities.

Climate change poses a serious threat to humans and natural ecosystems in the coastal zone of Kuala Selangor. The projected increase in surface temperature is expected to reduce the yield from paddy and oil palm plantations. Extreme climate and hydrological conditions are expected to contribute to this decline. Projected sea level rise will increase the susceptibility of low-lying areas to coastal inundation and compromise existing land use. Almost 91% of the exposed components are agricultural and forest areas while the rest comprises transport, residential, infrastructure, business, public institutions and industry (including aquaculture). In addition, the potential for saline intrusion into groundwater aquifers increases as the sea level rises and this has implications for fresh groundwater resource. The implications of climate change in Kuala Selangor can be addressed by undertaking adaptive measures that take into account both surface and sub-surface aspects.

A019

Soil nutrients and relation to basal stem rot disease incidences in oil palm estates with different agronomic practices

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Abstract: Basal stem rot (BSR)disease caused by Ganoderma boninense is the most threatening disease to the oil palm industry in South East Asia. Although there are numerous controls being proposed for BSR, however, none of them has provides a total solution for this disease. An in depth understanding about the soil condition may play an important role in managing the disease effectively to achieve a sustainable palm oil production. In this paper, we report the relation of the different soil nutrients of oil palm with high, low and no BSR incidences. Soil samples were collected from three different estates which are located at different regions; Sandakan, Lahad Datu and Tawau in Sabah which adopting different disease management and agronomic practices. Nutrient elements were analysed using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES) and an Ultraviolet-Visible Spectroscopy (UV-VIS) Spectrometer. Macro elements such as Nitrogen (N), Phosphorus (P) and Potassium (K) were found higher in disease free soil where these elements were considered adequate in these areas. On the other hand, Iron (Fe) and Aluminium (Al) were found higher in the areas with higher BSR incidences and without microbial augmentation in their disease management. There was not much different in term of other micro nutrients in the studied area.

Keywords: Oil palm, basal stem rot, soil nutrient

A075

Basic friction angle value of planar surface for the Sandakan Formation, Sabah, Malaysia

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INTRODUCTION

The basic friction angle is an essential input in estimating the shear strength of joints in stability analysis of rock slopes and underground excavations, and in the assessment of factors of safety of a number of failure mechanisms in rock engineering design expect when the rock had been softened and altered or when the discontinuity had been polished by displacement.

The chippers and simple's method to determine the basic friction angle, ϕ_b is using tilt testing (Ismail *et al.*, 2017). Alejano *et al.* (2012) has been conducting tilt testing by using various rock lithology's (slate, granite, magnesite and amphibolite) and sample types and arrangements to obtain the most suitable methods of reliable basic friction angle value for planar joints to combine with Barton's results for the shear strength of natural unfilled planar joints.

The square-base slab sample types and arrangements is the most suitable method for tilt testing found by Alejano *et al.* (2012; 2018). Rasyidah Moneey *et al.* (2015) and Ismail Abd Rahim *et al.* (2017) determine the basic friction value of Sandakan formation and Crocker formation's sandstone by tilt testing with square slab sample type are 25-35^o and 24^o, respectively.

This study has been conducted to provide a database and guideline for stability analysis and formulating the design for rock cut slope engineering purposes in Sandakan formation.

GEOLOGICAL BACKGROUND

Sandakan formation is the most dominant in study area. The bottom part is conglomerate layer which unconfirmably the volcanic unit. The lithology's of Sandakan formation consists of sandstone, siltstone, mudstone and thin coal layer. The sandstone is yellowish brown, soft and reaching 30 m thick. Lee (1970) was classified Sandakan formation sandstone as chemically and physically immature with rounded to sub rounded grain, good shorting and poorly cemented. The Sandakan Formation of early-late Late Miocene ages is a shallow marine and shoreface succession environmental deposition.

Sandakan Formation consists of seven lithofacies i.e. thick amalgamate sandstone; thin, lenticular interbedded hummocky cross stratification (HCS) sandstones and mudstone; laminated mudstone Rhizophora; trough cross-bedded sandstone; laminated mudstone; strip mudstone with thin laminated sandstone and siltstone; and interbedded HCS sandstone and mudstone (Chung *et al.*, 2015).

Quaternary alluvium consists of weakly consolidated deposit with the mixture of quartz gravels, sand, carbonaceous silt and plant fragment (Lee, 1970).

METHODOLOGY

Generally, methods in this study only covering field study and rocks sampling, laboratory testing and data analysis or evaluation. Geological observation and sandstone samples of Sandakan Formation from locality SSF1 Taman Grandview was utilised for this study.

Petrographic study and tilt testing were conducted to determine the classification of sandstone and the values of basic friction angles of planar surface for discontinuity in Sandakan Formation.

Sandstone samples with artificial discontinuity plane have been used in this tilt test due to the difficulty in collecting natural discontinuity plane. The tilt testing is also following ISRM (2014) but the samples types and arrangement by Alejano *et al.* (1018).

RESULTS AND DISCUSSION

Petrographically, the sandstone of Sandakan formation can be classified as fine and very fine sublitharenite which were dominated by quartz, lithic and minor of feldspar with less than 15% of matrix components.

The result of tilt test by rectangular-based slabs types samples arrangement are shown in Table 1. Average basic friction angle (ϕ^a_b) for fine and very fine sandstone are 33^o and 28^o, respectively. The greater grain size the more number for effective contact per unit area of the interface then the friction became higher. This contribute to the value of basic friction angle of fine sandstone are higher than very fine sandstone.

Table 1: The values of basic friction angle (average) (ϕ^a_b) of Sandakan formation's fine and very fine sandstone.

Sample No.	Rock unit	Inclination angle (°)					T (°C)	W (%)	ϕ^a_b
		β_1	β_2	β_3	β_4	β_5			
CS1	Fine sandstone	31	34	33	32	30	25	60	28 (28.41)
CS2	Very fine sandstone	41	34	36	37	34	25	60	33 (32.56)

CONCLUSIONS

The conclusions of this study are;

i. The sandstone of Sandakan formation can be classified as fine and very fine sublitharenite.

ii. Basic friction angle for planar surface of fine and very fine sublitharenite are 28° and 33°, respectively.

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A109

Flood susceptibility analysis using geospatial frequency ratio in Kota Belud, Sabah

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Abstract: Flood is one of the catastrophic natural hazards affecting human lives in Sabah, especially in the area of Kota Belud, Sabah. In 2017, around 4,441 people affected by this event involving 62 affected villages. These flooded areas have caused significant damage to people and their properties. In this research, the flood susceptibility analysis was defined using a Geographical Information System based-bivariate statistical analysis, namely the frequency ratio (FR) model. The frequency ratio model was used to predict the correlation between historical flood events and the likely supporting variables. The spatial relationship between each flood conditioning parameter and flash flooding hazards derived from the frequency ratio model is shown in Table 1. The value of the frequency ratio below 1 shows weak correlations; on the other side, the value below 1 relates to significant relationships. The flood inventory map was made using field surveys and formal reports from the local authorities in the study area. A total of 100 flood locations that were inundated in 2018 was used for statistical analysis as the training dataset, while data from the past flood report were applied to validate the developed model. Eight (8) parameters were considered concerning the causative factors to flooding (drainage density, drainage proximity, elevation, slope angle, slope curvature, land use, soil type, and topography wetness index) were extracted from the database, and the converted into a raster format with a cell size 5 x 5m (Figure 1). Finally, from the result suggest that 24% (47 km^2) of the area can be categorized as having very low susceptibility, 33% (65 km^2) as low susceptibility, 25% (49 km^2) as moderate susceptibility, 11% (21 km^2) as high susceptibility and 6% (12 km^2) as very high susceptibility (Figure 2). The accuracy of the flood susceptibility model was validated using the area under the curve (AUC) analysis. The AUC for success rate was estimated at 82.13%, while the prediction rate was 80.74% (Figure 3). The findings of this research show that integration of statistical bivariate frequency ratios and GIS technology offers a useful tool for decision-making in flood susceptibility mapping because this makes it possible

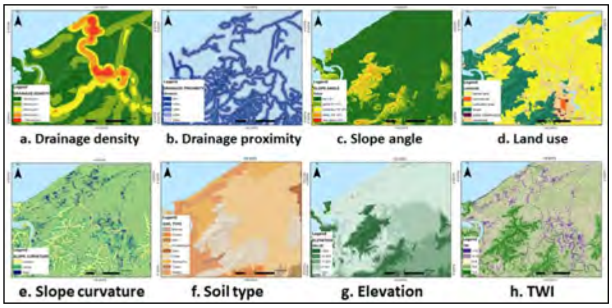

Figure 1: Flood conditioning factor used in frequency ratio model.

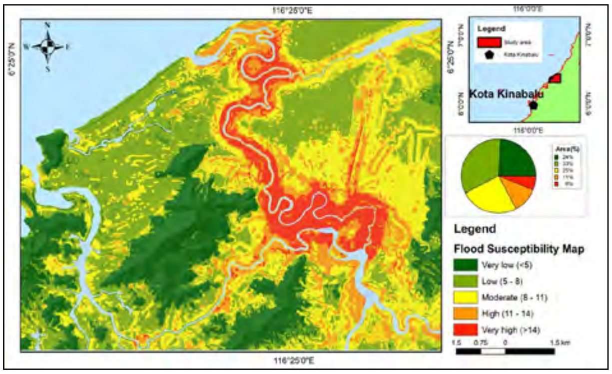

Figure 2: Flood susceptibility map.

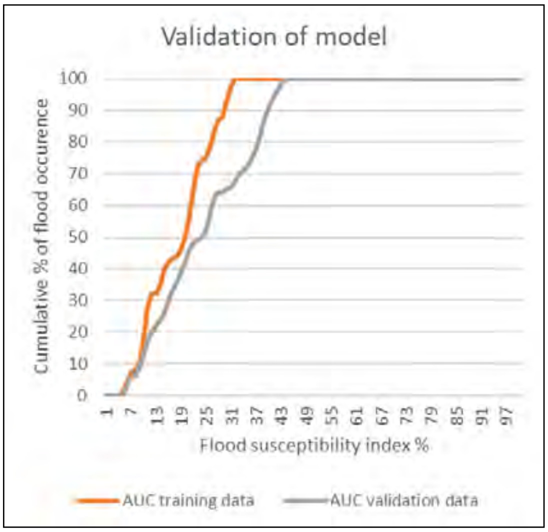

Figure 3: Validation of flood susceptibility.

Table 1: The frequency ratio analysis in each factor class.

Factor	Class	Pixels number in domain	Percentage pixels number in domain	Flood area number	Percentage flood area	Frequency Ratio
1.Drainage Density	10km/ sq km	2714768	54.71	6.00	6.00	0.11
	15km/ sq km	1256637	25.33	21.00	21.00	0.83
	20km/ sq km	545134	10.99	22.00	22.00	2.00
	25km/ sq km	317577	6.40	35.00	35.00	5.47
	> 30km/ sq km	127869	2.58	16.00	16.00	6.21
2.Drainage Proximity	50m	951567	19.18	7.00	7.00	0.37
	100m	829668	16.72	39.00	39.00	2.33
	150m	630568	12.71	26.00	26.00	2.05
	200m	463466	9.34	12.00	12.00	1.28
	250m	2087220	42.06	16.00	16.00	0.38
3.Slope Curvature	Convex	2531251	51.01	50.00	50.00	0.98
	Linear	322271	6.49	13.00	13.00	2.00
	Concave	2108459	42.49	37.00	37.00	0.87
4.Land Use	Cultivation area	2072617	43.61	36.00	36.00	0.83
	Commercial	17329	0.36	0.00	0.00	0.00
	Barren land	225564	4.75	7.00	7.00	1.48
	Forest	1806464	38.01	4.00	4.00	0.11
	Public infrastructure	29022	0.61	2.00	2.00	3.28
	Residential	602091	12.67	51.00	51.00	4.03
5.Elevation	<5m	2105004	42.42	29.00	29.00	0.68
	6 - 10m	1123427	22.64	62.00	62.00	2.74
	11 - 20m	652541	13.15	9.00	9.00	0.68
	20 - 30m	219644	4.43	0.00	0.00	0.00
	>30m	861357	17.36	0.00	0.00	0.00
6.Slope angle	<5°	3556050	71.67	98.00	98.00	1.37
	5° - 15°	671070	13.52	2.00	2.00	0.15
	15° - 25°	560512	11.30	0.00	0.00	0.00
	25° - 35°	168131	3.39	0.00	0.00	0.00
	>35°	6214	0.13	0.00	0.00	0.00
7.Soil type	Weston	655359	13.21	1.00	1.00	0.08
	Brantian	2243	0.05	0.00	0.00	0.00
	Tanjong Aru	569160	11.47	2.00	2.00	0.17
	Dalit	1695	0.03	0.00	0.00	0.00
	Lokan	1557048	31.38	11.00	11.00	0.35
	Tuaran	30414	0.61	0.00	0.00	0.00
	Crocker	2101	0.04	0.00	0.00	0.00
	Kinabatangan	2126207	42.85	86.00	86.00	2.01
	Klias	17968	0.36	0.00	0.00	0.00
8.Topograhic Wetness Index	TWI 1-5	747010	15.05	0.00	0.00	0.00
	TWI 5-6	1609155	32.43	21.00	21.00	0.65
	TWI 6-8	1577271	31.79	49.00	49.00	1.54
	TWI 8-10	812273	16.37	23.00	23.00	1.40
	TWI >10	216211	4.36	7.00	7.00	1.61

to make consistent and effective use of spatial information. Also, depending on the accessibility of the data, the method used in this research can be readily implemented in other fields to which different aspects can take account.

Keywords: Flood susceptibility analysis, frequency ratio, geospatial, Kota Belud

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A110

Landslide susceptibility analysis using Factor Analysis Model (FAM) in Kota Kinabalu, Sabah

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Abstract: The aim of this study was to prepare a landslide susceptibility level (LSL) map for the Kota Kinabalu area in Sabah, Malaysia. For this purpose, a statistical approach based on factor analysis model (FAM) integrated with a GIS environment, was applied to assess the LSL of the area. FAM is a data reduction technique used to reduce a large number of variables into a smaller set of underlying factors that summarizes the essential information contained in the variables. This model consists of a statistical comparison between landslide distribution as the dependant variable and a number of separate instability factors (input parameters). Specific attribute data are attributed to the grid cells, resulting in specific raster data layers for each input parameter. Ratings of different spatial factors from the best models calculated with the FAM were then derived. The results showed that the slope angle (β) (29% variance), lithology (17% variance), soil types (14% variance), rainfall (12% variance), effective cohesion (c') (11% variance), lineaments (9% of variance) and land use (8% of variance) play important roles. The data layers, in which each factor was subdivided into a convenient number of classes, were separately overlain and statistically compared with the landslide distribution map (LDM). Subsequently, the landslide density was calculated and the weighted value/rating as determined for each individual class. The final LSL was expressed as the sum of all parameter classes ranked according to the calculated landslide density for each class. In conclusion, the FAM results showed that two factors were extracted as the causative factors causing landslides; triggering factors (TF) and physical factors (PF). In addition, about 39.65% of the areas have stable conditions, 59.57% was basically unstable and 0.78% was strictly not recommended to be developed. This FAM had higher prediction accuracy of 83.90%. The resulting LSL map can be used by local administrator or developers to locate areas prone to landslides, determine the land use suitability area as well as to organize more detailed analysis of the identified "hot spot" areas.

Keywords: Landslide susceptibility mapping (LSM), Factor Analysis Model (FAM), statistical method, geospatial technology

ACKNOWLEDGEMENT

Sincere gratitude to Universiti Malaysia Sabah (UMS) for providing easy access to laboratories and research equipment. Highest appreciations also to the research grant award (SBK0335-2017 and GUG0373-1/2019) to finance all the costs of this research.

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The Sabah annex for DID guideline for erosion and sedimentation control in Malaysia: A case from Sabah west coast

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Abstract: This paper is based on feedback from the industry (typically civil engineering consultants) which have problem in producing accurate calculation for Erosion & Sedimentation Control Plan (ESCP) as part of the EIA submission or part of the local council / KK City Hall submission for Development Plan. The main aim of this research is to develop the Soil Erodibility Factor (K Values) for the use of practitioners and checkers when deriving erosion rate per storm event for soils at West Coast of Sabah. Currently, there is no proper standard and guideline, and specifically, K Values available for practitioners and professionals in Sabah. This issue was raised up during SWAM 2017 conference organized by the Malaysian Stormwater Organization (MSO) which also calls for the development for the guideline for both Sabah and Sarawak. The Guideline for Erosion and Sediment Control in Malaysia does not provide any soil-related parameter in generating the sediment yield especially the soil erodibility factor values for both Sabah and Sarawak. Thus, both states have no specific guideline especially in projecting the erosion rate and sediment yield for best management practice or for land conservation. In this study, 15 types of soil of various landforms have been selected and sampled. Tests have been conducted and the soil erodibility factor for each soil is determined.

Keywords: Erosion & Sedimentation Control Plan (ESCP), Soil Erodibility factor (K Values), Kota Belud

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Utilizing the Magnetic Source Edge Detection (MSED) method in mapping geologic features within a sedimentary basin

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Abstract: The source edge detection (SED) technique was applied to high resolution aeromagnetic data (HRAD) acquired from areas within the middle Benue sedimentary basin in northcentral Nigeria to delineate geological and magnetic source boundaries and map out shapes of intra-sedimentary features regardless of their depth. The International Geomagnetic Reference Field (IGRF) was first subtracted from the magnetic data to correct the drifting regional gradient of the earth's magnetic field. Then it was reduced to the equator (RTE) in order to center the anomaly source over the causative magnetic bodies. Several edge detectors operations were applied to make the magnetic boundaries conspicuous within sediments. The total horizontal gradient (HGRAD), horizontal tilt angle (TDX), the tilt angle derivatives and the first vertical derivatives were computed using geosoft oasis montaj software. They were then upward continued for between 2 km to 4 km from which the magnetic source boundaries were delineated. The results show the effectiveness of the method and its usefulness in mapping out mineral potential zones and geological features like dykes, faults, fractures and ore bodies in a geologic environment where these magnetic anomalies are not too distinct and comprising of little exposed rock outcrops.

Keywords: Edge detection, magnetic data, derivatives, anomaly

INTRODUCTION

Aeromagnetic data are important component for the exploration of minerals as they display distinct variations in rock magnetization (Eldosouky & Elkhateeb, 2018; Ekwok *et al.*, 2019). The magnetic method is effective as a mapping mechanism, especially where the magnetic susceptibility contrast exhibited by composite rock units of an area are relatively strong. These variations can be very useful in delineating geologic boundaries and features like dykes, faults, fractures and ore bodies (Eldosouky & Elkhateeb, 2018; Ekwok *et al.*, 2019; Ibraheem *et al.*, 2019). However, where these magnetic anomalies are not too distinct, they can be digitally enhanced on a filtered gridded map to aid this delineation. The applications of different derivatives to magnetic data can digitally enhanced the data and aid in defining the shapes of the causative source bodies regardless of their depths (Ibraheem *et al.*, 2019). The edge detectors techniques use magnetic derivatives to emphasize edges of magnetization boundaries and the most commonly applied is the horizontal and vertical derivatives (Oruç, 2011; Arisoy & Dikmen, 2013). However, the limitation to the horizontal and vertical derivatives is that determination of diminishing anomalies is often burdensome and ambiguous due to high amplitude variations of signals emanating from sources of contrasting depths, geometries and magnetization properties (Verduzco *et al.*, 2004; Ibraheem *et al.*, 2019). To overcome this limitation, several other edge detection techniques like the magnetic source edge detection (MSED) technique used in this current research is based on enhanced derivatives which have the ability to deal with complex anomalies and clearly depict the true magnetic source boundaries. This has resolved a comprehensive delineation of the shapes of causative magnetic sources regardless of their depths and amplitudes variations, by normalizing derivatives of the potential field data (Ferreira *et al.*, 2013). Among these enhanced techniques are; the total horizontal gradient, the tilt angle derivative, the total horizontal derivative of the tilt angle, horizontal tilt angle, the enhanced total horizontal gradient of the tilt angle, Euler deconvolution and the analytic signal (Miller & Singh, 1994; Verduzco *et al.*, 2004; Cooper & Cowan, 2006; Arisoy & Dikmen, 2013; Ibraheem *et al.*, 2019; Ekwok *et al.*, 2019). The magnetic source edge detection (MSED) method applied in this current research encompasses some of these derivatives. This technique was applied on high resolution aeromagnetic data (HRAD) within the in-land sedimentary basin of northcentral Nigeria in order to evaluate and delineate the magnetic source shapes, boundaries and depth. This is necessary as it can aid the mineral exploration potentials of the area.

Geologic setting

The area of investigation lies within the Cretaceous inland basin of the Middle Benue Trough (MBT) with the geographical location of latitude 7° to 8° N and longitude 8° to 9° E within the northcentral region of Nigeria. The geology of the area is made up of the sedimentary formations of the Albian Asu River Group of sediments which is mainly shales, limestones and siltstones; the

Turonian Eze-Aku Formation comprising mainly of sandstones; and the Quaternary detrital alluvium along the riverbanks (Obaje, 2009). The hard rock in the area corresponds to the Older Granites intrusions believed to be mostly Pre- Cambrian in age (Ofoegbu, 1985).

MATERIALS AND METHODS

The material used for this research work comprise of high-resolution aeromagnetic data (HRAD). It was acquired from the Nigerian Geological Survey Agency (NGSA) which had carried out air borne magnetic survey of the entire country from 2005 to 2009 through a third-party consultant, Fugro airborne geophysical. The magnetic data was acquired at an average flight altitude of 80 m, flight line spacing of 500 m and tie line spacing of 2 km. All necessary magnetic corrections including the international geomagnetic reference field (IGRF) using the 2005 model were performed on the data before archiving at the NGSA office.

The HRAD was displayed into digital grid maps of total magnetic intensity (TMI) using oasis montaj version 8.4. The TMI (Figure 1a) was further reduced to the Equator (Figure 1b) in order to center the anomalies peaks over the causative bodies. The RTE operations recalculates the TMI with the assumption of the body being in a horizontal position, thereby reconverting anomalies 'lows' to become anomalies 'highs' by applying a phase reversal of 180 degrees over the middle of the magnetic body at same location (Baranov, 1957; Leu, 1982).

The total horizontal derivative (THDR) or the horizontal gradient (HGRAD) method is based on the principle that the horizontal derivative of the RTE magnetic field produced by a tabular body have a tendency to display maximum values over the edges of the magnetic body especially when the edges are vertical and well-separated from each other (Cordell & Grauch, 1985). Major advantages of THDR over other derivatives is that it is less sensitive to noise and effective in delineation of shallow magnetic sources. The relationship can be expressed as (Cordell & Grauch, 1985):

$$\text{THDR} = \text{HGRAD} = \sqrt{\left(\partial M/\partial x\right)^2 + \left(\partial M/\partial y\right)^2}$$

Where δM/δx and δM/δy are derivatives in x and y direction of the magnetic field M.

The horizontal tilt angle derivatives (TDX) which is the amplitude of the horizontal gradient that is normalized to the absolute value of the vertical derivative can be represented as (Cooper & Cowan, 2006; Ibraheem *et al.*, 2019):

$$\text{TDX} = \tan^{-1}\left(\frac{HGRAD}{VDR}\right)$$

Where, VDR = δM/δZ

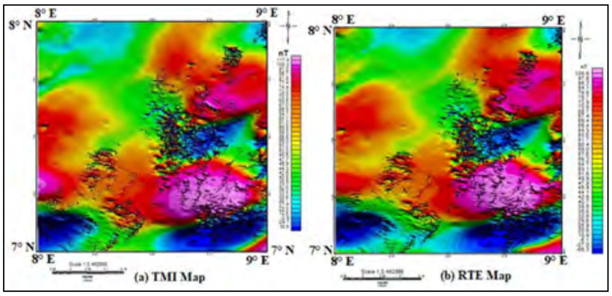

Figure 1: (a) Total magnetic intensity (TMI) and (b) Reduced to Equator (RTE) maps of the study area.

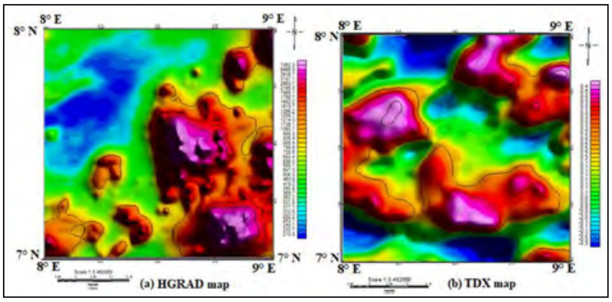

Figure 2: (a) The horizontal gradient (HGRAD) and (b) the horizontal tilt angle (TDX) derivatives maps of the study area.

RESULTS AND DISCUSSION

Results of the HGRAD and the TDX (Figure 2) depicts clearly the edges of the magnetic source bodies which was effectively delineated. The black contour lines on the maps coincides with the magnetic source boundaries.

The complexity of the geological situation in the study area which is made up of sedimentary cover of Cretaceous deposits with little exposed outcrop and less distinctive magnetic anomalies makes it necessary to apply an integrated source edge detecting method using multiple edge detection techniques. Intra-sedimentary geological features with the geological boundaries were effectively delineated.

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Slope failure run-out estimation from earthquake disaster: A case study in Mesilou, Kundasang

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Abstract: The study area is located at Mesilou, Kundasang, Sabah. Geological setting shows the area mostly covered by tilloid deposits namely Pinousuk Gravel with Late Pleistocene age. Pinousuk Gravel is divided into angular ultrabasic rocks as Lower Unit and rounded granodiorite classified as Upper Unit. Five slopes of Pinousuk Gravel were selected to estimate the distance of run-out of slope materials when slope failure occurs due to the tremor of earthquake. The tremor applied on the sandbox model is based on magnitude 5.2 earthquake which previously occurred in Ranau. The slope failure was simulated using shaking table equipment. A standard ratio of sand and clay was 1:1 and the tremor was 15 seconds. Results showed that all slopes with 30° angle will fail and the slope materials move from 1.6 meters to 6.1 meters before move further between 4.7 meters to 18.4 meters from the toe of the slopes from continuous shaking. The result for slope angle of 35° shows that the run-out distance of slope materials from 2.5 meters to 9.8 meters and 5.6 meters to 22.1 meters, respectively, with a longer shaking received. As a conclusion, the run-out distance of Pinousuk Gravel slopes is able to move further with the increase of slope height, slope angle and time period of tremor.

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Sedimentologi jujukan Batu Pasir Bertangga di Air Terjun Bukit Bertangga, Pahang

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PENDAHULUAN

Kajian sedimentologi telah dijalankan di air terjun Bukit Bertangga yang terletak berdekatan dengan Felda Kumai, Bera, Pahang. Jujukan batuan yang tersingkap di sini terdiri daripada Batu Pasir Bertangga yang berusia Jura-Kapur dan bertaburan sehingga telah dilaporkan oleh Cook & Suntaralingam (1971). Jujukan yang dicerap oleh Cook & Suntaralingam (1971) terdiri daripada batuan arenit yang dominan dan sedikit batuan argilit. Singkapan air terjun ini boleh diakses dari Felda Kumai, Teriang dengan perjalanan selama 30 minit melalui denai tertutup. Tujuan penyelidikan ini dijalankan adalah untuk penilaian sedimentologi untuk penjelasan terperinci analisis fasies dan model enapan dengan menggunakan kaedah huraian fasies dan fasies arkitektur oleh Miall (1996).

FASIES DAN UNSUR ARKITEKTUR

Kajian ini telah mengenal pasti 5 fasies iaitu fasies batu pasir masif (Sm), batu pasir berlapisan silang palung (St- Rajah 2A, 2C), batu pasir berlapisan silang planar (Sp), batu pasir berlapisan selari (Sh- Rajah 2D) dan konglomerat sokongan klasta (Gc- Rajah 2B). Huraian dan tafsiran untuk setiap fasies ini boleh didapati di Jadual 1. Secara ringkasnya, kajian irisan nipis menunjukkan komposisi sublitik- arenit untuk fasies St dan Sm dengan peratusan butiran kuarza melebihi 80%, serpihan litik lodak/lumpur yang minima dan tiada butiran feldspar. Isihan adalah sederhana hingga buruk. Butiran fasies St adalah lebih kasar berbanding dengan fasies Sm dan Sh.

Berdasarkan susunan fasies dan sempadan permukaan, unsur arkitektur perlapisan berpasir (SB – Sandy Bedform) yang dapat dikenal pasti melalui himpunan fasies-fasies batu pasir (Rajah 2A) dan ditafsirkan sebagai penghijrahan gumuk berskala perlapisan sama ada di tengah atau tepian alur (Allen, 1963; Cant & Walker, 1976; Capuzzo & Wetzel, 2004). Selain itu, terdapat unsur arkitektur perlapisan kelikir (GB – Gravel Bar and Bedform) yang terdiri daripada fasies Gc (Rajah 2B). Unsur GB ini ditafsirkan sebagai beban sedimen yang digerakkan semasa peristiwa banjir besar. Unsur tokokan ke hilir (DA – Downstream accretion) dan tokokan sisi (LA – Lateral accretion) tidak dihuraikan dalam kajian ini kerana memerlukan data yang lebih terperinci seperti bacaan arus kuno serta jurus dan kemiringan perlapisan sempadan permukaan tertib ke-5. Lazimnya, gabungan unsur GB dan SB menghasilkan trend menghalus ke atas yang didasari oleh fasies konglomerat Gm yang menghakis dan diikuti oleh St, Sm dan Sh. Trend menghalus ke atas ini mewakili beting liku sungai. Pertindihan trend menghalus ke atas juga dicerap menunjukkan pengadredan dan cantuman (isian) alur.

Hierarki sempadan permukaan sehingga tertib ke-4 telah dikenal pasti dan dilabel pada log sedimen (Rajah 1). Sempadan permukaan tertib pertama dan ke-2 diwakili oleh sempadan perlapisan, sempadan coset perlapisan silang dan lamina (cth. perlapisan silang dalam fasies St dan Sp). Sempadan permukaan tertib ke-3 dikenal pasti melalui permukaan tokokan yang landai (cth. sempadan antara fasies Sh dan St, dan, antara fasies St dan St tetapi dengan orientasi perlapisan silang yang lain arah. Permukaan terikat pada makroform seperti penghijrahan gumuk dikenal pasti sebagai tertib ke-4. Sempadan permukaan ke-4 lazimnya berkeduk di dasar dan melambangkan persekutuan fasies seperti gumuk, beting dan tebing. Penentuan sempadan permukaan tertib ke-5 memerlukan perlapisan dan singkapan yang lebih melanjut ke sisi (ditandai dengan (?) pada sela meter ke 25 log). Tertib ke-5 ini ditafsirkan untuk melambangkan sempadan palung utama yang tertoreh di atas enapan dataran banjir atas alur kuno.

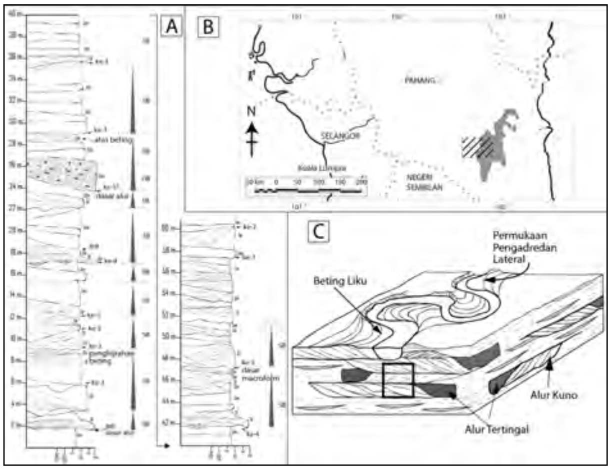
RUMUSAN

Model enapan sungai bermeander yang aktif telah dicadangkan berdasarkan maklumat dan tafsiran yang tertulis di atas (Rajah 1). Hasil hubungan alur kuno dan alur aktif melalui sempadan dasar yang menghakis (seperti yang tertunjuk dalam model) dan kemasukan sedimen yang tinggi menerangkan pembentukan keseluruhan jujukan singkapan ini yang hanya terdiri daripada pertindihan bertingkat alur.

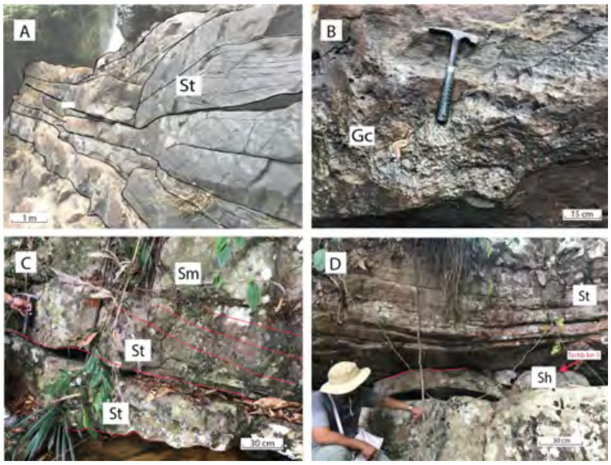
Kajian ini disifatkan berjaya menentukan model enapan sungai bermeander yang aktif berdasarkan pertindihan bertingkat trend menghalus ke atas yang

Jadual 1: Ringkasan analisis fasies, arkitektur dan tafsiran sekitaran pengendapan fasies-fasies batuan di singkapan air terjun Bertangga.

Kod	Fasies	Huraian	Tafsiran
Gc	Konglomerat sokongan klasta	Klas berdiameter 1-3 cm, imbrikasi lemah, geometri berbentuk cuping	Arus debris
St	Batu pasir berlapisan silang palung	Saiz butiran: sederhana – kasar, ketebalan: 0.5 – 2.0 m, geometri berbentuk baji	Rejim aliran bawah, bentuk perlapisan fluvial dan beting
Sp	Batu pasir berlapisan silang planar	Saiz butiran: sederhana, ketebalan: 0.6 – 1.2 m, geometri berbentuk tabular, lazimnya bergred kepada fasies St	Rejim aliran bawah, bahagian bawah beting liku
Sm	Batu pasir masif	Saiz butiran: halus – kasar, struktur sedimen tidak kelihatan, geometri utama adalah tabular, 0.6 – 2.0 m	Kadar pemendapan yang tinggi
Sh	Batu pasir berlapisan silang mendatar	Berlapisan satah dan mendatar, 0.2 – 0.8 m, bergeometri tabular	Rejim aliran atas dan bawah (aliran peralihan hingga satah / helaian)
Kod	**Unsur Arkitektur**	**Huraian**	**Tafsiran**
SB	Perlapisan berpasir (Sandy Bedform)	Helaian hingga kekanta geometri. Bertimbun.	Enapan via penghijrahan perlapisan berskala gumuk. Tengah atau tepian sungai.
GB	Perlapisan dan beting kelikir (Gravel bar and bedform)	Lob hingga kekanta geometri. Bertimbun. Menghalus ke atas. Dasar menghakis.	Beban perlapisan bergerak semasa banjir besar



Rajah 1: A) Log Sedimen berserta label fasies dan unsur arkitektur. B) Peta lokaliti singkapan kajian. C) Model enapan sungai bermeander yang aktif.



Rajah 2: A) Perlapisan batu pasir berunsur arkitektur SB yang mengandungi fasies St. B) Perlapisan Gc menghalus ke atas menampakkan stratifikasi planar. C) Dasar fasies St yang menghakis dengan jasad timbul yang cetek. D) Sempadan permukaan di antara fasies Sh dan St yang ditafsir sebagai permukaan pengadredan antara dua beting.

mengandungi susunan 5 fasies (Gc, St, Sp, Sm dan Sh), 2 unsur arkitektur (GB dan SB) dan 4 tertib sempadan permukaan.

PENGHARGAAN

Kajian ini telah dibiayai oleh projek penyelidikan Universiti Kebangsaan Malaysia GUP-2017-009. Kerjasama oleh semua pihak yang terlibat diucapkan terima kasih.

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Characterization of *Sacharomyces cerevisiae* isolated from Sabah soil for fuel ethanol production

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Abstract: A total of 20 soil samples were collected from 4 sampling sites around Kota Kinabalu: Penampang, Putatan, Taman Rekreasi Donggongon and HT. These 4 sampling sites were carefully selected due to their potential habitat of *S. cerevisiae*. The purpose of this study was to isolate and characterize *S. cerevisiae* from soil for bioethanol production. A total of six strains of yeast were isolated with the use of yeast-extract peptone agar medium. Morphology of colonies such as colour, elevation, surface and cell on the surface of YPG agar were observed and recorded. Morphological and physiological characterizations were carried out, resulting in determination of the *S. cerevisiae*. In physiological characterization by fermentation of six different carbohydrates showed that yeast isolates P2A have potential to ferment maltose, glucose and galactose. The strain P2A was evaluated further for their ethanol tolerance capacity. The strain can tolerate up to 12.5% concentration of ethanol. Pure strain of P2A was inoculated in anaerobic conditions with 200 rpm for 48 hours at 30 ºC to be used in fermentation of ethanol. The concentration of glucose after 72 hours of fermentation for P2A was found to be 0.982 mg/ml.

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Mining the microbiome: A mini review on natural products discovery from soil

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Abstract: In this review, we touch on the historical overview of natural products discovery from soil and discuss their classification up to date. New advancement on innovation and technological pipeline that contribute on the foundation of isolation of microbial biosynthetic diversity across soil environmental community have revealed massive reservoirs of as yet untapped natural product chemistry. We highlight the successful strategies that has emerged and threat that must be overcome to enable the development of high throughput approach for natural product discovery from complex microbial community.

Keywords: Metabolites, bioactive compound, natural product, soils science

A139

Environmental attitudes and preferences for mangrove conservation at Kilim Karst Geo-forest Park, Langkawi, Malaysia

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Abstract: Generally, a Global Geopark refers to a single, unified geographical area where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. A systematic well-planned conservation program at Kilim Karst Geoforest Park, Langkawi Island, Malaysia is crucial as a basis for ensuring sustainable geotourism, in order to establish and retain a UNESCO Global Geopark. One important approach is to improve the community appreciation of nature conservation. This requires understanding the underlying attitudes towards conservation, along with the needs, aspirations, background and culture of the local people. This paper aims to reveal the attitudes of domestic and international tourists towards mangrove and geotourism conservation at Kilim Karst Geoforest Park, Langkawi Island. A total of 150 respondents were interviewed randomly by using an experimental selection approach combined with attitude measures derived from the New Ecological Paradigm (NEP). The results revealed that domestic tourists acknowledge the right of other living animals and have faith in human technology and ingenuity to control the environment. Meanwhile, international tourists are less likely to be anthropocentric in their attitudes, which might explain their reluctance to allow human activities to modify the natural environment. Use of Principle Component Analysis (PCA) identified the eigenvectors that contributed most to the underlying factors in the 15 NEP statements. It showed that three factors dominated the test: "Risk of Overuse", "Biocentric" and "Technocentric Optimist" with eigenvalues of 4.11, 2.98 and 1.29 respectively. It is concluded that a strategic education plan could potentially increase public support for conservation.

Keywords: Geoforest, geotourism, mangrove, conservation

A140

Oligosen Akhir – Miosen Awal foraminifera bentos kecil dari Formasi Crocker dan Formasi Temburong, selatan Semenanjung Klias

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Abstrak: Bahagian selatan Semenanjung Klias terdiri daripada Formasi Temburong dan Formasi Crocker yang berusia daripada Oligosen Akhir hingga Miosen Awal. Kajian lapangan menunjukkan syal daripada kawasan kajian mengandungi kelimpahan mikrofosil foraminifera planktonik dan juga bentos. Tiada kajian khusus yang pernah dilakukan oleh pengkaji terdahulu terhadap kelimpahan foraminifera bentos kecil di kawasan kajian dan ini. Objektif kajian ini adalah untuk mencirikan dan mengkelaskan taksonomi foraminifera bentos kecil yang terdapat dalam sedimen Formasi Crocker dan Formasi Temburong di kawasan kajian serta menentukan sekitaran pengendapan berdasarkan himpunan forамininfera bentos kecil. Sebanyak 11 singkapan (Te01 hingga Te11) dipilih daripada Formasi Temburong dan 2 singkapan (Cr1 dan Cr2) daripada Formasi Crocker untuk dianalisa sampel syalnya. Semua sampel syal diproses mengikut standard penyediaan sampel mikrofosil foraminifera. Setiap specimen fosil dikira dan direkodkan dan yang baik pengewetannya digambar menggunakan SEM. Sebanyak 91 spesies foraminifera bentos kecil telah dikenalpasti. Kesemua sampel menunjukkan kelimpahan foraminifera bentos beragglutinat (berpasir) yang tinggi dan hanya sampel Te0501 sahaja yang didominasi oleh foraminifera bentos berkalka yang tinggi. Terdapat tiga himpunan foraminifera bentos kecil telah dikenal pasti iaitu Himpunan 1 Bathysiphon-Nothia yang menunjukkan zon bati hingga abis, Himpunan 2 Trochammina yang ditafsirkan sebagai zon neritic luar hingga abis dan Himpunan 3 Bolivina dikelaskan sebagai zon bati. Hasil analisis foraminifera bentos kecil ini menunjukkan bahawa Formasi Temburong dan Formasi Crocker diendapkan pada zon batimetri bati hingga abis, sekitaran laut dalam.

Kata kunci: Oligosen Akhir, Miosen Awal, foraminifera bentos, Crocker, Temburong, Klias

A142

A systematic literature review on community resilience to natural disaster: Enhance risk management for sustainable forest management in Sabah

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Abstract: Natural disasters can cause significant damage and impact on economic, social, and ecological system. Various approaches have been initiated to provides better platform in order to make people aware and understand about resilience and risk management related to natural disaster. This natural event can trigger unusual pressure on forests ecosystem and resources, which also affect the community livelihood. Therefore, forests are seen as positive approach to reduce the impact and risk of natural disasters. This paper aims to provide a conceptual overview on community resilience and identify the possible impacts of disaster on forests and community. In this paper, about 400 literature articles from year 2010 to 2018 related to community resilience and risk management on natural disaster has been reviewed. The information from database search has been synthesize and presented in semantic network using Atlas.ti qualitative data analysis software. The significant elements of community resilience and possible indicators of risk management of natural disaster has been proposed. Ultimately, the findings and recommendations will help communities to understand and identify the possible risk management that can be used for increasing resilience to natural disaster, as well as mitigate the risk disaster.

Keywords: community resilience, risk management, natural disaster, sustainable forest management

A144

Applying fuzzy contrast enhancement on earthquake impact images

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Abstract: Contrast enhancement plays an important role in image processing. It aims to improve the visibility of objects by enhancing the brightness difference between objects and its backgrounds. In this paper, the contrast of earthquake impacts images in Ranau, Sabah are enhanced by using ordinary fuzzy and intuitionistic fuzzy approaches whereby gray plane is mapped into fuzzy plane using membership function. The membership values represent the degree of brightness or darkness of the pixels. Moreover, the output images are compared for both techniques.

Keywords: Fuzzy image processing, intensification operator, membership degree

A145

Accumulation of heavy metals in rice grown from rainfed rice field in highland of Kiulu Valley, North Borneo

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Development of Pan Borneo Highway will provide alternative to road drivers to pass through the idyllic Kiulu town to Ranau town and an increase of vehicles driving through this highway is foreseen in years ahead. The Kiulu Pukak Mantob Road is a winding stretch road in Crocker Range connects to Pan Borneo Highway. Although Kiulu sub-district is located in the highland part of Crocker Range along the Kiulu Pukak Mantob Road there are limited number of flat lands that are used for wetland rice cultivation. Logistic improvement can also cause rapid changes in socio-ecological system of farming societies. Tropical rain brings runoffs that can include heavy metals from adjacent road and from nearby higher altitude level farming land to lower altitude level flatland that caused accumulation of heavy metals in paddy soils. This study intends to assess soil heavy metals bioavailability and heavy metal accumulation in rice grain from paddy grown in rainfed paddy field besides the Kiulu Pukak Mantob Road for future baseline data when Pan Borneo Highway project had been completed whether logistic development impact agriculture sustainability in this area particularly rice food safety and food security concern. Five Thai rice plants cultivator had been uprooted together with soil during rice vegetative phase and harvest season each for selected heavy metals (As, Cd, Cr, Cu, Fe, Ni, Pb, Zn) determination by inductively coupled plasma atomic emission spectroscopy (ICP-OES). The mean and standard deviation of soil samples heavy metal bioavailability, and rice grain heavy metal concentration collected at harvest season were As (0.22 ± 0.10; 0.17 ± 0.16), Cd (not detected both in soil and rice grain), Cr (2.51 ± 0.19; 0.08 ± 0.01), Cu (0.96 ± 0.02; 0.13 ± 0.01), Fe (911.54 ± 66.29; 6.14 ± 0.35), Ni (1.11 ± 0.10; 0.08 ± 0.03), Pb (0.62 ± 0.23; not detected in grain) and Zn (4.51 ± 0.38; 2.21 ± 0.40). None of the brown rice heavy metal concentration exceeded the permissible limit of Malaysia Food Regulation 1985 (MFR 1985). Translocation of heavy metals from husk to grain is highly efficient except for lead. Bioavailability of heavy metals in paddy field seemed to be influenced by the local climate and environmental factor. Periodic monitoring of rice needs to be conducted to ensure food safety and good health of the local communities living in Kiulu Valley from unexpected consequences of unsustainable development of the area.

A146

Bioleaching: A Microbial technology approach on environmentally friendly refinement of low grade metals - a review

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Abstract: Bioleaching is a promising technique in metal refinement which arises from the application of beneficial microorganism. This review aims to compile and discuss recent and up to date studies regarding the effects of bioleaching and its impact towards the environment. Low grade ores containing significant amount of metals are commonly discarded in waste heaps which enters the environment. Microbial technology provides a solution for refining ores which cannot be economically processed with chemical method due to containing low grade metals. We will focus on the two reactions mechanism in Bioleaching which are direct and indirect bacterial leaching which helps in extracting low grade metals such as nickel (Ni), lead (Pb), copper (Cu), Zinc (Zn) etc. This can add towards a greener approach in metal waste management and concurrent to allowing advancement in metal refining technology.

Keywords: Bioleaching, microbial technology, bioleaching reaction mechanism, metal refinement

A148

Enforced mechanical properties of Plaster Paris: Effect of organic fibre

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Abstract: This paper presents an experimental study of the enforced mechanical properties of Plaster Paris with incorporation of rice husk fibre as additive materials. A series of Plaster Paris containing rice husk fibre with distinctive sizes ranging from 38 µm, 63 µm, 125 µm and 250 µm is characterized by using Scanning Electron Microscopy (SEM), Energy Dispersive X-ray spectroscopy (SEM-EDX) and Universal Mechanical Testing. SEM images of free additives Plaster Paris and Plaster Paris containing 63 µm rice husk fibre shows the structure of calcium sulphate crystals are in the cluster of needle structures. EDX spectra of free additives Plaster Paris shows elemental traces of carbon, oxygen, sulphur, calcium and fluorine element. Meanwhile, Plaster Paris containing 63 µm rice husk fibre illustrates elemental traces of carbon, oxygen, sulphur, calcium, magnesium, sodium, potassium, copper, zinc and silicon elements. The universal mechanical testing machine shows the compressive strength in range of 187.61 MPa, 88.96 MPa, 263.27 MPa, 236.07 MPa and 130.07 MPa for free additives Plaster Paris and Plaster Paris containing rice husk fibre with varying sizes of 38 µm, 63 µm, 125 µm and 250 µm, respectively.

Keywords: Organic fibre, Plaster Paris, composite, compressive strength

A153

Model fitting on earthquake occurrence in Sabah

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One prominent way to forecast earthquake occurrences is by using Poisson distribution. Poisson distribution is a statistical distribution commonly applied to describe an event which rarely occur. This paper utilises independent Poisson distributions to model the observations in Sabah seismicity data from the year 1966 to 2018, and then estimates the number of earthquakes occurring in a fixed period of time.

Advanced Seminar on Economic Geology and Mineral Resources

DEPARTMENT OF GEOLOGY, UNIVERSITY OF MALAYA

19 August 2019

Dr. K.K. Cheang
Chairman, Working Group on Economic Geology, Geological Society of Malaysia.

Mr. Abdul Rasid Jaapar, President of the Geological Society of Malaysia, gave the opening speech and welcomed all participants to "The Advanced Seminar on Economic Geology and Mineral Resources" which was organized for economic and exploration geologists, mining and mineral process engineers, technical, production managers as well as government officers, mine owners and investors involved in tin, gold, rare earth, bauxite, iron/manganese ore, sand, clay, granite, marble mining, mineral resource development, researchers and university academics, to review current activities, be cognizant of the opportunities that may arise and to assess the future of mining in Malaysia.

This seminar is extremely timely in view of the new government's vision to rejuvenate the tin and other mining industries in Malaysia and was attended by almost one hundred, highly enthusiastic participants, signing up for the one-day intensive program, hosted at the Department of Geology, University of Malaya on 1st August, 2019. Participants came from all parts of Malaysia including from Penang, Kelantan, Perak, Selangor, Pahang, and even as far away as from Sabah and Sarawak.

The Advanced Seminar is organized and supported by various prestigious organizations such as the Geological Society of Malaysia, the Institute of Geology Malaysia, the Mineral and Geoscience Department of Malaysia (JMGM), the Malaysian Chamber of Mines, the Department of Geology, University of Malaya, the School of Chemical Engineering and Natural Resources, University Malaysia Pahang and the School of Materials and Mineral Resources Engineering, University Science Malaysia.

The Geological Society of Malaysia is grateful to SGS (Malaysia) Sdn. Bhd. and Acculab Sdn. Bhd., both of which have contributed generously to the sponsorship of the seminar.

The many esteemed, invited speakers have also contributed their invaluable time and experiences to the seminar, in the various fields of economic geology and mineral resources.

Mr. Abdul Rasid Jaapar, President of the Geological Society of Malaysia, touched upon the new frontiers of using drones and imagery satellite for mining applications.

The keynote speaker, Mr. Azemi H. Eki, Director of the Minerals and Geoscience Department (JMG), addressed many of the issues, challenges and ways to move forward, for the tin mining industry in Malaysia.

Mr. Teoh Lay Hock from the Malaysian Chamber of Mines reviewed the rare earth potentials in Malaysia, whereas the potentials of off-shore sand mining activities in several localities have been alluded to by Mr. Abdullah Sulaiman, from JMG Ipoh.

The importance and utilization of minerals in sustaining many of the manufacturing industries in Malaysia were highlighted by Dr. K. K. Cheang based on his technical and marketing experiences in the industries.

Field analytical services and testing (SGS FAST) with in-field rapid mineralogical and elemental data was jointly delivered by Mr. Firdaus Bawadi and Mr. Mike Bruinsma of SGS (Malaysia) Sdn. Bhd.

Trace elements geochemistry of galena related to gold mineralization and exploration was expounded by Dr. Zakaria Endut of University of Science Malaysia, while sulphur isotope and Re-Os geochronology studies of gold from selected gold deposits of Peninsular Malaysia, was delivered by Dr. Jasmi Hafiz, University of Malaya.

Dr. S. Paramananthan, M.D, Param Agricultural Soil Survey, stressed on the importance of geology for sustainable tropical agriculture, whereas Dr. Yves Cheze (an independent, professional, exploration geologist) described mineral exploration as a long, costly and risky business.

Some significant differences between tin-bearing and tin-barren granites were well illustrated by Mr. Askury Abdul Kadir, a freelance consultant (ex-UTP).

At the end of the seminar, Mr. Askury Abdul Kadir, also the Vice-President of the Geological Society of Malaysia proposed a vote of thanks to Dr. K.K. Cheang for developing an excellent program and for successfully organizing and managing the seminar.

Drone and satellite imagery application in mining industry

Abd. Rasid Jaapar
Geomapping Technology Sdn. Bhd.

The Industrial Revolution 4.0 (IR4.0) slowly transforming the mining activities. The Internet of Things (loT), Artificial Intelligence (AI), Robotics, etc. are transforming mining into a safer and more productive industry. This paper presents the applications of drone and satellite imagery in mining industry. An unmanned aerial vehicle (UAV) or commonly known as drone by lay public is an aircraft without a human pilot on board. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. Drone revolution has changed the ways how the exploration for mineral bodies which traditionally is time-consuming and expensive where making unsuccessful attempt is extremely costly. Managing mining site is much easier now with drone technology. Satellite imagery are images of Earth or other planets collected by imaging satellites operated by governments and businesses around the world. Satellite imagery provides a range spectral wavelength of light for specific processing stage. This information allows users to filter and process the relevant data for specific purposes. Drone platforms and sensors are getting smaller, lighter and less expensive; this will open possibility for new drone applications. In a foreseeable future, drones are likely to become an integral part of the mining "Internet of Things" framework, acting as auxiliary data collection, communication and delivery devices for autonomous mining systems. Drone technology is expected to make a major impact in the mining industry in terms of productivity and efficiency. On final note, today's mining sector, exploration companies need new tools and methods to make quality discoveries, conduct efficient exploration programmes and leave as little environmental footprint as possible. Innovators in the industry are developing such tools and methods and putting them to work in the field with surprisingly impressive results, dramatically improving the way resource companies evaluate, explore and extract value from mineral projects.

Malaysian tin mining industry: Issues, challenges and the way forward

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Department of Mineral and Geoscience Malaysia

Malaysia was once the world's largest tin producing countly, contributing about 40% to the total world tin production. The collapse of the world tin market in 1985 caused major closure of Malaysian tin mines. Despite the recovery of the tin price there has been no significant increase in Malaysia's tin production. There were thirty-eight (38) areas of tin deposit identified in Malaysia with a reserve of 2.1 million tonnes valued at RM 118 billion. These tin ore are found in Perak, Kedah, Selangor, Pahang, Johor and Kelantan. Malaysia tin-in-concentrates production for the year 2018 is about 3.868 tonnes value RM324.51 million, and at the same time Malaysia still imports tin ore from abroad such as Nigeria, Australia, Congo, Rwanda, China, Myanmar and Russia by 34,364 tonnes in 2018 worth RM1.68 billion. In addition, the total domestic consumption of tin metal in 2018, by the tin-based industries is about 1,964 tonnes with solder (52%), tin plate (39%), pewter (2%) and other tin-based manufacturing industries (7%). Among the key issues that impediment the development of the tin mining industry in the country are the sterilization of mineral ore due to the rapid development of land use especially for infrastructure constructions, as well as cases of tin deposit located near the natural sensitive area. In addition, some challenges such as less interest by the state government in opening new areas for prospecting/exploration work and mining activities, short lease periods and limited area of mineral tenement, state government policies that are not conducive to mineral development activities, and lack of investment incentives from the government has made potential investors less interested to invest in the mining industry. The Ministry of Water, Land and Natural Resources is drafting a policy and direction for sustainable mining development to restore the tin mining industry. The ministry will work with the state government to preserve the tin ore reserves from being wasted due to development other than mining. This can be done by making mineral resource zoning in land use planning by giving priority to the implementation of a sustainable mining. The Department of Mineral and Geoscience Malaysia (JMG) has and is currently mapping potential areas of tin ore through several development projects including the Airborne Magnetic and Radiometric Survey in the East Coast Economic Region (ECER) Malaysia which covers Kelantan, Terengganu, Pahang and North of Johore. The findings in this study will be communicated to interested companies through reports issued by JMG to carry out detailed studies after obtaining a license from the State Government. Hence, the development of the tin mining industry should be revitalized to increase the country's economic resources and provide employment opportunities to the people. At the same time, the state government also gets income through royalty collection. If local tin resources can be developed sustainably, the outflow of national currency can be reduced and national revenues can be increased through the export of such minerals.

Rare earth resource potential in Malaysia

Teoh Lay Hock
Malaysian Chamber Of Mines

The rare earth elements (REEs) comprise 15 elements in the Lanthanide Group in the Periodic Table with atomic numbers 57 to 71, plus scandium (21) and yttrium (39). Rare earth clements are commonly divided into two categories, namely the light rare earth elements (LREEs), comprising elements with atomic numbers ranging from 57 to 63, and heavy rare earth elements (HREEs), comprising elements with atomic numbers ranging from 64 to 71. Yttrium (39) and Scandium (21) are also commonly referred to as REEs as they display chemical properties and behaviours akin to REEs.

Rare earth (RE) minerals refer to minerals which contain significant amounts of REEs either as part of the crystal structure or as ionic substitution in the lattice. REEs do not occur in nature as metallic elements, but they are found in a variety of minerals which occur as accessory minerals in a variety of rocks.

Commercially significant RE deposits in the world can be differentiated into three main types, namely hard rock deposits, placer deposits and ion adsorption type clay deposits. Lately the occurrences of significant concentrations of REEs in deep sea mud have been highlighted but the exploitation of this resource is still being studied.

Malaysia's best rare earth resource potential lies in the placer deposits. Monazite and xenotime are known to occur ubiquitously throughout the Peninsula in the stream sediments draining granitic areas and as part of the heavy mineral assemblages in the alluvium in coastal areas, especially in the major tin fields. Although they have not been found to be present in concentrations high enough to be mined by themselves, monazite and xenotime have been produced lucratively as by-products of alluvial tin mining. Malaysia produces and exports a significant amount of monazite and xenotime.

The next best rare earth resource potential in Malaysia are deposits associated with ion adsorption clays. Ores with exchangeable REEs have become an important RE mineral resource in China since the early 1970s. The total reserve of this type of deposits have reached millions of tonnes of RE oxides and they form particularly significant resources for HREEs. The ores are also free from radioactive components. The main characteristics of RE clay deposits are that they are commonly found in tropical areas with hot and wet climatic conditions and deep weathering, and they are usually associated with tin-bearing granites. Peninsular Malaysia has similar climatic conditions and also large expanse of deeply weathered tin-bearing granites. It is for these reasons that there is good potential for the discovery of ion adsorption RE clay deposits in the tin belts of Peninsular Malaysia.

Malaysia's territorial waters, especially in the west coast, receive considerable amount of sediments from rivers draining granitic areas. Although not quite the same as deep sea mud, it may be worthwhile to examine the offshore samples already collected from previous other studies for any signs of REE mineralisation.

In Malaysia, chances of discovering RE deposits associated with hard rock is minimal. The principal concentrations of REEs in hard rocks are associated with uncommon varieties of igneous rocks, namely alkaline igneous rocks and carbonatites. Other rock types which have been known to host significant amount of REEs include stratiform phosphate deposits, pegmatites, replacement type deposits, various types of especially high grade metamorphic rocks and porphyries. These rock types are rare in Malaysia.

Field analytical services and testing (SGS FAST) - In-field rapid mineralogical and elemental data

Firdaus Bawadi, Mike Bruinsma
SGS Minerals

SGS has the locations, technical strength, independence, consistency and ethical compliance which all the industry players need. SGS's unmatched network of over 45 commercial labs and sample preparation facilities and over 70 mine-site labs are linked to form a consistent global platform that extends into an unparalleled number of countries and mining camps. SGS geochemical laboratories worldwide have standardized methods, method codes and sample preparation techniques to help industry players to meet growth objectives anywhere in the world. Through the SGS unparalleled global network, SGS can provide you with a range of services for geochemical analysis including sample preparation, fire assay analysis, ultra-trace and trace element analysis by ICP-AES and ICP-MS, X-ray fluorescence, carbon and sulfur analysis and other geochemistry services.

Aside from this commercial laboratory network, SGS also understands that getting analytical data quickly in the field is vital for making accurate and timely decisions during exploration, resource definition and production. SGS's FAST (Field Analytical Services & Testing) solutions provide industry players with essential analytical data within 24 to 48 hours from the sampling event using new portable analytical technologies. This dedicated field-based preparation and

analytical testing produces the data needed to quickly make decisions around exploration, mining and plant production. Getting accurate and validated analytical data quickly enough to make real-time decisions will allow you to make faster decisions during active exploration programs, which stand-out from your peers by demonstrating an optimized exploration spending, realize an earlier return on exploration investment and development activities. It ensures rapid project development through the life cycle, maintain consistent plant performance and minimize unexpected production downtime and achieve a more attractive company profile to investors by demonstrating project progress in a shorter timeframe.

Offshore sand resources and potentials for silica sand mining in Malaysia

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Offshore sand mining activity, if improperly managed, can result in economic loss and environment degradation. This is because the range of activities involved in offshore sand mining, such as dredging, extraction and transportation of the sand, all have a potentially deleterious effect on the hydrodynamics and biological environmental of the mining site and adjacent areas.

The National Offshore Sand Resource Study is a major effort by the Government to ensure that the mining of the offshore sand resources is carried out in a systematic and sustainable manner with least environmental impacts to the marine living resources and coastline. This comprehensive study that is undertaken by the Department of Mineral and Geoscience Malaysia (JMG) comprises geophysical survey, seabed sediment sampling, hydraulic and environmental assessment of the offshore sand resources. Towards this end, a comprehensive ranking methodology was developed to enable the offshore sand resources are ranked according to the potential impacts of their exploitation. The development of an appropriate ranking framework is of fundamental importance in guiding the overall mining of the sand reserve. Thirteen (13) environmental criteria (ranging from water quality, living resources, habitats, and non-living and man-made resources) are used to rank the sand reserve. The ranking involved two primary tiers in which sand resources were categorized as Non-Exploitable and Exploitable. Based on the study, the vast amount of sand reserve in Straits of Malacca and Sarawak offshore that amounted to about 9.67 billion m^3 and 17.1 billion m^3 respectively were categorized as exploitable. Based on the current royalty rates of RM3/tonne, the total potential Federal Government revenue that can be generated by the sustainable mining of these offshore sand reserves would amount to RM80.31 billion.

The study also indicated that the distribution of exploitable sand in offshore was greatly controlled by the environmental impact criteria that mainly comprised of coral reefs, marine protected areas, cables and oil pipelines, oil platforms, and to a smaller extend artificial reefs, living aquatic resources and turtle landing sites. Offshore silica sand potentials in Malaysia were first studied by JMG of Negeri Sembilan offshore in year 2015. This study was requested by Syarikat Kibing Group (M) Sdn. Bhd. for glass industry. Fifty (50) grab samples were collected from seabed and sent for grain size, carbonate, organic, silica (SiO_2), alumina (Al_2O_3) and iron (Fe_2O_3) content. The results showed silica content in 13 samples are ranging from 95%-98%. This study indicated that there are potential for offshore silica deposits especially in offshore of Negeri Sembilan. However, detailed study need to be done in order to confirm the silica sand reserve and its potentials for mining.

Keywords: Offshore sand resources, silica sand, sand mining, sand ranking, hydraulic modelling, environmental impact assessment

Importance of minerals in the development of sustainable manufacturing industries in Malaysia

K.K. Cheang
Working Group on Economic Geology, Geological Society of Malaysia

Malaysia, to lead in the ASEAN region, must renew and intensify efforts to explore for tin, gold, rare earth minerals, tantalum, iron / manganese and aluminium (bauxite) ores which are required not only for basic manufacturing and infrastructure development, but also for future, high-end technologies.

Tin for example, is used for solders in the electronics (hand phone, laptops), tin-plating, chemicals, pewter and float glass industries. Gold is used in jewelries, for electronics (best electrical conductor) and as a backing of the financial

systems of many countries. Rare earth elements are used as supermagnets in wind turbines and electric vehicles (EV), as well as in catalytic converters, batteries, sensors, jet engines, satellite communications system and space industries. Zircon is used mainly in ceramics, refractory and the foundry industries.

There must also be continued efforts to identify and produce quality industrial minerals such as silica sand, marble, barite, dolomite, bentonite, feldspar, kaolin, ballclay, coal (fuel), rock and stone aggregates, together with iron for steel and limestone for cement, for construction purposes, especially for houses, condominiums, commercial buildings, factories, power and cement plants, dams, tunnels, bridges, the East Coast Rail Link (ECRL), Light Rail Transit (LRT), Mass Rail Transit (MRT) and others.

Engineered, high quality, value-added industrial mineral products are also being used at an ever increasing rate in many manufacturing industries in Malaysia. These include the glass, ceramics, paint and coatings, rubber, plastics, oil & gas, automotive, environmental, agricultural and electronic industries. Their demand is forecast to rise meteorically, in tandem with the dynamic growth in the ASEAN region (4-5%). These create jobs for the youth and future generations of Malaysia, as well as spin-offs for finance, services, logistics and the transport industries.

Many of the engineered mineral products, which are scarce in Malaysia, are currently imported from all over the Asia-Pacific region. Mineral resources which are available in Malaysia, but have been gradually rendered "sterile", will also have to be imported at several times the price of local products, due to the non-availability and distance from the source. Hence, the need to develop innovative products from Malaysia's own local mineral resources, to complement those imported, would be critical to the competitiveness and sustainability of the manufacturing and service industries (and jobs) in Malaysia.

Characterization of sulphide minerals and vein paragenesis focusing on trace elements geochemistry of galena, lead isotope study and relationship to gold mineralization and exploration in Penjom Gold Mine, Malaysia

Zakaria Endut

Universiti Sains Malaysia

The Penjom Gold Mine is located 30 km from the Bentong-Raub Suture at the western boundary of the Central Belt in Peninsular Malaysia. The host rocks of the Penjom Gold Mine comprise shallow to deep marine sedimentary rocks belonging to the Padang Tengku Formation of the Raub Group (Leman, 1995). The sequences have been intruded by felsic dikes and sills. The main sedimentary units are interbedded carbonaceous shale, siltstone, sandstone, conglomerate and minor coarse-grained rhyolitic tuff. The host rocks in Penjom are folded into an anticline-syncline couple below the Penjom thrust with at least two phases of faulting after the fold has locked up.

This study has incorporated geological mapping, sampling, petrographic examination of ores and host rocks, trace element analysis and lead isotope analysis of galena by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICP-MS). Geological mapping was conducted on pit slopes at the Penjom Gold Mine, in particular outcrops around the ore bodies. Veins were classified in the field based on structural control and textures and distributions of the main vein systems has been mapped. Several representative samples of galena-bearing veins belonging to each of the different stages were collected for geochemistry and lead isotope analysis.

Gold mineralization hosted within the veins system is associated with pyrite, arsenopyrite, and minor base metals including galena. Trace element and lead isotope analysis was undertaken on nine galena samples that represent two stages of galena formed during two structural events. Both the Pb isotopes and the trace elements show that the first stage galena within the mineralized areas at the footwall has different geochemical characteristics compared with galena in non-mineralized areas in the hanging wall, suggesting that galena crystallized from two different ore fluids and probably at two different times. The Pb isotopic ratio composition are transitional between the bulk crustal growth and an upper crustal growth curve, indicating that derivation was from arc rocks associated with continental crust or a crustal source that includes arc volcanic and old continental sedimentary rocks.

Importance of geology for sustainable tropical agriculture

S. Paramananthan
Param Agricutural Soil Surveys (M) Sdn. Bhd.

Soil is formed by the weathering of rocks (in situ soils) and the transportation and deposition of three weathered materials (alluvial soils). A third group consists of an accumulation of organic deposits in waterlogged areas to form organic soils on peat. The formation of soils is governed by five soil forming factors as proposed by Vasily Vasilyevich Dokuchaev the father of modern pedology or the study of soils. This is summarised as follows:

s = f (c, o, p, r, t), where s = soil, c = climate, o = organisms, p = parent material (rocks), r = relief and t = time

Where all these factors are the same one should get a similar soil. If one compares tropical areas with temperate areas climate (hot/wet- summer all year) versus summer/winter. The difference will result in a different soils and one would plant different types of crops-tree crops (rubber / oil palm) against maize, sorghum and soya bean.
Within the tropics on the other hand Malaysia climate is uniform in most of the country and hence parent material or the rock types determines the type of soil formed. The weathering of rocks in the tropics determine the soil texture (sand, silt, clay), the colour (gray, yellow, brownish yellow, red or brown from content).
The amount clay, silt and sand determines the water holding capacity while the clay mineral type in the clay/ silt fraction determines the nutrient holding capacity (cation exchange capacity of the soil). This determines the fertility of the soil. Most tropical soils are of low fertility status and we have to apply fertilizers to get good yields. Clay holds these nutrients while leaching losses results in sandy soils. The micronutrients in a soil is also development on the parent material or rock type.
These soil properties also determine many soil engineering properties of the soil eg; erodibility landslide, water pipe failures. A good soil can tell us where one is likely to find tin ore, economic minerals such as bauxite, laterites, soil material for bricks, pottery etc. Thus one can say that the ‘ANSWER LIES IN THE SOIL’.
The presentation will show with examples of how the knowledge of geology can help determine what crops to plant and how to do it sustainability. It will also show how to improve land after mining example bauxite to replant crops such as rubber / oil palm. Why rice cultivation in their country has not reached 80 % self-sufficiency. Finally, it will address the issues of climate change and global warming-fact or fiction.
Keywords: geology, soil, assessing fertility

Mineral exploration: A long, costly and risky business

Yves Cheze
Independent professional exploration geologist

Minerals exploration is a long and financially risky process which success is defined as the identification of an economic deposit. It depends on long years of search using a wide range of methods from the most basic to very high tech ones and is often conducted in remote and inhospitable environments over a long period of time and involving very large sums of money.
Mineral exploration and development are investments; as such, companies spend money today in the expectation that future revenues will be sufficient not only to cover all costs but also to secure acceptable profit.
The work is carried out in several stages - illustrated from examples mainly in peninsular Malaysia and PNG - from an initial “grassroots” regional exploration, followed by the detailed survey of the best zones. At each step, a risk/ reward analysis and a decision whether to carry on to the next phase (“Go or no go” milestones) are made based on the results obtained in the preceding phases.
If the results are encouraging more detailed survey will be used until the degree of confidence in the estimation of the deposit resources is sufficient to finally prepare the technical then the bankable feasibility of the project. The total process may take between 5 and > 15 years with overall costs often exceeding $US 1000M. It is only then that the mine construction can start and the first gold or copper bar is poured or first ton of coal is produced.

Significant differences between tin-bearing and tin-barren granite in Malaysia

Askury Abd Kadir
Geological Society of Malaysia

The Southeast Asian Tin Belt is the most important tin-producing region of the World. Decreasing tin prices since the collapse of the price-support system of the International Tin Council in October 1985 are the major factors. It is difficult to predict whether this constitutes a permanent trend or whether SEA will become more competitive and tin production will rise again. The Main Range Granitoid province in Western Peninsular Malaysia is almost entirely made up of biotite granite (184-230 Ma). Tin deposits associated with these granites contributed almost 70% of the historic tin production in Malaysia. Late-Triassic S-type collision-related biotite granites, associated with Sn-W deposits, and subordinate muscovite- and hornblende-bearing granite built the Main Range Province. The Eastern Granitoid Province subdivided into the East Coast Belt (220-263 Ma), Boundary Range Belt (197-257 Ma) and Central Belt (79-219 Ma). The granitoids cover a wide compositional range from biotite granite to hornblende-biotite granite/granodiorite and diorite-gabbro. Most of tin deposits are associated with biotite granite in the East Coast Belt. Generally, tin-mineralization plutons are characterized by high concentration of SiO_2, K_2O, Rb, Sn, Th and U, whereas the concentration of Fe_2O_3, MgO, CaO, Na_2O, Ba, Sr as well as the Fe_2O_3/FeO ratio are low. It also distinguished by high initial $^{87}Sr/^{86}Sr$ ratio and low magnetic susceptibility. The Eastern Province contains mainly Early Permian to Late Triassic l-type arc-related biotite-hornblende granites, associated with Cu-Au deposit, and subordinate hornblende-barren plutons hosting limited Sn-W deposits. Mostly, tin-mineralized granitoids are characterized by incompatible behavior of tin during magmatic evolution. Tin concentration increases with increasing degree of magmatic differentiation, i.e. tin concentration in late-stage differentiates are significantly higher than in less evolved phases.

Sulfur isotope and Re-Os geochronology studies of gold application from selected gold deposits of Peninsular Malaysia

Jasmi Hafiz Abdul Aziz[1], Bernd Lehmann[2], Zakaria Endut[3]
[1] Department of Geology, Faculty of Science, University of Malaya
[2] Department of Mineral Resources, Technical University of Clausthal
[3] School of Materials and Mineral Resources Engineering, Engineering Campus, Univeristi Sains Malaysia

The Penjom gold mine (20 Mt @ 3 g/t Au) and Kecamas quarry near Kechau Tui (no gold resources defined) are two important shear-zone related gold deposits in the Central Belt of Peninsular Malaysia. Both deposits are located along NNE trending splays from the main Bentong-Raub Suture Zone, a major terrane boundary that marks the collision of the Sibumasu and East Malaya terranes during the lndosinian orogeny (Triassic). Late Permian sedimentary sequences, strongly altered aplite and mafic dykes, and Late Permian limestone characterize the Penjom and Kecamas quarry, respectively. The country rocks have undergone low-grade regional metamorphism. Wall rock alteration is characterized by sericitization, carbonatization, pyritization and chloritization in Penjom, and silicification and sericitization in Kecamas. Gold mineralization is confined to quartz veins and disseminations in the wall rock. The quartz (and minor carbonate) veins have the ore assemblage of pyrite, arsenopyrite, galena, chalcopyrite and sphalerite (Penjom), and tetrahedrite, pyrite, galena, chalcopyrite and sphalerite (Kecamas), with gold/electrum as visible gold and refractory in sulfides. Gold fineness varies from 748 to 955 (Penjom), and from 747 to 956 (Kecamas), with Au/Ag ratios in the ore from 1 to 5 (Penjom), and from 0.3 to 1 (Kecamas). The ore fluid is of low salinity, reduced, near-neutral pH, and mixed aqueous-carbonic composition with total homogenization temperatures ($T_{h(total)}$) between 250 to 322°C (Penjom) and 227 to 308°C (Kecamas). The pressure is estimated around 1 to 2 kbar (mesozonal depth at about 4 to 8 km). The $\delta^{34}S$ and $\delta^{34}S_{H2S(fluid)}$ values of sulfides range from -5.7 to 7.1 ‰ and -4.0 to 6.0‰ (Penjom), and from -3.0 to 3.8 ‰ and -1.2 to 2.7 ‰ (Kecamas), respectively. These values likely reflect derivation of sulfur from a magmatic source or from hydrothermal leaching of primary magmatic sulfide minerals. Re-Os isotope data suggest that the main-stage sulfide mineralization (arsenopyrite and pyrite) in the Penjom veins formed at 198 ±14 Ma (^{188}Os calculation). A weighted average of 200 ±26 Ma results when the ages from the two different calculations (^{188}Os and ^{187}Os) are pooled. The initial $^{187}Os/^{188}Os$ ratio is low (0.09 ± 0.11) and close to mantle Os composition. Thus, a mantle source for the ore metal is also likely. Wall rock sulfidation is possibly responsible for the bulk of the gold precipitation. Dissolution of arsenopyrite (for Penjom only), and hydraulic fracturing with pressure/temperature decrease are thought responsible for the precipitation of slightly later Ag-rich gold and electrum. The broader geotectonic context of ore formation is probably lithospheric delamination and both ore deposits can be considered as mesozonal orogenic gold deposits.
Keywords: Gold mineralization, orogenic gold, sulfur isotope, Re-Os isotope, gold fineness

Advanced Seminar on Economic Geology and Mineral Resources

DEPARTMENT OF GEOLOGY, UNIVERSITY OF MALAYA
19 August 2019

















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Contact information wanted

Information on postal address, email address and handphone number of **Mr. Muhammad Ammar Aziz Mohd Nassir** is very much appreciated. Please contact GSM Secretariat, Anna Lee (603-7957 7036, geologicalsociety@gmail.com) if you have any information.

University of Malaya American Association of Petroleum Geologists Student Chapter (UM AAPG Student Chapter)

2018/2019 Session

Event Report:
AAPG Sharing Session

On the 27th April 2019, the University of Malaya American Association of Petroleum Geologists (AAPG) Student Chapter organised a sharing session that involved AAPG Student Chapters around Malaysia. This event was held at the Geology Department, University of Malaya. This project was carried out to create a platform allowing AAPG SC across Malaysia to exchange ideas and share their problems. Solutions can be made in order to solve recurring problems as well as generating new ideas for upcoming projects. Further collaborations between AAPG SC across Malaysia are also aimed in the future. In addition to that, a bond is created between AAPG SC across Malaysia. The universities involved were the University of Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Malaysia Kelantan (UMK) and Universiti Teknologi Petronas (UTP), with a total of 33 participants.

The group first gathered at the Museum of Geology Department for breakfast at 9.30 a.m. before making their way to Dewan Kuliah Geologi (DKG) for the first session, i.e. presentation by representatives from the 4 universities on their past and upcoming projects.

In the second session, participants were separated into groups and every group was ensured to comprise at least 1 representative from each university. During this session, a discussion was held regarding problems within the society and the possible solutions. Among all the problems discussed, one common problem that is faced by every society is funding. Some ideas to overcome this problem include finding sponsors and initiating sales. In addition to that, participants were also asked to create a project that allows collaborations between all universities.

Next was lunch with self-bought food from Wok It. After the lunch break, a short sporting activity involving 3 games - “Where’re the Sweets?”, “Pick Up the Beans!” and “Queen Dodgeball” was carried out. Lastly was the closing ceremony where a token of appreciation was given to each university representative.

The AAPG UM SC Sharing Session was a success. From this project, we were able to achieve our objectives. We were also finally able to meet members of the AAPG Student Chapters from all over Malaysia. All the guests gave positive feedbacks. Aside from the memories made, we also created a network of contacts that will enable possible future collaborations between all AAPG Student Chapters.

Report prepared by:
Haziq Syafiq Suhaimee,
Secretary, AAPG UM SC Sharing Session
Muhammad Hafiz Zulkifli,
Director, AAPG UM SC Sharing Session

OBITUARY

Innalillahi wa inna ilaihi rojiun
"We belong to Allah and to Him we shall return"

Dr Ahmad Tajuddin Haji Ibrahim, 67, of Kuala Terengganu passed away on the 8^{th} of August, 2019. He was born on the 2^{nd} of October, 1952 in Kg. Ladang, Kuala Terengganu. He received his primary education at Sekolah Kebangsaan Ladang in Kuala Terengganu and Sekolah Kebangsaan Chukai in Kemanan. He then attended the prestigious Sekolah Tuanku Abdul Rahman (STAR, Ipoh) for his secondary education and was the Headboy of STAR in 1972. He enrolled in the Faculty of Science, University of Malaya and majored in Applied Geology. He graduated with a B.Sc. (Hons) in 1978. His thirst for knowledge then took him to Belgium in mid-1978, where he embarked on a Masters course in Quaternary Geology program and later to the University of Newcastle-Upon-Tyne in the United Kingdom where he was awarded a PhD in 1984 for his research contributions to the field of rock mechanics and engineering geology.

Dr Ahmad Tajuddin started his career in the academia as a tutor and then a lecturer at the Geology Department of the University of Malaya. A dedicated and engaging teacher, he was well-loved by his students and fellow staff members. He was often referred to as Che Mat or just Dr Ahmad. He was always neatly dressed with well ironed shirt and slacks that he was nicknamed Dr Ahmad Smart. He was a keen field geologist and explored many areas for new exposures especially in the State of Terengganu. He and his project students surveyed and mapped most areas of Terengganu in the course of his career.

He was also an active member in the Association of Academic Staff of the University of Malaya (PKAUM) and the Geological Society of Malaysia (GSM). He was the longest serving GSM Honorary Secretary to date. In the broader society, he was active in the Kampong community he lived in Puchong.

Dr Ahmad Tajuddin retired from the University of Malaya in 2010. He returned to Kuala Terengganu and led an active life tending to his garden and his many trees and still made time for his former students, giving them guidance and encouragement on various projects.

About 3 weeks ago, I was informed that Dr Ahmad was admitted to Hospital Sultanah Nur Zahirah (HSNZ) in Kuala Terengganu. I managed to visit him at his home on the 25^{th} of July, after he was discharged from the hospital. Although he looked tired, he was in high spirit and chatted well. As I left to head for Kuala Besut, I told him I will visit again in my next trip. Sadly, that was the last time we met. On the 5^{th} of August, he was readmitted to the Hospital Kuala Terengganu as his condition deteriorated. He was under close observation in the High Dependency Unit (HDU); stable but depended on oxygen. In the morning of the 8^{th} of August, he was brought back home, where after a few hours he passed away in the early evening, surrounded by his loved ones.

Dr Ahmad Tajuddin leaves behind his wife Puan Che Norliza Lat; his four children from a previous marriage, Nur Amani Natasha Ahmad Tajuddin, Nur Fauzana Ahmad Tajuddin, Ahmad Hafizuddin Ahmad Tajuddin and Nur Diyanah Syahirah Ahmad Tajuddin, and Darratun-Nashihah Ahmad Tajuddin, his daughter with Puan Che Norliza Lat. He also leaves behind 5 grandchildren.

Dr Ahmad Tajuddin was laid to rest in Perkuburan Sheikh Ibrahim, Jalan Pusara, Kuala Terengganu.

Azhar Haji Hussin
August 14, 2019

Dr Ahmad Tajuddin – an exemplar service leader of GSM

I will always remember Dr Ahmad Tajuddin as the most dedicated service-oriented Secretary of the Geological Society of Malaysia (GSM). He exemplified service leadership long before it was recognised as a critical success factor by corporate management consultants.

I first knew of Dr Ahmad through "Warta Geologi", which I read as an undergraduate in Universiti Kebangsaan Malaysia Kampus Sabah. I finally met the man himself at University of Malaya where I served as a Research Assistant briefly in 1989 before leaving for my Masters programme in the UK. I was totally bowled over by his simple down-to-earth and unassuming persona. He is one of the several people in my life that inspired me to serve the geoscience fraternity through his many selfless actions and contribution to GSM. I have personally seen him take on anything that required doing at the last minute when the designated person didn't turn up. He did so graciously without a fuss; from cooking at field trips to being an announcer at seminars and conferences of the Geological Society.

He organised many memorable field trips for GSM that I joined. Once, when I was helping him to fry chicken for a group of macho geologists after a field trip in Tasik Kenyir, I asked him why we should even bother cooking dinner for the thankless bunch as we ourselves were tired after a long day. He gently reminded me that we were doing this service for GSM and not for the macho bunch out there. I remember vividly his smiling face and soft chuckle when he said "if we didn't do these things for the Society, Joy – who else would?". Those words were profound in shaping my relationship with GSM.

When I graduated with a PhD, he told me that I was an important person for GSM and could do much for the fraternity. Imagine the power of such a message coming from the Secretary of GSM to a young female PhD graduate in a field dominated by men! I am always doing my best to meet this expectation. I hope that others in GSM whose lives he has touched, have been made richer as mine is from the goodness of his being. Rest in peace Dr. Ahmad.

Joy Jacqueline Pereira
15 August 2019

UPCOMING EVENTS

October 3-4, 2019: Workshop on the use of the electron probe microanalyzer (EPMA) with particular emphasis on modern developments and geological applications. For MSc students, PhD students, postdoctoral researchers and early career scientists from across the EU and beyond. Agricultural University of Athens, Athens, Geece. Visit website https://ibaziotis7.wixsite.com/epmaathens2019 for more details.

October 10-13, 2019: Euro-Mediterranean Conference for Environmental Integration (EMCEI); Sousse, Tunisia. Kindly contact the event organizer at www.emcei.net/ contact@emcei.net for further information.

October 15-16, 2019: AAPG Energy Transition Forum, Edinburgh, United Kingdom. Further information can be obtained at https://energytransition.aapg.org/2019.

October 26-27, 2019: Hotspring Hunting Fieldtrip, Ulu Slim, Perak, Malaysia. Contact: geologicalsociety@gmail.com for further details.

October 26-28, 2019: AAPG Geosciences Technology Workshop (GTW) New Tools, Challenges, and Opportunities; Beijing, China. For questions and additional information please contact: Susan Nash, Director, Innovation and Emerging Science and Technology, tel.no.: +1 918 560 2604, email: snash@aapg.org.

October 29-30, 2019: Asia Petroleum Geoscience Conference & Exhibition (APGCE), Kuala Lumpur, Malaysia. For more details, please visit http://www.apgce.com/.

November 4-8, 2019: Africa Oil Week, Cape Town, South Africa. More details can be found at https://www.africa-oilweek.com/Home.

November 18-19, 2019: Asia Pasific URTec 2019, Brisbane, Australia. Check out the site at https://www.spe.org/events/en/2019/conference/ for more information.

November 18-20, 2019: International Congress on Earth Sciences in SE Asia (ICES 2019), Bali, Indonesia. Visit website http://fos.ubd.edu.bn/foscon/ for more information.

November 25-26, 2019: LOSS PREVENTION ASIA (LPA) 2019; Kuala Lumpur, Malaysia. For queries, visit: https://lpa2019.blogspot.com/2018/11/about-loss-prevention-asia-2019.html.

December 19, 2019: National Tin Conference; Hotel Istana, Kuala Lumpur. Further information can be obtained at: https://www.malaysianminerals.com.

January 13-15, 2020: International Petroleum Technology Conference (IPTC), Dhahran EXPO; Dammam, Saudi Arabia. Visit event website at https://www.2020.iptcnet.org to learn more about the conference.

February 25-27, 2020: 1st AAPG/EAGE PNG Petroleum Geoscience Conference & Exhibition; Port Moresby, Papua New Guinea. For information, contact AAPG Asia Pacific Programs Manager Adrienne Pereira, email add.: apereira@aapg.org.

March 2-8, 2020: GEOEXPO International Geological Congress (36th); Delhi, India. Visit https://www.36igc.org/science-program for more details.

March 16-19, 2020: 14th Middle East Geosciences Conference and Exhibition; Bahrain. To find out more, visit website https://geo-expo.com/conference/.

March 17-18, 2020: 10th IGRSM International Conference and Exhibition on Geospatial and Remote Sensing; Putrajaya, Malaysia. Details at www.IGRSM.org/IGRSM2020.

May 12-14, 2020: AAPG/EAGE Fifth Myanmar Oil & Gas Conference; Yangon, Myanmar. Visit website at https://www.aapg.org/global/asiapacific/events for more information.

June 7-10, 2020: AAPG 2020 Annual Convention and Exhibition (ACE); Houston, Texas. Contact Terri Duncan (Technical Programs Coordinator) at tel.: +1 918 560 2641 with questions or for additional information.

June 15-18, 2020: Asian Current Research on Fluid Inclusions 8th Biennial ACROFI Conference; Queensland, Australia. For inquiries about the conference, please contact the EGRU Conference Committee - Jan Huizenga: Jan.Huizenga@jcu.edu.au; Yanbo Cheng - Yanbo.Cheng1@jcu.edu.au.

Geological Society of Malaysia Publications

Instruction to Authors

General Policy

Papers should be as concise as possible. They may include original results of basic, applied and policy research of national or international significance, current reviews, or discussions on techniques, research programs, organisations, information, or national and international policies in geoscience.

Submission of Papers

Only papers that have not been published elsewhere will be considered for publication. Authors must agree not to publish elsewhere a paper submitted and accepted. All papers will be subjected to review by two or more reviewers. Authors wishing to include published and unmodified figures or text passages are required to obtain permission from the copyright owner(s). Authors of English papers are strongly urged to have their manuscript edited for language before submission by a person whose first language is English.

The Editor reserves the right to reject all or any part of the paper submitted. The Geological Society of Malaysia assumes no responsibility for statements made by authors.

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Manuscript

The paper can be written in Bahasa Malaysia (Malay) or English. For English papers, use either British or American spelling but not a combination of both. The paper should be checked thoroughly for spelling and grammar. The manuscript must be printed at 1.5 spacing in a single column on one side of A4 paper. All pages should be numbered. Length of paper should be between 3,000 and 6,000 words for the *Bulletin* and between 2,000 and 3000 words for *Warta Geologi*, excluding tables and illustrations. Metric units should be used and all non-standard symbols, abbreviations and acronyms must be defined.

Title

Title must be informative and reflects the content of the paper. Title in Malay should include an English translation. It should be concise (less than 20 words). Avoid using abbreviation in the title.

Author's Address

Addresses of all authors must be provided. The addresses should be sufficient for correspondence. Please include email address, telephone and fax of the corresponding author.

Abstract

Abstract in both Malay and English, each in one paragraph and should not exceed 300 words. It should clearly identify the subject matter, results obtained, interpretations discussed and conclusions reached.

Keywords

Please include 3 to 8 keywords that best describe the content of the paper.

References

In the text, references should be cited by author and year and listed chronologically (e.g. Smith, 1964; Jones *et al*., 1998; Smith & Tan, 2000). For both Malay and English paper, all references must be listed in English. Title of non-English articles should be translated to English.

The list of references should only include articles cited in the text. The list should be arranged in alphabetical order. Please ensure that the reference list is complete and the bibliographical details are accurate. The references should be in the following manner:

Journal article:
Suntharalingam, T., 1968. Upper Palaeozoic stratigraphy of the area west of Kampar, Perak. Geol. Soc. Malaysia Bull., 1, 1-15.

Book:
Hutchison, C.S., 1989. Geological Evolution of South-east Asia. Clarendon Press, Oxford. 368 p.

Chapter of book and Symposium volume:
Hosking, K.F.G., 1973. Primary mineral deposits. In: Gobbett, D.J. and Hutchison, C.S. (Eds.), Geology of the Malay Peninsular (West Malaysia and Singapore). Wiley-Interscience, New York, 335-390.

Article in Malay:
Lim, C.H. & Mohd. Shafeea Leman, 1994. The occurrence of Lambir Formation in Ulu Bok Syncline, North Sarawak. Geol. Soc. Malaysia Bull., 35, 1-5. (in Malay with English abstract).

Tables

All tables should be cited in the text and numbered consecutively. Tables should have a title and a legend explaining any abbreviation or symbol used. Each table must be printed on a separate piece of paper. Do not insert the tables within the text. Data in tables should be aligned using tab stops rather than spaces. Avoid excessive tabulation of data.

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Please make sure that all illustrations are useful, necessary and of good quality. A maximum of ten (10) illustrations (photographs, graphs and diagrams) are allowed and these should be cited in the text and numbered consecutively as Figures. The papers are usually published in black-and-white but it may sometimes be possible to include colour figures at the author's expense. The scales for maps and photomicrographs should be drawn on the figure and not given as a magnification. Originals should not be greater than A4 size and annotations should be capable of being reduced down to 50 percent. The caption should be listed on a separate piece of paper. Do not insert the illustration within the text.

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Submission should be made through email as attachment files or using CD-ROM. The submission should be accompanied with a listing of all files and the software (name and version) used. The file names should reflect the content of the files (e.g. Ali_Fig1.tif).

Preferred Software

Text: Microsoft Word. Do not insert tables and illustration within the text.

Tables: Microsoft Word or Microsoft Excel. Please submit as separate files.

Illustrations – Vector Graphics: Adobe Illustrator (preferred), CorelDraw and Freehand. Final line thickness should be at least 0.5 point or 0.17 mm. For other software, please submit one copy in the native file format and export one copy as a PDF file with all fonts embedded and one copy as a high resolution TIFF or JPEG image.

Photographs or bitmap (raster) images: Adobe Photoshop. Please save as TIFF or PSD files. Save/scan line art at 600 to 1200 dpi and greyscale figures at 300 to 600 dpi. High resolution JPEG, TIFF or GIF files from other sources are also acceptable. The resolution must be high enough for printing at 300 dpi.

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