PERSATUAN GEOLOGI MALAYSIA

WARTA GEOLOGI

NEWSLETTER of the GEOLOGICAL SOCIETY OF MALAYSIA

NGC 2017

30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

9 - 10 October 2017

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Warta Geologi

Newsletter of the Geological Society of Malaysia

The Geological Society of Malaysia 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 (Newsletter of the Geological Society of Malaysia) is published quarterly by the Society. Warta Geologi covers short geological communications and original research, as well as reports on activities and news about the Society. It is distributed free-of-charge to members of the Society. Further information can be obtained from:

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NGC 2017

30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

50th Anniversary of Geological Society of Malaysia

1967-2017
GEOLOGICAL SOCIETY OF MALAYSIA

"Geoscience for a Sustainable Future"

Hotel Istana, Kuala Lumpur

9th & 10th October 2017

Officiated by:

Minister of Natural Resources & Environment

Organised by:

Co-organisers:

Newton-Ungku Omar Fund

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UTP — Universiti Teknologi Petronas

Universiti Malaysia Kelantan

Universiti Malaysia Terengganu

USM — Universiti Sains Malaysia

UTM — Universiti Teknologi Malaysia

UMS — Universiti Malaysia Sabah

SEGRM

seadpri — southeast asia disaster prevention research initiative

Malaysian Geological Heritage — WGM

Institut Geologi Malaysia

Malaysian Chamber of Mines

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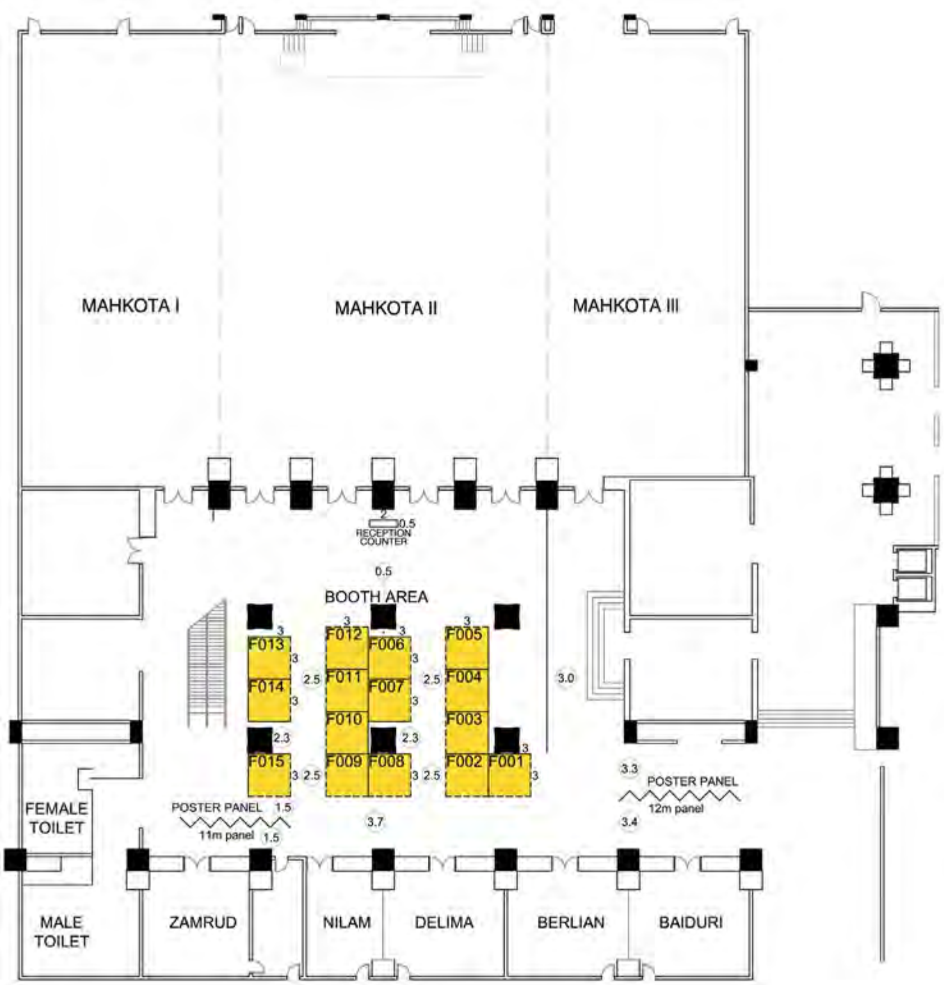
NGC2017 Venue Floor Plan



Welcome to NGC2017

Dear Fellow Participants,

On behalf of the organizing committee, I am honoured to welcome you to the 30th National Geoscience Conference and Exhibition (NGC2017) at Hotel Istana, Kuala Lumpur on 9th to 10th October 2017. This annual event is the landmark geoscience event in Malaysia, and this year we are delighted to invite our overseas counterparts. This event also coincides with the 50th anniversary of the Geological Society of Malaysia (GSM).

Renowned experts from Malaysia and other countries have been invited to share their knowledge and instil intellectual exchange to further enhance the geoscientific community. Forums, plenary and session keynotes, special lectures, oral presentation and posters from numerous researchers are presented in this event.

It has been a great honour for the committee to host the conference and fellow geoscientists and engineers from all over the world in Kuala Lumpur. We hope the geoscience community will greatly benefit from this event and forge unforgettable memories for the participants.

Abd Rasid Jaapar
Chairman, NGC2017
President, Geological Society of Malaysia

Exhibitors and Sponsors

PROGRAMME

Day 1: 9 October 2017

Time		Event		
0800 - 0830	RECEPTION OPEN			
0830 - 0850	Planery Keynotes (Mahkota I Hall)	APK00-188 - Historical Perspective of the Geological Society of Malaysia **Prof. Dr. John Kuna Raj (Consultant Geologist)**		
0850- 0915		APK01-177 - Ahli Geologi Ikhtisas di Malaysia: Peluang dan Cabaran (Professional Geologists in Malaysia: Opportunities and Challenges) **Prof. Emeritus Dato' Dr. Ibrahim Komoo (Head, Natural Resource and Environmental Cluster)**		
0915- 0940		APK02-179 - JMG: Past Achievements and Future Challenges **Tuan Haji Shahar Effendi (Director General, Mineral and Geoscience Department)**		
0940- 1000		APK03-154 - Dynamic Business Models for Sustainability and the Roles of Geoscientists **Dato Seri Dr. Mohd Ajib Anuar (President, Chamber of Mines, Malaysia)**		
1000 - 1030	COFFEE BREAK (Poster Presentation)			
1030 - 1145	FORUM: Ethics, Professionalism and Professional Development Panel: **Dato' Yunus Abd Razak (BOG), Dato Ir Dr Ts Abdul Rashid Maidin (BEM and MBOT), Dr Vanessa Banks (BGS and GSL), Prof Dr. Andrew Malone (HKU)** Moderator - Datuk **Mior Sallehhuddin Mior Jadid (IGM)** Mahkota I Hall			
1200 - 1400	LUNCH - GSM 50th Anniversary Official Launching by Minister of NRE (Mahkota II Hall)			
	Session Keynote	Engineering Geology & Rock Mechanics (Mahkota I Hall)	Mineral Resources & Renewable Energy (Delima Hall)	Petroleum Geology (Berlian Room Hall)
1400 - 1430		BEG01-161 - Understanding the Movement Behaviour of the Pos Selim Landslide, Malaysia Andrew Malone	CMR01-122 - Social and Economic Impacts of Applied Mineralogy Tsutomu Sato	DPT01-24 - The Continental Shelf – Five Decades of Progress (1966-2016) Mazlan Madon
1430 - 1500		BEG02-163 - Earthquake Design Ground Motion Taking Into Account Active Fault Displacement S. L. Wu, J. Kiyono, A. S. Fajar, Y. Maeda, T. Nakatani, S. Y. Li	CMR02-73 - Silica Sand Processing - Hashim Hussin	DPT02-79 - Malay Basin: The Impact of Tectonics and Basin Architecture on Petroleum Resources and Future Potential Md Yazid Mansor (UTP)
1500 - 1530		BEG03-85 - Geological Discontinuity's Quantification: From Theory to Practice Abdul Ghani Md Rafek	CMR03-16 - Critical Minerals in Facing the Challenges of a Sustainable Tomorrow Cheang Kok Keong	DPT03-165 - Sabah Oil and Gas Exploration - New Opportunities Jawati Bin Abu Naim
1530 - 1630	TEA BREAK (Poster Presentation)			

Time		Engineering Geology & Rock Mechanics (Mahkota I Hall)	Mineral Resources & Renewable Energy (Delima Hall)	Petroleum Geology (Berlian Room Hall)
1630 - 1645	Oral Session	BEG04-19 - Geology vis-à-vis Tunnelling in the Kuala Lumpur Area Tan Boon Kong	CMR04-123 - Suitability of Various Malaysian Clays for Ceramic Tiles Manufacturing Chee Lung Chin, Zainal Arifin Ahmad, Sew Seng Sow	DPT04-8 - Potential of UV-Visible Absorption Spectroscopy for Characterizing Devonian Black Shales Teivardashni Gunasergaran, Eswaran Padmanabhan, Ibad Mahmoodi, Yang Wang Chuan, Zaky Ahmad Riyadi
1645 - 1700	Oral Session	BEG05-42 - Dynamic Slope Stability Analysis During Sabah Earthquake Rini Asnida Abdullah, Mohd Nur Asmawisham Alel, Mohd Zamri Ramli, Lee Sze Shan	CMR05-41 - 3D Magnetic Modelling For Iron Ore Exploration in Gambang, Kuantan, Pahang Woo Chaw Hong, Rocky Martakusumah, Low Keng Lok, Aina Nadiah Abd Aziz	DPT05-2 - Developed Correlations between Porosity, Permeability and Sound Wave Velocity at Different Compaction Pressures for Sandstone Core Samples G.M. Hamada , E.S. Al-Homadhi
1700 - 1715	Oral Session	BEG06-12 - A Comparative Parametric Study on Several Published Rock Slope Assessment Case Studies Using Limit Equilibrium Method Abd Rasid Jaapar, Afiq Farhan Abdul Rahim	CMR06-30 - Potential of Rare Earth Elements (REE's) in Sediments of Labuan Island, Malaysia Siti Syaza Aiman Seh Wali, Surono Martosuwito, Nor Shahida Shafiee, Hafzan Eva Mansor	DPT06-13 - Application of TEM Technique in South-East Asia Yuri A. Agafonov, Igor V. Buddo, Olga V. Tokareva, M. Shukur M. Ali, Mustapha M. Salleh
1715 - 1730	Oral Session	BEG07-71 - Shear Strength Variability of Graphitic Schist Derived From Weathered Hawthornden Schist Zakaria Mohamad	CMR07-117 - Ketulenan Batu Silika Permatang Kuarza Genting Klang, Hulu Kelang, Selangor Berdasarkan Analisis Geokimia Mohd Rozi Umor, Mohd Shafeea Leman, Che Aziz Ali, Ibrahim Komoo, Tanot Unjah, Lim Choun Sian	DPT07-48 - Depth Distribution Of Benthic Foraminifera In The Middle And Deeper Sublittoral To Uppermost Bathyal Northwest Of Okinawa, Japan Wan Nurzalia Wan Saelan, Johann Hohenegger
1730 - 1745	Oral Session	BEG08-139 - Shear Strength Characteristic of Metasandstone Joint with Condition of Infilling Material Mohd Nordin, M.M. , Ismail N.I.N., Suid, M.Y.	CMR09-94 - Geological and Electromagnetic Studies of Mukah Coalfield Area, Sarawak, Malaysia Nadhirah Mohd Rosdi, M Suhaili bin Ismail, Nor Syazwani binti Zainal Abidin	DPT08-26 - Analysis of Heterogeneous Distribution of Petrophysical Properties in Sandstone Reservoir: A Case Study Alya Idayu Safitri, Joel Ben-Awuah, Haylay Tsegab Gebretsadik, Numair Ahmed Siddiqui, Marian Selorm Sapah
1745 - 1800	Oral Session	BEG09-3 -Kajian Kestabilan Cerun: Kajian Kes di Sekitar Kampung Kuala Abai, Kota Belud, Sabah, Malaysia Ismail Abd Rahim, Mohd Noor Raffee Usli		DPT09-47 - Effect of Coal Seams Thickness on the Performance of CO_2 Sequestration for Enhanced Coalbed Methane Recovery Edo Pratama, Mohd Suhaili Ismail, Syahrir Ridha
END OF DAY 1				

PROGRAMME

Day 2: 10 October 2017

Time		Event		
0800 - 0830	RECEPTION OPEN			
		Forum on DRR & Climate change Adaptation (Mahkota I Hall)	Hydrogeology & Roundtable Discussion on Geoheritage & Geoparks (Delima Hall)	Petroleum Geology & Regional Geology (Berlian Hall)
0830 - 0845	Oral Session	EDR21-14 - Adaptation to sea-level rise for Small Island Developing States Poh Poh Wong	ASL91-181 - Groundwater is Naturally Better Azuhan Mohamed	DPT21-49 - Better Imaging Of The Subsurface Using Primaries and Multiples: A Synthetic Example Abdul Rahim Md Arshad, Deva Ghosh
0845 - 0900				DPT22-17 - Variance in Reservoir Quality due to Diagenesis: A Study from Tidal Deposits, Nyalau Formation, Sarawak, East Malaysia Azirahtul Atifah binti Mohamed Sabri, Numair A. Siddiqui
0900 - 0915		EDR22-NRY-Coastal Vulnerability Index based on Sea-Level Rise Khairi Wahab	ASL92-182 - Prospect and Potential of Regional Groundwater Basin in Malaysia Mohd Nazan Awang	DPT23-64 - Integrated Reservoir Fluid Characterization in Thinly Laminated Formations – A Case Study from Deepwater Sabah Smail Chouya, John Jong, Janice Boay, Shota Nakatsuka, Samie Lee, Pascal Millot
0915 - 0930				DPT24-90 - The Holistic Approach in Petroleum Exploration Zuhar Zahir Tuan Harith
0930 - 0945		EDR23-164 - Communication of Geohazard Information to Non-Specialists Alan Thompson, Brian Marker, Jane Poole	ASL93-183 - The Significance of Groundwater Modelling Practices for Resources Evaluation in Malaysia Saim Suratman	DPT25-84 - A Case Study of Gas Hydrates in Offshore NW Sabah, Malaysia: Implications as a Shallow Geohazard for Exploration Drilling and a Potential Future Energy Resource Goh Hui Sin, John Jong,Steve McGiveron, Jim Fitton
0945 - 1000				DPT26-143 - FSM Based Interpretation of Complex Internal Carbonate Architectures, Facies and Karsts D.A. Uli, Z. Z. T. Harith, M.H.H. Mohammad, T. Kanesan, A. Kolupaev, Y.Y. Lee, L.S.Fun
1000 - 1030	TEA/COFFEE BREAK			
1030 - 1045	Oral Session	EDR24-105 - A Snapshot on the Economic Value of Geoscience In Malaysia Mohd Suhaili Ismail	BDG21-166 - Current Status of Geoheritage Development in Thailand Anukoon Wongyai	DRG21-21 - Crustal Thickness and Velocity Structure of Southern Peninsular Malaysia Abdul Halim Abdul Latiff, Amin Esmail Khalil
1045 - 1100		EDR25-138 - Geohazards from the Oil & Gas Industry Perspective Norhasliza Kasim, Mustaza Musa, Quah Khoon Beng		DRG22-39 - Tidally-influenced Deposition in the Early Miocene Balingian Province of Sarawak: Sedimentary Characteristics, Geologic Cause and Impact on Earth History Meor H. Amir Hassan, D.S. Collins, H.D. Johnson, P.A. Allison, Wan Hasiah Abdullah

1100 - 1115	Oral Session	EDR26-137 - Peaty Sediment Distribution in the Straits of Malacca and its Potential Use as the Sea Level indicators Abdullah Sulaiman, Mohd Lokman Husain, VijayanV.R., Rosnan Yaacob	BDG22-167 - The Development of Geoheritage and Geopark in Indonesia - Case Sudy in Petrolem Geoheritage Bojonegoro Jatmika Setiawan, Dedy Kristanto	DRG23-56 - Geosite Assesment of the Trace of Mesozoic Subduction in Lubar Village, Muara Dua Distric, South Sumatera Province, Indonesia Ugi Kurnia Gusti, Fadlan Atmaja Nursiwan
1115 - 1130		EDR27-57 - Ecological Distribution of Modern Benthic Foraminifera of Kedah Coastal Waters and their Potential Used as Sea Level Indicator Fatin Izzati Minhat, Mohd Lokman Husain, Behara Satyanarayana, Vijayan V.V. Rajan, Hasrizal Shaari, Sanatul Salwa Hasan		DRG24-61 - A Re-assessment of Mesozoic Meta-sedimentary Successions in Singapore: Terrestrial to Deep Marine Depositional Environments and Stratigraphical Framework TJH Dodd, MR Gillespie, AG Leslie, RS Kendall, T Bide, MR Dobbs, KW Lee, SL Chiam, KH Goay
1130 - 1145		DISCUSSION	BDG23-169 - Current Status of Geoheritage and Geopark Development in Vietnam Tran Tan Van	DRG25-70 - Late Quaternary River systems of Sarawak Shelf: Geomorphic features from Near Surface 3D Seismic data Satyabrata Nayak, Abdul Jailani B Che Johari
1145 - 1200		EDR28-55 - The Identification of Paleotsunami Deposit along Manjung Coastline, Perak by Trenching and Ground Penetration Radar Surveys Mustaffa Kamal Shuib, Mohamad Zul Fadlie Mohamad Fithol, Muhd Rerdza Fahmi, Samsudin Hj Taib, Mohd Nadzari Ismail, Hanafi Yusop, Ahmad Rosly Abbas, Jasmi Hafiz Abdul Aziz, Ahmad Farid Abu Bakar, Muhammad Amiruddin Amran		DRG26-72 - An Appraisal of the Tectonic Evolution of Borneo, SE Asia - Constraints from Petrotectonic Assemblages and Geophysical Gravity Anomaly Aftab Alam Khan
1200 - 1215		EDR29-186 - Numerical Analysis of Evacuation Start in Elderly Care Facility During the 2011 Tohoku Tsunami Yuhi Doji, Yoshihiro Okumura, & Junji Kiyono	BDG24-168 - Current Status of Geoheritage Development in Malaysia Mohd Shafeea Leman	DRG27-92 - Deformation Profile Analysis of a Deepwater Toe-Thrust Structural Trend – Implications on Structural Kinematics and Sedimentary Patterns Mohd Asraf Khamis, John Jong, Steven M. Barker
1215 - 1230		EDR30-101 - Geological and Geophysical Studies for Multiple Hazards Assessments in an Occupied Residential Area, Puchong, Selangor Tajul Anuar Jamaluddin, Mohd Hariri Arifin, Hamzah Hussin, Mohd Amir Asyraf Sulaiman		DRG28-103 - Preliminary Studies on Morphology and Post-Depositional History of Toba Volcanic Ash in Padang Terap, Perak, West Malaysia Ros Fatihah Muhammad, Ridzuan Giarto Gatot, Adibah Jani, Nur Susila Md Saaid

1230 - 1245	Oral Session	EDR31-148 - Preliminary Landslide Susceptibility Assessment of the Kundasang Ranau Area, Sabah Malaysia based on Information Value Statistical Method FREDERICK FRANCIS TATING, ZAMRI RAMLI, BAILON GOLUTIN, ARTHUR CLEMENT MAKULIM, GOH KHEAN SIONG	DISCUSSION	DRG29-112 - Oligocene-Miocene Large Benthic Foraminifera from the Tajau Sandstone Member, Kudat Formation, Sabah HAFZAN EVA MANSOR, JUNAIDI ASIS, MEOR HAKIF AMIR HASSAN
1245 - 1300		DISCUSSION		DRG30-128 - Highly Fractionated I-type of Maras-Jong Pluton, Eastern Belt Granitoids – Geochemical Constraints AZMIAH JAMIL, AZMAN A. GHANI
1300 - 1400	LUNCH (Mahkota II Hall) Presentation on Industrial Implementation by Virtual Geology Trip & Soft Launching of VR Geology Field Trip by Carol Hopkins, Geoscience Technical Director, nrgEDGE			
		Engineering Geology & Rock Mechanics & Hydrogeology (Mahkota I Hall)	Mineral Resources & Renewable Energy (Delima Hall)	Regional Geology (Berlian Hall)
1400 - 1430	Special Lectures	ASLA2-184 - Geoscientists' opportunities to contribute to disaster risk reduction and management of geophysical hazards in cities S. BRICKER, S.D.G. CAMPBELL, H.J. REEVES, J.C. GILL, V. BANKS	ASLB1-20 - Investigation And Evaluation Of Sericitic Kaolinitic Clay Resources Of Bukit Lata And Ulu Sukor, Kelantan As Ceramic Raw Materials NORWAHIDAH MAHIYUDDIN, KAMAR S. ARIFFIN	ASLC1-170 - Phanerozoic palaeogeography of Peninsular Malaysia: Overviews in selected time periods MASATOSHI SONE
1430 - 1450		ASLA1-18 - Engineering Geology in Malaysia – Some Case Histories TAN BOON KONG	ASLB2-74 - Mineral Exploration from Grassroots to Feasibility; overview of Projects in Malaysia and Paoua New Guinea YVES CHEZE	ASLC2-162 - A type granite of Peninsular Malaysia and comments on tectonic setting AZMAN A. GHANI
1450 - 1510		ASLA3-NRY-Geotechnical Aspects of Underground Section of Sungai Buloh - Kajang Line of KVMRT OOI LEAN HOCK	ASLB3-126 - The Kuantan Bauxite Debacle LOW KENG LOK	ASLC3-97 - Last Glacial Maximum (LGM) to Present Day sea level change for Sunda land based on geological research, tide gauges and satellite data EDLIC SATHIAMURTHY
1510 - 1530		ASLA4-180 - Multi-Geohazard and Disaster Risk Assessment: A Technological's Perspective KHAMARRUL AZAHARI RAZAK	ASLB4-115 - Mechanism of Intense Chemical Weathering of Gabbro to Bauxite in Bukit Jebong, Sarawak MUHAMMAD NAIM NASARUDDIN, HASSAN BAIOUMY, AHMAD MUZAKKIR @ KHAIROM MUZAKKIR BIN BAHAROM	ASLC4-81 - Perubahan Aras Laut Kuno Di Barat Daya Semenanjung Malaysia: Bukti Litologi Dan Tinggalan Cengkerang Di Dalam Sampel Teras Gerudi Di Pontian, Johor HABIBAH HJ JAMIL, ABDUL HADI HASHIM
1530 - 1630	TEA BREAK			

1630 - 1645	Oral Session	BEG41-100 - Isu, Realiti dan Peranan Ahli Geologi Dalam Pembangunan Di Kawasan Berbukit di Malaysia – Kajian Kes dari Projek Perumahan Mewah di Taiping, Perak Tajul Anuar Jamaluddin, Hamzah Hussin, Mohd Amir Asyraf Sulaiman	CMR41-153 - The Use of Isotope and Geochemical Techniques for Geothermal Reservoir Studies, in Tawau, Sabah, Malaysia Fredolin Javino	DRG41-116 - Review of 50-Years (1966-2016) Debate on Age of Sabah Crystalline Basement Granitic Rocks; Are the Granitic Rocks in Upper Segama Sabah Fragments of Supercontinent Pangaea? K.M. Leong
1645 - 1700		BEG42-51 - Penilaian Cerun Batuan di Tapak Bekas Kuari untuk Tebusguna Pembangunan-Kajian Kes di Kuari Granit Kajang, Kajang, Selangor Hamzah Hussin, Tajul Anuar Jamaluddin	CMR42-27 - Impact of Bauxite Mining Activities in Pengerang, Johor on Soils and Environment Shamshuddin Jusop	DRG42-134 - Tertiary coastal and shallow marine successions of the Sandakan Formation (Sabah), Miri and Nyalau Formations (Sarawak): Facies, stratification and reservoir properties Abdul Hadi Abd Rahman, Numair Ahmed Siddiqui, Zainey Konjing
1700 - 1715		BEG43-113 - Relationship between the Static and Dynamic Elastic Modulus in Limestone Rock Material Ailie Sofyiana Serasa, Goh Thian Lai, Abdul Ghani Md Rafek	CMR43-149 - Integrated Remote Sensing and GIS in Lineament Mapping for Geothermal Potential Resources – a Case Study in the Ulu Slim, Perak Mohamad Abd Manap	DRG43-140 - Geology of Setap Shale Formation, Sarawak along Jalan Beluru-Bakong, Subis, Sarawak Nurin Firzanah binti Abu Bakar, Askury Abd. Kadir, Eswaran A/L A.R. Padmanabhan
1715 - 1730		BEG44-43 - Establishing the Hydrological Conditions Beneath an Unlined Municipal Landfill and an Engineered Landfill Site in Malaysia Using Numerical Groundwater Flow Models – Case Studies Mustapha Atta, Abd Rasid Jaapar, Dharam Singh, Wan Zuhairi Wan Yaacob	CMR44-10 - Kajian Sedimen Teras bagi Projek Kajian Tumbesaran dan Kematian Kerang di Lot-lot Ternakan Kerang di Negeri Selangor Noran Alwakhir bin Shaarani, Abdullah bin Sulaiman, Alias Man	DRG44-156 - Sequence Stratigraphy Of Marginal Marine Coal-Bearing Succession of North Sarawak Muhammad Murtaza , Abdul Hadi Abd Rahman, Chow Weng Sum, Numair Ahmed Siddiqui, Mazshurraiezal Nasir, Nur Afiqah Ismail
1730 - 1745		BEG45-40 - How Detailed Geological Observation During Drilling Helps To Understand The Aquifer Behavior. Case study: UKM Bangi, Selangor, Malaysia Norsyafina Roslan, Othman JaafarMardhiya, Zakiyah Ainul Kamal	CMR45-15 - Characteristics of Kaolinitic Clay from Tanjung Rambutan - Simpang Pulai, Perak Khong Ling Han, Hareyani Zabidi, Kamar Shah Ariffin, Cheang Kok Keong	DRG45-158 - Analisa Fosil Radiolaria daripada Unit Batuan Bersilika di Pos Blau (Singkapan Pb-1), Baratdaya Kelantan, Malaysia Muhammad Ashahadi Dzulkafli, Mohd Shafeea Leman, Basir Jasin
1745 - 1800		BEG46-114 - Evaluating the suitability of shallow aquifer for irrigational purposes in some parts of Kelantan, Malaysia Mohammad Muqtada Ali Khan, Kishan Raj Pillai A/L Mathialagan, Ainaa Mardhiya, Zakiyah Ainul Kamal	CMR46-125 - Geological Investigation on Batumilmil Formation Deposit in Langkat, North Sumatera Gustam Lubis, Syed Fuad S Hashim , Kamar Shah Ariffin	DRG46-60 - Mesozoic arc accretionary tectonics and dextral strike-slip faulting in Singapore A.G. Leslie, T.J.H. Dodd, M.R. Gillespie, R.S. Kendall, T. Bide, M.R. Dobbs, K.W. Lee, S.L. Chiam, K.K. Lat
1530 - 1630	CLOSING CEREMONY & PRIZE PRESENTATION			

LIST OF POSTERS (Day 1, 9 October 2017)

Poster No.	Title	Authors
GEOHERITAGE		
PBDG01	THE DISCOVERY OF PHALLIC ROCK AT JENAGOR, TERENGGANU	Mustaffa Kamal Shuib, Mohamad Zul Fadlie Mohamad Fithol, Muhd Rerdza Fahmi, Muhammad Amiruddin Amran
PBDG02	PEMETAAN GUA DI LANGKAWI UNESCO GLOBAL GEOPARK: STATUS DAN POTENSI GEOPELANCONGAN	Kamal Roslan Mohamed, Che Aziz Ali, Juliana Senawi, Ku Adriani Ku Ayob, Asbiyatulaida Derahman
PBDG03	TOWARDS ASPIRING KINTA VALLEY GEOPARK IN THE NATIONAL LEVEL	Tuan Rusli Tuan Mohamed, Mohd Shafeea Leman, Kamaludin Hassan, Mohd Sidi Daud, Othman Kangsar, Nurul 'Amalina Md Nor
PBDG04	PENGENALPASTIAN GEOTAPAK DALAM CADANGAN GEOPARK JERAI	Nur Susila bt. Md. Saaid, Zainol bin Husin
ENGINEERING GEOLOGY		
PBEG01	THE CORRELATION OF BULK DENSITY, POROSITY AND VELOCITY OF CORES FROM VARIES DEPTH IN CTW-1 WELL OF KATI FORMATION IN UTP CAMPUS, SERI ISKANDAR, PERAK, MALAYSIA	Norsyafiqah Binti Salimun, Abdul Ghani Rafek, Khairul Arifin Mohd. Noh
PBEG02	KAJIAN HIDROGEOLOGI DALAMSINGKAPAN GRANIT DI LEBUHRAYA SILK SEPANJANG KAJANG – SUNGAI LONG, HULU LANGAT, SELANGOR	Muhammad Fuad Razali, Norsyafina Roslan
PBEG03	GROUNDWATER IN FRACTURED METASEDIMENTARY ROCKS OF KENNY HILL FORMATION	Nursyafiqah Zaini, Norsyafina Roslan
PBEG04	GROUNDWATER IN FRACTURED GRANITE IN SELANGOR	Hamizah Mohamad, Norsyafina Roslan
PBEG05	SOIL PROPERTIES AND STABILITY OF PUNCAK SETIAWANGSA AND BUKIT AMAN SLOPE FAILURES, KUALA LUMPUR, MALAYSIA	Nurul Iffah Ismaila, Wan Zuhairi Wan Yaacob Rashid
PBEG06	ELECTRICAL RESISTIVITY SURVEY IN SEDIMENT DISPOSAL AREA SUNGAI JASIK, CAMERON HIGHLANDS FOR SUBSURFACE STRUCTURE AND SUBSURFACE WATER FLOW POTENTIAL	Siti Noraishah Binti Mohd Azli, Mohd Rozi Bin Umor
PBEG07	FIELD STUDY TO IDENTIFY RIVER PLUME EXTENSION OF KERIAN RIVER DISCHARGE DURING NEAP TIDE AND SPRING TIDE	Eko March Handoko Bin Masyhur, Wan Nursyafiqah Wan Jusoh, Mohd Noordin Abu Bakar
PBEG08	SLOPE STABILITY ASSESSMENT OF KEK LOOK TONG LIMESTONE HILLS, KINTA VALLEY, PERAK, MALAYSIA	Jihan Rufaidah Binti Mustapha,Chow Weng Sum, Abdul Ghani Rafek
PBEG09	ROCK PHYSICAL PROPERTIES OF KATI FORMATION IN SERI ISKANDAR, PERAK	Sufizikri Sahari, Ahmed Mohamed Ahmed Salim, Khairul Arifin Mohd. Noh
PBEG10	ENGINEERING GEOLOGICAL CHARACTERISATION OF SEDIMENTARY ROCKS AT PARIT TO KUALA KANGSAR, PERAK, MALAYSIA	Wong Jia Mang, Abdul Ghani Rafek
PBEG11	SLOPE STABILITY EVALUATION BY GEOLOGICAL STRENGTH INDEX (GSI) ON SELECTED SLOPES OF THE CROCKER FORMATION, SABAH, MALAYSIA	Lee Kiun You, Ismail Abd Rahim
PBEG12	POTENTIAL OF LIMESTONE GEOHAZARD BY USING GIS ANALYSIS AT KG. GUNUNG BATU MELINTANG, JELI, KELANTAN	Rhushashafira Rosle, Muhammad Izzudin Abdul Manan, Shaparas Daliman
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Historical Perspective of the Geological Society of Malaysia

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The Geological Society of Malaysia was formally established on 31/01/1967 and has grown in strength and numbers over the past 50 years to become one of the most active and successful geological societies in the Asian region. During its' first decade (31/01/1967-25/03/1977), the General Meeting, often with a Presidential Address was the premier annual event and organized together with a Discussion Meeting and Society Dinner. A Newsletter was issued regularly every two months, whilst 7 Bulletins and the book on the "Geology of the Malay Peninsula" were published. The second decade (26/03/1977-13/04/1985) started with introduction of the Petroleum Geology Seminar (first held on 16/12/1977) which together with the General Meeting (organized with a two-day Discussion Meeting) became the premier annual events of the Society. The Newsletter (renamed Warta Geologi in January 1975) continued to be issued regularly every two to three months, while 10 Bulletins were published.

The third decade (14/04/1985-30/04/1994) started with introduction of a two day Annual Geology Conference (on 28-29/04/1986) that replaced the Discussion Meeting earlier held with the General Meeting. This Annual Conference was introduced to provide the locale and opportunity for geoscientists to meet and discuss ideas, experience and knowledge on topics relevant to Malaysian geology, and together with the General Meeting and Petroleum Geology Conference became the premier annual events. During the third decade, the Warta Geologi was regularly issued at intervals of two to three months and 19 Bulletins published. Working Groups on Engineering Geology & Hydrogeology, Economic Geology, Stratigraphy & Sedimentology, Petroleum Geology and Structural Geology & Tectonics were also appointed in March 1987 to encourage research and provide forums for discussion and exchange of ideas and knowledge. The third decade also saw establishment of the Institute of Geology Malaysia and preparatory work on drafting the Professional Geologists Act.

The fourth decade (01/05/1994-24/04/2005) was marked by rebranding of the Petroleum Geology Seminar in 1995 as the Petroleum Geology Conference (renamed Petroleum Geology Conference and Exhibition from 15/12/2002). This Petroleum Conference with the General Meeting, and Annual Conference, then became the premier annual events. During the fourth decade, the Warta Geologi was issued at variable intervals of between two and four months, while a total of 12 Bulletins were published. Five additional Working Groups were also appointed on Environmental Geology & Hydrology, Promotion of Geosciences, Geophysics, Young Geoscientists and Society Website. A most commendable project during the second decade involved the "Redefinition of GSM" and culminated in the setting-up of the Society's official website (www.gsm.org.my) in 2004. During the fourth decade, there were formal representations of the Institute of Geology to the Government of Malaysia for gazetting the Professional Geologist's Act.

The fifth decade (25/04/2005 - present) started with rebranding the Annual Geology Conference as the National Geology Conference in 2016; this National Conference, General Meeting and Petroleum Geology Conference and Exhibition then becoming the premier annual events. The Petroleum Geology Conference and Exhibition was rebranded the Petroleum Geoscience Conference and Exhibition in 2011 and held twice (7-8/03/2011) and (18-19/03/2013); the cooperative framework for organizing the Conference ending after 3 years in 2014. The Intellectual Property Corporation of Malaysia furthermore, granted GSM sole ownership of the name "Petroleum Geoscience Conference and Exhibition" in 2012. During the fifth decade, a marked improvement in the editorial process resulted in the Bulletin becoming a Scopus indexed publication. The 2014/2015 Council also took the initiative to upload all Society publications onto its website; a decision that will make the publications widely available. The Society together with the University of Malaya published in 2009 the book on "Geology of Peninsular Malaysia". During the fifth decade, the then 10 Working Groups were streamlined into 5 groups and a Joint GSM-IGM Committee set-up on 05/04/2013. The 2014/2015 Council also arrived at a general understanding with the Department of Geology University of Malaya regarding a more permanent Society Secretariat. The fifth decade finally saw the passing of the Geologists Act 2008 (Act 689) on 15/07/2008 by the Malaysian Parliament.

In the early years, the Society received donations from several companies and they helped to put the Society on a sound financial footing. The Petroleum

Geology Seminar also became accepted as a premier annual seminar and started to generate the much-needed funds for the Society's publications and activities. At the 47th AGM (05/04/2013), it was announced that a new cooperative framework had been agreed on the running of the Petroleum Geoscience Conference and Exhibition (PGCE) with funds transferred to a newly created GSM Endowment Fund. The Society would administer this fund as a separate account, to ensure that the principal sum is maintained in perpetuity, while the interest it generates is used to conduct capacity building activities.

With its main annual events, i.e. National Geoscience Conference, and Petroleum Geoscience Conference & Exhibition, as well as regularly organized technical talks, fieldtrips, Seminars and Conferences, sound financial position, and timely publication of the Warta Geologi and Bulletin, the Society can look forward to continue being one of the most successful geological societies in Asia. There is, however, a need for caution as the number (595 on 08/092017) of GSM members is not in tandem with the number (1,815 on 31/07/2017) of "registered geologists" in Malaysia. This discrepancy in numbers, as well as declining attendance at Society organized events and activities, raises questions on the quality of the "Registered Professional Geologists" as many of them do not appear to be interested in keeping their knowledge and skills current and up-to-date. In my opinion, it is imperative that "CPD" (Continuous Professional Development) be an essential prerequisite for initial, and extension of, registration, of members of the Institute of Geology Malaysia, as well as recognition by the Board of Geologists Malaysia. The GSM will directly benefit from such a requirement as participation in Society activities and events can be used as evidence of "CPD".

In closing, I wish the Society all good wishes for a bright future with the hope that all geologists in the country will be members of the Society and seek continuously to improve their knowledge and skill by attending and participating in technical talks, training courses, Workshops, field trips, Seminars, Conferences and Symposia organized by the Society.

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Ahli Geologi Ikhtisas di Malaysia: Peluang dan Cabaran

Professional Geologists in Malaysia: Opportunities and Challenges

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Pengenalan

Apabila Akta Ahli Geologi 2008 (Akta 689) berkuatkuasa pada tahun 2015, semua pengamal ilmu geologi di Malaysia diiktiraf sebagai ahli ikhtisas (profesional). Ini adalah anjakan penting warga geosains dalam mengharungi abad ke-21. Anjakan ini mencetus perubahan daripada ahli sains yang berpegang kepada etika akademik kepada pengamal ilmu yang dikawal oleh perundangan keikhtisasan. Semua ahli geosains, sama ada ahli akademik (pensyarah dan pendidik), penyelidik (pembangun ilmu), dan pengamal (pemberi khidmat) tertakluk kepada etika keikhtisasan dan dikawal oleh undang-undang.

Beberapa kata kunci dalam Akta Ahli Geologi 2008 yang perlu difahami ialah: a) akta menubuhkan Lembaga Ahli Geologi (BoG)bagi menyediakan peruntukan pendaftaran ahli geologi, mengawalselia amalan geologi dan perkara yang berhubungan dengannya; b) ahli geologi profesional iaitu seseorang yang memegang ijazah geologi atau setara, boleh menjalankan amalan/ urusan/ khidmat sebagai ahli geologi dan diluluskan oleh Lembaga; dan c) perkhidmatan geologi ialah penasihatan dan perkhidmatan geologi berkaitan kajian kebolehlaksanaan, perancangan, servei geologi, pelaksanaan dan pengurusan projek servei geologi, dan perkhidmatan lain yang diluluskan oleh Lembaga.

Ahli Geologi dan Peranannya

Secara tradisi ahli geologi ditafsirkan sebagai ahli sains tulen, ahli sains gunaan, dan ahli geologi profesional. Sebagai ahli sains tulen, mereka menjalankan penyelidikan ufuk ilmu berkaitan Sains Bumi, khususnya mencari kebenaran atau jawapan kepada fenomena alam berkaitan Bumi dan prosesnya yang masih belum diketahui atau dapat dijelaskan. Hasilnya diterbitkan dalam jurnal berwibawa dan disampaikan kepada pelajar geologi di pusat pengajian tinggi. Kewibawaan mereka ditentukan oleh rakan kesepakaran (*peers*).

Ahli sains gunaan ialah penyelidik atau pengamal berkaitan Sains Bumi yang menjalankan kerja geologi bagi menyelesaikan masalah umum atau menyediakan maklumat (peta geologi) untuk kegunaan persendirian atau jabatan dan kurang melibatkan kepentingan awam. Kualiti kerja beliau ditentukan oleh rakan kesepakaran atau ketua jabatan. Ahli geologi profesional pula ialah mereka yang memberi nasihat/ khidmat teknikal atau perkhidmatan geologi kepada pihak kedua (umumnya bukan ahli geologi) dan hasil nasihat/ khidmat boleh menjejas kepentingan awam.

Governans Ahli Geologi Malaysia

Ahli geologi di Malaysia secara tradisinya ialah ahli akademik di universiti, pegawai sains/penyelidik di agensi kerajaan, khususnya Jabatan Mineral dan Geosains, dan di syarikat berkaitan perlombongan, pengkuarian dan sumber petroleum. Pada tahun 1967, mereka telah mewujudkan Persatuan Geologi Malaysia (GSM), sebuah badan NGO berperanan mempromosi perkembangan bidang geosains di Malaysia dan Asia Tenggara. Persatuan ini menerbitkan Warta, Buletin dan menganjurkan seminar dan persidangan untuk berkongsi ilmu berkaitan geosains.

Institut Geologi Malaysia (IGM) pula didaftarkan sebagai persatuan pada tahun 1989, bertujuan menggerakkan penubuhan sebuah badan profesional bagi mengawalselia kerjaya ahli geologi di Malaysia. Ia berperanan sebagai sebuah institusi ahli terpelajar dan sains geologi bagi memenuhi keperluan menjaga etika dan amalan sumbangan geologi kepada masyarakat. IGM juga telah memainkan peranan penting dalam mempengaruhi kerajaan sehingga wujudnya Akta Ahli Geologi 2008.

Pada tahun 2015, selepas berkuatkuasanya Akta Ahli Geologi 2008, apakah GSM dan IGM yang melibatkan ahli hampir sama ini masih relevan? Hubungkait dan peranan ketiga-tiga organisasi ahli geologi ini boleh diringkaskan seperti Rajah 1.

Walaupun komuniti ahli geologi di Malaysia agak kecil, kita masih memerlukan tiga organisasi ini untuk melengkapkan kepimpinan perkembangan dan perkhidmatan geologi secara berterusan. Oleh kerana fungsi GSM dan IGM bersifat organisasi sukarela bukan kerajaan (NGO), kerjasama lebih rapat diperlukan bagi memperkasa kepakaran dan amalan Sains Bumi.

Sementara Lembaga di bawah naungan Akta 689 pula bertindak sebagai pendaftar dan kawalselia amalan/perkhidmatan ahli geologi.

Peluang dan Cabaran

Memandangkan Lembaga Ahli Geologi masih baharu, banyak peluang boleh diterokai dan cabaran perlu dilalui. Antara peluang yang jelas ialah bagaimana untuk memperluaskan sumbangan ahli geologi dalam sektor bukan tradisi (sektor tradisi: industri huluan perlombongan, petroleum, kejuruteraan dan bahan binaan). Industri semasa dan baharu muncul yang perlu diterokai meliputi sektor pembuatan, air tanah, alam sekitar (kelestarian), perancangan wilayah, pendidikan, warisan tabii dan pelancongan (Pereira & Ibrahim Komoo, 2006; Ibrahim Komoo, 2011).

Cabaran pula meliputi usaha promosi kepentingan perkhidmatan geologi dalam pembangunan negara, meningkatkan kualiti perkhidmatan, latihan kemahiran dan kepakaran, dan piawaian perkhidmatan profesional. Geologi sebagai sains mengenai 'sumber bukan hidupan' (abiotik) masih belum diketahui umum. Pada masa ini kebanyakan urusan mengenai pembangunan dan pengurusan berkaitan sumber abiotik telah dilakukan oleh ahli profesional lain. Cabaran paling getis ialah bagaimana menyampaikan perkhidmatan berkualiti tinggi dengan piawaian profesional yang menarik perhatian pihak berkepentingan.

Syarahan ini memberikan penekanan kepada bagaimana menggembleng usahasama erat GSM-IGM-BoG, meneroka peranan baharu muncul, dan memperkemas diri ke arah perkhidmatan berkualiti dan profesional.

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Rajah 1: Hubungkait dan peranan ketiga-tiga organisasi ahli geologi.

APK02-179

JMG'S Past Achievements and Future Challenges

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The Department of Mineral and Geoscience (Jabatan Mineral dan Geosains Malaysia, JMG) was formed as a result of a merger between both Geological Survey Department and the Department of Mines in 1999. Since then, it has endured years of journey in fulfilling its expectation in enhancing the role of geosciences and regulatory control of mineral industry for the development and well-being of the country.

These have been achieved by many of its contribution, _inter alia_, the revision and improvement of policy, laws and regulation including the formulation of the 2nd National Mineral Policy (NMP2) and the passing of the Geologist Act, strengthening the expertise and physical development in several geoscience activities such as ground water resources determination in remote and water stressed areas, formation of National Geopark Committee, geological hazard evaluation and prediction and by the introduction to new and potential uses of the country mineral resources, to name a few.

Apart from the above, JMG has also taken the mantle on the exploration of minerals such as the REE metals, building the capacity to advice and amplify on the use of ground water and water needs for domestic and peat fire fighting, advancing the use of geological information with modern technologies for rapid decision making and execution.

The role of JMG will be further enhanced to meet the challenges of the future in the ever developing technologies to include staff capacity building and welfare, realignment of workforce to overcome constraint in manpower and funds, collaborating with other parties by adopting initiatives under the National Blue Ocean Strategy (NBOS) and embracing full sustainability concept such as self regulatory, self auditing and reporting, self funding apart from keeping in pace with the Industrial Revolution 4.0 through R&D&C.

In the global scene, JMG needs to be prepared with the submission on the sovereignty claim in the South China Sea and EEZ in drafting of laws relating to offshore mineral exploration and mining as well as meeting the 17 sustainable development goals set by the United Nations.

Despite the many challenges faced throughout the years, JMG through its strategic plans has successfully manoeuvered through the challenges of the past and is poised to take advantage of opportunities ahead and challenges of the future.

APK03-154

Dynamic Business Models for Sustainability and the Roles of Geoscientists

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In today's diverse, challenging, resource-constrained, and connected world a more innovative and dynamic approach to sustainability is crucial for our long term prosperity. Our resources are scarce, precious, and diminishing. Our human population is diverse, disperse, and rapidly growing. Massive demographic change means market dynamics will continue to change rapidly. We are already seeing dramatic changes in communication, information and transportation technologies, consumer behavior, and human and natural resources. These disruptive forces will create exciting growth opportunities for the organizations that harness them and will ruin those that ignore them. Leaders must move beyond the relentless pursuit of short-term profitability towards long-term sustainability. A strategy for sustainability requires dynamic business models that are adaptive and flexible enough to the changing environment, attuned to the world around us and focused on long term view.

The business models move beyond compliance-orientated green initiatives. They address the long term impact on social, economic, environmental and cultural components of the business. The business strategy is not just about making profits first. It is also, as equally important, about how the business goes about in making those profits. The business models comprise three success factors for sustainability.

The first crucial success factor is about value creation and sharing across the entire supply and value chains - moving from static zero-sum equations to dynamic non zero-sum equations. This factor requires a fundamental shift in our individual and collective mind-sets regarding value creation. The second factor is the elements of dynamic specialization, innovation and creativity and leveraged capability. The third factor is constructive stakeholder engagement, networking and connectivity. The business models form the strategic component for sustainability.

An equally important success factor for sustainability is values and beliefs. At the core of a business culture is its principles and beliefs. These shared values shape how the business is conducted for long-term sustainability. Geoscientists, with their intimate knowledge of the earth, its contents and behavior, play a very important role in creating long-term growth, sustainability and prosperity for the world's growing population. In the mineral resource sector of the world, the expertise of geoscientists and their dynamic specialization are featured in every stage of the mineral supply chain. Through innovation, creativity and leveraged capability the world will benefit tremendously from value creation under dynamic non zero-sum equations of the business models.

SPECIAL LECTURES

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

ASL91-181

Groundwater is Naturally Better

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Malaysia, with a high annual rainfall, is not spared with lack of raw water episodes. The main reason is that both the domestic and industrial water supplies and irrigation water supplies are too dependent on surface water resources that is, highly dependent on recent rainwater. A quick-fix is to develop groundwater as a supplementary raw water supply for all users. Groundwater is an ancient rainwater that has been stored in the ground for ages. For sustainable groundwater development, an in-depth study of groundwater resources is necessary to ensure the success of groundwater development besides avoiding the inherent negative impacts. This paper is to redirect the current initiatives to diversify raw water resources through the development of coastal water resources that include the construction of off-stream river storages, coastal reservoirs and underground dams. The development of coastal water resources involves massive infrastructure development and the development of coastal reservoirs involve new knowledge and technology and their long-term impacts on the environment is yet to be fully ascertained. The development of groundwater resources has many benefits besides small footprint for it harnesses the natural capitals. The latter include natural water storages, massive storage capacity and natural filter-plant functions. Thus, groundwater is naturally better.

ASL92-182

Prospect and Potential of Regional Groundwater Basin in Malaysia

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Malaysia has 200 rivers system with 150 systems in Peninsular and a further 50 systems in Sarawak and Sabah. Practically for the time being these rivers catchment also define as groundwater basin or catchment. As part of integrated river basin management, groundwater potential has been evaluate systematically by Mineral and Geoscience Department under National Groundwater Reserve Study and also in collaboration with The Department of Irrigation and Drainage Malaysia to study the groundwater regime and its reserve under National Water Balance Study. Both of these studies are carried out under Eleventh Malaysian Development Project, 2016-2020

For the beginning, a total of ten river basins out of 200 are currently under systematic study to attain the accurate invisible groundwater reserve beneath the surface which previously was done haphazardly. When completed, the study finding will help us to utilise, protect and manage our groundwater resource in sustainable manners.

ASL93-183

The Significance of Groundwater Modelling Practices for Resources Evaluation in Malaysia

Saim Suratman

Consulting Hydrogeologist

Groundwater modelling is normally carried out to estimate groundwater resources potential and to predict environmental impacts caused by groundwater abstraction as well as pollution migration in the chosen area. The results of simulation is normally able to characterise the groundwater conditions in the area and potentially enable to support technical decisions and policy making in planning for the sustainable groundwater resources development in the area. The model should enable the authorities to formulate optimal management strategies leading to a development and protection of the water resources of the area.

Groundwater models are conceptual descriptions, or approximations, that describe physical systems using mathematical equations and they are not exact descriptions of physical systems or processes. The applicability, or usefulness, of a model depends on how closely the mathematical equations approximate the physical system being modeled. For this reason, models that are based on a thorough understanding of the physical system and the assumptions embedded in the derivation of the mathematical equations produce better predictions. Some definitions of a model are:

"a model is a simplified representation of a complex system" or:

"*a model is any device that represents an approximation of a field situation*" (Anderson & Woessner, 1992).

Groundwater flow model can provide useful information on flow rates, drawdown and flow directions of the modelled area and hence allow for design of various remedial alternatives for hazardous waste sites. The flow model can also give information on the impact of resulting development. For managing the resource sustainably, the groundwater modelling was carried out in the area to:

- Improve the understanding of the modelled area (current or proposed abstraction area) and its surrounding regional groundwater flow system from the idealisation of the aquifer system in this area,
- Predict the potential migration of contaminant,
- Simulate systems for water supply, remediation and dewatering, and
- Predict the steady-state flow characteristics and the future regional changes caused by variable discharge of groundwater in the proposed abstraction area following extensive abstraction of groundwater from the multi-layered aquifers.

A contaminant transport model is necessary if information to assess the mechanisms of contaminant transport such as on concentration movement and reduction, mass fluxes and travel times are desired. It is used to:

- Estimate and track the possible migration pathway of groundwater contamination,
- Design and evaluate the design of hydraulic containment and pump-and-treat systems,
- Design and evaluate groundwater monitoring networks,
- Estimation of the possible fate and migration of contaminants for risk evaluation, or
- Assess the remediation work including: determining the effectiveness of hydraulic containment systems, estimating contaminant removal rate and cleanup time, evaluating the potential impact to downgradient receptors such surface water bodies or potable water supply wells, and predicting contaminant concentrations for natural attenuation remedies.

In Malaysia, the increased demand for the use of groundwater has resulted in significant advances in regional groundwater flow modelling. The modelling works have been driven by the demand to predict regional impacts of human inferences on groundwater systems and associated environment. The wide availability of powerful computers, user friendly modelling software (such as MODFLOW and MIKE SHE) and GIS stimulates an exponential growth of regional groundwater modelling in the country. The technology has made it possible to even understand rather complex processes of the hydrologic cycle by means of executing a *model* on the computer.

ASLA1-18

Engineering Geology in Malaysia – Some Case Histories

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Engineering geology deals with the application of geology to civil engineering and construction works. The fundamental input in engineering geology would involve, among other things, studies on the lithologies, geologic structures and weathering grades of the rock masses since together they determine the characteristics and behaviours of the rock masses. In addition, project-specific requirements and problems need to be addressed.

This paper presents several case histories on Engineering Geology in Malaysia such as: Foundations in Limestone Bedrock, Limestone Cliff Stability, Rock Slope Stability, Dams, Tunnels, Riverbank Instability, Slope Failure due to Rapid Draw-down, Urban Geology & Hillsite Development, and Airports. The various case histories presented here are based mainly on the author's ~35 years of past practice and experiences. Previous papers covering various case studies in engineering geology include Tan (1999, 2004, 2007, 2016 and 2017).

Figures 1-6 show some examples of these case histories.

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Figure 1: Limestone bedrock pinnacle, Sunway, KL.

Figure 2: Limestone cliff, Batu Caves, KL.

Figure 3: Slope failure in graphitic schist soils, Air Keroh.

Figure 4: Diversion tunnel in granite, Sg. Selangor Dam.

Figure 5: Slope failure due to rapid draw-down.

Figure 6: Slope failure associated with housing project in hilly terrain, KL.

ASLA2-184

Geoscientists' Opportunities to Contribute to Disaster Risk Reduction and Management of Geophysical Hazards in Cities

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British Geological Survey

Understanding geological processes and how they underpin sustainable urbanisation and resilience to change is critical and is an active research area under the broader umbrella of the rapidly evolving "Science of Cities"[1] - 1 in 7 people live in urban poverty with inadequate provision of water and sanitation; access to clean energy is intrinsically linked to economic development, and; 40% of the urban population live within 100 km of the coastline, many of whom are poor and vulnerable to natural hazards[2].

Whilst cities in Asia have improved access to water and sanitation the pace of urbanisation is overwhelming, many live in urban slums (>20% in India and Vietnam[3]) and additional challenges around urban planning, infrastructure failure, resource management, and environmental degradation remain[4,5]. Evidence from more established economies, shows that access to geoscience research allows better decisions to be made by city partners to support growth e.g. use of geohazard maps by the insurance sector and use of 3D geological models to plan transport tunnels[6-9].

At the British Geological Survey (BGS) there is a long-term aim to embed geoscience information in urban policy and decision-making i.e. within development strategies, environment plans, and risk assessments to underpin the four pillars of sustainable cities: urban governance, environmental management, and social and economic development. This will be developed through a number platforms for urban development using an approach that will develop platforms at a city-scale. In Kuala Lumpur, BGS are working with Malaysian partners, such as the Malaysian Geological Survey (JMG), University of Malaya and SEADPRI, through a Newton-Ungku Omar project ("Disaster resilient cities: Forecasting local level climate extremes & physical hazards for Kuala Lumpur") to develop better 3D ground information that will enable better decision-support tools for planners to communicate of geophysical hazard information effectively. A few examples of this work will presented in this paper.

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ASLA4-180

Multi-Geohazard and Disaster Risk Assessment: A Technological's Perspective

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Understanding geological hazard and associated risk is a step forward to better reducing disaster future risk in the tropics. It is also critical step to access reliable data, information and knowledge for successfully managing disaster risk. Given extreme climate, rapid urbanization, and environmental degradation, it is crucial for us to better coping the disaster capacity, assessing our increased exposure and vulnerability to natural hazards and disaster risk in a quantitative manner. This session urges the need for smart innovation and cross-sectoral partnership, linked to practice and diverse stakeholders to support the evidence based decision-making for multi-geohazard and associated risk in Malaysia. Some lesson learned and challenges based on experiences from Taiwan, Japan and Korea are used to formulate a comprehensive disaster research and nurturing networking various stakeholders. This slot also addresses the solution-oriented knowledge as a result of multi-discipline centric approaches in dealing with complex multi-hazard and disaster risk. This session puts forth a comprehensive methodological-, and operational framework, and future direction of state-of-the-art technology for mapping, monitoring and assessing geomorphological process-response system in the tropics. It highlights integrated disaster research, stakeholder's engagement and knowledge domain for supporting trans-disciplinary disaster solution and building disaster smart resilient society in Malaysia.

ASLB1-20

Investigation and Evaluation of Sericitic Kaolinitic Clay Resources of Bukit Lata and Ulu Sukor, Kelantan as Ceramic Raw Materials

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Sericite mica and kaolinic clay are common industrial mineral widely find a lot of application such as filler, extender, absorbents, coating, ceramic industries etc. Due to rapid industrialization and shortage of industrial grade of such mineral has prompted an initiative in venture into evaluating and processing of substandard or non-traditional resourses. In this project, investigation of non-traditional grade of kaolinitic-seritic clay for ceramic application was envisaged. Raw sericitic bearing kalonitic clay of meta-sedimentary origin from Bukit Lata (BLW and BLB) and Ulu Sukor (USS), Kelantan were technically evaluated.

All clay (< 63µm) appeared white accept BLB which slightly brownish white in color with LOI value < 7%. Mineralogical and geochemical analyses indicated BL resource is typically rich with fine muscovite, illite and kaolinitic mineral fraction, whilst USS mainly high in Kaolinite, apart from quartz fraction and traces of iron (0.88%), titania (2.26%), MgO(0.26%). Total alkaline content (i.e. feldspar origin), CaO+MgO+K_2O = 0.45% which contributed to strength and durability and less water absorption.

Firing tests (950^{o}C, 1050^{o}C, 1150^{o}C and 1250^{o}C) of BLW and BLB shows presence of iron/organic matters degraded the finishing body color (brownish tint), however, the body strength increased especially at higher temperature (1250^{o}C). Whilst USS return slightly better finishing color, body shrinkage, however, slightly lower in strength. Generally this initial evaluation indicated the resources could be developed provided or subjected to beneficiation in quality in accordance with industrial standards and requirements especially for ceramic industry.

ASLB2-74

Mineral Exploration from Grassroots to Feasibility: Overview of Projects in Malaysia and Papua New Guinea

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Discovery of an economic deposit is a long process which encompasses several phases of exploration from grassroots to feasibility over a variable period of time and at a cost which varies considerably depending on local conditions. Mineral exploration costs increase exponentially from the early stage to the feasibility; furthermore a deposit considered as potentially economic after several years of detailed exploration can suddenly be declassified and abandoned following a drop in commodities price or other factors including change in the local geo-political environment. Mineral exploration is therefore a very risky business with considerable financial implication; each stage is important and must be conducted with the best professional practice because its results will be the key to decide whether to proceed or not with the next and more costly stage.

Examples of mineral exploration projects managed by the author in different environments like Malaysia and Papua New Guinea for various commodities including precious and base metals as well as bauxite, are presented with the main techniques used to illustrate the financial but also logistic and human aspects of such an enterprise.

Objectives are significantly different between countries like peninsular Malaysia where exploration costs are relatively cheap and economic targets can therefore be small, compared to the very challenging environment of Papua New Guinea where the objectives are only world class deposits since logistic often represents more than half of exploration budgets, security is a critical aspect of the field work and operating costs of mines often colossal.

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ASLB3-126

The Kuantan Bauxite Debacle

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In January 2014, Indonesia banned the export of raw bauxite mined in their country. The Chinese, who were buying from them, have to look for alternate sources, and prompted miners in Malaysia to mine the bauxite deposit found in and around the Kuantan area. Mining started around the middle of 2014 and it flourished into an extremely busy hive of activities, with more than 50 miners mining the bauxite and more than a thousand trailer lorries carrying the bauxite to Kuantan Port for export. This resulted in Malaysia becoming the world's largest exporter of raw bauxite to China then. However, this mining activity became an environmental issue highlighted in the media by academia, NGOs, politicians and the local residents. With so much hue and cry, the authorities stepped in and imposed a moratorium to stop all the bauxite mining activity in January 2016. Till today one and a half years later, this ban is still in effect.

This presentation summarizes the various aspects of this debacle from the geology and mineralization of the Kuantan bauxite deposit to its exploration and evaluation, mining and haulage; and the many battles between the miners and the people against them.

ASLB4-115

Mechanism of Intense Chemical Weathering of Gabbro to Bauxite in Bukit Jebong, Sarawak

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Bauxite is referred as the type of ore that contains high amount of aluminium content and are formed through a chemical weathering mechanism from a parent igneous rock such as gabbro. Bukit Jebong, Sarawak, composed abundant amount of bauxite deposits are form from gabbro. However, the mechanism of how the minerals within the gabbro evolve to bauxite in Bukit Jebong, Sarawak has never been fully evaluated. The paper shall discuss the integration and correlation the petrology, mineralogy and geochemistry, of the fresh gabbro and bauxite deposit in Bukit Jebong Sarawak, and discuss the mechanism of how mineral within the gabbro are transformed into the bauxite minerals through chemical weathering. In order to achieve these objectives, both gabbro and bauxite deposits from Bukit Jebong, Sarawak were subjected to petrological, mineralogical, and chemical analysis.

The petrological, mineralogical and chemical compositions of the bauxite deposits are controlled by the original composition of the parent rock, gabbro. Based on the petrological analysis, plagioclase, pyroxene, muscovite and quartz are identified to be presence within the gabbro sample. For the bauxite samples, two minerals are identified to be presence which is the bauxite and goethite. Albite, $Na(Si_3Al)O_8$, an alkaline plagioclase minerals composed an abundant amount within the gabbro followed by forsterite, diopside, tremolite, clintonite and quartz based on the mineralogical analysis. Meanwhile the bauxite that is composed of mainly gibbsite $Al(OH)_3$ followed by goethite and hydro gibbsite minerals. Based on the geochemical analysis, gabbro shows high amount of SiO_2 and Al_2O_3, but the amount of the SiO_2 and Al_2O_3 seems to be reduced in the bauxite. Apart from that, the amount of Fe_2O_3 has increased in the bauxite. Intense chemical weathering due to the tropic conditions and good drainage system tends to alter the mineral composition of the gabbro and transforms it directly into bauxite minerals without any intermediate stage. High amount of Albite, $Na(Si_3Al)O_8$ within the gabbro to converted to gibbsite $Al(OH)_3$ due to the chemical weathering. Apart from that, the presences of abundant amount of goethite, FeO(OH), within the bauxite are also results from the intense chemical weathering.

The objective of the study was achieved through integration and correlation the petrology, mineralogy and geochemistry of the fresh gabbro and bauxite deposit in Bukit Jebong Sarawak. The main finding from this study is the presence of albite minerals in the gabbro has been undergone heavy weathering which alter the albite minerals and good drainage system which cause it to transform into goethite.

ASLC1-170

Phanerozoic Palaeogeography of Peninsular Malaysia: Overviews in Selected Time Periods

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Peninsular Malaysia constitutes the core of Sundaland that is largely a pre-Cenozoic composite terrane. It consists of two fundamental Palaeozoic terranes; namely, the Shan-Thai (=Sibumasu) block and the East Malaya block. The two blocks were united only at a Triassic time. Prior to it, there was no framework of today's peninsula. This short review aims at introducing our up-to-date knowledge about the palaeogeographic history of Peninsular Malaysia, with some episodes before and after the 'peninsula' was formed.

First, during the early Palaeozoic, Shan-Thai was part of northwestern Gondwana, as likely located in the Prototethys side. This is evident with sedimentological, volcanic and palaeobiogeographic records. For example, Siluro-Ordovician nautiloids from Langkawi (Shan-Thai) now firmly support linkage to the peri-Gondwana platform (e.g. Niko *et al*., 2017) (Fig. 1). Langkawi Islands in particularly demonstrate a near-complete set of Palaeozoic stratigraphy, which overall reveals the fact that Shan-Thai remained part of Gondwana until its breakup in the Early Permian. In contrast, East Malaya has no evidence of early Palaeozoic strata, although it may have the crustal basement.

Second, the Permian–Triassic was the most dynamic period for the tectonic history of the peninsula. Shan-Thai as part of the Cimmerian microcontinent ended its trans-Tethyan journey and eventually collided to the East Malaya and Sukhothai arcs at mid-Triassic time, culminating the Indosinian Orogeny (see Sone & Metcalfe, 2008a,b). As a result, the Palaeotethys ocean was closed along the Bentong-Raub suture. Later peninsula's foundations were established, and marine conditions were mostly terminated by the end-Triassic.

Third, a completely new environment emerged in later Mesozoic, that is, non-marine conditions prevailed over much of Peninsular Malaysia. Jurassic?–Cretaceous Fe-rich sediments were deposited in fluvial and lacustrine settings, as evident substantially in the inner parts of the peninsula. Dinosaur and non-dinosaur vertebrate remains now reveal some images of a Malaysian Cretaceous world. New palaeomagnetic results suggest that, during the late Mesozoic, Peninsular Malaysia was located at least 13° higher in latitudes than today (Otofuji *et al*., 2017) (Fig. 2).

Finally, Sundaland was ready to emerge in the Cenozoic. The major destructions to SE Asia has been ongoing since the Palaeogene. The recent palaeomagnetic data from the late Mesozoic sediments of Pahang reveal that Peninsular Malaysia experienced two phases of block rotations during the Cenozoic (Otofuji *et al*., 2017) (Fig. 2). First, a clockwise (CW) rotation, together with significant southwards displacement, took place between Eocene and Oligocene (55–25 Ma); the first time that evidence of a CW rotation with the primary remnant magnetisation was revealed from Peninsular Malaysia. This is interpreted owing to India's collision to Eurasia. Second, a counter-CW rotation occurred during the Neogene (after 25 Ma): we interpret this related to the collision of Australia to SE Asia. These deformations have contributed to the reshaping of Sundaland that we see today.

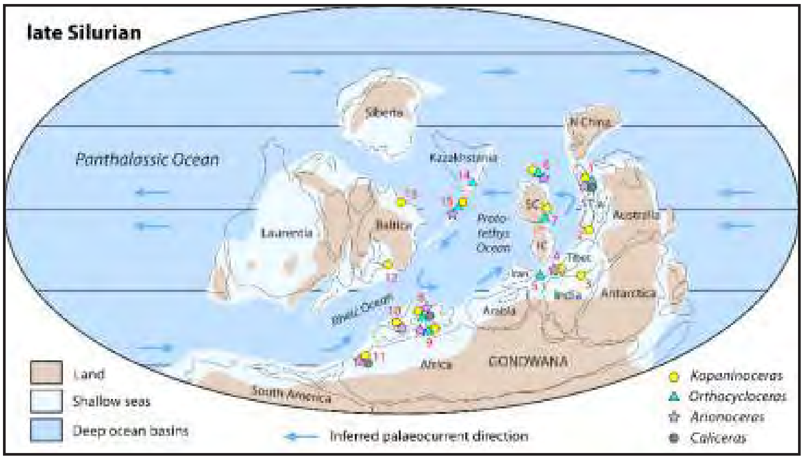

Figure 1: Silurian palaeogeographic reconstruction showing Shan-Thai (ST) within the peri-Gondwanan or circum-pan-Prototethys distribution of the *Kopaninoceras* nautiloid faunas (from Niko *et al*., 2017).

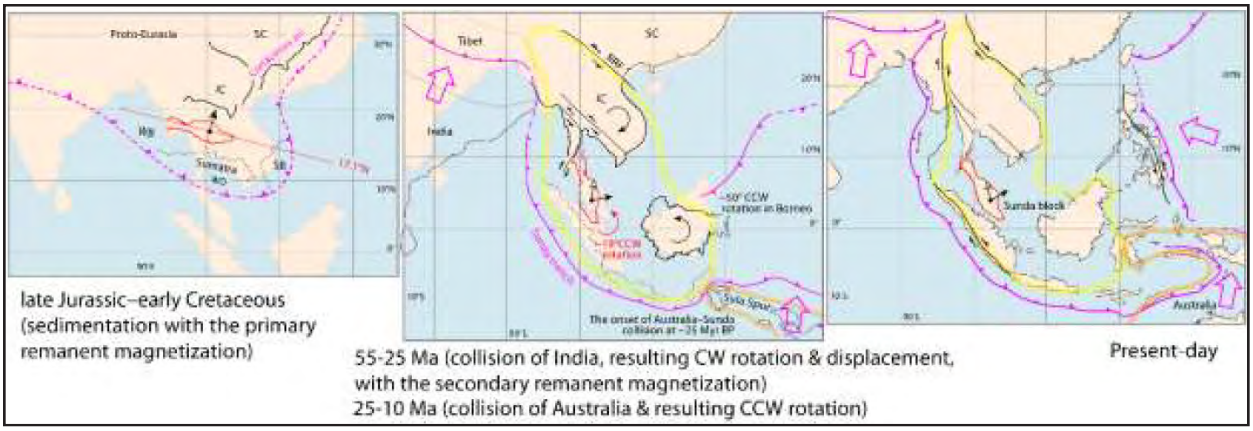

Figure 2: Late Mesozoic–Cenozoic evolution of Sundaland, showing two-phase block rotations (CW then CCW) of Peninsular Malaysia (modified after Otofuji *et al*., 2017).

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ASLC2-162

A-type Granite of Peninsular Malaysia and Comments on Tectonic Setting

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The granitic rocks of Peninsula Malaysia traditionally been divided into two provinces, i.e., Western and Eastern provinces, correspond to S– and I–type granite respectively. The Western province granite is characterised by megacrystic and coarse–grained biotite, tin–mineralised, continental collision granite, whereas, the Eastern Province granite is bimodal I–type dominated by granodiorite and associated gabbroic of arc type granite.

Recently, new A type granite have been reported by Ghani et al. 2014 in Besar island group (Besar, Tengah and Hujung islands) SE Johor. The main granite from the three islands (with average %) consist of K-feldspar (40%), plagioclase (20%), quartz (35%), biotite (<5%), amphibole (trace), apatite (trace), zircon (trace), sericite and chlorite. The granite is characterized by shallow level emplacement texture such as abundant granophyric. Quartz in the granophyric texture displays various shapes from rounded elongate to square to worm-like to tiny rounded shapes. The granite is highly felsic with SiO_2 ranging from 75.70% to 77.90% (differentiation index = 94.2 to 97.04), weakly peraluminous (average ACNK=1.02), normative hypersthene ranging from 0.09 to 2.19% and high alkali content (8.32 to 8.60%), high Ga, FeT/MgO and low P, Sr, Ti, CaO and Nb. All rock samples plot in the A–type field in FeOt/MgO vs Zr+Nb+Ce+Y, (b) $(Na_2O+K_2O)/CaO$ vs. Zr+Nb+Ce+Y, (c) K_2O/MgO vs. 10000*Ga/Al, (d) FeOt/MgO vs 10000*Ga/Al, (e) Ce vs 10000*Ga/Al and (f) Y vs 10000*Ga/Al diagrams.

Calculated zircon saturation temperatures for the Besar magma ranging from 793 to 806ºC which is consistent with high temperature partial melting of a felsic infracrustal source. The temperature of the Besar magma was higher compared with the haplogranitic magma (Chappell 1999) which represents a low temperature hydrous silicate melt in equilibrium with quartz and feldspar (Tuttle and Bowen 1958). It is generally accepted that the high temperature of the magma may suggest that the A–type magma originated from partial melting of tonalitic sources which could be one of the candidates for the Besar granite source rock. U Pb zircon age of the A type granite ranging from 280 to 281 Ma which suggested that they are among the oldest granitic rocks in Peninsular Malaysia.

It is generally accepted that the subduction of Paleo-Tethys oceanic floor beneath Indochina terrane started in Early Permian. The subduction will caused an early magmatism along the eastern margin of the Indochina terrane which will resulted in the development of the Sukhotai island arc system. Convection astenosphere driven by the downward drag of the downgoing oceanic slab will caused a spreading and produced the back arc basin behind the magmatic arc (Sukhotai Arc). Regional extension occurs when continental lithosphere breaks in response to long-lived mantle perturbations when hot mantle rises and erodes continental lithosphere, leading to full-scale rifting. These back arc basin now represent by Nan suture and Sra Kaeo suture of central and southern Thailand which can be traced southward to the eastern offshore Malay Peninsular. The extension will cause the hot asthenosphere rises, undergoes decompression melting, and induces melting in the overlying continental crust. Both regional extensional regimes have been proposed as likely tectonic regimes for A-type granites and related rocks.

ASLC3-97

Last Glacial Maximum (LGM) to Present Day Sea Level Change for Sunda Land Based on Geological Research, Tide Gauges and Satellite Data

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The Pleistocene Sunda land since 2.2. Ma has recorded many glacial and inter-glacial sea level cycles. From the LGM to the mid Holocene, sea level rose from about -125 m to about +5 m above present day sea level. After the high stand, this region generally experienced a regression phase which is evident from many regressive tract geomorphologic features visible on coastal areas today.

Past sea level change for Sunda land since LGM is examined from researches done on this subject from a localized study to the generalized Sunda sea level curve. As for present day or modern sea level change, this paper presents the current sea level change trend with the focus on the heterogeneity of sea level change in the Sunda shelf area that implied not just eustatic factor but differential crustal movement (tectonic factor) which further challenge the notion that Sunda shelf has been stable since early Pleistocene.

Tide gauge data of varying data lengths from 26 stations (Figure 1) and satellite altimetry data from Topex/Posiedon and Jason mission were analysed using simple regression after GIA adjustments were made. While a general trend of sea level rise of varying rates could be inferred, several areas indicated sea level drop probably caused by uplifting. However, the use of modern sea level measurements must take into account short term signals such as thermal expansion due to SST changes resulting from ENSO, water density changes, storm surges and hydrodynamics that form part of sea level records.

An interesting point to note from the results is that while North Borneo region (Figure 2) is still experiencing uplifting, its SLR trend is higher than the central part of Sunda land. This could be due to a more active tectonics, sea level change oscillations or hydrodynamics or other reasons worthy of discussions.

The potential impact of present day sea level rise on human is discussed also. Since the advent of mankind and consequent extensive occupation of coastal plains susceptible to the impact of sea level changes, SLR is fast becoming an issue in the light of anthropogenic induced global warming not just globally but also among South East Asian nations.

Figure 1: Tide Gauges (Source: adapted from PSMSL, GLOSS, UHSLC and Google Earth).

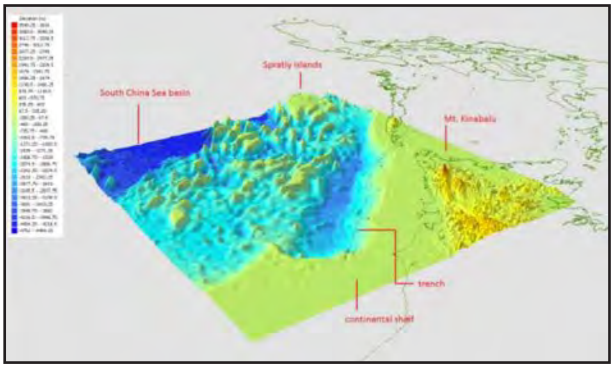

Figure 2: North Borneo DTM (Source: EdlicSathiamurthy & NOAA).

Perubahan Aras Laut Kuno di Barat Daya Semenanjung Malaysia: Bukti Litologi dan Tinggalan Cengkerang di dalam Sampel Teras Gerudi di Pontian, Johor

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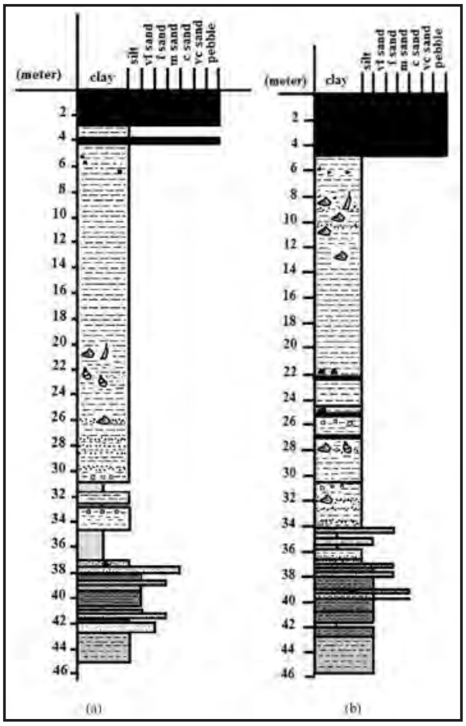
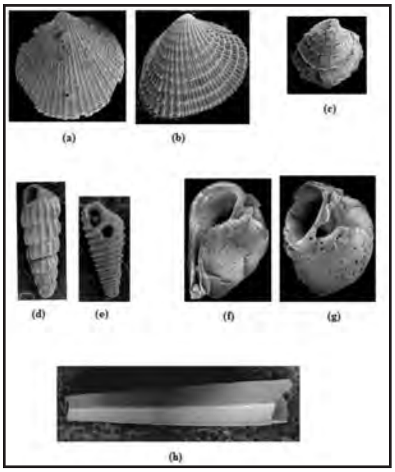
Kenaikan dan penurunan aras laut boleh menjejaskan sosioekonomi penduduk di kawasan tanah pamah di Malaysia, terutamanya di kawasan pantai. Kajian mengenai perubahan aras laut kuno perlu dilakukan untuk memahami ragam kejadian, dan seterusnya maklumat ini dapat digunakan untuk meramal perubahan aras air laut pada masa akan datang. Kajian perubahan aras laut kuno telah dijalankan di barat daya Semenanjung Malaysia, iaitu di Pontian, Johor. Dua sampel teras gerudi diperoleh menggunakan *Eijelkamp peat sampler*, diikuti dengan teknik *Mazier core barrel*. Perubahan aras laut kuno ditafsirkan berdasarkan perubahan litologi dan kandungan tinggalan cengkerang di sepanjang kedua-dua teras berkenaan. Kajian ini mendapati, kedua-dua teras gerudi (BH1=42.5 m dan BH2=42.3 m) menindih tidak selaras batuan dasar syal. Litologi aluvium terdiri daripada selang lapis lumpur berkarbon, pasir dan lempung (BH1=9.8 m dan BH2=8.4 m), ditindih tidak selaras oleh lempung tebal berwarna kelabu kehijauan (BH1=29.6 m dan BH2=29.4 m) dan lapisan gambut (BH1=29.6 m dan BH2=29.4 m). Tinggalan cengkerang di dalam lapisan berkarbonat pada beberapa kedalaman dikenalpasti sebagai bivalvia (Cardiidae dan Veneridae), gastropoda (Turbinidae, Nassariidae, Turritellidae dan Naticidae) dan skafopoda, menggambarkan jarak angkutan minimum di kawasan bertenaga rendah hingga sederhana. Kesimpulannya, jujukan selang-lapis lumpur berkarbon, pasir dan lempung yang lebih padat (endapan sungai) menindih batuan dasar syal. Apabila aras air laut kuno meningkat, sekitaran endapan bertukar menjadi *mudflat* dan muara sungai (lempung kelabu kehijauan yang mengandungi bahan berkarbon dan lapisan berkarbonat), dan seterusnya menjadi laut cetek (lempung masif). Kemudian, aras air laut turun semula (*mudflat* dan muara sungai) sebelum berlaku maraan paya bakau dan bertukar menjadi daratan (gambut).



Rajah 1: Teras gerudi terdiri daripada batuan dasar syal, lapisan jujukan selang-lapis lumpur berkarbon, pasir dan lempung yang lebih padat, lempung masif, dan gambut. (a) BH1 dan (b) BH2.



Rajah 2: Tinggalan cengkerang bivalvia, gastropoda dan skafopoda di dalam lapisan berkarbonat. (a) dan (b) Cengkerang hampir dewasa hingga dewasa. Filum: Moluska, Kelas: Bivalvia, Order: Veneroida, Famili: Cardiidae. (c) Cengkerang remaja. Filum: Moluska, Kelas: Bivalvia, Order: Veneroida, Famili: Veneridae. (d) dan (e) Cengkerang hampir dewasa. Filum: Moluska, Kelas: Gastropoda, Order: Cerithioidea, Famili: Turritellidae. (f) dan (g) Cengkerang remaja hingga hampir dewasa. Filum: Moluska, Kelas: Gastropoda, Order: Littorinimorpha, Famili: Naticidae. (h) Filum: Moluska, Kelas: Scafopoda.

ORAL PRESENTATIONS

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GEOHERITAGE

SESSION KEYNOTE

BDG21-166

Current Status of Geoheritage Development in Thailand

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Exploration and information dissemination for geological heritage conservation in Thailand is mainly under the responsibility of the Department of Mineral Resources (DMR); while the development of these geoheritage sites in the country could be operated by various organizations including: government departments, academic institutions, local communities or even private organizations. With its strength in geosciences together with demand of newer product creation of geotourism, DMR had initiated programs to promote and developed geoheritage and Geopark for number of provinces such as Ubon Rachathani, Khon Khen, Kalasin, Tak and Satun Provinces.

In the early stage, DMR had used its technical strength as the main approach to drive the development, with little active involvement from local agencies or communities. There were numbers of obstacles in the area such as the continuity in the development, initiative from local community or lacking of the sense of ownership. The desirable success, as a consequences, seemed to progress slowly.

In response, DMR had attempted number of approaches to remedy the situation. Importantly, with sharing experiences form networking organizations from many countries, DMR had gained more clear directions and cultivated more effective approaches to cope the situation. In addition, the UNESCO Global Geopark Guideline with which community engagement, visibility, networking and sustainable development being stated, had been adopted as their mainstream to all actions.

In Satun, the province with rich natures, active leaders and communities which majority preferred traditional lifestyles; things started to change their ways. These factors had strengthened and speeded up the development of geoheritage and Geopark in the country substantially. In 2016, Satun had applied for UNESCO Global Geopark title. It was the first time in Thailand and it was the place where certain UNESCO Geopark principles and guidelines had been explored and transformed into implementation. Experiences from networking in Asia-Pacific and around the world were carefully studied, customized and localized. The case also allowed DMR to device appropriate frameworks and mechanisms to promote and sustain each individual geoheritage and Geopark development. Moreover, by learning form Satun experiences, other provinces in Thailand could boost up their better practices and become a faster and more effective Geopark development.

SESSION KEYNOTE BDG22-167

The Development of Geoheritage and Geopark in Indonesia: Case Study in Petrolem Geoheritage Bojonegoro

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The development of geopark is increasingly vibrant in the world today, this is followed by the development of geopark in Indonesia. Proven now, Indonesia already has two International Geoparks (Batur Global Geopark in Bali and Gunungsewu Global Geopark in Gunungkidul, Yogyakarta) and dozens of National Geoparks as well as some National Geopark candidates including Petroleum Geopark Bojonegoro. Bojonegoro District very rich in resources including the hydrocarbons (oil and gas). Hydrocarbon is a non-renewable energy, so there is a possibility at one time that it would become depleted. In order to anticipate it, the development of the Bojonegoro Geoheritage is proposed at national level which include geological sites as: Watu Gandul, Selo Rejo & Sumber Air Panas, Gunung Watu, Banyu Kuning, Formasi Kalibeng, Dung Lantung, Kedung Maor, Goa Soko, Goa Fosfat, Makam Orang Kalang, Lokasi Penemuan Fosil, Penambangan Bentonite, Kayangan Api, Sendang Gong, Gunung Pegat, Struktur Lapangan Kawengan, dan Undak Bengawan Solo Purba dan Negri Atas Angin. These geosites will support the development of Petroleum Geoheritage Bojonegoro at National and International levels for natural geology tourism object and will be developed based on the concept of sustainable development. This Geoheritage area will be an alternative for income in Bojonegoro District if the hydrocarbon supply has depleted.

SESSION KEYNOTE BDG23-169

Current Status of Geoheritage and Geopark Development in Vietnam

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Located in a unique tectonic position and experiencing a long, complex and diverse history of geologic evolution, although covering not so big area, Vietnam is quite well-known with many types of geo-resources, in particular geoheritage. Considerable attention is being paid by Vietnamese geoscientists during the last two decades to geoheritage and geopark development. A recently completed State-funded research project (2008-2010) shows 10-15 perspective areas in North Vietnam. At the same time a Vietnamese-Belgian cooperative project (2007-2012) in Ha Giang, the northernmost and one of the poorest karst mountainous provinces of Vietnam, in addition, has helped to result in the first geopark in Vietnam in 2009, which was accepted into the Global Geoparks Network in 2010. An extension, but even more comprehensive, of the above-mentioned State-funded project was approved in the form of a Governmental Program by the Prime Minister in 2014, not only for the Southern part of the country where preliminary surveys also indicate 10-15 promising areas, but also for the development of several, most matured areas into geoparks. And in fact, works are on-going for the establishment of 4-5 geoparks in North, Central and Central Highlands of Vietnam. Recommendations are made for the systematic and well-founded development of the geopark network in Vietnam, including the preparation of the legal basis for the identification, assessment and appraisal of geoheritage and the establishment and management of geoparks, further survey works and especially the capacity building and awareness raising activities. A focal point for the Global Geoparks Program was set up at VIGMR in 2009 by the Vietnam National Commission for UNESCO, which was then in 2016 upgraded into the Technical Committee on Global Geoparks Program. The Vietnam Geoparks Network was also set up in the same year, which includes the existing Dong Van UGG and several national and aspiring geoparks. Also in 2016 the aspiring Non Nuoc Cao Bang Geopark in North Vietnam submitted its dossier for a possible approval by the UNESCO and an evaluation mission was held by a UNESCO expert team in Mid-July 2017. A plan to develop 3-4 geoparks is envisioned in the next 1-2 years and further on by 2020. Internationally, the country also actively participates in promoting this initiative, having successfully hosted the 2nd Asia-Pacific Geoparks Network Symposium in 2011 and attended all the UNESCO and APGN events.

SESSION KEYNOTE BDG24-168

Current Status of Geoheritage Development in Malaysia

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Geoheritage development endeavor started to bloom in Malaysia when a group of geoscientists formed Kumpulan Warisan Geologi Malaysia (Malaysian Geological Heritage Group) or KWGM in mid-1990s to face mounting challenge in shifting local geoscientists' paradigme towards sustainable utilization of critical geological resources of high intrinsic and extrinsic values. KWGM was pioneered jointly by academicians from various universities and researchers from Mineral and Geoscience Department. KWGM's strategic win win approach through geotourism - geoconservation concept had remarkably successful in convincing state and federal policy makers to fund research projects and adopting the research findings into their development guidelines and policies. Results from numerous highly rated research projects were communicated through series of National (now becomes Regional) Geoheritage Conferences and other national, regional and international conferences and dialogues, and published in series of books on *Geological Heritage of Malaysia*, and many other non-serial books as well as in national and international journal and proceeding articles.

Through continuous meetings and dialogues with spectrum of stakeholders, KWGM managed to persuade State Governments to develop areas with rich geoheritage resources into National and UNESCO Global Geoparks and to protect several geosites as National and World Heritage Sites and several geoheritage objects as National Heritage Objects. Today, Malaysia can be proud of its Langkawi UNESCO Global Geopark (UGGp) since 2007, Jerai and Lembah Kinta National Geoparks (since 2017), the nomination of Gombak Selangor Quartz Ridge into World Heritage Tentative List (since 2017), with several other geopark projects in almost every states, several nomination of National (Geological) Heritage Sites and several National (Geological) Heritage Objects kept in various geological museums across the counties. Furthermore, Malaysia through Langkawi UGGp proudly host the Asia Pacific Geoparks Network (APGN), hence become focal point for developing geoparks, geotourism and geoheritage conservation through series of regional workshops, training and short courses.

ORAL PRESENTATIONS

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ENGINEERING GEOLOGY

SESSION KEYNOTE BEG01-161

Understanding the Movement Behaviour of the Pos Selim Landslide Malaysia

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Evidence is presented showing that the Pos Selim landslide has experienced the four stages of movement of the standard model (Figure 1, after Vaunat *et al* 1994), pre-failure, failure, post-failure and active landslide; and there are three components of movement, seasonal surges, rainstorm-related surges and constant velocity movement (Figure 2).

The 190m high 9.5ha Pos Selim landslide formed within a 25ha cutting excavated for the second East-West Highway (Figure 3). Cracking at the main scarp and toe of the landslide appeared in 2002 (pre-failure) and rapid movement became evident in September 2003 (failure). Velocity peaked in October and declined until January 2004 (post-failure) (Figure 2). Thereafter the landslide surged seasonally (active landslide) (Figure 2).

The Cameron Highlands generally has two 'wetter' seasons each year. The pattern of seasonal surges is similar to the seasonal 30-day rainfall pattern (Figure 2). Short surges are superimposed on seasonal surges and some of these short surges coincide with individual rainstorms. The peak velocity of seasonal surges diminished year-by-year, though 30-day rainfalls were similar each year. Also the start of seasonal surges lagged behind rainfall in 2005 and no surge occurred in summer 2006. It seems the landslide was becoming less responsive to rainfall, less active, just as depicted in the standard model (Figure 1).

The periods of constant velocity seen between surges (4mm/day at cluster 2 Figure 2), as shown in the standard model (Figure 1), indicate viscous movement ('creep').

It's not only rainfall and creep that keeps this 3Mm^3 landslide on the move. A strong surge was triggered in November 2004 when about 100,000m^3 of ground was removed from the toe. The report by AML 2007 http://goo.gl/DJ03Ru has further details.

So far, the movement behaviour of the Pos Selim landslide is as expected from the standard model.

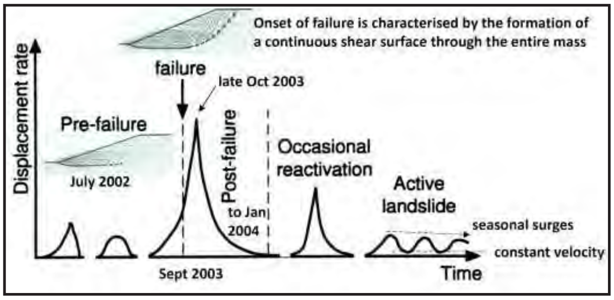

Figure 1: The four stages in the life history of a landslide, after Vaunat, J., Leroueil, S. & Faure, R., 1994 Slope movements: a geotechnical perspective. *Proc 7th International Congress International Association Engineering Geology*, Lisbon v1, 397-404.

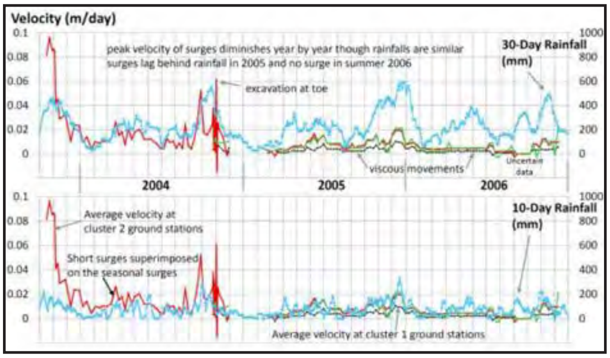

Figure 2: Average velocities at landslide ground stations (3 clusters) during total station monitoring (2003-6) with 30-day and 10-day rainfall at Cameron Highlands Station superimposed.

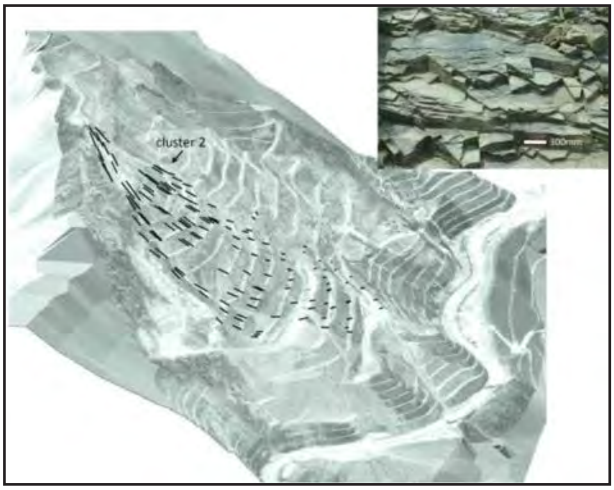

Figure 3: 3D visualisation of the excavated hillside (by A Hansen) showing the surface displacement vectors (2003-5) to scale. Inset: Several joint sets cutting the low-dipping foliation within the *Quartz Mica Schist Unit.* The quartz mica schists are generally strong and slightly to moderately weathered at outcrop within the cutting (using the terminology of MS 2038/2006).

SESSION KEYNOTE

BEG02-163

Earthquake Design Ground Motion Taking into Account Active Fault Displacement

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Until now, since there is no concrete synthesis method of design ground displacements for structures located near or cross the fault-rupture zones, thus in this paper, it proposed a procedure to conduct seismic analysis on fault-rupture crossing bridge structures. Firstly, relayed on the combination of stochastic Green's function method and theoretical Green's function method, a hybrid synthesis method considered the complete near-fault ground motions was adopted. Then based on the dynamic theory on multiple-support excitation method considering the fling-step displacements, the procedure for seismic design of fault-crossing bridge is briefly presented. And liner analysis on a simple 5-span bridge structure across a reverse surface fault was conducted. The calculation resulted that the non-synchronized excitations of time-histories of displacements lead to significant differences in the seismic behavior of fault-rupture crossing bridge structures. Furthermore, the effects of crossing angle between bridge and fault were explored. The research results could provide a useful reference for the design guidelines for such near-fault bridge engineering.

SESSION KEYNOTE

BEG03-85

Geological Discontinuity's Quantification: From Theory to Practice

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The surface roughness of geological discontinuities plays a significant role in influencing the peak friction angle, ϕ_p of these discontinuity surfaces. Its determination is of considerable importance in the assessment of the stability of open cut excavations as well as underground openings. Direct shear tests on natural (rough) discontinuities can be considered the most accurate method to determine the peak friction angle, ϕ_p and a significant number of publications have reported the results of large and elaborate testing, in particular in-situ testing especially in the 1960s and 1970s. However, this approach has a number of technical complications such as difficulties of sampling undisturbed discontinuities, test sample encapsulation and also the testing itself, not to mention the high costs of such tests especially in-situ testing and the difficulty of interpreting the results. The results of an alternative approach for the determination of this important parameter are presented here which is based on the opinion of Dr. Evert Hoek "that it makes both economical and practical sense to conduct many simple tests to obtain this parameter". In this approach, the Joint Roughness Coefficient, JRC of natural (rough) discontinuities is determined using a comb profiler (Fig. 1) and the peak friction angle, ϕ_p of the same discontinuity surface is measured using a self-fabricated tilt testing apparatus (Fig. 2). A total of 8607 tilt tests were conducted to obtain the correlations between peak friction angles with JRC for natural discontinuities of granite, schist, limestone, quartzite and sandstone. From these results, polynomial equations were derived to determine the peak friction angle, ϕ_p from the JRC values. The respective derived polynomial equations are as follows:

for granite $\phi_p = -0.071\ JRC^2 + 3.56\ JRC + 35.6°$
for schist $\phi_p = -0.022\ JRC^2 + 3.21\ JRC + 28.1°$
for limestone $\phi_p = -0.0635\ JRC^2 + 3.95\ JRC + 25.2°$
for quartzite $\phi_p = -0.083\ JRC^2 + 4.17\ JRC + 27.6°$
for sandstone $\phi_p = 0.0424\ JRC^2 + 1.13\ JRC + 29.2°$

For all the derived polynomials, the coefficient of determination, R^2 was greater than 0.9. The JRC can be determined as part of an engineering geological investigation and the respective polynomial applied to determine the peak friction angle, ϕp for the specific lithology. These results offer a low cost alternative for the determination of this important parameter.

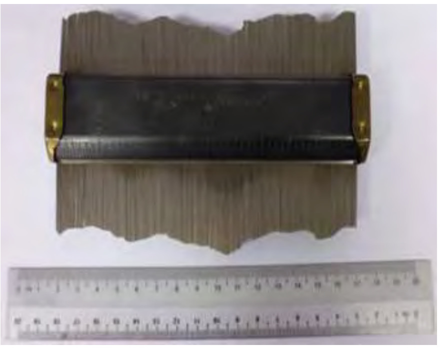

Figure 1: The 15 cm comb profiler or Barton comb for the determination of the joint roughness coefficient, JRC.

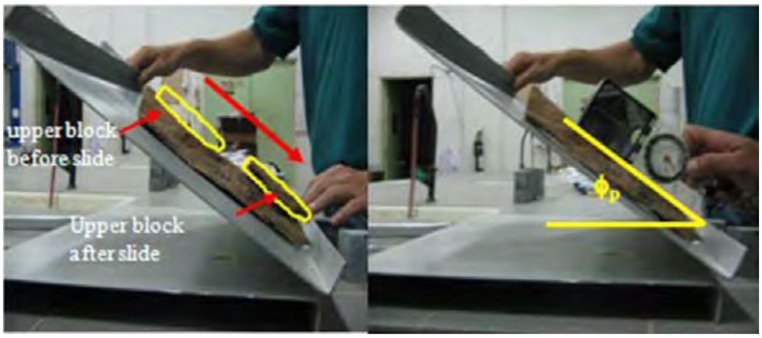

Figure 2: The tilt test apparatus employed for the determination of peak friction angle, ϕ_p (a) position of upper block before and after sliding (b) peak friction angle (ϕ_p) is measured after sliding of upper block.

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

BEG04-19

Geology vis-à-vis Tunnelling in the Kuala Lumpur Area

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Geology has a direct impact on tunnelling works. Risk assessment of potential geohazards due to various ground conditions (i.e. geology) is an important component in the planning and execution of tunnelling projects. This paper discusses the geology of the Kuala Lumpur (KL) area and its impact on recent tunnelling works carried out in the area. Previous papers on geology and tunnelling include Tan *et al*. (2012), Tan (2017) and Ting *et al*. (2007).

The rock formations encountered in recent tunnelling projects in the area include Granite, the Kenny Hill Formation, and the KL Limestone. Since these rock formations have their own unique features and characteristics, they impact tunnelling works differently. For example, granite exhibits distinct weathering profiles with possible boulders in the grade IV zone; hence potential soil-rock mixed face with boulders for the Tunnel Boring Machine (TBM). The Kenny Hill Formation comprises interbedded Quartzite and Phyllite, with the former having very high strength (Unconfined Compressive Strength, UCS of up to ~ 300 MPa) which impedes the progress of TBM. Quartzite is also highly abrasive to TBM cutters since its mineralogical composition is basically 100% quartz or silica (SiO_2). The KL Limestone is well known for its karstic features (irregular or pinnacled bedrock profile, cavities and solution channels, slump zone with Standard Penetration Test, SPT N = 0, etc.) which pose serious geohazards to tunnelling works.

In addition, superficial deposits such as Alluvium and Mine Tailings also pose potential problems since they are weak materials/soils. Mining slime deposits are particularly treacherous with SPT N = 0. The occurrence of mine tailings in the Limestone pinnacle zone can potentially trigger a sinkhole when intersected by a TBM.

Finally, geological structures such as major faults, quartz and granitic dykes which are prevalent in the KL area can also impact on tunnelling works. Tunnelling through major faults or fault zones would encounter highly crushed/brecciated rock weathered to soils (i.e. weak zones). Quartz dykes consisting of crystalline quartz would be highly abrasive to TBM cutters and impede TBM progress. Granitic dykes encountered tend to be weathered to weaker materials/soils. In any case, faults and dykes would serve as conduits for groundwater ingress into the tunnels.

Figures 1 and 2 show limestone and granite, and their impact on tunnelling.

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Figure 1: Karstic limestone exposed during mining.

Figure 2: Smooth circular section produced by TBM in granite.

BEG05-42

Dynamic Slope Stability Analysis During Sabah Earthquake

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An earthquake commonly triggers widespread and destructive damages; these can be building collapse, tsunami, liquefaction and landslide. The earthquake that struck west region of Sabah on June 5th, 2015, with a local magnitude of 5.9, has induced severe and extensive land instabilities in areas such as Ranau, Tambunan, Tuaran, Kota Kinabalu, and Kota Belud. Unfortunately, there is a very limited study on the earthquake induced landslide in Malaysia. Therefore, the aim of this study is to understand the mechanism of earthquake induced landslide. The slope instability at Sekolah Menengah Kebangsaan (SMK) Ranau is modelled using the 2D finite element method in RS^2 with imposing the seismic load. The earthquake time history from Kota Kinabalu station has been used. The displacement measured from the slope at SMK Ranau is used to verify the model and the effect of the seismic load has been monitored. It is important to understand the mechanism of earthquake induced landslide, in order to prevent the future slope failure and mitigation work that requires when dealing with the earthquake prone zone, in Sabah specifically.

BEG06-12

A comparative Parametric Study on Several Published Rock Slope Assessment Case Studies Using Limit Equilibrium Method

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Several case studies on rock slope stability assessment have been published and selected for this study including Tan (2004), Mustaffa & Tajul (2004), Abd Rasid (2005), Tajul & Nizam (2001), Edy Tonizam & Seyed Vahid Alavi (2011) and Aziman & Husaini (2001). All case studies used kinematic analysis to conclude their findings. Kinematic analysis is a method used to analyse the potential for the various modes of rock slope failures (plane, wedge, toppling), that occur due to presence of unfavourable oriented discontinuities. Kinematic analysis is based on Markland's test which is described in Wyllie & Mah (2004) which is based on Hoek and Bray (1981). It is happened that all case studies were in granitic rock. A comparative parametric study was carried out focusing on potential planar and wedge failure due to limitation of software availability. Limit equilibrium analysis is used to calculate factor of safety (FOS) of a slope against failure if the kinematic analysis indicates the potential for failure. Some assumptions have to be made such as slope height, unit weight, discontinuities condition, and groundwater conditions along the discontinuity plane in case these parameters were not mentioned in the papers. Three conditions of groundwater are used in this study, i.e. dry situation (0% of water), damp situation (50% of water) and wet/flowing water (100% of water). Results of this study are presented. Findings showed that discontinuity poles or great circle intersections plotting within kinematic envelopes on stereonets does not necessarily means there is possibility of rock failure on the slope that we are assessing. It just shows possible failure mode. There are a quite a few of other conditions that need to be satisfied before rock slope failure can happen. For future rock slope assessment works by engineering geologist, the authors would like to recommend the process should start with fieldwork follow with laboratory testing and kinematic analysis. The process should not stop at kinematic analysis. It should then follow with limit equilibrium before producing report and recommendation on stabilisation measures. Two different sets of analysis base on deterministic and probability approach may be produced should sufficient data available.

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BEG07-71

Shear Strength Variability of Graphitic Schist Derived from Weathered Hawthornden Schist

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In the Kuala Lumpur area, Gobbett (1964) identified two schist units, namely, the Hawthornden Schist which is a fine-grained black (graphite) schist, and lower down the sequence, the Dinding Schist which is a quartz mica schist and quartz-schist. Later Yin (1980) combined the two schist units into the Hawthornden Schist and he introduced another schist unit, namely Kajang Formation, for schist which have intercalation limestone. The Hawthornden Formation is originated from sediments which were deposited in western basin of Peninsular in the Middle to Upper Silurian time. The sediments has been both regional and thermally metamorphosed. The grade of metamorphism is generally low. It consists of mainly schist , phyllite and minor hornfels. It is found in the northern half of the Klang Valley. The foliation trend of the schistose rocks generally north-northwest and south-southeaster (Yin, 1980). This foliation direction changes locally, especially near the contacts with the granite where there is a tendency for the trend to be parallel to the contact. Shu (1989) mapped similar schist units in Jelebu areas (Negeri Sembilan) and estimated the schist units is almost 4000m in thickness. Similar schist units are exposed along the Senawang-Air Keroh (Melaka-Negeri Sembilan) section of the North-South Highway (Tan, 1992). Slope failures on cut slope which consist of weathered graphitic schist ourcrop along highway is reported (Tan, 1992).

The shear strength of soil and rock which can be developed along a surface through the material, is dependent on four main factors: (i) magnitude of the effective stress, s¢, acting normal to the surface, (ii) frictional properties of the material; (iii) dilatency, which is a measure of the volume increase or decrease experienced by the material when shear movement occurs, and other components of strength, such as cohesion, manifested by the bonding of particles(Fookes,1997). The shear strength of tropically weathered in-situ materials(TWIMs) derived from graphic schist was tested at four different angles orientation of undisturbed samples. The samples were tested using circular shear box under soaked condition therefore the influence of moisture condition is eliminated in this analysis. Index properties, mineralogy and micro-meso fabric form of tested samples is investigated. This paper give a description of the characterisation procedures used in the study of weathered in-situ geomaterial derived from graphitic schist outcrop on man made slope in Klang Valley. The evolution of microfabric due to weathering of parent materials together with mineralogy and index properties are shown to illustrate the application of the procedure. The result of strength variability of the TWIMs tested at horizontal(0^{o}), inclined 30^{o} and 60^{o} and vertical (90^{o}) to horizontal surface are shown. The directional shear strength test was carried out under fully drained condition using circular shear box. Sampling techniques used to collect orientated 'undisturbed' tube sample for shear strength and fabric orientation study are illustrated.

BEG08-139

Shear Strength Characteristic of Meta-Sediment Sandstone Rock Joint with Condition of Infilling Material

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In civil engineering, rock mass structures are importantly to be analyze for their stabilization and strengthening. There are many parameters that adopted in determining the strength of rocks such friction angle and cohesion. However, all these parameters significantly controlled by several factors such as joint infilling condition, weathering and joint roughness. The tropical climate in Malaysia which shows the rapid changes of temperature had accelerated the weathering process of the rock mass. This study attempted to determine the physical properties of rock joint infilling material in discontinuities meta-sediment sandstone rock joint and to evaluate the empirical relation between rock joint infilling thickness with rock joint shear strength of the sample. The Direct Shear test is a standard test used to evaluate the shear strength parameters. Meanwhile, the Schmidt Rebound Hammer test is introduced to classify the weathering grade of the host rock sample. The Joint Roughness Coefficient (JRC) assessment graphically classified the surface roughness profile. The tilting test generally was carried out to establish the basic friction angle of the natural jointed rock surface. Other physical properties were obtained such P-wave velocity from Portable Ultrasonic Non-Destructive Test (PUNDIT) and density for the rock sample. the cohesion values inversely proportional to the thickness of infilling material in rock joint. The increasing of the thickness may reduce the shear strength of the joints of rocks. In this condition, the friction resistance from rock joint surface foreseen decrease between each surface of the contacts area of rock and its made shear strength become low. The fine sand particles of infilling between the joint surface seems take the role to influence the shear characteristic by cohesion properties. Hence, this empirical relationship between the shear strength with infilling material in rock joint surface should properly estimate importantly to simulate the shear behavior in numerical analysis.

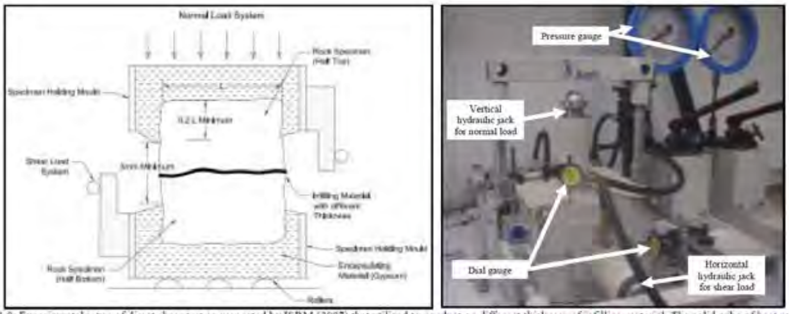

Figure 1.0: Experimental setup of direct shear test as suggested by ISRM (2007) that utilized to conduct on different thickness of infilling material. The solid cube of host rock with dimension of 150mm x 150mm x 30mm was splatted to create a jointed rock specimen with natural surfaces on joint surface and the infilling material was laid onto the joint surface with 3mm, 5mm and 10mm thickness prior with clean surface.

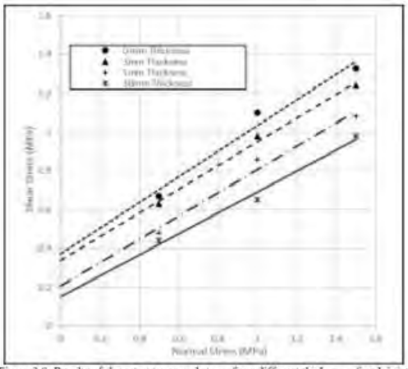

Figure 2.0: Results of shear test to normal stress from different thickness of rock joint infilling material. Consequently, the intersect of linear line with the shear stress axis indicated for the value of cohesion for the joint surfaces (Barton, 2013).

Table 1.0: Summary of basic properties of host rock sample

Properties	Classification / Characterization
Weathering Grade Classification	Grade I/II
Density, ρ (kg/mm^3)	2.829 x 10^{-6}
Average Rebound Hardness Number	46.0
Average P-wave Velocity (m/s)	4030
Basic Friction Angle, ϕ_{basic}	43°
Joint Roughness Coefficient, JRC	10-12 (Rough & Undulating)

$$\tau = C + \sigma_n \tan\phi \quad \text{(Equation 1.0)}$$

Table 2.0: Summary result of shear strength characteristic obtained from measured friction angle and cohesion values that adapted from linear shear strength parameter constitutive based on Mohr-Columb criterion.

Thickness of Infilling Material (mm)	Peak Friction Angle, ϕ	Cohesion, C (MPa)	Shear Strength, τ (MPa) σ_n = 1.50 MPa
0	34°	0.38	1.39
3	32°	0.34	1.28
5	31°	0.20	1.10
10	28°	0.16	0.96

BEG09-03

Kajian Kestabilan Cerun: Kajian Kes di Sekitar Kampung Kuala Abai, Kota Belud, Sabah, Malaysia

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PENGENALAN

Kegagalan cerun adalah isu utama dalam kehilangan nyawa dan harta benda hampir di seluruh permukaan bumi ini. Analisis kestabilan sejagat yang digunakan bagi rekabentuk cerun adalah kaedah stereografik dan kinematik, kinetik, kaedah numerkal, simulasi jatuhan batuan, pendekatan kebarangkalian dan sebagainya.

Kewujudan lebih dari satu (1) meter padu (m^3) jatuhan blok batuan pada kaki potongan cerun batuan di jalan Kampung Kuala Abai, Kota Belud menjadi isu untuk kajian ini.

Kawasan kajian didasari oleh formasi Crocker yang berusia Eosen Akhir-akhir Miosen Akhir dan telah mengalami sejarah tektonik yang kompleks dan memiliki struktur geologi unik (Rajah 1). Formasi ini adalah suatu endapan turbidit yang terdiri dari selang lapis unit batu pasir, batu lodak dan syal.

METODOLOGI

Metodologi yang digunakan adalah pemetaan geologi kejuruteraan, analisis kinematik (Markland, 1972), new approach of adjustment factor (NAAF) (Ismail Abd Rahim, *et al*., 2012), analisis ketumpatan kering (ISRM, 2007), analisis kinetik (Kliche, 1999), penentuan secara stereografik dan kaedah preskriptif (Yu *et al*., 2005).

KEPUTUSAN DAN PERBINCANGAN

Keputusan ujian Markland ditunjukan dalam Jadual 1. Ragam kegagalan adalah baji. Kegagalan baji berpotensi pada cerun 2 dan 3 tetapi hanya berkemungkinan pada cerun 1 dan 4. Kegagalan baji pada cerun 1, 2, 3 dan 4 secara kinematiknya terbentuk masing- masing dari persilangan satah B dan J3, J1 dan J2, B dan J2 dan J1 dengan J3.

Kestabilan cerun terpilih atau faktor keselamatan (F.O.S) ditunjukan dalam Jadual4. Kaedah had keseimbangan (analisis kinetik) menunjukan kesemua cerun umumnya adalah stabil. Kebanyakan cerun (cerun 1, 3 dan 4) dianalisis secara kergagalan baji. Cerun 2 juga dianalisis menggunakan kegagalan baji selepas didapati persilangan J1 dan J2 adalah kegagalan yang paling berpotensi melalui kaedah NAAF.

Hasil analisis kestabilan cerun terpilih di kawasan kajian didapati bertentangan. Analisis kinematik menunjukan ragam kegagalan baji adalah berpotensi, manakala analisis kinetik mendapati FOS adalah melebihi nilai satu (1) atau stabil (Jadual 2). Bagaimanapun, cerapan dan kajian mendapati faktor utama yang mengawal kestabilan cerun adalah unit litologi dan ketinggian. Kabanyakan cerun didominasi oleh lapisan batu pasir iaitu 70-95%. Kebanyakan cerun juga berketinggian kurang dari 10m dan merupakan cerun rendah. Secara teorinya cerun rendah adalah lebih stabil berbanding cerun tinggi.

Cadangan rekabentuk cerun adalah mengurangkan sudut cerun kepada 31°-45°, pemasangan jaring dawai, parit perangkap batuan dan kancing batuan secara terpilih.

KESIMPULAN

Kesimpulan kajian ini adalah;

1. Jenis ragam kegagalan yang berpotensi adalah baji.
2. Faktor keselamatan berjulat dari 1.93 hingga 4.43 dan cerun dianggap stabil.
3. Cadangan rekabentuk cerun adalah mengurangkan sudut cerun 31°-45°, pemasangan jaring dawai, parit perangkap batuan dan kancing batuan secara terpilih.

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Rajah 1: Kedudukan, cerun dan peta geologi kawasan kajian.

Jadual 1: Geometri, litologi dan jenis ragam kegagalan cerun terpilih**.**

Lokaliti	SF & USF (jurus/ mir)	Unit litologi	Tinggi (m)	Jenis ragam kegagalan (paling kritikal)	Satah DC	Satah kegagalan (jurus/ mir)
S1	280/55 & 280/12	S/lapis Ss dan Sh; dominan Ss (80%)	7.75	Baji	BK3	B-172/56 K3-300/64
S2	245/63 & 245/13	Selanglapis Ss dan Sh; dominan Ss (90%)	5.85	Baji	K1K2	K1-290/65 K2-185/79
S3	360/45 & 360/14	Selanglapis Ss dan Sh; dominan Ss (95%)	2.94	Baji	BK2	B-72/50 K2-299/66
S4	330/51 & 241/63	Selanglapis Ss and Sh; dominan Ss (70%)	4.68	Baji	K1K3	K1-300/80 K3-248/75

Nota: Muka cerun- SF; Muka cerun atas -USF; Ss- Sandstone; Sh- Shale; jurus/ mir- jurus/ kemiringan: DC- ketakselanjaran

Jadual 2: Sifat baji dan nilai F.O.S.

Lokaliti	Luas satah A (m^2)	Luas satah B (m^2)	Isipadu baji (m^3)	Berat baji (Kg)	F.O.S
S1	17.96	7.36	6.35	15049.5	1.93
S2	1.43	0.98	0.137	323.93	3.01
S3	4.07	4.34	1.66	3934.2	2.50
S4	3.07	2.36	0.48	1137.6	4.43

BEG41-100

Isu, Realiti dan Peranan Ahli Geologi Dalam Pembangunan di Kawasan Berbukit di Malaysia – Kajian Kes dari Projek Perumahan Mewah di Taiping, Perak

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Permintaan yang tinggi terhadap pemilikan rumah dan hartanah menyebabkan pembangunan di kawasan berbukit semakin meluas, terutama kawasan pinggir bandar di Malaysia. Pembangunan di kawasan berbukit selalunya berasosiasi dengan geobahaya kegagalan cerun dan/atau tanah runtuh. Aspek geobahaya dan geobencana di kawasan berbukit sering terabai pada pandangan masyarakat kerana status rumah mewah yang eksklusif di tempat tinggi seakan-akan menyembunyikan kewujudan ancaman geobencana. Objektif utama kertas ini ialah untuk menyaji dan membincangkan isu-isu geologi dan realiti sebenar yang berlaku dalam masyarakat kita di sebalik polisi, akta dan peraturan serta garis panduan untuk pembangunan di kawasan berbukit, berdasarkan sebuah kajian kes di Taiping, Perak. Kejadian tercetus daripada aduan seorang pemilik rumah yang tidak berpuashati dengan pihak pemaju tentang keadaan rumah mewahnya yang terletak terlalu hampir dengan cerun yang tampak berbahaya. Beliau berasa tidak selamat untuk menduduki rumah tersebut. Kajian geologi telah dilakukan bagi memberi justifikasi daripada perspektif ahli geologi professional. Geologi dan geologi kejuruteraan cerun telah dicerap dan dinilai melalui satu kajian lapangan yang ringkas dan tuntas. Kewujudan geobahaya dan risiko geobencana telah dinilai secara kualitatif melalui bukti-bukti lapangan dan rekod bergambar kejadian geobencana berskala kecil yang telah dirakam oleh pemilik rumah. Cerun yang dikaji terdiri daripada cerun potogan batuan granit terluluhawa tinggi. Jasad batuan pembentuk cerun itu juga berkekar baik dan turut dipintasi oleh sesar-sesar berkala kecil. Analisis kinematik terhadap data ketakselanjaran relikta mengesahkan kewujudan unsur ketakstabilan pada cerun dan berpotensi untuk gagal dalam bentuk baji, satah dan/atau terbalikan. Hasil analisis ini disokong oleh kewujudan parut-parut kegagalan berskala kecil dan bongkah batuan yang terkumpul dikaki cerun. Walaupun cerun telah dipasang dengan struktur jaringan wayar keluli, namun kaedah pemasangan dan rekabentuknya ternyata tidak menepati spesikasi kejuruteraan yang baik. Daripada kajian kes ini, ternyata isu keselamatan dan hak pengguna yang membeli rumah di kawasan berbukit telah terabai dan dikesampingkan oleh pihak pemaju dan juga pihak berkuasa tempatan. Keadaan bertambah buruk apabila di bahagian atas cerun tersebut terdapat sebuah lagi projek mewah sedang rancak berjalan, yang mengubah keadaan fizikal dan geomorfologi cerun. Persoalannya bagaimanakah pemaju masih boleh terlepas daripada peraturan, garis panduan dan akta-akta yang wujud bagi mengawal pembangunan di kawasan berbukit. Realiti sebenarnya sangat sedih dan mengecewakan. Masih wujud pembangunan rakus yang mengancam nyawa dan keselamatan harta benda walaupun negara kini sedang pesat mengorak langkah menuju status negara maju dengan hasrat persekitaran kehidupan lestari. Oleh itu, ahli geologi perlu berperanan secara lebih proaktif dalam meningkatkan kesedaran awam tentang penilaian geobahaya dan risiko geobencana di kawasan berbukit. Pada masa yang sama ahli geologi yang terlibat perlu memperkasakan diri dan diperkasakan lagi dengan kuasa untuk mengawal pembangunan di kawasan berbukit.

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BEG42-51

Penilaian Cerun Batuan di Tapak Bekas Kuari untuk Tebusguna Pembangunan-Kajian Kes di Kuari Granit Kajang, Kajang, Selangor

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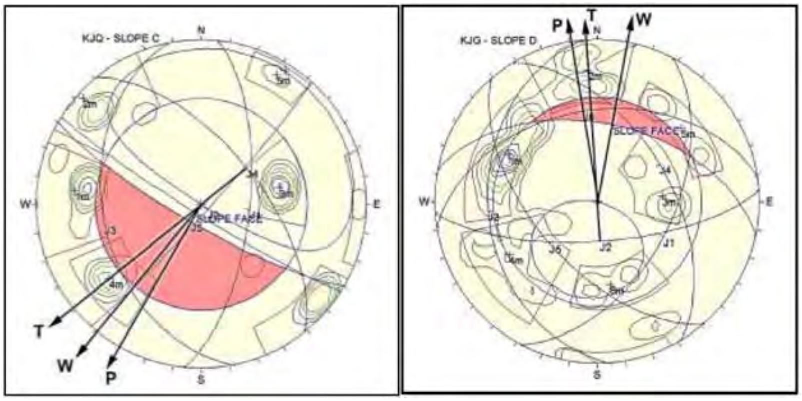
Penggunaan kawasan bekas kuari yang ditebusguna bagi pembangunan komersil semakin meningkat terutamanya di kawasan bandar. Bekas tapak kuari seperti Taman Bukit Permai, Cheras telah dibangunkan bagi tujuan pembinaan unit-unit perumahan. Keadaan yang sama turut berlaku pada Kuari Granit Kajang yang terletak di Daerah Kajang, bersebelahan dengan Lebuhraya SILK. Kawasan bekas kauri ini telah dicadangkan dibangunkan dengan unit perumahan dan unit komersil. Kawasan bekas kuari yang dikelaskan sebagai Kawasan Sensitif Alam Sekitar perlu dilakukan pemetaan kejuruteraan terperinci bagi memastikan keselamatan terutamanya pada cerun batuan. Penilaian cerun dilakukan menggunkan dua kaedah iaitu tafsiran lineamen dan pemetaan lapangan. Tafsiran lineamen menunjukkan kehadiran 4 set yang berorientasi barat laut-tenggara, hampit utara-selatan, timur laut-barat daya dan timur timur laut-barat barat daya. Hasil pemetaan menunjukkan cerun berpotensi untuk mengalami pelbagai kegagalan seperti kegagalan baji, satah, terbalikan atau gabungan antara kegagalan tersebut. Kesan daripada penggunaan kaedah letupan telah menghasilkan jasad batuan yang hancur, mempunyai blok –blok yang longgar dan tergantung serta tidak stabil. Saiz blok yang pelbagai berpotensi untutk gagal dalam bentuk jatuhan batuan. Pilihan sistem mitigasi yang sesuai perlu untuk menstabilkan cerun potongan tersebut.

Rajah 1: Tafsiran lineamen di kawasan kajian menggunakan imej satelit daripada Google Earth.



Rajah 2: Analisis kinematik kestabilan menunjukkan potensi kegagalan pada cerun potongan.

BEG43(PBEG13)-113

Relationship Between the Static and Dynamic Elastic Modulus in Limestone Rock Material

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Elastic moduli are a set of constants that defines the deformation behavior of rock material that undergoes stress and strain. The characterization of rock material was studied through the Young's modulus parameter which describes the relationship between the load applied to the rock material (stress) and the deformation (strain) resulting from the stress. In measuring Young's modulus, two available methods are available which are the static and dynamic methods. The characterization of rock material by using static method is a more accurate method, where it involves direct measurement where rock samples are subjected to a uniform reinforcing stress and thus measuring the strain resulting from the stresses. The static measurement is more accurate because the performance of the rock material can be viewed and analyzed more accurately with every increase in stress applied until failure occurs. However, the characterization of deformation by using the static method involves time-consuming laboratory measurement, which also expensive to conduct and requires complex procedures. In addition, the characterization of rock material using the static method is destructive, which is unfavorable especially when availability of specimen is scarce. Therefore, the application of dynamic method is used in change for the static method. The characterization of rock material by using dynamic method is a more common method due to its simplicity, inexpensiveness, time-saving and non-destructive. This paper presents the relationship between the static and dynamic elastic modulus in limestone rock material from a set of 15 static and dynamic testing. The results confirmed the differences in both of the measurement. A linear equation of $E_s = 0.9264 (Edyn) + 0.4976$ was proposed to predict the values of static elastic modulus from dynamic elastic modulus.

BEG44-43

Establishing the Hydrological Conditions Beneath an Unlined Municipal Landfill and an Engineered Landfill Site in Malaysia Using Numerical Groundwater Flow Models – Case Studies

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As part of the measures to initiate effective remedial program once aberrations are detected, numerical groundwater flow model is the effective tool to understand the hydrological conditions beneath the subsurface. An unlined ex-landfill site in Kuala Lumpur (Site A) and an operating engineered landfill site in the coastal area of Pahang (Site B) were investigated. Visual MODFLOW (VMOD) flex models was used to establish the groundwater flow system at the two-landfill site. MODFLOW 2005 engine code was used to construct the groundwater flow models while the flow path of particles was modelled using MODPATH. The groundwater flow model for Site A was calibrated and modelled as a three (3) layer steady-state VMOD flex model while Site B was set up as a (6) layer transient groundwater flow model. The steady state groundwater models for Site A was simulated for a model time scale of 30 years while the transient's groundwater model for Site B was simulated for Five (5) different modelling time scale up to 30 years. The steady - state VMOD flex model revealed that the hydraulic gradient in Site A is mainly from the north-west around the landfill area and groundwater flow is discharging in the north-east and south-east in the river and ponds located within the landfill site. The entire VMODFLOW flex transient simulations for Site B generally indicate that the hydraulic gradient originates from the northern boundary of the site and the general trend of groundwater flow is in the north-southeast directions towards the eastern boundary of the project site and discharging to the South China Sea which is located at 3km east of the site. In addition, the pond at Site A is discharging directly to the aquifer at Layer 2 (silty SAND). While at Site B, the retention pond is hydraulically connected to the Layer 2 (sandy clayey SILT) and equally providing seepages to the Layer 3 (shallow silty SAND aquifer). MODPATH demonstrate that the major groundwater flow (or movement) in Site A is in the Layer 2, (Silty SAND formation) which is the main aquifer at the site and where most of the groundwater is located. In contrast, at Site B the major groundwater flow is in the shallow silty SAND aquifer (Layer 3) rather than the deeper aquifer (layer 5) at the site where the greatest potentials for groundwater could be located. The VMOD flex models' simulations signify that the pathways in which contaminates will follow is largely dependent on the directions of groundwater flow at the site. It is recommended that the aquifer, ponds and river at the sites should be protected from surface contaminations because the impact of groundwater contamination will be direct on the aquifer at Layer 2 (silty SAND layer) at Site A, while the effect is expected to be minor at the aquifer at Layer 3 (shallow silty SAND aquifer) at Site B due to confining- unconfining sandy CLAY layers. This paper showed that the numerical groundwater flow modelling for analyzing and solving groundwater problems is a useful tool for evaluating the hydrological conditions in the groundwater regime at the two landfill sites.

BEG45-50

How Detailed Geological Observation During Drilling Helps to Understand the Aquifer Behavior: A Case Study of UKM Bangi, Selangor, Malaysia

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Currently, there are 10 abstraction wells installed in Universiti Kebangsaan Malaysia (UKM) Bangi campus, with depth ranging between 70 and 135 meters. There are located at Kolej Keris Mas (three wells), Kolej Aminuddin Baki (two wells), Kolej Burhanuddin Helmi (two wells) and Kolej Ungku Omar (three wells). The wells at Kolej Keris Mas were installed in 2005 while the other wells were commissioned in 2015.There are also seven shallow wells (< 5 meters depth) at various locations UKM Bangi campus. The abstraction wells were built to overcome the prolonged water crisis in UKM particularly those occurred during dry months which is in February and June. These wells lie in fractured interbedded sandstone and shale of Kenny Hill Formation with low grade of metamorphism. Quartz veins were observed as parallel and also perpendicular to the bedding. This paper aims to highlight on how the detail geological observation during the drilling stage will help to understanding the aquifer behavior and also will help to solve the problems arise during monitoring stage.

Keywords: fractured rock aquifer, Kenny Hill Formation

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BEG46-114

Evaluating the Suitability of Shallow Aquifer for Irrigational Purposes in Some Parts of Kelantan, Malaysia

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Groundwater is a very important asset to the people of the Kelantan, Malaysia where most the water requirements are met by groundwater. Groundwater serves as the most reliable source of water for their domestic and agricultural activities. This study was aimed at assessing the suitability of groundwater for irrigational purposes in some selected communities of Kelantan where farming activities are very intensive. Thirty-two (29 groundwater and 3 surface water) samples were collected and analysed for major anions and cations. Physicochemical parameters such as electrical conductivity (EC) and total dissolved solids (TDS) were also measured. From the results of the analyses and measurements, the suitability of the groundwater for irrigation were evaluated based on the TDS, EC, percentage sodium (%Na), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), Boron classification and Nitrate. US salinity laboratory (USSL) diagram and distribution maps of different parameters were also applied in the present investigation. In terms of quality assessment as irrigation water, the analysis from SAR plots indicates that groundwater are categorized in excellence class. In sodium percentage technique, most of the samples are plotted in doubtful class with few samples in permissible class. In residual sodium carbonate technique, majority of the samples exhibit doubtful class with only few samples in permissible limit. Other samples recorded are not suitable for irrigation. Based on the boron classification, almost all of the boron concentration suggests excellent water class in the study area. The groundwater in the study area is generally good for irrigation purposes. However, there are few instances which are problematic and would require special irrigation methods.

ORAL PRESENTATIONS

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MINERAL RESOURCES

SESSION KEYNOTE CMR01-122

Social and Economic Impacts of Applied Mineralogy

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Most of us use the products of modern technology without fully appreciating which minerals are required to make a cell phone, a modern internal combustion engine, an aluminum can, ceramics and the concrete used in buildings. For example, in Japan, all students in junior high school have to learn "what are minerals" and "what is the definition of minerals" with some examples from rock-forming minerals such as quartz, feldspar, mica, and so on, although the author does not know the situation of minerals in education at other countries. I suppose that the situation is not so different in different countries. However, as stated in the special issue of Elements on "Social and economic impact of geochemistry", minerals are definitely central not only to our natural and technological environments but also to our social and economic environments. Environmental mineralogy is a fast-growing multidisciplinary field, addressing major societal concerns about the impact of anthropogenic activities on the global ecosystem. However, mineralogists are still not very good at communicating the social and economic impacts of mineralogy to the public. Of course, minerals may sometimes inspire us to design new materials for advanced technologies. Minerals and mineralogical processes such as adsorption, sorption, and precipitation may play an important role to solve problems in negative legacy such as pollution, health effect, and waste disposal. The author, as an environmental mineralogist, has been involved in many activities against the negative legacies of the accident and contamination and positive new discovery of advance technology. In this presentation, the author shows how applied mineralogy has been and will be an important component in social and economic impacts based on the author's experiences.

SESSION KEYNOTE CMR02-73

Silica Sand Processing

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Sources of silica sand in Malaysia may come from beach sand, tailing sand, sea sand, and river sand. These sands can be used directly, or may need some beneficiation before it can be used by the various industries. Processing methods that are frequently used by the silica sand producers include sizing, the removal of impurities by spiral concentrator, attrition scrubbing, magnetic separation, high tension separation and froth flotation.

Silica sand deposits in Malaysia are not suitable for use in the glass industry until it has been beneficiated to certain limits of coloured mineral such as iron oxides, and minimum refractory minerals such as zircon and rutile. Besides that, size and shape of the silica sand particles also play an important role in the making of glass.

The availability of high grade silica sand deposit in Malaysia, at a relatively low price, is almost non-existing. Potential deposits need a series of processing methods to up-grade its silica content before this commodity can be sold at a reasonable market price. This is because the various stages of processing, to upgrade its quality, directly increase the operating cost and time.

This paper discusses the research on a few silica sand deposits found in Malaysia. The techniques used in this work are batch processes, and may be combined in various ways to complete the processing circuit until the quality of the silica sand products have achieved the market requirements.

SESSION KEYNOTE CMR03-16v2

Critical Minerals in Facing the Challenges of a Sustainable Tomorrow

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It is important to distinguish between environmental disasters that are attributed to natural geological processes, which are generally irregular, haphazard, sudden and violent, and environmental issues that are man-made, which are more regular, occurs mostly in areas of human activities, and less violent, but just as hazardous.

Most people are quite aware of man-made environental issues. However, few members of the public are aware that minerals also provide major solutions to the environmental problems created by humans, in their voracious appetitie for industrialization and infrastructure development.

Some critical minerals have been identified and engineered, to be made suitable for reducing the negative effects on the environment (environmental remediation), based on what is required by the industries. Discussions will centre on understanding in which industries these minerals are used and, and the reasons why they are used, in order to develop creative solutions to existing, and to new environmental problems. Minerals do not replace technological or engineering solutions to environmental problems, but instead, complement them. Existing industries include those from the mining, extraction, power, cement, construction, chemical plants, metallurgical, steelmills, ceramics, glass, paints, rubber, plastics, electrical and electronic, petroleum, agriculture and even the aerospace industry.

We need to further develop continuous, systematic, relevant mineral education and training to current and future generations of the mining industry/fraternity and public at large, to be aware of the possibilities of minerals in solving or reducing some of the environmental issues. This shoud include implementing environmental management standards, in all the industries, and in all relevant government instituitions, to ensure Malaysia moves rapidly towards sustainable developed nation status by 2020.

CMR04-123

Suitability of Various Malaysian Clays for Ceramic Tiles Manufacturing

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Clays are one of the most important raw materials in manufacturing of ceramic tiles. The application of clay in ceramic tile is highly dependent on the properties and characteristics of the clay minerals. For ceramic tile industries in Malaysia, clays were mainly obtained from the states of Johor and Selangor, due to the advantages in transportation cost and specific properties in the development of ceramic tile body formulation. The aim of this research work is to determine the suitability of various clays in Johor (Kahang, Chamek, Nitar and Jemaluang) and Selangor (Batang Berjuntai) as the main material of ceramic tiles. The Batang Berjuntai clay has been identified as a good plastic clay for the ceramic tile industry, due to the high dry modulus of rupture, which is above 50 kgf/cm^3 and is crucial for processing of ceramic tiles prior to the firing operation. For Chamek clay, it is considered as a semi plastic clay with fluxing characteristics. Both Kahang and Nitar clays have been identified as sandy kaolin clays, with advantages in fired colours above 85, which is suitable to be used for technical porcelain. Jemaluang clay has important fluxing characteristics and is able to reduce the usage of feldspar in ceramic tile body formulation. Therefore, the suitability and application of the studied clays in manufacturing of ceramic tiles, are highly dependent on the properties and characteristics of the clays.

CMR05-41

3D Magnetic Modelling For Iron Ore Exploration in Gambang, Kuantan, Pahang

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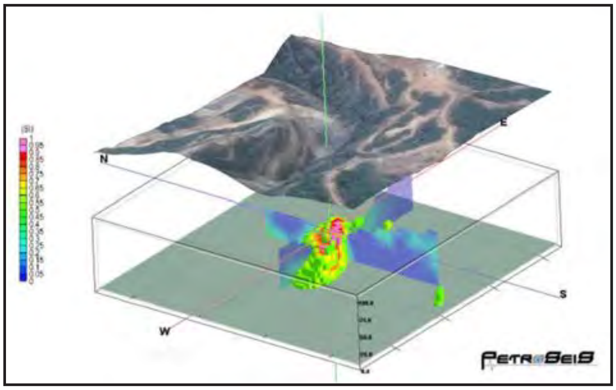
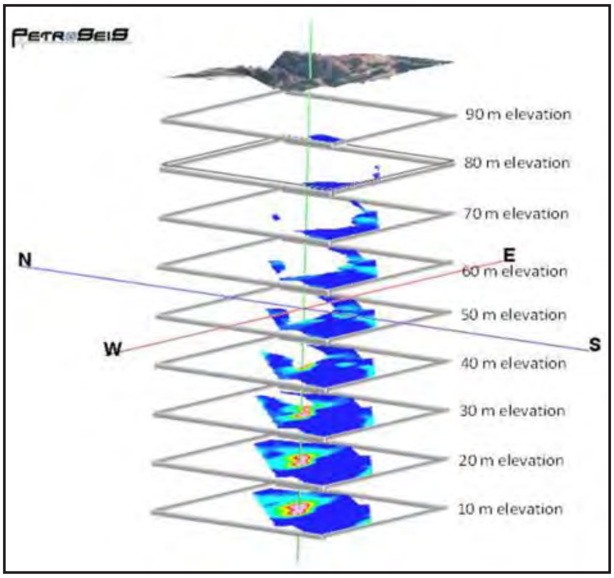
The geology of the survey area at Gambang consists of weathered soil near the surface with underlying meta-sedimentary rock, which was formed as a result of contact metamorphism from the granitic body at deeper zone. The meta-sedimentary rocks are mainly grey colour hornfels with poor lineation and shale in some places. Mineralisation of iron ore occurred as isolated body within the meta-sedimentary rock. The iron ore deposit is mainly Magnetite associated with Pyrite, Chlorite and Galena. A ground magnetic survey conducted within the area has enabled detailed mapping of the iron ore deposit, which lead to 3D magnetic modelling of the ore body.

More than 500 magnetic station readings with 10m spacing were collected within the 4.5 hectares area. The magnetic data were processed to obtain a diurnal effect corrected, reduced-to-equator Total Magnetic Intensity (TMI) map, which represents the actual magnetization for the survey area. A negative magnetism area of -1000nT to -6000nT with lower magnetic values concentrated in the centre portion is identified as the magnetic anomaly. The magnetic readings in surrounding area range from 0 to 1000nT. The anomaly is interpreted as a causative body with a higher susceptibility near the surface and extends downward. An Analytical Signal (AS) map, which is defined as gradient of magnetic force, shows an area of high magnetic gradient which can be correlated to the magnetic anomaly found in TMI map. In addition, a 3D modelling based on the susceptibility contrast was constructed to study the subsurface distribution of this magnetic anomaly.

The 3D inversion of magnetic data shows an area of high magnetic susceptibility with the dimension of about 100m x 30m, and oriented in NE-SW direction. Based on 3D inversion modelling, the ore body is measured to be 20 to 40 metres thick and dipping towards the southwest. This 3D modelling result was found agreeable to the field observation and borehole data.





CMR06-30

Potential of Rare Earth Elements (REE's) in Sediments of Labuan Island, Malaysia

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Labuan is one of the three Federal Territories in Malaysia located 10km from Borneo Island coast which is in the west coast area. Consisting of five lithological units; Crocker Formation, Temburong Formation, Setap Shale, Belait Formation and Quaternary alluvium, Labuan Island become one of the important sources to study the sedimentary strata of the island. The main objective of this study is to distinguish the distribution of rare earth elements at five localities named BH1, BH2, BH3, BH4 and BH5 within the area 97km^2. As the demand for rare earth elements (REEs) continues to increase, many efforts have been made to reestablish mining and production of REEs. Results from Inductive Coupled Plasma Mass Spectrometry (ICP-MS) analysis which have been carried out to find the concentration of lanthanum and terbium showed that concentration of REEs in BH1 is 1265.7 ppb, BH2 1590.8 ppb, BH3 2124.8 ppb, BH4 1259.4 ppb, and BH5 1934.0 ppb. Highest concentration of REEs was recorded at BH3 followed by BH5, BH2, BH1 and lowest concentration of REE's was at BH4. This study revealed that enrichment of REEs occurred at area which near to Crocker Formation and Belait Formation.

CMR07-117

Ketulenan Batu Silika Permatang Kuarza Genting Klang, Hulu Kelang, Selangor Berdasarkan Analisis Geokimia

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Permatang Kuarza Genting Klang terletak lebih kurang 9.5 km daripada Kuala Lumpur merupakan telerang kuarza yang terpanjang di dunia. Ia memiliki panjang lebih kurang 14 km dengan kelebaran 50 m serta ketinggian lebih daripada 300 m daripada aras laut. Kajian ini dilakukan untuk melihat ketulenan batu silika Permatang Kuarza Genting Klang berdasarkan analisis geokimia untuk diketengahkan sebagai satu sumber nilai intrinsik. Ia boleh dijadikan satu aspek penilaian untuk memartabatkan Permatang Kuarza Genting Klang sebagai geowarisan. Terdapat 61 lokaliti cerapan telah dijalankan semasa kerja lapangan. Daripada jumlah ini 36 sampel telah dipilih untuk dianalisis geokimia secara XRF untuk mendapatkan unsur-unsur major, minor dan surih. Ketulenan batu silika dilihat kepada peratusan unsur SiO_2, Al_2O_3, Fe_2O_3 dan TiO_2. Nilai purata peratus berat SiO_2 bagi 36 sampel ialah 97.66 wt% dengan julat antara 94.7 wt% hingga 99.2 wt%. Nilai ini menunjukkan batu silika di Permatang Kuarza Genting Klang adalah bermutu tinggi kerana melebihi 95.0 wt% bagi SiO_2. Nilai peratusan purata unsur-unsur Al_2O_3, Fe_2O_3 dan TiO_2 adalah masing-masing 1.10 wt%, 0.04 wt% dan 0.01 wt%. Unsur-unsur ini menganggu ketulenan batu silika. Kebiasaan di dalam industri, nilai minimum yang dibenarkan adalah kurang daripada 0.05 wt% bagi Fe_2O_3 dan TiO_2, sementara 1.0 wt% bagi Al_2O_3. Berdasarkan nilai geokimia ini, batu silika Permatang Kuarza Genting Klang dikelaskan sebagai batu silika bermutu tinggi dalam industry. Namun begitu, nilai geowarisan dengan mengekalkan kewujudan Permatang Kuarza adalah lebih tinggi bagi generasi akan datang.

CMR09-94

Geological and Electromagnetic Studies of Mukah Coalfield Area, Sarawak, Malaysia

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Tertiary coal seams in Mukah Coalfield appeared to be not continuous laterally in terms of depth and thickness of the seams. This may be attributed to the tectonic events in the past which had also resulted in the formation of Teres-Bakau anticline and Badengan syncline found in the area. Numerous localized faults with significant displacement are found to be common in Mukah Coalfield which increase the tectonic complexity of the area. The complexity posed a challenge in estimating the amount of coal that can be economically extracted. A preliminary Transient Electromagnetic (TEM) survey was conducted to delineate the coal seams in the Mukah Coalfield area in order to find out the direction of the coal seams extension. It is found that the extension of the coal is trending East-West and dipping South. The coal seams were detected at the depth of 13 m and were observed to be going deeper towards south reaching the depth of 29 m. A possible fault was also detected in the model produced.

CMR41-153

The Use of Isotope and Geochemical Techniques for Geothermal Reservoir Studies, in Tawau, Sabah, Malaysia

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The main objectives of the studies were to determine the baseline isotopic and chemical characteristics of the geothermal outflowing fluids and the surface and shallow/deep groundwater systems which are useful to determine the recharge zones and origin of the water. The isotopic and geochemical data obtained may assist in assessment of geothermal resource potential and development. The extended sampling programme includes sampling for Tawau precipitations, catchments/surface waters, hot and cold springs for isotope and hydrogeochemical analyses. Isotope samples collected includes 18-O, deuterium and tritium. The data for 14-C/13-C (TDIC), 34-S/18-O (ppt.) were taken from the similar program, prior to this extended sampling. The hydrogeochemical samplings were mainly for the hot spring waters to determine the water type and the level of solutes in the geothermal waters. The isotope and geochemistry data may be used to estimate the subsurface or the reservoir temperatures. The sampling programme for Tawau precipitations includes at least one hydrological cycle in various catchments areas, to form the regression line for Tawau area. This regression line are created for the first time in this area. From the studies done, geochemically the water type in the Tawau geothermal prospect are steam-heated waters of typical upflow zone i.e high in SO_4 and low in Cl contents in the Upper Tawau River(T2) and Balung areas. In the Lower Tawau River area (T1), the water type is chloride-bicarbonate i.e high in Cl and HCO_3 contents and in the Apas Kiri area, the water type is chloride which is typical of the outflow zone of a geothermal system. The plot for Na-K-Mg for Apas Kiri geothermal waters shows that the waters are partially equilibrated, and plot for Cl-SO_4-HCO_3 shows that the waters are near matured chloride waters. Isotopically, the water in the Apas Kiri is enriched. The δ18-O is about -5‰ VSMOW and the δ2-H is about -45‰ VSMOW. The geothermal waters, which is δ18-O shifted for about -2‰ VSMOW from the surface waters, indicate that the old geothermal waters are in non-mixtures with the young groundwaters. This indicate that, the reservoir is capped by a confining sequence, in this system case called 'clay cap'. The clay capping is one of the indications of a promising and stable geothermal reservoirs. For the Apas Kiri geothermal prospect system, the sub-surface temperature estimated by using several Na/K geothermometers are in the range of 185.7 – 220.3°C (Fournier 1979), (158.3 – 198.9°C, Arnorsson, 1983), 203.0-235.4 °C (Giggenbach 1988), 149.1-191.8°C (Truesdell 1976). By using several quartz geothermometers, the range of 188.9-202.1°C (F&P, 1982), 169.1-187.8°C (Arnorsson, 1985), 178.58-201.08°C (Fournier 1977, no steam loss). By using chalcedony geothermometers, the range of sub-surface temperature is 151.6-175.2°C (Arnorsson, 1983), 157.3-183.4°C (Fournier 1977). By using isotope techniques, alfa (SO_4-H_2O), the temperature estimate range from 152.17-195.14°C.

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CMR42-27

Impact of Bauxite Mining Activities in Pengerang, Johor on Soils and Environment

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Land in Peninsular Malaysia is classified into 5 categories of which the one having mineral is at the top of the list. This means that mining of bauxite is allowed and encouraged, but it should be sustainable in nature. Bauxite contains precious metal called Al that is widely used to manufacture many industrial goods. The materials having the ore contains many minerals, among which are gibbsite [$Al(OH)_3$] mixed with goethite (FeOOH), hematite (Fe_2O_3) and kaolin. This paper explains how bauxite mining activities in Pengerang, Johor since 1950s had degraded the land in the surroundings areas beyond imagination.

The chemical properties of the materials left by the mining activities were as follows. The pH of the materials was 4-5, comparable to that of normal acid soils in Peninsular Malaysia. The salt contents in the samples did not exceed the limit for healthy crop growth. Total C and N contents were very low. The low productivity of the materials was further evidenced by very low available P and low exchangeable K values. To make it worse, exchangeable Ca and Mg were also low, which in combination with low NPK would make it hard for crops growing in the materials to survive without high fertilizer input.

During wet season, water flowing through the mined land had gone into the water system in the surrounding area. The color of the muddy water in the drain was distinctly reddish, indicative of the presence of bauxite having a lot of hematite in it; hematite is red in color. What happens to the surrounding area or the river system if this bauxite-laden water flows into them? The answer is environmental degradation that affects biodiversity.

The excess water could also overflow the drainage canal, painting the local road network red. When the mud on the road dries out during dry months of the year, bauxite dust will be flown everywhere in the air, causing air pollution that affects people's lives in the vicinity of Pengerang area. Furthermore, flash flood would occur if the excess water flow into the lower reaches of the mined land. The area left by the mining activities is mostly barren. As it were, much of the degraded land has been left to nature. The soil materials in the areas affected by the mining activities is infertile because of lack of plant nutrients, low organic matter content or even the presence of some toxic elements. To rehabilitate this disturbed land for sustainable crop production is a costly affair that requires high agronomic inputs.

CMR43-149

Integrated Remote Sensing and GIS in Lineament Mapping for Geothermal Potential Resources – A Case Study in the Ulu Slim, Perak

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Automatic and manual extraction methods were utilized in this study to delineate lineaments from the digital terrain model (DTM) and satellite images covering the study area of Ulu Slim, Perak. Enhanced topographic illumination under varied light directions enables interpretation of lineaments from DTMs effectively. For the automatic lineament extraction, eight shaded relief images were generated using the DTM and subsequently compressed into two resultant images with multi-directional light. The automatic lineament extraction process was carried out with LINE module of PCI Geomatica V9.1 based on automatic detection algorithms. Several image enhancement techniques such as filtering and colour composites were respectively employed in manual extraction of lineaments from Inferometric Synthetic Aperture Radar (IFSAR) image of the study area. The comparison of the automatic and manual lineament extraction with the published fault maps of the area in terms of total length, number of lineaments and directions.

CMR44-10

Kajian Sedimen Teras bagi Projek Kajian Tumbesaran dan Kematian Kerang di Lot-Lot Ternakan Kerang di Negeri Selangor

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The blood cockle were cultured extensively in Selangor from 2007 and has become a major producer of cockles in the country. However, starting in 2011, production of cockles began to decline. Fisheries Research Institute (FRI) has conducted intensive research project to find the causes of the decline in the number of cockles landing, including studies of sediment at the cockle farming plot. To carry out the sediments study, FRI has requested expert assistance from JMG to identified the sediments classes, relative hardness of sediment, organic and carbonate content; and heavy metals content in cockle farming plots. A total of 17 cockle plots were selected in this study, which involved a total of 53 core sediment samples and 117 sediment samples for analysis. Cockle farming plots in the area of Tanjung Karang to Kuala Selangor (Lot KS12, KS26 and KS42) recorded a higher relative hardness of the surface sediments compared with other lots. However, the relative hardness value did not show a clear correlation with a total annual production of cockles. For the sediments distribution study, mud sediments in the presence of a sand and gravel (gsM - gravelly sandy Mud) is shows a good correlation with high productivity cockle plot, while gravel dominated sediment shows a good correlation with low or no productivity cockle plot. Cockle plot with high carbonate content is usually has less or no cockle productivity. No significant relationship or a clear correlation between cockle production and organic content in the sediment. Heavy metals content in sediments in the study area were within the background value and showed no significant differences compared with other places; except for arsenic in Lot SB30 which show high value even though the plot has a good cockle production.

Kerang telah diternak secara giat di Selangor bermula dari tahun 2007 dan telah menjadi pengeluar utama kerang negara. Namun, bermula pada 2011, pendaratan kerang mula merosot. Institut Penyelidikan Perikanan (FRI) telah menjalankan satu projek penyelidikan yang intensif bagi mencari punca-punca kemerosotan jumlah pendaratan kerang tersebut termasuklah kajian sedimen di tapak ternakan kerang. Bagi melaksanakan kajian sedimen tersebut, FRI telah memohon bantuan kepakaran daripada JMG bagi mengenalpasti kelas sedimen, kekerasan relatif sedimen, kandungan karbonat dan organik serta kandungan logam berat di kawasan lot-lot ternakan kerang. Sebanyak 17 lot ternakan kerang terpilih telah terlibat dalam kajian ini yang melibatkan sejumlah 53 sampel sedimen teras dan 117 sampel sedimen untuk dianalisa. Lot-lot kajian di kawasan Tanjung Karang hingga ke Kuala Selangor (Lot KS12; KS26 dan KS42) mencatatkan bacaan kekerasan relatif sedimen permukaan yang lebih tinggi berbanding dengan lot-lot yang lain. Namun begitu, nilai kekerasan relatif ini tidak menunjukkan kaitan yang jelas dengan jumlah pengeluaran kerang tahunan. Bagi taburan sedimen, kawasan utama bagi lot-lot yang mempunyai pengeluaran kerang yang baik adalah lot yang dominasi oleh sedimen lumpur dengan kehadiran sedikit pasir dan kelikir (gsM – Lumpur berpasir dan berkelikir) manakala lot yang mempunyai rekod pengeluaran kerang yang rendah atau tiada pengeluaran, dominasi oleh sedimen berbutir kelikir. Lot ternakan kerang yang mempunyai kandungan karbonat yang tinggi pula biasanya merupakan lot ternakan yang kurang berpotensi dari segi jumlah pengeluaran kerang. Tiada kaitan yang ketara/jelas dapat disimpulkan antara pengeluaran kerang dan juga kandungan bahan organik dalam sedimen. Kandungan logam berat dalam sedimen di kawasan kajian masih berada dalam lingkungan nilai latar belakang (background value) dan tidak menunjukkan perbezaan yang begitu ketara antara kawasan lain kecuali unsur As di Lot SB30 yang perlu diberi perhatian walaupun lot tersebut masih mencatatakan nilai pengeluaran kerang yang baik.

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CMR45-15

Characteristics of Kaolinitic Clay from Tanjung Rambutan - Simpang Pulai, Perak

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This paper presents a summary of the preliminary literature studies on the suitability of kaolinitic clay deposits in Perak Malaysia, for various industrial application. Kaolinitic clay occurrences from three locations where exploitation of kaolin is currently operating (Tapah-Bidor, Simpang Pulai, Tanjung Rambutan) were compared for their physical, chemical and mineralogical properties. Engineering properties of their respective degritted clay are also assessed to determine the applicability of these clays for paint, paper, ceramic and glass fibre industry. The data is obtained from either published literature, or by laboratory tests of field collected samples when information from literature is not sufficient.

Study shows that the high value processed kaolin products are all from primary type deposit. The kaolin from Tanjung Rambutan has very similar chemical, textural and mineralogical properties with the Lampas kaolin. The clays are characterized by very low Fe_2O_3 and TiO_2 content (0.19% and 0.11% respectively), with presence of 40-60% of free silica. They are suggested to have identical origin, which are derived from the Kinta aplites. On the other hand, Bidor Tapah kaolin has significantly higher Fe_2O_3 (0.50 – 1.05%) and TiO_2 content (0.04 – 0.52%) when compared to the aplite-derived kaolin. The contrast can be attributed to the different origin, chemical and mineralogical content of their parent material. The Changkat Rembian granite which derived the Bidor-Tapah kaolin, has composition corresponding to the granitoids of the western granite belt in Peninsular Malaysia. It consists of higher amount of undesirable elements which can contaminates and reduces the value of kaolin for certain applications if cannot be removed, such as the iron, magnesium and titanium oxides which reduce brightness and whiteness properties of the clay. On the other hand, the Kinta aplite consists essentially of quartz, alkali feldspar, and minor muscovite. It highly acidic composition makes it more favorable in forming kaolin desired by the industry.

CMR46-125

Geological Investigation on Batumilmil Formation Deposit in Langkat, North Sumatera and Potential Economic Impact

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Geological structure of Batumilmil formation is strongly affected by regional structures runing from Northwest to Southeast. It's morphological structures has similar directions to mountain region of Bukit Barisan. Batumilmil formation possesses relative steep slope downwards and ramps at the top. In terms of tectonic framework of Sumatra, both originate from Pre–Tertiary, possessing similar composition. Most of the limestone occupy the elongated ridge hills in Batumilmil formation. The presence of Sulkam and Lae Ketuken river split down the deposited limestone covered with Tertiary tuff and claystone units. The appearance of karst topography results from the dissolution of limestone indicated by surface activities (exokarst) and underground activities (endokarst). The exokarst manifestation is observable by the presence of conical hills, whereas endokarst structures are manifested by the appearence of stalagtites and stalagmites inside limestone caves. The unit distribution of Batumilmil formation is tangibly observable in Sulkam, Kejaren and Kaperas. It is a dark-grey to black, fine-grained, sandy, massive unit consisting of veins filled with calcite minerals. Other spots experienced weathering dominated by dissolution calcite mineral. Petrographic studies using the polarizing microscope show mudstone dominates the area with mainly matrix micrite, fossil, less sparit. Chemical analysis reveals that the limestone of Batumilmil has high quality of calcium oxide (CaO) 53.36% and magnesium oxide (MgO) 0.53%. The high quality of calcium oxide has definitely high economic value for various industrial sectors such as cement.

ORAL PRESENTATIONS

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PETROLEUM GEOLOGY

SESSION KEYNOTE DPT01-24

The Continental Shelf – Five Decades of Progress (1966-2016)

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In the inaugural issue of the Newsletter of the Geological Society of Malaysia (no. 1, July 1966), the Society's founding president, Neville S. Haile, wrote a note entitled '*The Continental Shelf – Malaysia's new frontier?*' in which he highlighted the Malaysian Parliament's enactment of the Continental Shelf Act 1966. Haile's note is interesting in two respects: from a legal standpoint, the "continental shelf" then was still a relatively new and developing legal concept, which was later incorporated in the United Nations Convention on the Law of the Sea 1982 ('UNCLOS'). Our understanding of the continental shelf (**Figure 1**) has advanced rapidly since 1966, from both the scientific and legal perspectives. In commemoration of the 50th anniversary of the Society's founding and of the enactment of the Continental Shelf Act, this paper provides an overview of the development of the concept of the continental shelf and its implementation in the Malaysian context during the five decades from 1966 to 2016.

In 1966, while the geology of the continental shelf of Malaysia was, in the words of Haile, "virtually unknown", offshore oil exploration activities began to increase rapidly, following the award of new offshore oil concessions by the government between 1957 and 1965 (Ramli, 1986). In that same year, on 11-12 November 1966, a scientific meeting entitled the "History of the Earth's Crust Symposium", was held at NASA's Goddard Institute for Space Studies in New York City, to gather all the geological knowledge of the oceans up to that time. Key geological concepts were discussed at that meeting, such as sea-floor spreading (Dietz, 1961; Hess, 1962), hotspots, and transform boundaries (Vine, 1963; Vine and Matthews, 1965; Wilson, 1963, 1965), and are said to have led to the theory of global plate tectonics (Phinney, 1968).

Now, fifty years later, and thanks to extensive geophysical and geological surveys, academic research and petroleum exploration, our understanding of the geology of the continental shelf has improved tremendously (**Figures 2, 3**). Haile noted in 1966 that 'wide possibilities exist for potentially oil-bearing basins under the shallow seas of Malaysia'. Haile's prediction was proven right; the Malay Basin is now one of the most prolific oil basins in Malaysia. In contrast, knowledge of the continental shelf off Sarawak and Sabah had been gained earlier through oil exploration during the pre-independence era (Scherer, 1980; Doust, 1977, 1980; ASCOPE, 1981). Scientific papers by oil companies on the structure and stratigraphy of the Sabah and Sarawak continental shelves during the 1980s and 1990s, based on multichannel seismic reflection data (Bol and van Hoorn, 1980; Epting, 1980), opened a new phase of geological exploration of the NW Borneo continental shelf. During the past decade, our geological understanding of the continental shelves of Malaysia has advanced even further through exploration by the oil industry and through dedicated marine scientific surveys for the purpose of continental shelf delineation (Hutchison and Vijayan, 2010; Vijayan et al., 2013).

Legal Concept of the Continental Shelf

In parallel with the rapid advances in the geological understanding of continental margins and in the theory of plate tectonics, legal instruments have been put in place, internationally and nationally, to enable coastal States (i.e., countries with marine coastlines) to exercise jurisdiction over their maritime spaces for the purpose of exploration and exploitation of natural resources, including oil, gas and minerals. Under article 4 of annex II to UNCLOS, a coastal State intending to establish the outer limits to its continental shelf beyond 200 nautical miles (symbol 'M'; 1 nautical mile = 1.852 km), in accordance with article 76, should submit particulars of such limits to the Commission on the Limits of the Continental Shelf (CLCS) along with supporting scientific and technical data.

Paragraph 1 of Article 76 of UNCLOS states that:

"The continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance."

Article 76 contains terms that are familiar to geologists, such as "continental shelf" and "continental margin". Most geologists understand these terms in the

1. The author is also a member of the Commission on the Limits of the Continental Shelf (2012-2017), a UN body established under the UN Convention on the Law of the Sea 1982. The views expressed in this paper are solely of the author's in his personal capacity and do not necessarily reflect the views of the Commission on the Limits of the Continental Shelf.

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geomorphological sense, but article 76 gives them a legal meaning, and a basis upon which coastal States may submit information regarding their extended continental shelf beyond 200 M from the coastlines (**Figure 4**). In order to assist states in making their submissions, the CLCS published its Scientific and Technical Guidelines (CLCS/11, 1999), explaining the technical terms and the approaches States may take in establishing the outer limits of the continental shelf.

Establishment of the outer limits of the continental shelf by a coastal State based on the recommendations of the CLCS would result in the extension of maritime space that would come under its national jurisdiction. **Figure 5** shows the extended continental shelves on a world map, based on the submissions made by the coastal States to the CLCS to date.

The Malaysian Continental Shelf Project

For the purpose of making its submission regarding the outer limits of its continental shelf to the CLCS, Malaysia embarked on this national project in 2002. Upon the approval by the Cabinet in 2006, a Malaysian marine research survey (dubbed "MyMRS") was undertaken from 2007 to 2008 on the continental shelf off Sarawak and Sabah in the southern part of the South China Sea. A project team comprising various collaborating government agencies, with the assistance from PETRONAS, was tasked to prepare Malaysia's submission to the CLCS. On 6 May 2009, a joint submission by Malaysia and Vietnam was successfully delivered to the CLCS, and is awaiting consideration (**Figure 6**).

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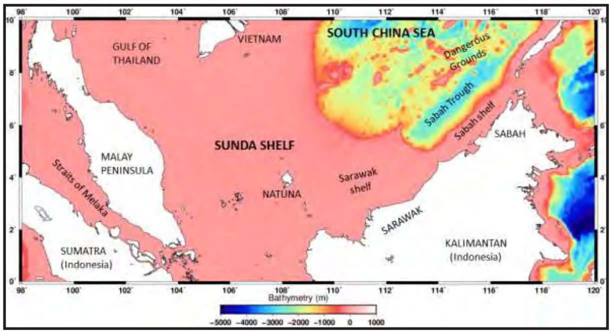

Figure 1: Physiographic map of the continental shelf of Malaysia (Malay Peninsula, Sarawak and Sabah) and surrounding regions. The physical continental shelf (shaded in pink) is the offshore areas in which the water depth is generally less than 200 m. The "continental shelf" has a different meaning under UNCLOS.

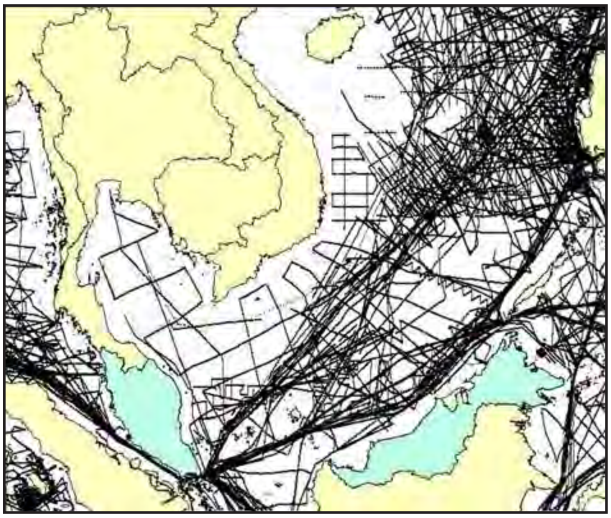

Figure 2: Geophysical data track lines data, including single-beam bathymetry, gravity and magnetic data from the US National Centers for Environmental Information (NCEI), formerly National Geophysical Data Center (NGDC) (https://www.ngdc.noaa.gov/mgg/mggd.html).

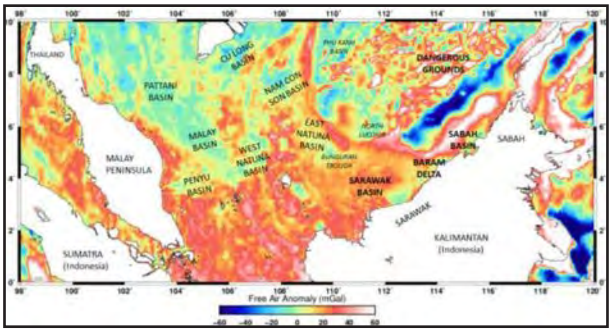

Figure 3: Satellite-derived free-air gravity data, on which this map is based, have the advantage of full coverage over the offshore regions. Visible are features associated with sedimentary basins and major structures beneath the continental shelf and ocean basins. Map based on gridded data from Sandwell and Smith (2009).

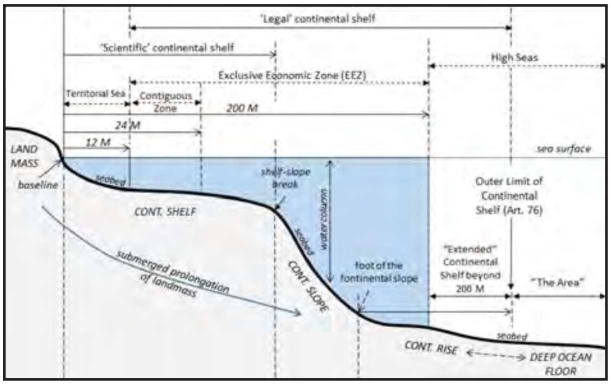

Figure 4: According to Article 76 of UNCLOS, wherever its continental margin extends beyond 200 M a coastal state may delineate the outer limits of its 'legal' continental shelf by establishing the foot of the continental slope and the outer limit of the continental margin, using the provisions in paragraphs 4 to 7 of Article 76. Figure modified from CLCS website http://www.un.org/depts/los/clcs_new/marinezones.jpg.

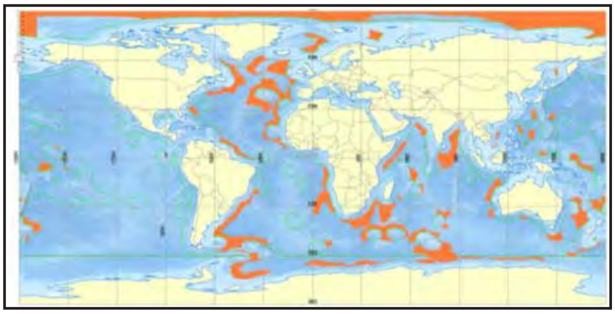

Figure 5: Global map of extended continental shelves (orange shaded areas) based on the information on the outer limits of the continental shelf submitted by coastal States to the CLCS. From UNEP website, www.continentalshelf.org.

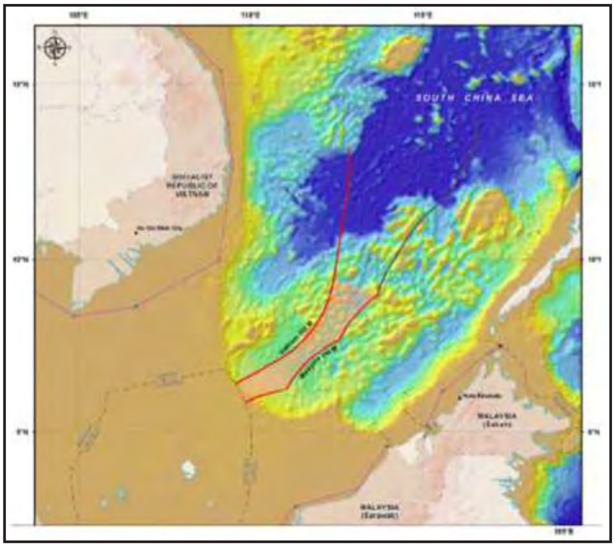

Figure 6: The extended continental shelf in the Malaysia-Vietnam joint submission to the CLCS (shaded area between the two coastal States). Red lines represent the 200 M limit measured from the baselines of the respective State. Map is from the Executive Summary of the submission posted on the CLCS website: http://www.un.org/depts/los/clcs_new/commission_submissions.htm.

SESSION KEYNOTE DPT02-79

Malay Basin: The Impact of Tectonics and Basin Architecture on Petroleum Resources and Future Potential

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The regional context of Sundaland is an assortment of continental crusts from eastern Gondwana and southeastern Eurasia. The Sibumasu, West Burma, Indochina–East Malaya tectonic blocks accreted and formed Sundaland in the early Mesozoic, and sutured up the Palaeo-Tethys ocean. The development of Sundaland deformation concepts has its influence on the intracratonic Malay Basin. A new tectono-stratigraphic framework for the Malay Basin was developed from research and analyses of regional tectonic data, stratigraphic and basin scale seismic data. The proposed Malay Basin Ridge and Graben Model identified a total of twelve (12) tectonic sub-provinces, which are flanked by basement escarpments. The polyphased tectonic evolution of the intracratonic Malay Basin initiated from a Mesozoic pre-rift basement, through to Palaeogene syn-rift phase, early to mid-Miocene subsidence, late Miocene pulsed inversion and Plio-Pleistocene sag. This regional Sundaland to Malay Basin deformation hierarchy can be arranged from a 1^{st} order plate scale, 2^{nd} order tectonic block, 3^{rd} order major basin, with 4^{th} order sub-basins, filled with 5^{th} order broad fold lineaments, and smaller 6th order traps. It is these 6^{th} order traps that are being drilled by oil companies.

The refined ridge and graben model is an update on the understanding on regional Malay Basin morphology, and it is able to explain the tectono-stratigraphic distribution of the oil and gas fields better. The basin south-eastern sector has enhanced, high relief E-W strike folds of major oil fields such as Bekok-Seligi-Pulai, Tapis-Tiong-Kepong, and Tabu-Guntong-Palas, which were inverted during middle to late Miocene from Sundaland collision with Indo-Australian plate, and synchronous with early oil generation/migration phase. Whereas, on the basin northwestern sector are moderate relief E-W strike folds of Bintang-Lawit-Jerneh, Noring-Sepat-Laho, which were inverted progressively later during end of late Miocene being farthest from the collision front, thereby mainly capturing late gas generation from deeply buried source beds.

The intra-basin tectonic deformation scale also correlates comparably well to the hydrocarbon trap size. These 6th order trap closures can be: Giant (>500 mmbbl) fields, Major (>100 mmbbl) fields, Medium (>50 mmbbl) fields, Marginal (<30 mmbbl) fields, and Small (<10 mmbbl) fields. The marginal and small sized traps often rank low on the exploration prospect drilling list. However, if several of these 6^{th} order minor traps align on a broader 5^{th} order structural trend, thus amalgamate into a larger continuous closure, then this very large structure could, hypothetically hold a prospective resource volume of a few billion barrels oil equivalent. The role of the petroleum geoscientists is to continuously seek new and different exploration perspective to make future economic-size discovery which will supplement the growing global demand for hydrocarbon resources such as the expensive Tapis-type crude oil from the Malay Basin.

SESSION KEYNOTE DPT03-165

Sabah Oil and Gas Exploration - New Opportunities

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Malaysia is a major oil producer; the largest natural gas and the 3rd largest oil exporter in South East Asia, and globally, the 2nd-largest LNG exporter after Qatar.

The domestic oil consumption has risen, while production has been falling that led efforts to encourage increase in the reserves replacement ratio. Recent government incentives and new oil and natural gas discoveries in deep water offshore areas of Sabah basins considered " mature" basins has encouraged companies to seek new production sources such as complex stratigraphic and deeper reservoir targets, fractured reservoirs, tight sands, coal bed methane, shale gas, enhanced oil recovery, and exploration in frontier areas.

Basins in Sabah are amongst the most prolific basins in Malaysia with over 50 years of exploration history, and discovered resource of 3.7 BOEB (1.5 BBO, 13 TCF) in mainly clastic reservoirs, the 4th largest oil reserves in Asia-Pacific (after China, India & Vietnam).

Large and easy to find fields are difficult, thus improved understanding of the basins history is crucial to identify remaining undiscovered potential in plays that have not been fully tested. It is more important for the industry to come together to share solutions and expertise on how to innovate – not only for survival, but for growth. Industry has to promote new ideas, be creative and challenge existing dogma.

Predicted future resource potential was primarily in traditional clastic plays as shown by an almost flat creaming curve trend of the discovered resource until the anticlinal thrust structure play of Tertiary deep-water sandstones at Kikeh in 2002. Malaysia's deepwater acreage remains relatively underexplored. At present, only 3 Billion barrels of oil equivalent (BOEB) of deepwater resources have been proven, but at least 7 BOEB could be waiting to be discovered (Malaysia's Business Times, 2016).

This remaining potential over half the total discovered resource will provide the industry with opportunities in areas previously thought to be mature and risky.

DPT04-08

Potential of UV-Visible Absorption Spectroscopy for Characterizing Devonian Black Shales

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The Timah Tasoh Formation (Devonian) conformably overlies pelagic limestone of the Silurian Mempelam Limestone and ranges between 5 to 40 m in thickness [1, 2]. The Timah Tasoh Formation comprises black mudstone, with subordinate amounts of chert. The Timah Tasoh Formation is exposed at three different localities: A) Hutan Aji, B) Pulau Langgun and C) Sanai Hill [2]. In the present study, black shales were collected from the Sanai Hill A (Figure 1). Organic spectroscopic characterization was carried out to explore the hydrocarbon distribution and type of humic substances present in these black shales. The UV-visible ratio (E_4/E_6) indicated that the samples have almost equal proportions of both fractions (Figure 2). All sample showed presence of humic acids. This indicates that possibly the origin of organic material could have been terrestrial in nature. Unsaturated and aromatic hydrocarbons were identified using Attenuated total reflectance (ATR) Fourier transform infrared spectroscopy (FTIR). The ATR-FTIR shows that the aromatic out of plane CH stretching (aromatic OPCH) hydrocarbon and aromatic out of plane CH stretching (aromatic OPCH) hydrocarbon groups (both occur in the finger print region) are found more in the Timah Tasoh Formation as compared to other functional groups (Figure 3). It is concluded that the Timah Tasoh Formation comprises -OH groups stretching vibration, Alkyne C-H bending bands in aliphatic hydrocarbons and absorption spectrum of aromatic IPCH and aromatic OPCH[3-7].

Acknowledgment

The authors would like to acknowledge and appreciate the PETRONAS Research Fund (PRF) grant for providing financial facilities throughout the studies.

Figure 1: Study outcrop of the Timah Tasoh Formation represented by a thick unit of grayish black shale.

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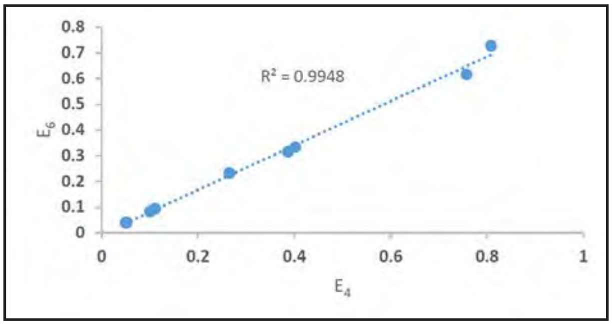

Figure 2: Relationship between E_4 and E_6.

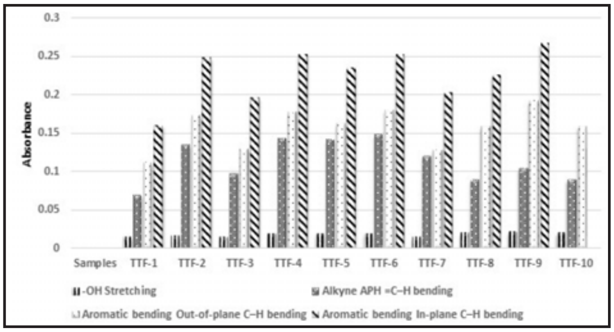

Figure 3: Absorbance of Functional groups identified through FTIR spectra in the Timah Tasoh black shale samples.

DPT05-02

Developed Correlations Between Porosity, Permeability and Sound Wave Velocity at Different Compaction Pressures for Sandstone Core Samples

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In the evaluation of a petroleum reserve, it is necessary to determine accurately certain petrophysical properties such as porosity and permeability of the reservoir rocks under different compaction conditions. These properties are affected by the relevant physical properties and such physical properties and also mechanical properties affect the drilling programs and the development plans for a reservoir. It is more convenient to use homogenous rock samples with nearly constant initial permeability, 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. The physical properties include grain size, cementing material concentration, and compaction (confining) pressure. The effect of these properties on the petrophysical properties of Rock such as permeability and porosity were also known. For the same simulated natural sandstone rocks, Sound wave velocity was measured using an ultra sound tool. Good relationships have been developed between sound wave velocity and other rock properties; porosity, permeability, cementing condition at different confining pressures. The sandstone cores have been grouped according grain size to five groups ranged between 45 and 300 µm mixed with different concentrations of cementing material. The mixture was compacted at three different compaction pressure ranges from 11000 to 23000 psi. These varying lithification factors gave these sandstone rocks a wide range of petrophysical and physical properties. The results of this study were presented as graphs of simulated lithification factors, porosity, and permeability versus sound wave velocity.

DPT06-13

Application of TEM Technique in South-East Asia

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Application of electromagnetic methods for oil and gas exploration is developing world-wide. Two main types of EM methods are applied: natural source (MT) and methods with artificial source of EM field (TDEM, FDEM). For hydrocarbon exploration on land high efficiency has transient electromagnetic method in frequency or time domain mode. The role of EM methods is increasing at the areas with poor seismic data quality, non-structural fields and zones with complicated structure of sedimentary cover. Joint interpretation of EM data with seismic or other geological data is a way to reduce the risks and optimize the process of geophysical investigation.

For oil and gas exploration it is possible to study sedimentary layers resistivity at the depth interval from surface to basement and also a lot of information can be received from induced polarization (IP) parameters. The paper is devoted to technique of EM methods combination – TEM and EM-IP for oil and gas exploration, and possible ways of its effective application.

Electroprospecting surveys have been performed over one of the blocks in the Southeast Asia. Two techniques were used: Transient Electromagnetic Soundings in Time Domain (TEM) and Induced Polarization Electromagnetic method (EM-IP). The objective is to conduct a comprehensive study of the sedimentary cover using TDEM. This includes mapping of zones with potential reservoirs properties from TEM, and to qualify these areas with Induced Polarization (IP) anomalies, usually related to presence of hydrocarbon system.

DPT07-48

Depth Distribution of Benthic Foraminifera in the Middle and Deeper Sublittoral to Uppermost Bathyal Northwest of Okinawa, Japan

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Distribution of optimally preserved benthic foraminifera is related to depth in the sublittoral and uppermost bathyal around Okinawa, Japan. Depth is a composite factor that influences physical factors, i.e., temperature, salinity, substrate caused by hydrodynamics and illumination. Sediment samples between 64m and 275m depth were taken from the seafloor by grab sampler. Optimally preserved tests were analyzed using a Motic SMZ- 168 microscope. Grain sizes < 63µm were analyzed using Micromeritics Sedigraph ET5100. Grain sizes > 63µm were analyzed by sieving. Statistical analysis performed on seven larger and 45 smaller benthic foraminiferal species includes canonical correspondence and correspondence analyses. Depth distributions are fitted by power transformed normal distributions. Distributions in grain size classes and percentages of silt and clay are depicted in circle graphs. Taxonomic description grouped the benthic foraminiferal tests into seven orders, 55 families, 100 genera and 175 species. The first components of the bimodal distribution pattern of *Amphistegina lessonii, Calcarina hispida, A. bicirculata, A. radiata, A. papillosa* and *Operculina complanata* demonstrate optimal depth distributions in the middle sublittoral. *Planostegina longisepta* demonstrates optimal depth distribution in the deeper sublittoral. Dependence on coarse sand is demonstrated by *A. bicirculata, A. radiata* and *C. hispida*. Dependence on fine sand is demonstrated by *A. lessonii*. Dependence on very fine sand is demonstrated by *O. complanata* and *P. longisepta*. *A. papillosa* does not show dependence on any particular substrate type. Optimal depth distributions of the larger foraminifera are in agreements with the living individuals. Larger foraminiferal specimens picked between the 125 - 250µm sieve fraction demonstrate depth transport. Low depth transport is demonstrated by *A. lessonii* and *C. hispida*. High depth transports at 210m are demonstrated by *A. bicirculata, A. papillosa, O. complanata* and *P. longisepta* indicating similar test buoyancies. Highest depth transport at 270m is demonstrated by *A. radiata*. Depth distributions of optimally preserved smaller benthic foraminiferal tests demonstrate optima in the middle sublittoral, deeper sublittoral and uppermost bathyal. Optimal depth distributions of the tests in the middle and deeper sublittoral is related to dependence on either coarse sand, medium sand or no dependence on specific substrate type. Optimal depth distributions of the tests in the uppermost bathyal is related to dependence on fine and very fine sand. Agglutinated foraminiferal tests have demonstrated agreement between optimal depth distribution and dependence on substrate type. Benthic foraminifera with secreted $CaCO_3$ tests have shown partial agreement between optimal depth distribution and dependence on substrate type. Life position of the smaller benthic foraminifera is influenced by test dominance in percentages of silt and clay. Test dominance in the high or highest percentages of silt and clay is reflected on infaunal life position. Test dominance in the low or lowest percentages of silt and clay is reflected on epifaunal life position. Test dominance in medium percentages or no dominance reflects on either epifaunal or infaunal life position. Test dominance in percentages of silt and clay is related to its dependence on substrate type.

DPT08-26

Analysis of Heterogeneous Distribution of Petrophysical Properties in Sandstone Reservoir: A Case Study

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Introduction

Reservoir heterogeneity is usually described as the complexity of the geological of a reservoir, which also related to the complexity of the fluids flow in reservoir (Alpay, 1972). This complexity occurred due to several factors found during or after the depositional processes, such as depositional features, diagenetic processes, bioturbation, faults and fractures, which will give variability in the properties reading (Ben-Awuah and Padmanabhan, 2014, 2015; Ben-Awuah et al., 2016). For this study, the observations will be carried out by utilising the core samples obtained from onshore sandstone reservoir at West Baram Delta, which lies on the North Eastern of Sarawak and Western side of Sabah, Malaysia. West Baram Delta is a sandstone reservoir basin, which is expected to have varying porosity and permeability distribution with different grain size from fine to coarse, textures, and mineralogy. The sandstone in Baram Delta is known with its major fossilferous type of rocks which have undergone several diagenetic processes (Ben-Awuah & Padmanabhan, 2014). The aim of this paper therefore is to analyse the heterogeneous distribution of petrophysical properties in West Baram Delta reservoir.

The objectives of this paper is to identify the important forms of geological and petrophysical heterogeneities in reservoirs, and the factors that control their distribution, to determine which types of heterogeneities affect petrophyscial properties.

Materials and Methodology

Several laboratory works were done by using 3 core samples obtained from different wells in West Baram Delta, to achieve more details in heterogeneous distribution of petrophysical properties. Porosity and permeability measurement was carried by using ULTRAPORE-300 device and Klikenberg correction applied (Crain, 2015). The contact angle of the rock samples was obtained by using Phoenix-150 contact angle analyser and interpreted in terms of wettability. To identify the clay mineralogy of the samples, XRD measurement was carried out on oriented clay slides. Clay mineralogy and morphology was confirmed using SEM.

Results and Discussion

The porosity laboratory experiment indicates that the highest porosity comes from core sample C (17.95%) followed by core sample B (17.49%) and the lowest comes from core sample A (16.95 %). The low porosity measured in core sample A might have affected by compaction and the presence of iron oxide filling up the pore (Fig.2). Whereas, the high value of core sample C is the result of great pore space and grain size distribution, as shown in Fig.1. However, core sample A has the highest permeability, which is 134.27 mD and core sample B has the lowest permeability at 12.05 mD. Although the porosity B and C have a slight different value, the permeability of both samples show high difference, 12.05 mD and 44.38 mD respectively.

The high difference permeability value of core sample B and C is a result of diagenetic processes, which holds a big role in secondary control of petrophysical properties characterization, especially in porosity and permeability (Jia & Rahman, 2009). The interaction between primary and secondary porosity lead to heterogeneous characteristics. The presence of fossils in the core sample B obtained from the thin section images (Fig 3; Fig. 4) show that the fossils have affected the flow of the fluids through the rock, resulted in low permeability. Based on the characteristics of the sandstone and the amount of the fossils found in core sample B indicate that the facies might be deposited in a coastal environment. Besides thin section analysis, the presence of fossil in core sample B can be analysed through SEM analysis as shown in Fig.8, which expected to be a type of Foraminifera.

The amount of the minerals identified using XRD analysis in the core sample C, indeed affect the petrophysical properties of this rock, too. Based on XRD analysis graph, core sample C has the most number of peaks, which indicates more minerals content compared to other 2 samples (Fig. 5). The features of the textures, mineralogy and diagenetic process give high heterogeneity to the formation. These results were also confirmed by the pictures obtained by SEM analysis (Fig. 7; Fig. 8).

However, the contact angle investigation of all the core samples show an indication of angle below 90°. This indication defines that the rock has high wetting tendency and the formation is classified as a water-wet formation.

Conclusions

The heterogeneous distribution of the petrophysical properties in this reservoir has been proved by several laboratory experiments. In this study, there are two different facies identified, which are moderately sorted fine sandstone and fossilferous sandstone. The fossilferous sandstone is demonstrated by the analysis of core sample B, where the porosity value is 15.268% and the permeability value is at 10.26 mD. Compared to the core sample C, which was taken from the same formation, it has similar porosity as core sample B, but has higher value of permeability than core sample B. The low value of permeability in core sample B shows that this rock has been affected by diagenetic processes, when most of the secondary porosity occurred. The presence of fossils in core sample B concludes that this formation is a fossilferous formation, which gives various textures and abundance of minerals. The formation that vary in textures and minerals will give a diverse petrophysical properties reading, and is attributed to the heterogeneity formation. The difference in petrophysical properties values of non-fosilferous and fossilferous sandstone is due to the fact that the distribution of porosity and permeability in this formation varies. Also, the mineral contents that have been supported by the XRD analysis are proofs that these heterogeneities affect the petrophysical properties of this formation.

Keywords: Reservoir heterogeneity, Baram Delta, petrophysics

Figure 1: Core sample C thin section image using x5 magnification which shows high porosity.

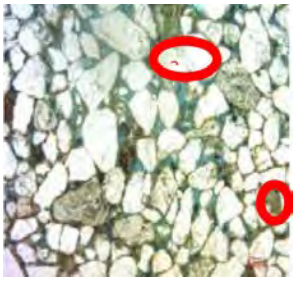

Figure 2: Core Sample A thin section image using x5 magnification shows low porosity, compared to core sample C due to compaction(a) and some of iron oxide(b).

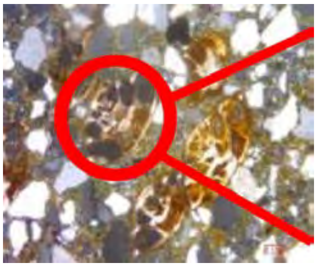

Figure 3: The thin section image using x10 magnification showing the presence of fossils.

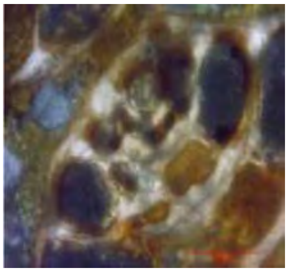

Figure 4: The presence of fossil in x40 magnification.

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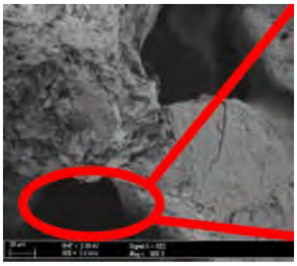

Figure 6: SEM image shows a pore space in between the grain.

Figure 7: SEM image identifies the pore space that is filled by minerals (Kaolinite)

Figure 8: SEM image shows the presence of fossils.

DPT09-47

Effect of Coal Seams Thickness on the Performance of CO_2 Sequestration for Enhanced Coalbed Methane Recovery

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Coalbed methane (CBM) is one of a promising unconventional energy for fulfilling of future Indonesia's gas demand. Sequestering CO_2 in coal seams is benefit to enhance coalbed methane recovery (CO_2-ECBM) and mitigate greenhouse gas emissions. Studies show that coal seams located in South Sumatera Basin, Indonesia are suitable for the application of CO_2-ECBM based on economic, regulatory, and reservoir engineering criteria. From reservoir-geology assessment, there are very limited study undertaken in this area, especially for linking the effects of geological parameter on the CBM reservoir performance due to CO_2 sequestration. This study has therefore aimed to investigate the effect of coal seams thickness on CO_2 storage and CH_4 recovery factor during the CO_2-ECBM process in South Sumatera Basin's coal seams.

In this study, adsorption trapping was considered as the main sequestration mechanism in coal seams and coal matrix was fully saturated by CH_4. Using sensitivity analysis, ranges of coal seams thickness values in South Sumatera Basin were examined on its effects to CO_2-ECBM performance. Compositional simulation results show that CO_2 storage increases proportionally to increasing coal seams thickness. However, a parabolic relationship exists between coal seams thickness and additional CH_4 recovery factor due to CO_2-ECBM. Therefore, the optimum range of coal seams thickness is essential for the successful application of CO_2-ECBM.

From this study, the ideal coal seams thickness for CO_2 storage and enhance CH_4 recovery purposes will be proposed. Optimizations in order to maximize CO_2 storage efficiency and additional CH_4 recovery factor due to CO_2-ECBM will be also recommended. Thus, geoscientists and engineers can screen specific prospects and design appropriate operations for the optimum CO_2-ECBM process.

DPT21-49

Better Imaging of the Subsurface using Primaries and Multiples: A Synthetic Example

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Contrary to the standard seismic processing which is to run seismic migration after demultiple, a synthetic line mimicking a seismic line in the Malay Basin was imaged by simultaneously migrating the primaries and the multiples. The motivation for this approach are 1) illumination from multiples covers greater subsurface extent, 2) angle gathers generated from imaging of multiples are much denser than those produced by imaging of primaries alone, 3) multiple imaging can supplement subsurface illumination that is not found in the primary signals. The method applied is the Joint Migration Inversion (JMI). Seismic migration is done in a closed-loop manner as opposed to the standard seismic processing open-loop method. The initial migrated seismic image is feedback to a forward modelling algorithm. This allows an iterative minimization of the difference between the simulated and the real measurements. Additionally, this also enable velocity estimation to be carried-out simultaneously. The JMI method is currently tested with a synthetic data before an application to a real data set. The results obtained showed that multiples can be utilized to get a much better seismic image of the subsurface than the standard method. The good final velocity model resulted from the JMI method is a welcome bonus.

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DPT22-17

Variance in Reservoir Quality Due to Diagenesis: A Study from Tidal Deposits, Nyalau Formation, Sarawak, East Malaysia

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Prediction of reservoir quality become more challenging in terms of micro distribution of pore geometry. Here diagenesis play important role in determining the reservoir quality with better understanding. The main objective of this work is to study the diagenetic alteration in tidal sandstone deposits in Nyalau formation, Sarawak, East Malaysia. This has been done with traditional field sedimentology i.e macroscopic to microscopic (thin-section) with grain size analysis and porosity-permeability determination for 26 samples taken from the outcrops. Air permeability tester was carried out for quantitative and qualitative analysis of permeability at different bedding. The flow rate and pressure were monitored as the results of the experiment. From the readings obtained by the TinyPerm2 machine convert to permeability by using formula as;

$$T = (-0.8206) \times \log_{10} K + 12.8737$$

$$\text{where } T = TinyPerm2\ readings, K = Permeability$$

Represented outcrops from the study area show sedimentary features such as herringbone, cross-bedding, flaser, wavy and bioturbidite structures (Figure 1). The grain size of the outcrop mainly very fine to fine. In terms of petrography the porosity ranges from 15% to 35% where it proofs that the reservoir quality of the outcrop is good to very good and permeability of the sandstone facies is high ranges from 46.77 to 19136.69 mD (Figure 2). Petrography analysis of the samples showing the sorting of the grains are very poor to fair depending on type of the facies and a lot of quartz overgrowth indicating the diagenesis alteration affecting the reservoir quality. By integrating the results of these analysis it has been concluded from the tidal sandstone in Nyalau Formation is a good quality sandstone reservoir.

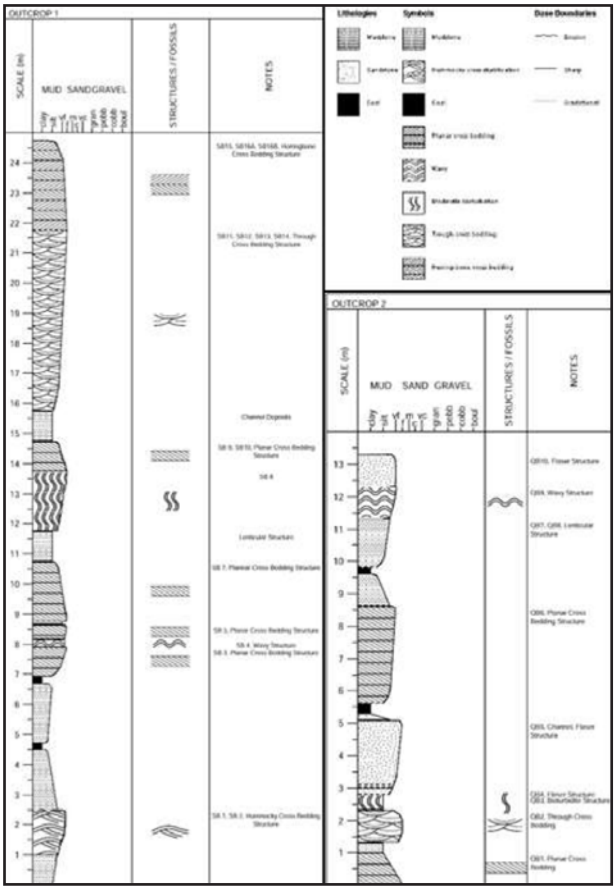

Figure 1: Sedimentary Log of Nyalau Formation (outcrop 1) with its sedimentary structures and grain size distribution.

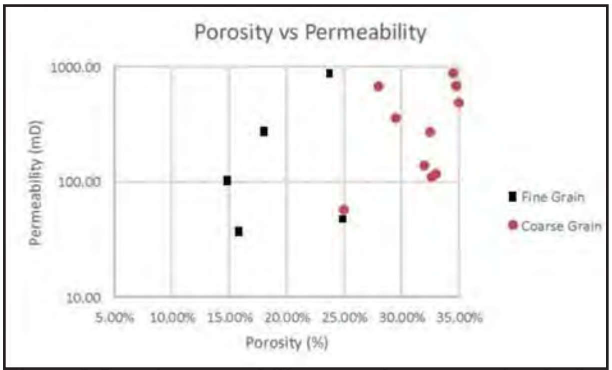

Figure 2: Porosity-permeability cross plot representing the fine grain and coarse grain distribution.

DPT23-64

Integrated Reservoir Fluid Characterization in Thinly Laminated Formations – A Case Study from Deepwater Sabah

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Introduction

Reservoir properties such as fluid compositions, formation pressures, and fluid contacts are critical in the early phase of the well life and represent the key inputs for comprehensive production and reservoir engineering studies in the development phase. Accurate measurements and evaluations of reservoir fluid properties tend to become more complex in challenging drilling environments, coupled with complicated reservoir facies such as the thinly laminated formations (Figure 1). To reduce the uncertainty in the estimation of hydrocarbon in place and fluid contacts in clastic reservoirs, it is paramount to integrate various measurements such as core data, log analysis, image logs, pressure data, and fluid sampling results for a holistic and meaningful evaluation approach.

Methodology and Discussion

A number of methods are available nowadays for reservoir fluid characterization but each method has its own limitations and advantages. However, technical advancement achieved in individual technology alone may not necessarily provide a complete answer for the formation fluid evaluation task. To reduce this uncertainty and to improve reservoir fluid evaluations, an integrated approach that combined various methods such as Advanced Mug Gas Logging (AMG), wireline Downhole Fluid Analysis (DFA) and PVT laboratory analysis is developed (Figures 1 and 2), based on a case study of an exploration well from deepwater Sabah.

In this paper, the developed integrated approach and workflow that combined these independent measurement methods proved to be the key to the success for formation fluid characterization. We focused on how the integration of various methodologies can complement each other through the following strategies: assessment of reservoir fluid properties, starting from the early stages of open hole measurements, can be complemented by measurements obtained from AMG logging and wireline DFA and sampling (Figure 3). The AMG provides an early approach to reservoir fluid identification through its capability to generate a continuous fluid facies logged across the entire drilling interval (e.g. Ivan et al., 2015).

This early quantitative assessment of fluid compositions and sampling optimization of potential pay zones can help in making timely decisions during the exploration or development phases. This approach aids in reducing data acquisition risk, and optimizes operation time spent by correctly evaluating zones of interest during the appraisal phase. At a later stage, the fluid compositions and PVT information can provide important inputs for petrophysical analysis to more precisely evaluate the reservoir properties and volume of hydrocarbons present in the reservoirs. This will reduce the geological uncertainties at an early stage of the field development (e.g. Ko et al., 2014), which is critical for the development and production of high-cost deepwater discoveries such as those found in offshore Sabah turbidity channel-fan systems (Jong et al., 2015). Subsequently, the paper also discusses the integration of the fluid property information in a *petrophysics multi-mineral simultaneous solver workflow* to reduce the uncertainty of formation evaluation (Figure 4).

Conclusion

This paper presents a successful case study conducted for three drilling sections of an offshore exploration well. It demonstrates the strategies used for accurate fluid characterization assessments in a challenging deepwater environment. The methodology, workflow, analysis, and applications of this field study are discussed and presented in detailed, which may be beneficial for the subsurface assessment of other discoveries made in similar depositional setting.

Acknowledgements

We thank our exploration colleagues in JX Nippon and Schlumberger for the technical support and discussion on the integrated reservoir fluid characterization of exploration wells from the Sabah deepwater drilling campaign in 2015. Our appreciation is also extended to JX Nippon Management and PETRONAS for their support and permission to publish this paper.

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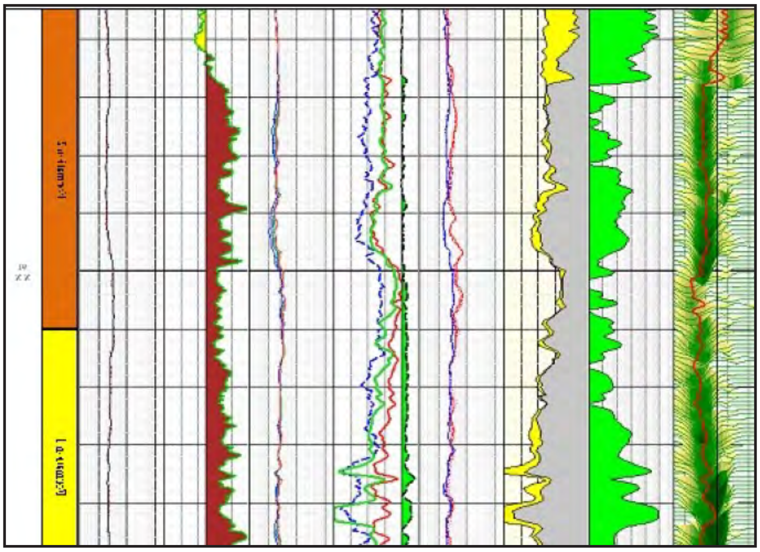

Figure 1: An example of thinly laminated formation response.

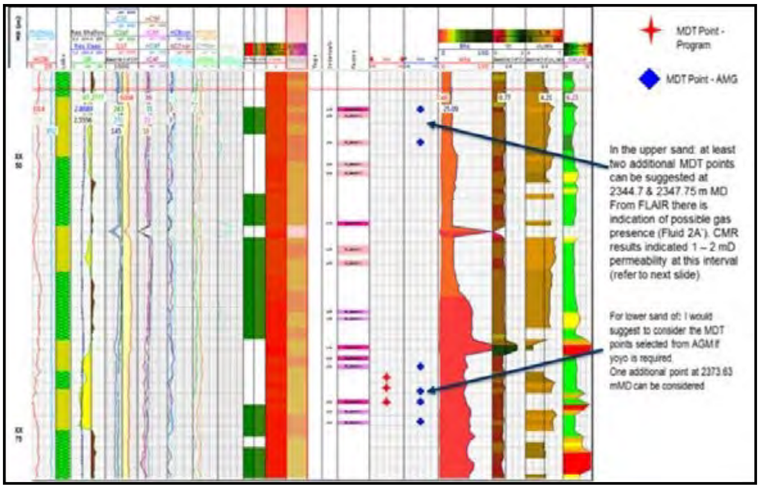

Figure 2: An example of AMG and petrophysical logs integration to optimize wireline formation testing (WFT) pressure point selection.

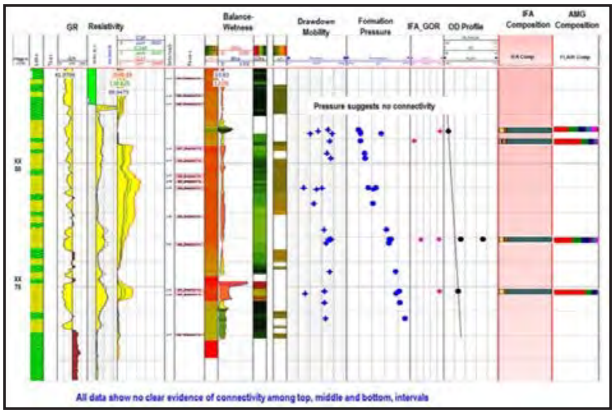

Figure 3: An example of AMG, DFA, and Petrophysical results integration for better reservoir fluid characterization. Inset shows the spider plot for gas component concentrations.

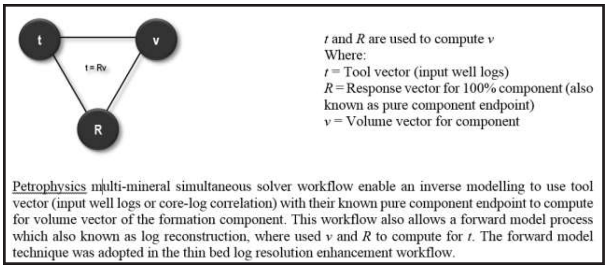

Figure 4: Petrophysics multi-mineral simultaneous solver workflow.

DPT24-90

The Holistic Approach in Petroleum Exploration

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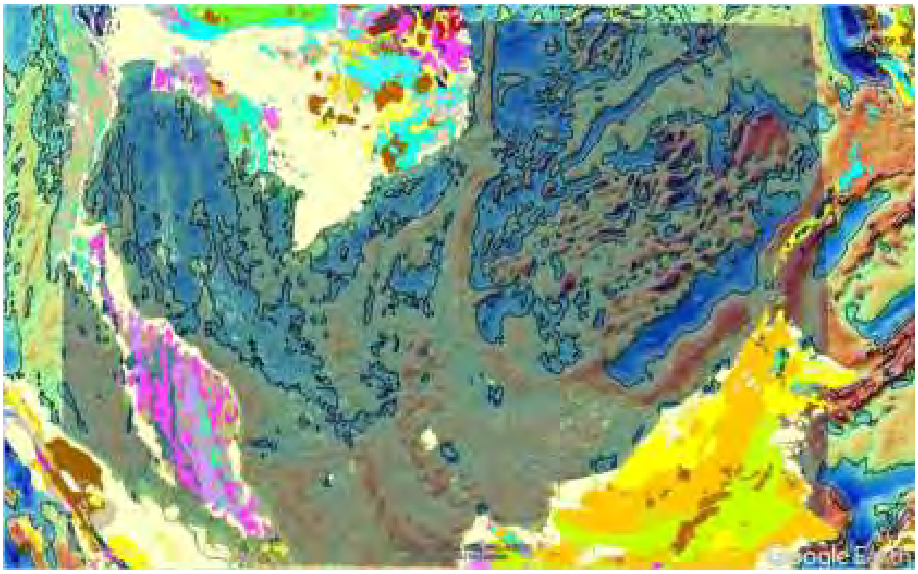
The current practice of exploration is highly data driven. Geological concepts become localized in order to suit the small scale seismic and well data. More often than not, the regional geology is sidelined in order to suit the "individual" data. Without a detailed understanding of the region; especially in the South East Asia region that has complex tectonic, geological concepts can easily vary from one geologist to the other depending on their perspective and also on their interpretation of the data studied. The "trapping in local minima" phenomena becomes increasingly prominent during exploration scale studies whereby selective "simple" exploration regions are successfully explored while many less favourable areas would be "left out".

The sedimentary basins of Malaysia have diverse origins and occur in different tectonic settings representing almost all the stages of the Wilson cycle; from divergent (extensional), intraplate, to convergent margin settings. The Malay (and Penyu) basin are classified as intracontinental rifts that never made it to the oceanic stage. On the other side of Peninsular Malaysia, compressional deformation has resulted in the uplift of the Barisan volcanic arc and the formation of the retroarc foreland basin in the Straits of Melaka. On the other hand, tectonic origins of the sedimentary basins onshore and offshore Borneo are still subject to intense debate (especially between Robert Hall and Paul Tapponnier) as they are still poorly understood. This makes it difficult to generalize the type of sedimentary basin, thus leading to the question whether these basins could be fully exploited if they are misunderstood.

Figure below shows a surface geology map of Malaysia (and some part of Thailand and Indonesia) overlaid the basement gravity map over South China Sea and the distribution of hydrocarbon fields in Malaysia and Gulf of Siam. Interestingly the hydrocarbon trends in al three basins in Malaysia is behaving differently. Event the trend in Malay Basin as compared to Patani Basin in Gulf of Siam.

The success of any exploration campaign hinges mainly on how well the "global" petroleum system is understood especially regarding petroleum system processes such as generation, migration, accumulation and trapping. The "local minima mindset" limits and constrains the ability to fully picture the geological history surrounding these basins leaving many opportunities besides conventional simple anticline and fault bounded structures to be unexploited despite having proven active petroleum systesm.

Even though more than hundreds of researches have been conducted in the region, the question remains is how well do we know our basin. The continued efforts to study the area proves that the current understanding of the region is still insufficient.



Gravity map of South East Asia overlain with the geological maps of Peninsular Malaysia, Sabah and Sarawak.

DPT25-84

A Case Study of Gas Hydrates in Offshore NW Sabah, Malaysia: Implications as a Shallow Geohazard for Exploration Drilling and a Potential Future Energy Resource

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Introduction

Gas hydrates are crystalline solids sometimes referred to as "flammable ice" (Figure 1a), consisting of hydrocarbon gases with low molecular weight such as methane, ethane and propane, bound with water molecules within cage-like lattices. Methane gas hydrates are the most common form. In addition, a small amount of carbon dioxide (CO_2) and hydrogen sulphide (H_2S) may also exist in gas hydrates. The water molecules and low molecular weight gas hydrate lattices are stable within a specific range of temperatures and pressures (Shankar *et al.,* 2004). The source of the gases can be biogenic or thermogenic in origin. Biogenic gases commonly come from the fermentative decomposition of organic matter and generation of bacterial gases within shallow sediments, while the thermogenic gases are derived at depth from the conversion of thermocatalytic organic materials (Figure 1b; Behain, 2005). Gas hydrates are most common in polar permafrost areas and the upper hundreds of metres of sub-sea floor sediments on the continental margins at water depths greater than about 500m. According to Kvenvolden (1993, 1998), one cubic metre of dissociated gas hydrate is equivalent to 164m3 of gas released at normal atmospheric pressure. Methane gas hydrates therefore represent a significant potential energy resource and may represent one of the world's largest reservoirs of carbon-based fuel. Presently, in many countries such as China, India, Japan and USA, national programmes exist for the research and production of natural gas from gas-hydrate deposits. As a result, hundreds of gas hydrate deposits have been discovered, with a few hundred wells drilled, and kilometres of hydrated cores studied (Makogon *et al.,* 2007).

Study Objectives and Gas Hydrate Identification

The study area is located in the Malaysian NW Sabah deepwater area where a gas hydrate deposit was investigated for potential resource estimation. The NW Sabah Basin is classified as a foreland basin associated with an active fold and thrust belt (Figure 2), where from the latest Miocene to Holocene epochs, a consistent palaeo-shelf edge position is established with the narrow shelf area restricted due to constant uplift and very rapid subsidence rates of the basinal area (Behain, 2005; Lambiase and Cullen, 2013). Consequently, a steep slope exists with water depths rapidly deepened to the deepwater trough area where gas hydrates are found.

Gas hydrates represent both a potential drilling geohazard and conversely a potential resource. Hence the objectives of this study are:

- To identify the presence of gas hydrates and to mitigate them as a drilling geohazard in offshore deepwater Sabah area,
- To estimate the potential resource volume of a gas hydrate deposit in deepwater Sabah, and
- To investigate gas hydrates as a potential future energy resource and the associated risk of extraction.

Seismic reflection profiles, wireline well logs and core data can be used as indicators for the presence of gas hydrates. On the seismic profiles, gas hydrates are typically associated with a Bottom Simulation Reflector (BSR) as shown in Figure 3. The BSR identifies the solid hydrates – with free gas phase boundary at the base of the gas hydrate stability zone (GHSZ), and tends to mimic the seafloor reflection. The BSR phase boundary is governed by temperature, pressure, gas composition and pore water salinity (Behain, 2005; Hyndman and Davis, 1992; Kvenvolden*,* 1993). As such, the existence of BSR in seismic reflection data can help to identify the presence of marine or ocean gas hydrates. Gas hydrates also can be detected through wireline well logs such as caliper, spontaneous potential and resistivity (Kvenvolden and Lorenson, 2001; Goodman, 1980). When the gas hydrates are present, the electrical resistivity log is higher, whilst spontaneous potential is lower. Neutron porosity for gas hydrate bearing sediments increases, whilst density and acoustic transit time decreases (Collett and Ladd, 2000). Overall, gas hydrate and free gas concentrations, as well as the reservoir facies and parameters can be identified through core analysis and by down-hole logging (Behain, 2005).

Mitigation of Gas Hydrates as a Drilling Geohazard

As hydrocarbon exploration and production activities move from shallow shelf to deepwater environment, the chances of drilling through a gas hydrate deposit increases. The drilling of gas hydrates may affect the stability of the wellbore. Dissociation of a gas hydrate deposit may occur when the equilibrium temperature and pressure condition of the deposit is disturbed. This can lead to a decrease in the drilling fluid density and hydrostatic pressure through gassification, and changes in the rheology of any drilling mud. The result may be the instability of the wellbore and casing collapse. Gas hydrates can also act as an effective seal to underlying shallow gas accumulations. Due to gas hydrate contribution as a drilling geohazard, operators will mitigate the risk by avoiding potential pockets of shallow gas trapped below hydrate deposits (Nimblett *et al.,* 2005). This can be achieved during the pre-drill operation phase, where the risk of encountering gas hydrates can be assessed by evaluating the high resolution shallow seismic data to identify the occurrence of a BSR, the potential thickness of gas hydrate accumulations and by conducting amplitude analysis to identify the potential risk of shallow gas accumulations. Additionally, rapid variations in gas hydrate thickness may be used to identify migrating fluid plumes and anomalies in the geothermal gradient. This pre-drill analysis is a practice commonly conducted in the oil and gas industry through shallow hazard desktop studies. The wellbore can then be positioned accordingly to minimize the risk posed by gas hydrates.

Resource Estimation of a Gas Hydrate Deposit in Deepwater Sabah

The estimation of the potential resource volume of a gas hydrate deposit offshore NW Sabah was conducted, which required well-derived input parameters in the detailed volumetric calculations. The essential parameters for resource estimation are:

- GRV = Gross rock volume in MMm^3
- N/G = Net to gross ratio
- ρ = Porosity
- Sh = Gas hydrate saturation in pore volume
- VR = Volume ratio
- CO = Cage occupancy

Based on this volumetric assessment method, the potential resource volume of the investigated gas hydrate deposit is calculated from the equation below:

Gas Hydrate GIIP (gas-in-place, BCF) = GRV × N/G ×ρ × Sh ×VR × CO/28.3

Based on this methodology, the amount of total gas hydrates in the offshore NW Sabah example is around 1003.4 BCF (2.84×1010 m^3).

Gas Hydrate Extraction and Associated Risks

Methane can be extracted from natural gas hydrates through three methods namely:

1. Depressurization where the pressure is decreased below the equilibrium pressure of hydrates (Figure 4a),

2. Injection of chemical inhibitor such as methanol into the gas hydrate sediments to promote hydrate dissociation by lowering the temperature (Figure 4b), and

3. Thermal stimulation by increasing the temperature in order to accomplish gas hydrate dissociation (Figure 4c).

However, no commercial-scale technologies to exploit gas hydrates have been demonstrated so far with many complex problems for efficient and sustainable production currently under research. In addition, with abundant availability of natural gas from conventional and shale resources, there is currently no economic incentive to extract and develop gas hydrate resources.

A key issue for the extraction of gas hydrate is its potential contribution to global warming. Solid methane hydrates contribute to geotechnical stability. However, if the solid methane hydrates undergo dissociation, the area around the formation can become destabilised. The small shift in the seabed can damage the wellbores and resulted in additional cost for drillers and operators. Other risk factors associated with gas hydrate extraction include submarine slope failure and a decrease in microbial communities associated with methane-hydrate ecosystem.

Conclusions

Gas hydrates are both a drilling geohazard and a potential future energy resource. Their presence and extent can be estimated from seismic profiles based upon the identification of a phase boundary bottom simulating reflector, BSR. Wellbore instability and casing collapse can be caused by the dissociation of gas hydrates encountered while drilling. The risk can be minimized by careful pre-drill well path planning. At some point in the future with improved gas prices, gas hydrates can be a vast potential source of natural gas. However, significant additional research and technological improvements are needed before safe commercial productions can be achieved. Nonetheless, the recent extended production test conducted by the Chinese in the South China Sea provides a positive encouragement to overcome technical obstacles for a future sustainable production.

Acknowledgements

We thank our exploration colleagues in JX Nippon for the technical support and discussion on the topic of hydrate research, the focus of an MSc project in Petroleum Geology by the first author. Our appreciation is also extended to JX Nippon Management and PETRONAS for their support and permission to publish this paper.

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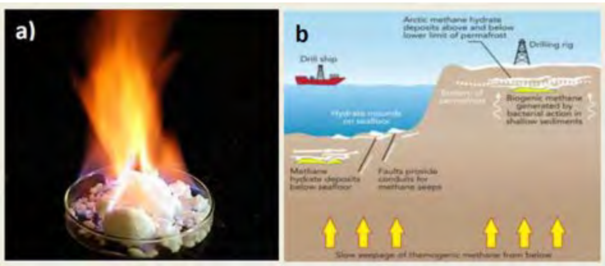

Figure 1: a) "Flammable ice" – Gas hydrates (Cox, 2008), and b) Types of methane hydrate deposits (Spalding and Fox, 2014).

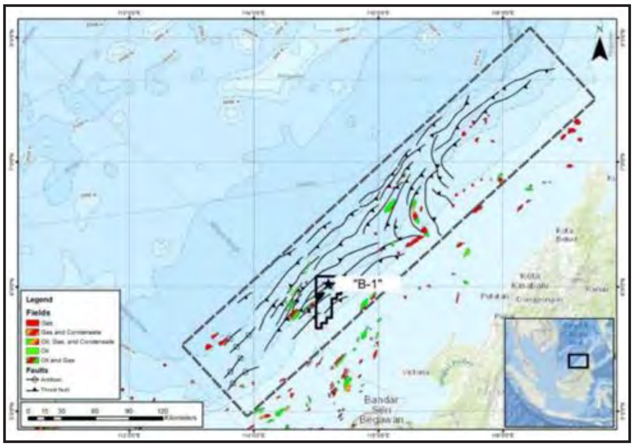

Figure 2: Location map of the study area offshore deepwater Sabah within the Sabah Fold Thrust Belt, where the discovery of "B-1" was made within JX Nippon operated block enclosed in the dark line polygon (Ogawa and Jong, 2016).

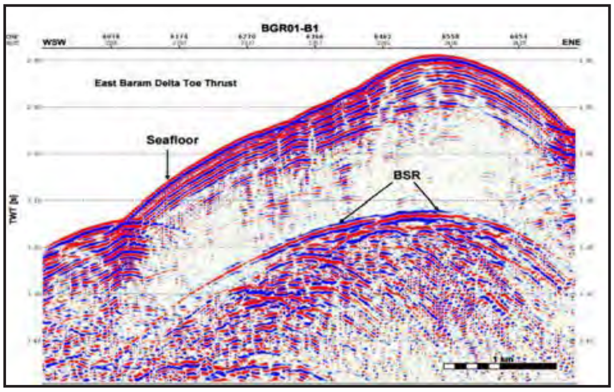

Figure 3: Detection of BSR, paralleling the seafloor reflector in the seismic profile (Behain, 2005).

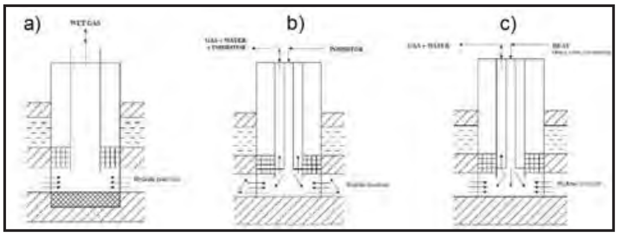

Figure 4: Production of gas from hydrate deposits *via:* a) depressurization method, b) inhibitor injection, and c) injection of heat through thermal stimulation method (Demirbas, 2010).

DPT26-143

FSM Based Interpretation of Complex Internal Carbonate Architectures, Facies and Karsts

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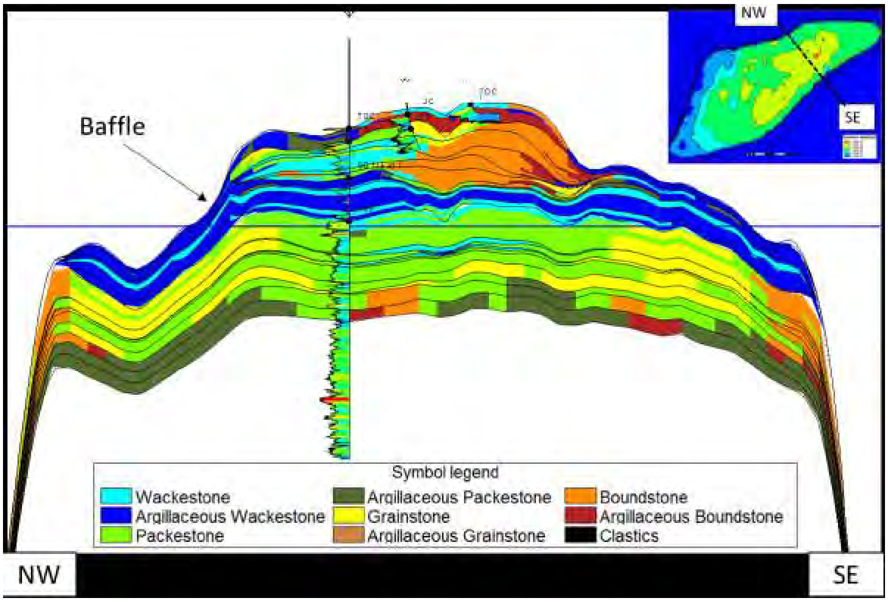
The paper discusses an innovative methodology of designing a carbonate reservoir model on a field in Central Luconia for planning further optimal field development and reservoir management & surveillance (RMS) using a Forward Stratigraphic Modelling (FSM) approach. Understanding of carbonate reservoir architecture is important for successful, stable hydrocarbon production and reservoir management plan. This understanding on early stages can help to prevent unpredictably low productivity & recovery, early water breakthrough and design field-customized RMS formulation.

The method used in the FSM approach is to first set the modelling input parameters which mostly represents the main depositional processes such as conditions of wave energy & direction, paleobathymetry, carbonate production rate, eustatic changes, amount of subsidence etc. These input parameters are obtained from an integrated approach of analysis on all hard data available including understanding of modern analogues to create a conceptual model at time of deposition. Once these input parameters have been identified, the simulation is computed to provide a first-pass model which is validated with hard data. If present mismatch, the input parameters will be tweaked and another simulation is computed. The steps are repeated again until an acceptable match between the model results and the hard data is obtained.

Overall, the FSM model aided greatly in understanding the Internal Reservoir Architecture, Facies distribution and also Karst Interpretation in the field. All this assisted the Geomodeller in construction of a more robust Geological Model which also provides a better fluid flow prediction in the dynamic simulation.



FSM Facies for the entire modelled sequence

ORAL PRESENTATIONS

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REGIONAL GEOLOGY

Crustal Thickness and Velocity Structure of Southern Peninsular Malaysia

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The tectonic setting of Peninsular Malaysia can be described by three distinctive stratigraphic belts, known as Western, Central and Eastern belts. These Western and Eastern belts which were formed during the Paleo-Tethys subduction process in the Late Paleozoic are separated by the Bentong-Raub suture zone. Although there are various study had evaluated this formation process, the geological detail of the region's crust is still unknown. The velocity and detail information of the Earth's crust is crucial in determining the earthquake's location and seismic hazard. Since the cost to conduct a large scale geophysical study to determine the Earth's structure is high, a better and efficient method is by incorporating the receiver function method. The receiver function is computed from the tele-seismic earthquake waveform which involve P-wave, P-S wave and pPpS + pPsS multiple phases recorded by a three-component seismogram. In this work, the data recorded at the two broadband seismometer stations located in Kota Tinggi, Johor (KOM station) and Singapore (BTDF station) (Figure 1), were investigated for the receiver function analysis, crustal thickness estimation through H-k method and waveform inversion for 1-D velocity. There are a total of 448 (for KOM station) (Figure 2) and 73 (for BTDF station) tele-seismic earthquakes which occurred in between 2005 to 2016, were evaluated for the crustal thickness and velocity structure analysis. From the H-k thickness analysis, the Moho boundary was found at 35km (Figure 3) and 30km for region beneath KOM and BTDF stations respectively, while the 1-D velocity profile indicate a gradual velocity increment from Conrad boundary (around 18km depth) to Moho thickness in both cases. The findings of these stations' crustal thickness are consistent with the past findings although it also indicates the thickness for southern Johor and Singapore is more similar to the Western belt of the Peninsular Malaysia.

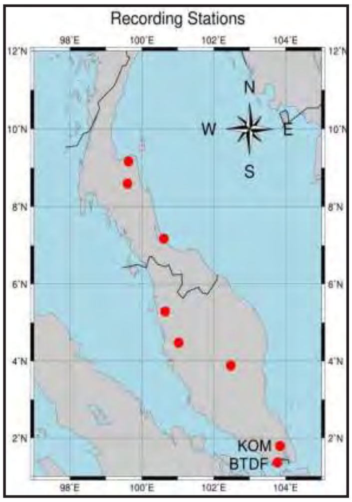

Figure 1: The map of Malay Peninsula shows the location of broadband seismometer station (red dot) used for receiver function analysis.

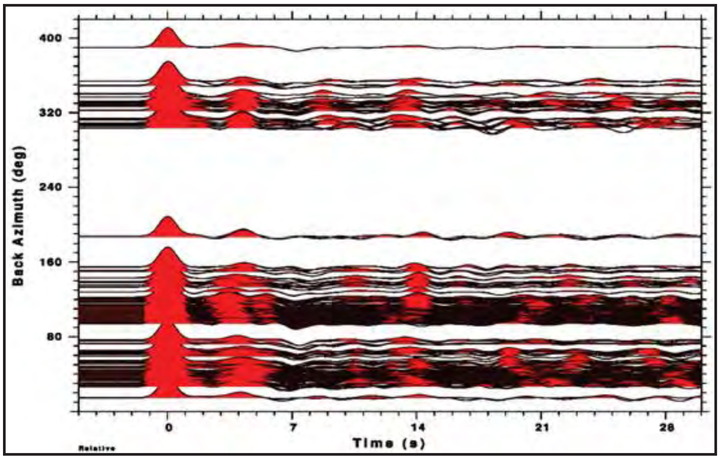

Figure 2: Receiver function of KOM station as a result of waveform rotation and deconvolution process. There are 448 waveforms analyzed from tele-seismic earthquake in between 2005 – 2016.

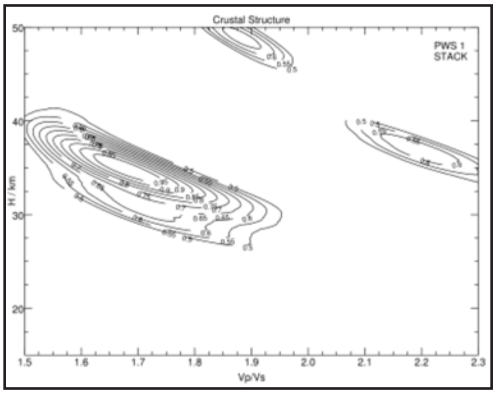

Figure 3: H-k contour map indicates the thickness of crust-mantle boundary (y-axis) vs. k, V_p/V_s ratio (x-axis). The thickness beneath Kota Tinggi region (KOM station) was found at 35km with V_p/V_s ratio at 1.68.

DRG22-39

Tidally-Influenced Deposition in the Early Miocene Balingian Province of Sarawak: Sedimentary Characteristics, Geologic Cause and Impact on Earth history

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Tidally-influenced strata are important hydrocarbon source and reservoir rocks in the Early Miocene Cycle II interval of the Balingian Province, north-west Borneo. The Cycle II strata, consists of two c. 100–300 m thick, fining-upwards megasequences containing several higher-order units. The megasequences formed during c. 2-4.5 Myr periods of hinterland denudation and overall eustatic sea-level rise. The age-equivalent, onshore Nyalau Formation consists of several higher-order stratigraphic units that are interpreted as representing high frequency, regressive–transgressive cycles and deposition in a mixed wave- and tide-influenced coastal–deltaic depositional system. Stratigraphic architecture was strongly influenced by high frequency tectonic movement along the West Balingian Line fault zone. The offshore Cycle II strata show greater fluvial dominance, coarser grained sediments, mixed fluvial-tidal coastal systems and a paucity of wave-dominated successions. The higher fluvial influence reflects increased proximity to sediment source areas, including uplifted fault blocks of the West Balingian Line and the Penian High. The increased distance from sediment source areas resulted in decreased fluvial influence during deposition of the Nyalau Formation system, which increased the relative influence of tide and wave processes. Integrated palaeogeographic reconstructions, palaeotidal modelling and facies analysis indicate that Early Miocene tides in the Balingian Province may have had a 5–7 m tidal range and been capable of transporting coarse sand. Strong tides were the result of a regional-scale (100 – 1000 km) increase in tidal inflow and decrease in tidal outflow into the South China Sea, and relatively local-scale (10 – 100 km) funnelling effects in embayed shorelines in the Sarawak Basin. These conditions optimized the development of tide- and mangrove-influenced depositional systems across the South China Sea region, potentially resulting in enhanced lithospheric storage of organic carbon of up to 4,000 Gt (equivalent to 2,000 p.p.m. of atmospheric CO_2).

DRG23-56

Geosite Assesment of the Trace of Mesozoic Subduction in Lubar Village, Muara Dua Distric, South Sumatera Province, Indonesia

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Lubar Village is one of the trace of Mesozoic Subduction located at the distric of Muara Dua, South Sumatera Province, Indonesia. This study aims to give geological knowledge of Lubar village from the earth science perspective that could be the information and tour guidance for the visitors of the Lubar village. The geological informations are the result between integration of field examination, laboratory analysis and initial study of Lubar village. Petrographic analysis deepicts that the volcanic rocks is formed at the earth surface as oceanic crust. Paleontological analysis based on thin section of limestone shows the age of Lubar village limestone is Early – Middle Miocene. Based on field examination, Insu river in Lubar village flows between the unconformation of a long steep cherty hill and shallow marine sediment. It is necessary to have an effective organizing and monitoring as well as continual in order to develop this particular place to be geosite. The development of geosite potential towards Lubar village is impressive to go along with tour of pra tertiary rocks and waterfall.

DRG24-61

A re-assessment of Mesozoic Meta-sedimentary Successions in Singapore: Terrestrial to Deep Marine Depositional Environments and Stratigraphical Framework

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To address competing land-use requirements, and the needs of an ever-growing population, Singapore looks to the subsurface to meet many of its future development needs. The subsurface is now considered an attractive development space for, amongst other things, energy production and infrastructure, waste disposal and treatment, groundwater abstraction and water storage, transportation infrastructure, industrial manufacturing and logistics. Singapore aspires to become a 'smart' nation/city that integrates transportation, utilities and services infrastructure with information communications technology (ICT) in order to facilitate sustainable management of its societal assets. A comprehensive understanding of Singapore's geology is therefore critical to both future development and ongoing management of the subsurface.

The British Geological Survey (BGS) is working with Singapore Building and Construction Authority (BCA) to deliver that modern geological knowledge-base to benefit the widest possible stakeholder community, including the public and private sectors and academic institutions. BCA have implemented a new and comprehensive ground investigation programme, recovering drillcores from c. 100 deep boreholes (typically to 200 m depth) and acquiring conventional 2D seismic reflection data from across some 350 km^2 of ground. All of this new data provides an unprecedented opportunity to unravel the complex geological relationships that exist in the Jurong Group, a complex fore-arc succession which crops out in southwest Singapore and is a correlative of the Raub Group in Malaysia. This paper presents a summary of work to date by BGS to conduct a new sedimentological environment analysis of the Singapore outcrop of the Jurong Group, which will underpin a revision of the stratigraphical framework for Singapore. A revised structural framework for the Jurong Group is described in a companion paper also presented at this conference (Leslie *et al.* also in this volume).

The geology of Singapore is dominated by Permian to Triassic arc magmatism and sedimentation succeeded by collisional accretion tectonics in the latest Triassic to early Jurassic. The sedimentary successions, which are characterised by marked lateral and vertical variability, are interpreted to reflect deposition in a range of environments. The generalized vertical succession within the Jurong Group on Singapore is now understood to consist of the following components, in chronological order.

1. A shallow marine, cyclic carbonate and siliciclastic environment that is succeeded by a range of deep, shallow and marginal marine environments, and by a terrestrial-fluvial environment. This association of depositional settings is characteristic of a basin margin. The products of contemporaneous volcanism - including air-fall and ignimbritic pyroclastic rocks and tuffites - are a common feature in much of the succession, forming deposits up to around 200 metres thick.

2. Thickly bedded carbonates, thin siltstones, and minor tuffs that were deposited within a relatively restricted basin when compared with the underlying succession. The basin then experienced renewed siliciclastic input from terrestrial fluvial systems, which acted to shut down carbonate production. The siliciclastic sediment was re-worked in marginal marine to shallow marine settings. Limited accommodation space resulted in basin shallowing, with fluvial processes gradually becoming dominant. The upper portion of the succession is dominated by fluvial/alluvial and/or fluvio-lacustrine deposition, during which a vast quantity of immature sediment was brought into the basin through activation of alluvial fans.

3. Two early Cretaceous (Berriasian and Barremian), mainly terrestrial, successions overlie a significant unconformity, and overstep the collisional tectonic structures. Dextral strike-slip tectonics in the mid-Cretaceous (?Cenomanian) produced brittle faulting across Singapore which may have resulted in alluvial fan rejuvenation, particularly in the hanging walls of developing normal faults.

A revised stratigraphical framework will be constructed through a combination of: litho-facies analysis; an appreciation for sedimentological variability in 3D space and time; and constraining the age of key units and boundaries within the sequence introducing an important element of chronostratigraphical control. Furthermore, the variations observed and documented in this paper are being developed alongside, and greatly complement, recent advances in the understanding of the structural framework, presented in Leslie *et al.* (also in this volume). These new integrated studies will redefine the stratigraphic framework for Singapore, enabling it to be properly placed within the regional geological context.

DRG25-70

Late Quaternary River Systems of Sarawak Shelf: Geomorphic Features from Near Surface 3D Seismic Data

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Near surface data of multi vintage seismic surveys from Continental shelf of Sarawak offshore are analyzed to identify and characterize depositional features in the shallow section. The studied section which could be correlated to late Quaternary period is characterized by presence of well-defined fluvial-estuarine geomorphic features. Prominent fluvial systems consisting of rivers, incised valleys and tidal channel inlets have been interpreted from time slices of 3D seismic data. This study is first of its kind on the Sarawak shelf which uses extensive seismic data for interpretation and characterization of geomorphic features in the region. Present day water depth in the study area ranges from less than 20 m to more than 200 m.

Conspicuous channelized features, with major trunk valley associated with dendritic tributaries are identified (Figure1).These features referred here as incised valley extends for more than 200 m trending South-North. Presence of incised valley could be correlated to sea level fluctuation in the late quaternary time in the region, which have been reported by various authors before. Although the actual amount of sea level lowering could not be calculated from seismic data set, it could be said that because of the low gradient of the Sarawak shelf even a smaller sea level change could have exposed the whole self-area. Interestingly the major channel systems identified in the study could be spatially correlated to present day river systems of Sarawak.

Understandings from this study could be used as an analogue to features in deeper stratigraphy, which are deposited in similar environment and potential hydrocarbon exploration targets. Study of these depositional features give a better understanding about the paleogeography of the area in very recent past as well as how far the Sarawak shelf was exposed, which has bigger impact on various geologic studies.

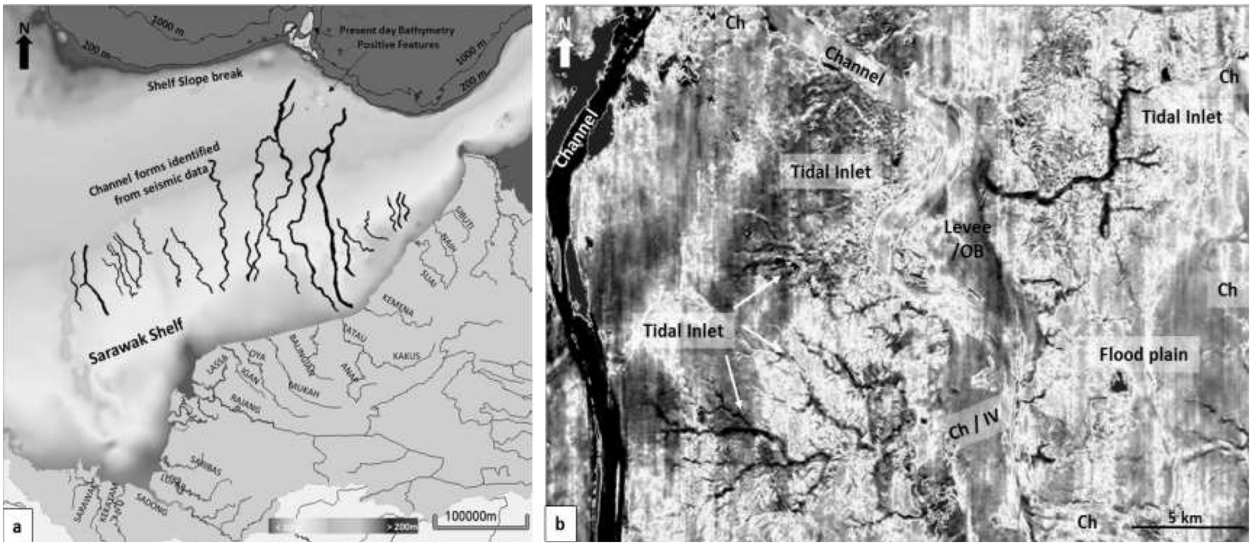

Figure1: (a) Identified channelized features overlaid on present day bathymetry map. Extent of interpreted channels are constrained by the availability and quality of seismic data. The above channelized features could be well correlated to present day major rivers of Sarawak .(b) A time slice near to sea bottom shows very prominent geomorphic features like wide channel/incised valley (?) , tidal inlets/tributaries , smaller channels etc. Sea level fluctuation during late Quaternary time caused exposure and drowning of the shelf in the region leading to formation of these features. Ch-Channel, OB- Over Bank, IV-Incised Valley.

DRG26-72

An appraisal of the Tectonic Evolution of Borneo, SE Asia - Constraints from Petrotectonic Assemblages and Geophysical Gravity Anomaly

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Based on petrotectonic assemblages and terrane pattern three morphotectonic zones of Borneo Island has been proposed. Three morphotectonic divisions of Borneo are i) West Borneo (Borneo Core) of the continental basement and widespread igneous rocks of Lr Cretaceous to Miocene, metasedimentary rocks of mostly Tertiary period occur in the Schwaner Mountains; ii) North Borneo characterizes Tatau-Mersing sinistral transform trench, Tatau high and Lupar thrust zone of the Meso-Cenozoic sediments intruded by the intense igneous intrusives; iii) East Borneo is characterized by dominantly metasedimentary rocks of Cretaceous to Miocene in the Sabah orogen and metasedimentary rocks of Jurassic to Miocene in the Meratus Mountains (Fig. 1). Evidences derived from petrotectonic assemblages signify that the Borneo Core (West Borneo), being the oldest, has evolved from depleted basaltic to enriched andesitic composition of subduction melts. A tectogenetic model of the Borneo basement is proposed here based on the model of Precambrian crustal development wherein subcrustal lithosphere has undergone delamination and sinking through spontaneous instability due to rupture and resulted downwarping. Due to intrusion and lateral spreading of hot upper mantle, crust has undergone heating and partial melting resulting extrusion of primitive tholeiitic magma into overlying basins. In addition, hot lower crust has undergone attenuation due to ductile spreading (Fig. 2). Occurrence of tectonically transported oceanic assemblages viz., turbidites, chert, serpentinite, pillow basalt, sheeted basalt and other oceanic assemblages in parallel with the Lupar Thrust zone between Sri Aman in the east and Lundu in the west mark a suture zone (Sarawak Suture). Sarawak Suture marks the zone of collision between Luconia block in the north and foreland shelf of West Borneo in the south. Makassar Strait and Celebes Sea of East Borneo are the remnant paleo-ocean basins that have undergone late-Cretaceous partial closure, accretion and exhumation; and Cenozoic rifting and extension.

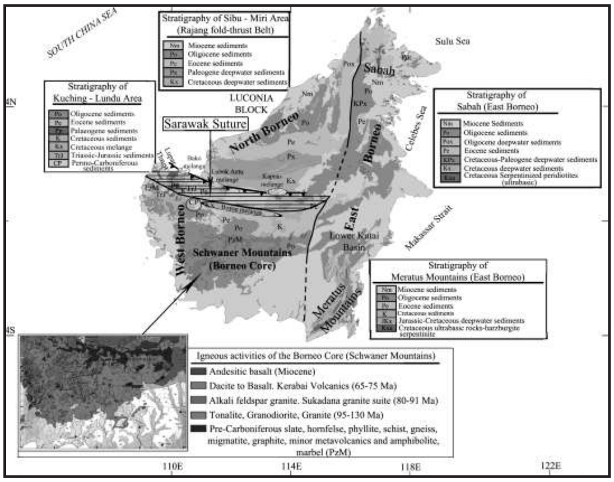

Figure 1: Morphotectonic zoning and petrotectonic assemblages of Borneo.

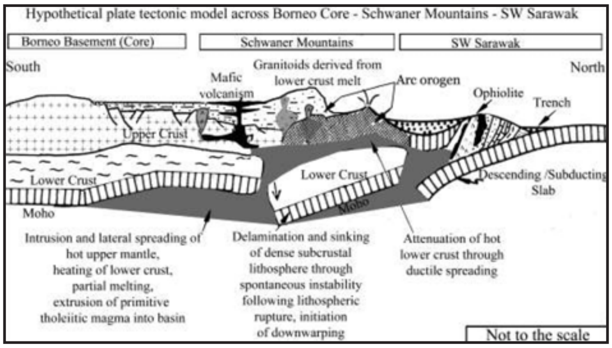

Figure 2: Proposed geotectonic model and crust-mantle configuration along North - South cross-section of Borneo Core.

DRG27-92

Deformation Profile Analysis of a Deepwater Toe-Thrust Structural Trend – Implications on Structural Kinematics and Sedimentary Patterns

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Introduction

This paper focuses on the structural geology and the deformation analysis of an anticlinal structural ridge, the L-B-P Trend, which resides in the deepwater setting in the NW Borneo Fold Thrust Belt (Figure 1), offshore Sabah. The structures are complex (Figure 2) with a genesis related to the gravitational collapse of the up-dip delta and the associated down-dip compressional thin-skinned tectonics. The anticlines have a strong flexural element later in their history, which occurs as the faults become inefficient, with the structures eventually becoming translated and vergent to the northwest. The timing of structuration and deformation of most of the toe-thrust features is primarily reflected by the Shallow-Regional Unconformity (SRU), which separates the pre- and post-kinematic phases.

For reservoir fairway prediction, a good understanding of the timing of the structural development is paramount in the analyses of sedimentary fairways and depositional patterns over the deepwater area. The pre-kinematic phase is likely to result in an unconfined depositional setting, while structurally influence syn-kinematic depositional phases tend to deflect turbidite sand fairways, and trap turbiditic sand in between structural ridges forming ponded turbidites in the associated synclines.

This study aims to provide further support for the semi-quantitative understanding of the various deformational episodes experienced in the L-B-P structural trend, from the oldest interpretable interval, the Kinarut to the recent seabed (Figure 2). A quantitative analysis of the deformation profiles was conducted to observe the effect on the sedimentary patterns, by integration with amplitude analysis and spectral decomposition interpretation. The chrono-stratigraphic scheme used for this study area is shown in Figure 3.

Methodology and Discussion

Deformation profile analysis was conducted to evaluate the tectonic history and structural development of the L-B-P Trend. The principal of line balance restoration is employed in this study with the fundamental assumption being that a geological section will restore at any particular moment in time to an unstructured section; the laws of superposition and horizontality. Multiple cross-section lines were selected across each individual anticline. The folded representative line lengths (6 key horizons – Lingan, Yellow, Pink, Kamunsu, Kinarut and Kebabangan) were measured and compared with the cross-sectional length. The input was then used to calculate the rate of shorting (ROS) at different geological times, using biostratigraphy as a temporal framework.

The rate of shorting is used here as a proxy for the rate of growth and is calculated by measuring the full length of the folded horizon and comparing it with the current day line length. Then shorting is simply calculated:

Line shortening (m) = Folded length (m) - Present day cross-section length (m)

The rate of shortening can then be calculated based on the temporal data and is calculated:

Rate of Shortening (m/Ma) = Line shortening (m) / Time period (Ma)

L-B-P Trend has experienced a NW-SE oriented compression from Early Miocene until the Late Miocene. Variations in the kinematic growth for each structure were identified and it is clear that structural growth varies along strike (Figure 4); where (1) the P structure forms earlier compared to the B and L structures, and (2) maximum deformation occurred during Yellow time for L structure, and at the Lingan time for the B and P structures. The significant effect of late stage deformation (higher stress regime) can be seen by a substantial shortening in the B and P structures during this Lingan time. In addition, the formation of steeply dipping forelimbs on the B and P structures results in the triggering of erosive slumping at these locations driven by the anticlinal fold geometry, as can be seen on seismic sections.

One of the key inputs in determining possible sand fairways is to generate attribute maps and integrate those maps with other G&G data in order to highlight the most prospective areas in term of reservoir. Since no rock physics or seismic inversion have been carried out outside of Nippon's operated block, basic seismic attributes were generated to delineate and identify potential sand fairways over the study area. Some of these attributes indicate channel and fan features, which are therefore considered as the potential reservoirs..

To enhance the understanding of the sedimentary patterns, spectral decomposition analysis was performed (Figure 5), which can help to reveal the geology that is present, but often hidden within the seismic data. This can create meaningful geological images and delineate the sedimentary features such as reservoir fairways, by outputting a number of band-pass and amplitude response (magnitude) volumes generated at discrete frequencies bands chosen by the interpreter, (these generally support the simple attribute extractions, such as RMS amplitude). Spectral decomposition maps give much clearer images with greater detail when compared to the RMS maps.

From the attribute analysis (both spectral decomposition and simple attributes) a clear 1st order correlation between the sediment fairways and structural development can be inferred. It is clear that the identified sedimentary fairways are in agreement with the structural deformation analysis which was carried out independently. Areas identified as pre-kinematic show broad unconfined fan geometries which cover the yet-to-form structures; while during times of syn-kinematic deformation the sedimentary fairways flow around the structures or though them, but as confined channel fan complexes before the smaller lobe fans form in the synclinal areas (Figure 5). This 1st order effect between deformation and sedimentation therefore has major implication for reservoir quality and effectiveness.

The L-B-P Trend is considered as the most promising trend in terms of reservoir development as most of the deepwater fans during the Kinarut and Kamunsu times are deposited over these structures.

Conclusion

This quantitative analysis has shown that the structuration and deformation history of the ridge which makes up the L-B-P Trend varied along strike (Figure 6). These variations are in agreement with isopach maps generated by latest seismic interpretation. The outcome plays a significant role on sediment fairway distribution patterns and subsequently impacts the selection of exploration reservoir objectives. It is noted that the structures were well-developed by at latest the Yellow time, which is favourable considering that the timing of hydrocarbon generation is modelled to occur during and post the Yellow time. Thus providing favourable timing for HC entrapment and accumulation (Figure 7). With the aid of attribute and spectral decomposition maps, a depositional system model can be developed in order understand the deepwater fan behavior in relation to the structuration.

Acknowledgements

We thank our exploration colleagues in JX Nippon for the technical support and discussion on the comprehensive G&G evaluations of the study area. Our appreciation is also extended to JX Nippon Management and PETRONAS for their support and permission to publish this paper.

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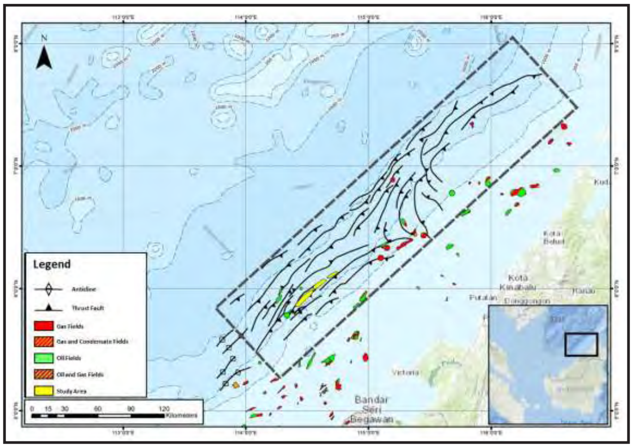

Figure 1: Location map of the study area offshore deepwater Sabah within the NW Borneo Fold Thrust Belt (black dashed polygon), where the location of the L-B-P structural trend is annotated in yellow.

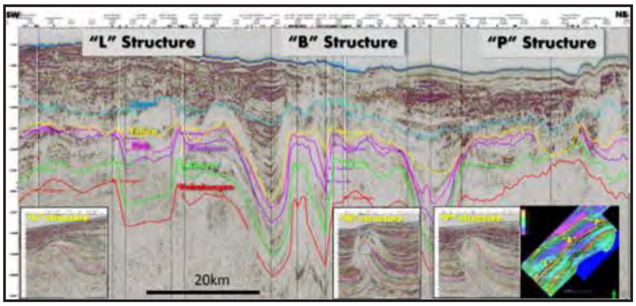

Figure 2: Strike section across the investigated L-B-P structural trend with interpreted horizons annotated. Inset figures show dip-orientated snapshots of individual structure and a depth structural map of the three L-B-P features.

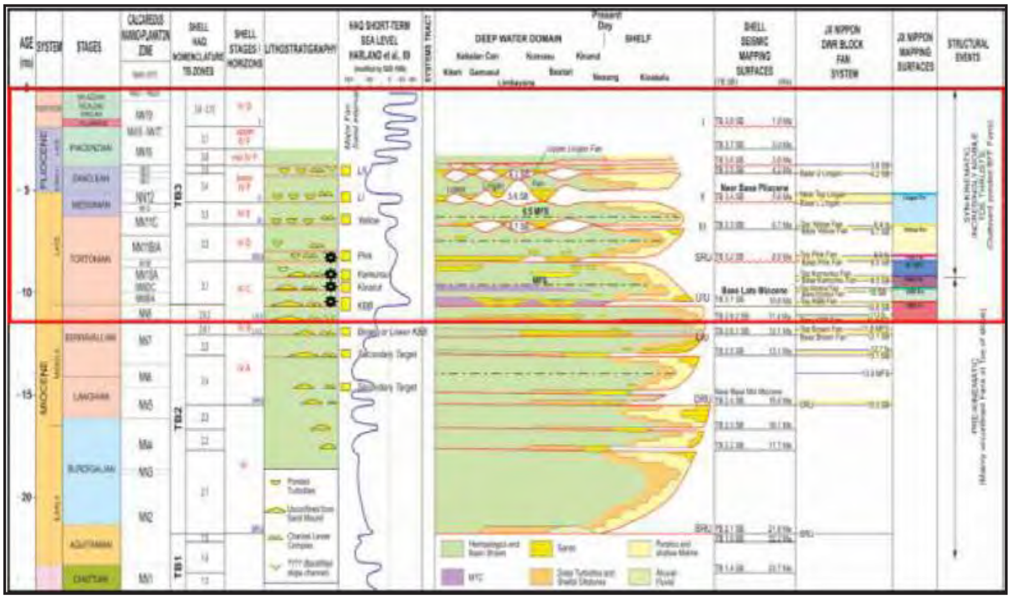

Figure 3: Chrono-stratigraphic scheme of the study area (red box represent the main stratigraphy column).

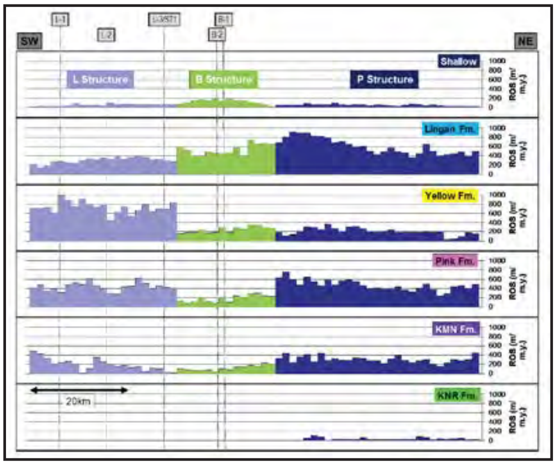

Figure 4: Structural profile across the L-B-P structural trend from Kinarut time to seabed.

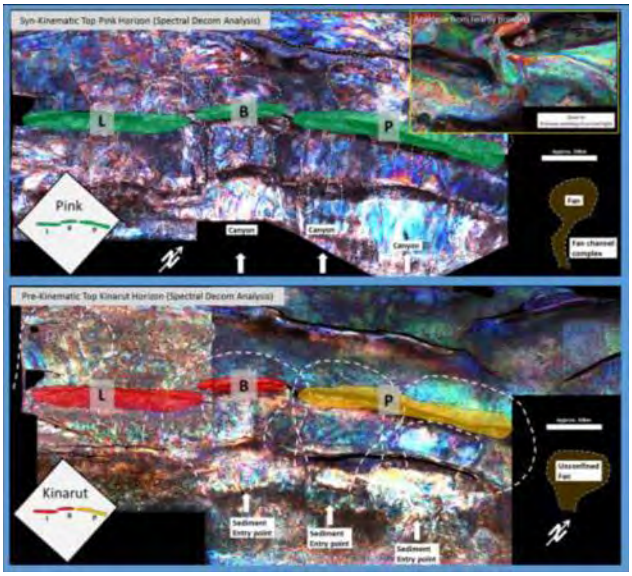

Figure 5: Deformation history of L-B-P structural trend through Kinarut and Pink, overlaid on spectral decomposition maps, which demonstrate the effect on the sedimentary patterns.

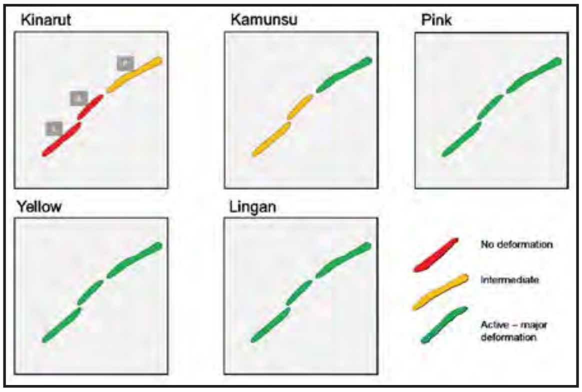

Figure 6: Deformation history of L-B-P structural trend through time.

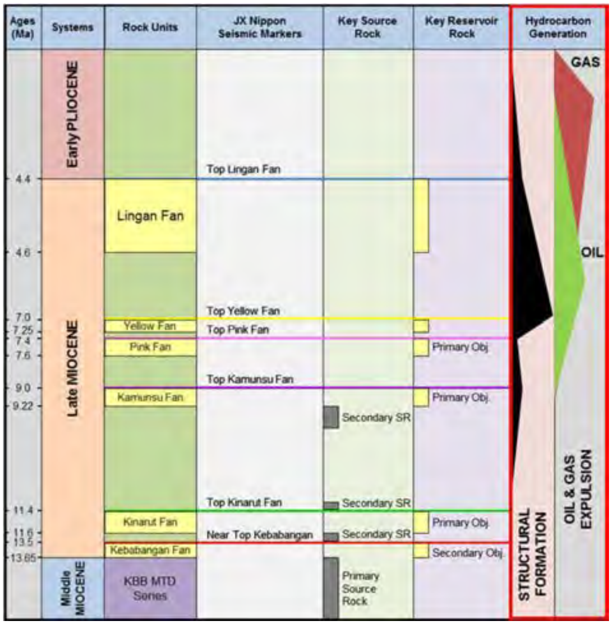

Figure 7: Peak oil and gas generation in the study area took place after the toe-thrust structures are well-developed, providing a favourable timing for HC trapping and oil/gas accumulations (Jong, J. *et. al*, 2014).

DRG28-103

The Distribution and Characterization of Volcanic Ash in Padang Terap, Kedah

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Throughout Quaternary period, multiple volcanic outbursts reported to occur in Sumatera. Based on various microscopial and chemical analysis conducted, volcanic ashes found at localities within Peninsular Malaysia is believed to be originated from these eruptions. Detailed mapping and characterization of reworked volcanic ash in Padang Terap, Kedah area is done to understand the depositional process and the reworking mechanisms. On-site stratigraphy shows association of volcanic ash layers with pebble fluvial deposits, sedimentary structures such as cross lamination, planar lamination suggesting fluvial environment of deposition. Oxidised layer within volcanic as beds are observable by orange coloured layer that marks the change in porosity and permeability of volcanic ash grain layers. Grain size analysis shows very poorly sorted, fine skewed to very fine skewed, mesokurtic to very leptokurtic and trimodal to unimodal distribution in nature. Other than that, mud sized bimodal tephra layers overlain by packages of biotitic coarse sandy layer with overlying mud sized volcanic ash top at Kg Padang Gelanggang suggesting two phases of depositional processes. The geomorphological controls on the distribution pattern of volcanic ash in this area is also highlighted. In general, Padang Terap is located at the west-northern edge of Bintang Range and containing two almost parallel ridges of Semanggol Formation within it. The easternmost ridge divide Padang Terap River into higher-stream high energy and lower-stream low energy environment that is classified based on sedimentological observation. Volcanic ash beds are found on plain area river terrace 1, T1 only. Geomorphological condition of the area controls the capability of the area to preserve volcanic ash that is reflected by the thickness of volcanic ash beds.

Next, in collaboration with Minerology and Geoscience Department (JMG) of Kedah, geotrail and few other development plan of Padang Terap as geoheritage site are also provided in this study. The abundance of volcanic ash beds in Padang Terap area with variation kind of layers and different characteristics is one of the key factor that makes this area as an important site for tourism activity. Besides, the location is also significant in terms of ecological and cultural relation as it is a home to Siamese and Malay culture. By providing well planned geotrail, Padang Terap Gallery as well as systematic bus services hopefully Padang Terap Geoheritage will be more visitor-friendly. Thus, contributes in sustainable development of the country itself.

DRG29-112

Oligocene-Miocene Large Benthic Foraminifera from the Tajau Sandstone Member, Kudat Formation, Sabah

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Introduction

The Tajau Sandstone Member of the Kudat Formation is well-exposed along Kudat-Sikuati Road and coastal areas of Kudat Peninsula, Sabah. It lithologically consists of thickly bedded, coarse grained to gritty micaceous and calcareous sandstone which is locally conglomeratic forming conspicuous ridge in the northern part of the Kudat Peninsula. The thick pebbly sandstones are gently folded, and interpreted as coarse sandy proximal debris flow by Suggate and Hall (2013). The age and stratigraphy of this member is poorly understood due to the existence of not age-determining microfossil as well as some fossils found by previous researchers are reworked (e.g by Stephens, 1956). Its Te$_{1-4}$ (Upper Oligocene to Lower Miocene) age which was tentatively concluded by previous researchers on the basis of the occurrence of a few larger pelagic foraminiferal associations found in Tajau Sandstone and that also rich of benthonic foraminifera such as *Bathysiphon* spp., *Cyclammina* spp., and *Trochammina* spp., which unfortunately cannot become an indicator for age determination (Koh, 1977).

Result and Discussion

Sandstone from the Tajau Sandstone Member of the Kudat Formation collected from three localities (Sri Mengayau Homestay (L1), SW of Tg. Simpang Mengayau (L2), and Jalan Stesen TV (L3)) consist of some significant foraminifera. Mostly are larger benthic foraminifera with rare occurrence of gastropod fragment. The larger benthic foraminifera consist of *Heterostegina borneensis* van der Vlerk, *Heterostegina* sp., *Lepidocyclina (Eulepidina)* sp., *Lepidocyclina (Nephrolepidina)* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., and rare occurrence of planktonic foraminifera. The *Lepidocyclina (Eulepidina)* sp. was common in all samples. The presence of *Heterostegina borneensis* van der Vlerk in sample indicate the age of Lower Te (Te$_1$-Te$_4$) based on Adam (1970) and Lunt (2013). Only one specimen of planktic foraminifera with poor preservation presence in the collected samples but it does not give significant age. The larger benthic foraminifera assemblage is indicative of Lower Te (Te$_1$-Te$_4$) of Letter Stage or Late Oligocene age (Figure 1). Some of the foraminifera specimen undergoes dilution and broken suggesting that are probably reworked specimen. But some specimen has good preservation and these indicate a Late Oligocene age. The sediment of calcareous sandstone cannot be older that Late Oligocene age because of the presence of *Heterostegina borneensis*, and probably slightly younger than Late Oligocene or probably in Upper Te (Te$_5$) of Early Miocene.

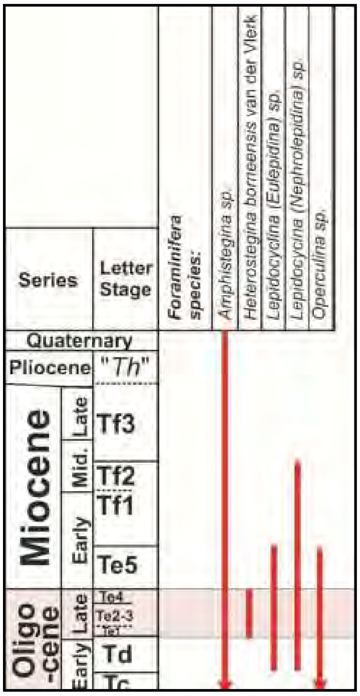

Figure 1: Stratigraphic distribution of larger benthic foraminfera.

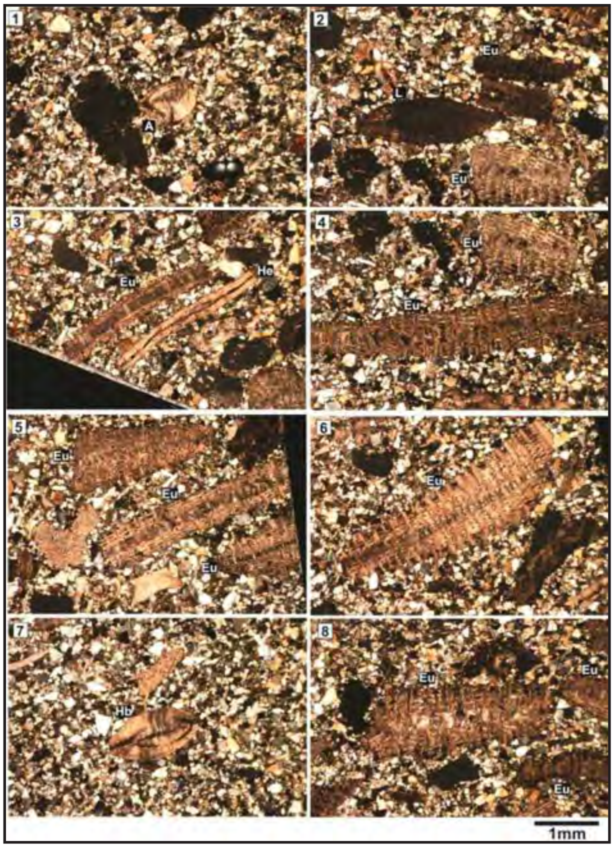

Figure 2. Photomicrograph of foraminifera present in the thin section samples; A- *Amphistegina* sp., Eu- *Lepidocyclina (Eulepidina)* sp., He- *Heterostegina* sp., Hb- *Heterostegina borneensis* van der Vlerk,

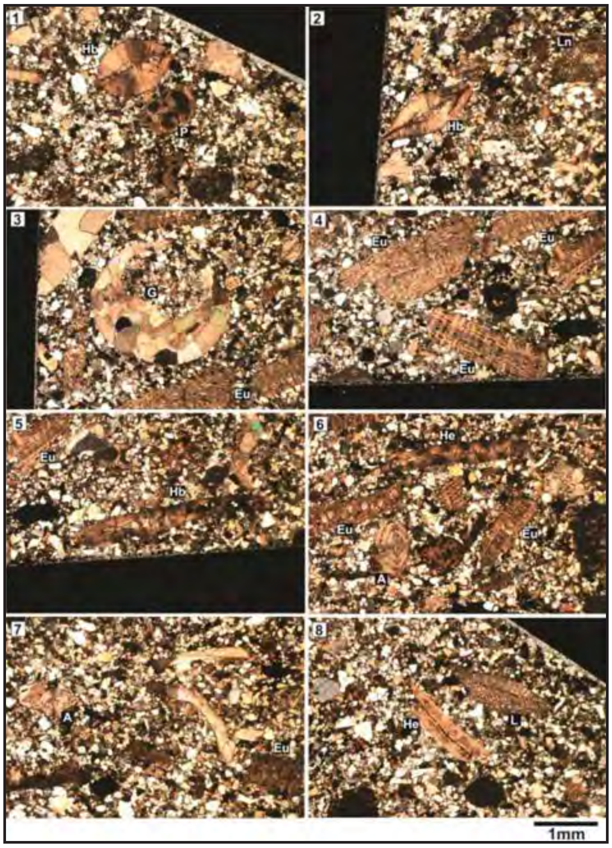

Figure 3. Photomicrograph of foraminifera present in the thin section samples; A- Amphistegina sp., Eu- Lepidocyclina (Eulepidina) sp., He- Heterostegina sp., Hb- Heterostegina borneensis van der Vlerk, Ln- Lepidocyclina (Nephrolepidina) sp., L- Lepidocyclina sp., G- Gastropod fragment, P- Planktonic foraminifera.

DRG30-128

Highly Fractionated I-type of Maras-Jong Pluton, Eastern Belt Granitoids – Geochemical Constraints

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The Eastern Belt granitoids of Peninsular Malaysia consist mainly of I-type granites with anomalous S-type granites. The monzo- to syenogranite Maras-Jong pluton in the Eastern Belt granite shows many S-type characteristics such as presence of tourmaline and garnet, and similar texture to the Main Range granitoids (both granites are coarse grained primary textured sometimes dominated by K-feldspar phenocrysts) and high SiO_2 contents. This may lead to conclusions that the Maras-Jong granite is S-type rather than I-type. However, detailed geochemical analyses indicate that these granite display typical affinities of highly fractionated I-type granites. They are weakly peraluminous (A/CNK = 1.04-1.14), high K_2O contents, depleted in high field strength elements (HFSEs), enriched in light rare earth elements (LREEs) and large ion lithophile elements (LILEs), as well as negative Sr, Ba and Eu anomalies in the spidergram. These observations indicate that the Maras-Jong pluton should not be considered as S-type granite, but instead it may be highly fractionated I-type granite.

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

DRG41-116

Review of 50-Years (1966-2016) Debate on Age of Sabah Crystalline Basement Granitic Rocks: Are the Granitic Rocks in Upper Segama Sabah Fragments of Supercontinent Pangaea?

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1.*Facts do not cease to exist because they are ignored*-A.Huxley

2.*Deletion of Sabah Pre-Cretaceous was factual error*-H.D.Tjia(2016)

The 50-years (1966-2016) debate key questions were: *Was there Pre-Cretaceous Geology in Sabah*? *Were granitic rocks in Upper Segama Pre-Cretaceous and continental, not derived from oceanic ophiolites*? ('Granitic rocks' include granite, granodiorite and tonalite)

The 50-years debate was between one group with field work and analytical data on Jurassic/Triassic or older granitic rocks in Upper Segama Sabah and the other group without field work and analytical data on the granitic rocks, and with the conclusions Cretaceous rocks /ophiolites were Sabah oldest and '*basement*' rocks, and the granitic rocks were derived from ophiolites and were not Pre-Cretaceous.

An article published by New Sabah Times dated 5 July 2016 under heading ***Poised for Geotourism*** reported Professor Dr Felix Tongkul of Universiti Malaysia Sabah as stating: '*the Kawag Forest Area was literally sitting on a 200 million years old Crystalline Basement, making it a high potential place for geological heritage site'*. Upper Segama had a '*gold rush'* in 1800s (Fitch 1955; Leong 1974). To date Sabah oldest radiometric K:Ar age from tonalite is minimum 210 million years (Triassic or older) in Upper Segama (Leong 1971, 1974).

In contrast to Tongkul (2016), 50 years earlier, without field work in Upper Segama and no new analytical data on the granitic rocks, Hutchison (1966) proposed *Tectogene Hypothesis* which had Cretaceous formations/ophiolites as Sabah oldest. The *Hypothesis* had omitted Upper Segama Jurassic radiometric age data from tonalite and others in Kirk (1964)-(Leong 1974). Geological Survey *Geological Map of Sabah* (Wilford 1967) showed Sabah oldest rocks to be Jurassic or older Crystalline Basement granitic and metamorphic rocks underlying Cretaceous formations. An unconformity in Upper Segama of fossiliferous Cretaceous sedimentary-volcanic rocks overlying amphibolites had precluded Cretaceous formations/ophiolites to be Sabah oldest or 'basement' rocks-(Wong and Leong 1968)-*Unconformity between Chert-Spilite Formation and Crystalline Basement in Agob-Dabalan Upper Segama*,

Further support for Sabah Pre-Cretaceous came from a 210 Ma radiometric K:Ar age from tonalite (Leong 1971, 1974). The 210 Ma K:Ar age from tonalite and significant potassium values of the granitic rocks (Leong 1998, 2009), indicating a continental origin, had invalidated Cretaceous ophiolites as Sabah oldest in Hutchison (1966). Hutchison (1988) and Omang and Barber (1996) dismissed Leong (1974) as '*spurious*' without providing factual evidence. Hutchison (1989)-*Geologic Evolution of Southeast Asia* and GSM 1996 Edition of Hutchison (1989) dismissed 210 Ma K:Ar age in Leong (1971, 1974) as '*have to be spurious'* and concluded that the granitic rocks in Upper Segama were '*genetically related to the ophiolites'* . On closer scrutiny, it was found that Hutchison 1989, 1996) dismissal of Leong (1974)/210 Ma radiometric K:Ar age in it and that the granitic rocks were '*genetically related to the ophiolites'* had not been based on new data, but on changed data, rock types changed from granite, tonalite to *metagabbro, gabbro* and not low to high potassium values of the granitic rocks changed to *extremely low potassium values* (Leong 1998, 2009). In Omang and Barber (1996), the age of granitic rocks in Upper Segama was changed to Neogene age without evidence (Leong 1998, 2009). Hutchison (1997) reference to Sabah Cretaceous formations as '*ophiolite basement'* was shown to be not Sabah oldest in Leong (1999). Milsom and Holt (2001) regarded term '*ophiolite basement'* as inappropriate as in several regions worldwide, oceanic ophiolites often obducted over older continental basement. Hutchison (1988, 1989, 1996) and Omang and Barber (1996) dismissal of Leong (1974)/210 Ma radiometric K:Ar age data in Leong (1971, 1974) were reversed by new field work and new data from granitic rocks in Upper Segama in Graves et al (2000): '*The oldest K:Ar radiometric age determined from granitoid in nearby Kawag Gibong river is 210 Ma±3 Ma (Early Jurassic) (Leong 1974). We have added additional dating* (185 Ma, granite) *which supports Jurassic age'*. '*The acidic rocks belong to calc alkaline series and could not have been derived from ophiolites'*.

As disclosed in Leong (2016), the following post-2000 publications, without field work in Upper Segama and new analysis of granitic samples, had omitted/deleted published Pre-Cretaceous Geology /Geochronology data in Graves et al (2000), Leong (1998, 1999), Lim (1985), Leong (1971, 1974), Wong and Leong (1968), Wilford (1967), and Kirk (1964, 1968)---Tate (2002) *Geology of Borneo Island Map,* Balaguru et al (2003), Lee et al (2004)

Lexicon of Malaysia Geology and Wan Nursaiedah Wan Ismail et al (2014). The stated 4 post-2000 publications had, without new evidence/data, reverted to Hutchison (1966) Cretaceous formations/ophiolites as Sabah oldest and had ignored author of Hutchison (1966) support for minimum Jurassic in Graves et al (2000)-i.e. Graves Hutchison, Bergman,_Swauger (2000).

Tate (2002) *'Cretaceous crystalline basement'* and Tongkul (2005) *'Mesozoic crystalline basement'* had included Cretaceous fossiliferous limestones as '*basement*' rocks in Sabah. Tongkul (2005) '*Mesozoic crystalline basement'* had Cretaceous fossiliferous limestones 'lumped' with Pre-Cretaceous granites. Tongkul (2016) '*200 million years Crystalline Basement'* excluded Cretaceous rocks.

Sabah Pre-Cretaceous Geology Affirmed; Regional Aspects:

Granitic rocks of Sabah Crystalline Basement had radiometric ages of minimum 210, 185 million years (Leong 1971, 1974; Graves et al (2000) and '*could not have been derived from the ophiolites* (Graves, et al 2000). Ophiolites have been regarded as sea floor rocks formed in marginal oceans next to continents (Plummer et al 2003). Supercontinent Pangaea began to break-apart about 175 million years ago (Rogers and Santosh 2004). Were granitic rocks in Upper Segama (older than 175 Ma at minimum radiometric ages 185 Ma, 210 Ma) part of Pangaea/part of Laurasia?

From Tjia (1999) after Tjia (1988)-'*Accretion Tectonics in Sabah…' – 'It has been proposed that eastern Sabah is an exotic terrane originating from the continental margin of eastern Asia through sea-floor spreading of a Proto-South China Sea Basin. This continental fragment broke off eastern Asia and drifted in a southerly direction to ultimately become attached into Borneo in early Miocene'*. The Jurassic-Triassic or older granitic outcrops in Upper Segama, which lie within Tjia (1999) *Kinabalu Suture* Zone, most likely indicate 'exhumed' parts of an underlying Pre-Cretaceous continental basement in Sabah.

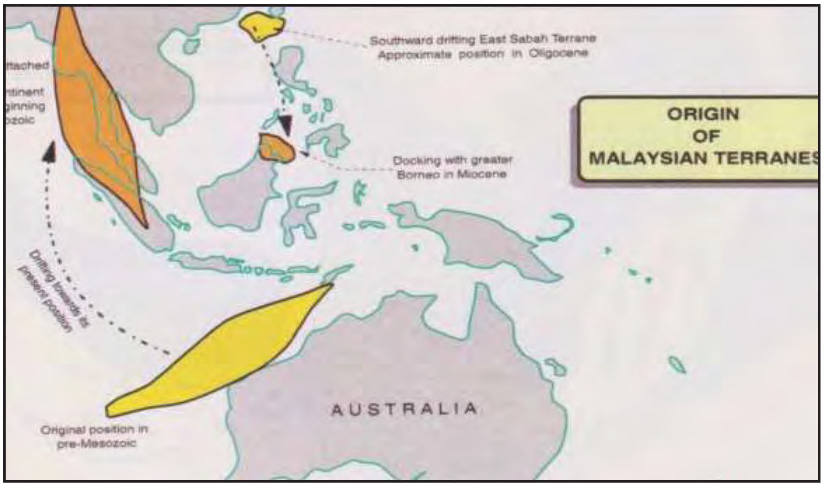

Figure 1: Origin of Malaysian Terranes: Source: Tjia (1999).

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

DRG42-134

Tertiary Coastal and Shallow Marine Successions of the Sandakan Formation (Sabah), Miri and Nyalau Formations (Sarawak): Facies, Stratification and Reservoir Properties

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Introduction

Siliciclastic shallow-marine deposits form major reservoirs in many hydrocarbon provinces worldwide (e.g. North Sea, Nigeria, Brunei, Venezuela etc.). In Malaysia, they form the main reservoirs in the Malay Basin, Sarawak Basin and Baram Delta Province. Siliciclastic shallow-marine deposits are sedimentary records of the environments between land and sea, and their responses to a variety of forcing mechanisms, such as physical process regime, the internal dynamics of coastal and shelf depositional systems, relative sea level, sediment flux, tectonic setting and climate. In the present work, we investigated the facies and stratigraphic architecture of known shallow marine outcrops in Sandakan (Sabah), Miri and Bintulu (Sarawak) as possible analogue for the offshore hydrocarbon-bearing sequences in the Sarawak, and Malay basins.

Sedimentary Formations, Facies Associations and Stratigraphic Architecture

The Nyalau Formation of Bintulu, Sarawak. The Nyalau Formation (Late Oligocene – Middle Miocene) which is equivalent to Cycle II & III of the offshore hydrocarbon-bearing formation is well exposed in the Bintulu area in Sarawak. The Nyalau Formation consists predominantly of soft to moderately hard, thinly to thickly cross-bedded sandstones alternating with mudstone and sandstone with occasional coal seams. Integrated facies analysis and biofacies studies were carried out on several well exposed outcrops in south Bintulu to characterize the facies, facies associations and biofacies, and to interpret the depositional environment of the successions. Fourteen sedimentary facies were recorded they are; tabular-planar cross bedded sandstone, amalgamated trough cross bedded sandstone, trough cross bedded sandstone, flaser, wavy ripple sandstone, heterolithic sandstone, heterolithic mudstone, bioturbated flaser, wavy-ripple sandstone heterolithic, bioturbated cross laminated sandstone heterolithic, interbedded sandstone and bioturbated mudstone, well bioturbated mudstone, laminated mudstone, carbonaceous mudstone, carbonaceous mudstone and coal, coal and paleosol. These are grouped into six facies associations: i) tidal channel, ii) tidal flat, iii) sand flat, iv) tidal sand bar, v) mangrove swamp and vi) coastal peat swamp. Biofacies data revealed that the sedimentary successions are dominated by mangrove pollen notably *Florschuetzia trilobata* and *Zonocostites ramonae* and commonly associated with marginal marine foraminifera such as *Miliammina fusca* and *Trochammina maceresens* different with the coal facies which content mainly freshwater and/or peat swamp pollen. Based on the integration studies, the sedimentary successions from this area are interpreted to be deposited within tide-dominated estuary with varying degree of fresh water and salinity influx (Zainey Konjing, 2015).

The Miri Formation of Miri, Sarawak. The rock exposed around the Miri town, are of Middle- to Late-Miocene age, and they are part of the subsurface, oil-bearing sedimentary strata of the onshore and offshore West Baram Delta, which have been uplifted and are exposed predominantly as an arenaceous succession. At the Hospital Road-Hillside Garden outcrop, a thick succession of sandstone–mudstone interbedding are well exposed with a total stratigraphic thickness of 34 m. The outcrop is divided into three successions. *Facies succession I:* The first unit is interbedded sandstone-mudstone, very fine-grained and having primary structures of hummocky cross-stratification. It has a total stratigraphic thickness of 8 m. *Facies succession II:* The second unit comprise hummocky cross-stratifed, yellowish brown, well-sorted sandstones interbedded with thin mudstone with a total of 10 m thick succession. Bioturbation and fossils are distributed throughout the unit. *Facies succession III:* The third unit is thick, very fine- to fine-grained, yellowish, well-sorted sandstone with a total of 15 m thick succession. The primary structures are small trough cross-bedding, massive sandstone and hummocky cross-stratified sandstone facies (Numair Siddique, 2015).

The Sandakan Formation of Sandakan, Sabah. The Upper Miocene Sandakan Formation of the Segama Group is well exposed around the Sandakan town and across the Sandakan Peninsular in eastern Sabah. It unconformably overlies the Garinono Formation and is conformably overlain by the Bongaya Formation. Seven lithofacies were identified: i) thick amalgamated SCS/HCS sandstone; ii) thin, lenticular interbedded HCS sandstones and mudstone; iii) laminated mudstone with Rhizophora; iv) trough cross-bedded sandstone; iv) laminated mudstone; vi) striped mudstone with thin sandstone and siltstone; and vii) interbedded HCS sandstone and mudstone. The presence of *Rhizophora, Brownlowia, Florchuetia sp., Polypodium, Stenochleana palustris, Ascidian* spicule, low angle cross bedding, very fine grained sandstone, thin alternations of very fine sandstone, silt and clay layers showing cyclicity (muddy rhythemites), rocks in the Sandakan Formation are interpreted as mangal estuary and open marine facies *(Khor Wei Chung et al., 2015)*.

The common facies associations displayed within the Sandakan Formation comprises a lower mud–dominated interval, bearing shallow water nannofossil (*Sphenulitus Abies)*, an intermediate interval of thin HCS beds and capped by a thick (4 - 5m) SCS-HCS unit. This upward-coarsening, upward-thickening succession from mudstone-dominated to sandstone-dominated sediment intervals is typical of siliciclastic wave-dominated shoreline that has undergone normal regression, and progradation. The facies successions display bioturbated and non-bioturbated offshore mudstones in the lower part, passing through the HCS storm beds of the lower shoreface, continue through the trough crossbedding of the upper shoreface, pass upwards into the seaward inclined laminae of the foreshore.

Reservoir quality of coastal and shallow marine sandstones

We identified five reccurring sandstone facies in the Sandakan, Miri and Nyalau Formations. These are:

a) hummocky cross-stratifies sandstone (HCSS),
b) herringbone cross-bedded sandstone (HBCBS),
c) trough cross-bedded sandstone (TCBS),
d) flaser- to wavy-bedded sandstone (W-FBS),
e) bioturbated sandstone (BS).

HCSS, HBCBS and TCBS sandstones form the best quality sandstone reservoir in terms of grain distribution, porosity (>15%) and permeability (>250 mD), and its lateral and vertical extend, at outcrop scale (300-500 m extent).

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DRG43-140

Geology of Setap Shale Formation, Sarawak along Jalan Beluru-Bakong, Subis, Sarawak

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This study is aiming on observing the potential of shale gas in the Setap shale formation. The main objectives is to identify the properties of shale from Setap Formation including both physical and chemical properties. The outcrop is located on street sideways of Jalan Beluru-Bakong. There is deepwater turbidite sediments observed with interbedded of marl, calcareous mudstone and shale. Ten samples have been collected for laboratory test including thin section and hydrochloric acid test to observe the presence of calcite mineral. The content of calcite in precisely means displayed by XRD and EDX/SEM results which is confirmed the occurrence of marlstone in this area. Potential of shale gas according from this outcrop only is possible based on the TOC results. This area is suitable place to study marlstone and calcareous mudstone. Somehow, more thorough study must be done in terms of the area extension and lab analysis, in order to prove Setap shale formation as shale gas reservoir.

DRG44-156

Sequence Stratigraphy Of Marginal Marine Coal-Bearing Succession of North Sarawak

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This work presents the result of the integrated study of the marginal marine coal-bearing succession of North Sarawak. Malaysia. The studied interval comprises the Balingian Formation, Begrih Formation and Liang Formation exposed along the Mukah-Selangau road, Sarawak. Eleven facies associations were recognized and are presented in terms of sequence stratigraphy. The most of the thick coal seams were originated in fluvial setting, while thin supra-tidal coal was also encountered. The internal stratigraphic architecture of the exposed formations varies which is a function of a combination of sea level, tectonic, and autogenic controls.

DRG45-158

Analisa Fosil Radiolaria daripada Unit Batuan Bersilika di Pos Blau (Singkapan Pb-1), Baratdaya Kelantan, Malaysia

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Satu analisa kandungan fosil radiolaria daripada batuan bersilika yang ditemui di cerun potongan jalanraya di kilometer 38, lebuhraya Gua Musang-Cameron Highland berhampiran Pos Blau pada kedudukan 4°45´05.23″ utara dan 101°45´21.51″ timur telah dijalankan. Cerun potongan mempunyai 4 teres dan terdiri daripada batu lumpur bersilika dan rijang berargilit yang berwarna merah jambu, perang dan kelabu cerah hingga gelap berselanglapis dengan syal nipis. Tebal keseluruhan jujukan adalah 12 meter dengan arah jurus ke utara-timur laut dan sudut kemiringan yang rendah. Sebanyak 56 sampel telah dipungut dari singkapan ini dan sejumlah 40 spesies radiolaria telah dikenal pasti. Spesies tersebut terawet dengan baik dan tergolong dalam 15 genera daripada 7 famili. Spesies-spesies dalam famili Follicucullidae ialah *Pseudoalbaillella lomentaria* Ishiga & Imoto, *Pseudoalbaillella sakmarensis* (Kozur), *Pseudoalbaillella scalprata scalprata* Ishiga, *Pseudoalbaillella scalprata postscalprata* Ishiga, *Pseudoalbaillella scalprata rhombothoracata* Ishiga, *Pseudoalbaillella ornata* Ishiga & Imoto, *Pseudoalbaillella simplex* Ishiga & Imoto, *Pseudoalbaillella* aff. *longicornis* Ishiga & Imoto, *Pseudoalbaillella* sp. A, *Pseudoalbaillella* sp. B, *Longtanella* aff. *zhengpanshanensis* Sheng & Wang dan *Longtanella* sp. Famili Pseudolitheliidae terdiri daripada spesies *Hegleria mammilla* (Sheng & Wang), *Hegleria* sp. A. Spesies-spesies dalam famili Latentifistulidae ialah *Latentifistula patagilaterala* Nazarov & Ormiston, *Latentifistula crux* Nazarov & Ormiston, *Latentifistula texana* Nazarov & Ormiston, *Latentifistula* sp. A, *Latentifistula* sp. B, *Latentifistula* sp. C, *Latentifistula* sp. D dan Latentifistulidae gen. et. spec. indet. Famili Ruzhencevispongidae merangkumi spesies-spesies seperti *Latentibifistula asperspongiosa* Sashida & Tonishi, *Latentibifistula triacanthophora* Nazarov & Ormiston, *Pseudotormentus kamigoriensis* De Wever & Caridroit, *Ruzhencevispongus girtyi* Nazarov & Ormiston, *Ruzhencevispongus triradiatus* Wang, *Tormentum? inflatum* Nazarov & Ormiston dan *Tormentum* sp.. Dalam famili Cauletellidae pula, spesies-spesies yang ditemui ialah *Nazarovella philogides* Wang & Li, *Nazarovella* cf. *gracilis* De Wever & Caridroit, *Quadricaulis inflata* (Sashida & Tonishi), *Quinqueremis robusta* Nazarov & Ormiston dan *Polyfistula* sp.. Spesies-spesies dalam famili Archaeospongoprunidae ialah seperti *Copielintra orbiculata* Nestell & Nestell, *Copicyntra* cf. *akikawaensis* Sashida & Tonishi dan *Copicyntra* sp. manakala bagi famili Entactiniidae, spesies-spesies yang ditemui ialah *Stigmosphaerostylus* cf. *parapycnoclada* (Nazarov & Ormiston), *Stigmosphaerostylus itsukaichiensis* (Sashida & Tonishi) dan *Stigmosphaerostylus* sp. Berdasarkan taburan stratigrafi beberapa fosil indeks yang ditemui, spesies-spesies dari singkapan ini boleh dimasukkan ke dalam dua zon himpunan iaitu Zon Himpunan *Pseudoalbaillella lomentaria* dan Zon Himpunan *Pseudoalbaillella scalprata m. rhombothoracata* masing-masing mewakili usia Sakmarian Awal dan Sakmarian Akhir dalam tempoh masa Perm.

Rajah 1: Peta singkapan kajian.

DRG46-60

Mesozoic Arc Accretionary Tectonics and Dextral Strike-Slip Faulting in Singapore

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To address competing land-use requirements, and the needs of an ever-growing population, Singapore looks to the subsurface to meet many of its future development needs. The subsurface is now considered an attractive development space for, amongst other things, energy production and infrastructure, waste disposal and treatment, groundwater abstraction and water storage, transportation infrastructure, industrial manufacturing and logistics. Singapore aspires to become a 'smart' nation/city that integrates transportation, utilities and services infrastructure with information communications technology (ICT) in order to facilitate sustainable management of its societal assets. A comprehensive understanding of Singapore's geology is therefore critical to both future development and ongoing management of the subsurface.

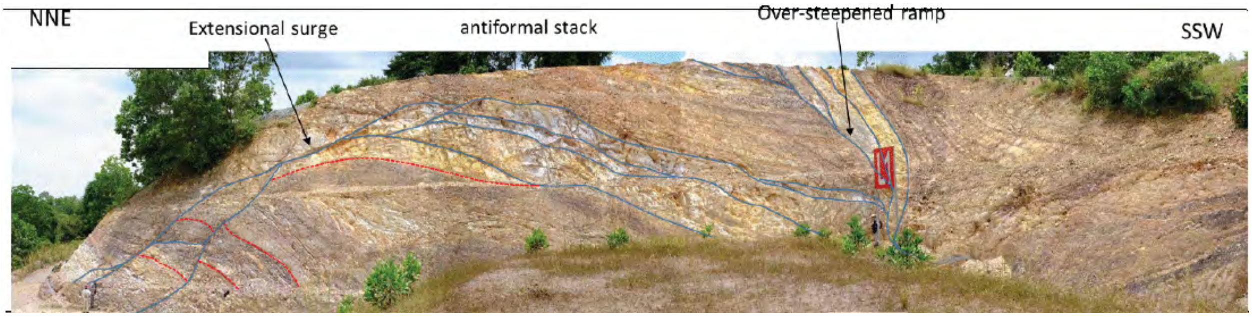
The British Geological Survey (BGS) is working with Singapore Building and Construction Authority (BCA) to deliver that modern geological knowledge-base to benefit the widest possible stakeholder community, including the public and private sectors and academic institutions. BCA have implemented a new and comprehensive ground investigation programme, recovering drillcores from c. 100 deep boreholes (typically to 200 m depth) and acquiring conventional 2D seismic reflection data from across some 350 km2 of ground. All of this new data provides an unprecedented opportunity to unravel the complex geological relationships that exist, especially in southwest Singapore.

The geology of Singapore is dominated by the products of a period of late Permian to Triassic arc magmatism that was succeeded by collisional accretion tectonics in the latest Triassic to early Jurassic. Two distinct early Cretaceous (Berriasian and Barremian) sedimentary successions overstep the collisional tectonic structures. Faulting developed across Singapore in response to dextral strike slip tectonics in the mid-Cretaceous (?Cenomanian) further complicates the structural geological framework, and delineates the distribution of lithologies across Singapore. This paper reports on our new understanding of the structural geological evolution of Singapore; a new sedimentological environment analysis that supports a fully revised stratigraphical framework is described in a companion paper also presented at this conference (Dodd *et al.*).

In southwest Singapore, we assign the marine sedimentary succession that includes early Triassic volcanic rocks (ash, tuff and ignimbrite) to the Jurong Group, a correlative of the Raub Group in Malaysia. These strata have been deformed, along with an overlying succession of mainly coarse sandstones and conglomerate, into a northeast-vergent pattern of inclined asymmetrical folds. That shortening culminated in the development of a large scale northeast-vergent thrust system, most likely in the latest Triassic to earliest Jurassic Indosinian Orogeny. The fluvial succession that dominates the south-eastern part of the Jurong Group crop in Singapore may represent a piggyback succession in this fold and thrust collisional setting. The subduction-related magmatic complex represented by the Central Singapore Granite pluton probably acted as a backstop to thrusting at this time.

The fold and thrust deformation observed in Singapore is progressive with the earlier formed folds becoming transposed in the thrust transport direction; strata are typically very steeply dipping to the northeast, or even overturned, in the hanging wall of the thrust discontinuities. The long limbs of the hanging wall anticline/syncline structures are broadly flat-lying though undulating, and may locally display open to close upright folding at < 1 km wavelength. A locally penetrative S1 cleavage is developed in incompetent lithologies (mudstone to fine sandstone); in more competent sandstones a spaced fracture cleavage is locally seen, especially so in very steep to overturned strata. The Murai Thrust structure dominates the onshore geology of southwest Singapore, stretching from Murai Reservoir in the northwest through the Kent Ridge/Mount Faber area to the southeast where a thrust duplex is judged to explain the observed structural features and imbricated stratigraphy. Along with the thrusts, the S1 cleavage typically dips southwestwards, often as convergent or divergent fans in fold hinges according to the rheology of the folded rocks. This tectonostratigraphic framework is likely to continue into South Johor in Malaysia, and potentially also into Batam.

Age dating of detrital zircon population suggests that at least two distinct sedimentary successions overstep this orogenic deformation in the early Cretaceous before dextral strike-slip faulting affected the region, that deformation presumably co-eval with the period of dextral shear recorded across SE Asia at this time (c. 90-100 Ma). The Bukit Timah Fault that defines the southwest margin of the Central Singapore Granite pluton (and its continuation into adjacent Johor and Batam) was a principal displacement zone (PDZ) at this time; an associated and geometrically consistent array of steeply dipping R1, R2, P and X discontinuities are widely developed across Singapore and its offshore islands, and will essentially constrain the major features on the new geological map of Singapore.



Antiformal stacking of thrust imbricates in Jurong Group strata, top to NE tectonic transport. Murai Reservoir, NW Singapore.

Upright open anticline (Lokos Anticline) at the southeast end of St. John's Island, Singapore. View NNW. A fanning fracture cleavage is developed around the hinge of the anticline in these fluvial sandstones; a closely spaced fanning cleavage is seen in the NE-dipping fold limb.

ORAL PRESENTATIONS

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DISASTER RISK REDUCTION

SESSION KEYNOTE EDR21-14

Coastal Protection Measures for Small Island Developing States (SIDS) – A First-Cut Classification

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Small Island Developing States (SIDS) are considered as one of most severely affected by climate change and sea-level rise (SLR). Some atoll nations would virtually disappear with one metre sea-level rise. The main objective is to derive a first-cut classification of coastal protection technology for the SIDS to address SLR. First, an assessment is made of the existing and future adaptation measures to SLR in the latest 35 English-language National Communications (NCs) submitted by the SIDS to the UNFCCC; the cut-off date is 23 January 2017. Next, a wide variety of adaptation measures is culled from key coastal engineering manuals and other sources with a focus on more innovative tools and ideas beyond the traditional hard and soft measures. This yielded several possible adaptation tools that could be applied to the SIDS, and with further research, more tools could be applied. In conclusion, a first-cut classification of coastal protection technology is proposed for the SIDS to address SLR. The resulting table shows eight categories graded from the usual hard and soft measures to new and innovative ideas.

SESSION KEYNOTE EDR22-NRY

Coastal Vulnerability Index based on Sea-Level Rise

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The IPCC Fifth Assessment Report (AR5) stated that it is very likely that the sea level will rise in more than about 95% of the ocean area and that the global mean sea level rise (SLR) will continue for many centuries beyond 2100. Malaysia has approximately 4,809km length of coastlines in Peninsular Malaysia, Sabah and Sarawak. Apart from the visible threats of coastal erosion, the impending sea level rise presents complex challenges to the coastal zone, where about 70% of the country's population reside. A study in 2010 projected SLR in 2100 to be between 0.25-0.5m in Peninsular Malaysia, 0.69-1.06m in Sabah and 0.43-0.64m in Sarawak. The IPCC AR5 working group further suggested that published global projections may even be exceeded resulting from sustained mass loss by ice sheets. The impact to our coastal zones was assessed through a tool that measures the relative vulnerability along the coast, known as the Coastal Vulnerability Index (CVI) to sea level rise. A pilot study was conducted using this technique on two diverse coastlines namely Tanjung Piai in Johor and Pantai Chenang in Langkawi, Kedah. Tanjung Piai has a gently sloped muddy foreshore with natural mangrove cover facing the Straits of Melaka. Pantai Chenang on the other hand overlooks beyond the Straits of Melaka towards the Andaman Sea. It has a mild to gently sloped sandy beachfront, is highly populated and frequented and have a mix of flat to hilly nearshore land features. Langkawi International Airport is situated here. The CVI is on a scale of 1 to 5, from the least to highest vulnerability. It is derived from physical, biological and socio-economic parameters unique to defined sectors along the coastline. The CVI value is calculated based on the weightage of each parameters with respect to its sensitivity to sea level rise.

SESSION KEYNOTE EDR23-164

Communication of Geohazard Information to Non-Specialists

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Geoscientists have an essential role to play in helping to reduce the risks to people, and to property, that may be associated with natural geological and physical hazards, such as landslides, subsidence and flooding ('geohazards').

That role is perhaps primarily concerned with ***understanding the nature of the hazards***, in terms of the locations likely to be affected and their magnitude and frequency characteristics. Geoscientists are also traditionally involved in helping to devise ***engineering solutions*** to reduce the likelihood and/or scale of the hazards (e.g. through foundation design, slope stabilisation or flood defences). But they also have an increasingly important and potentially vital role to play in the ***communication of hazard information*** to planners, emergency services, insurers and others, in order to enable risks to be reduced in other, complementary ways.

The starting point for any given hazard involves the geoscientist's traditional role in developing a thorough understanding of the hazard itself (What is the cause? Which areas are likely to be affected? How serious are the consequences likely to be? How frequently will incidents occur? and can the risk be avoided or controlled by affordable engineering solutions?).

Where there is likely to be any significant residual risk, which cannot be controlled, there is a need to develop additional strategies to reduce that risk. Depending on the nature of the risk, these may involve ***forward planning*** (to guide future development to less hazardous areas); ***development management*** (to provide site-specific checks to ensure buildings and structures are suitable for their location and suitably resilient); ***emergency action plans***, to evacuate or protect people in real time during a hazard event; and/or the provision of suitable and affordable ***insurance cover***, to protect businesses and livelihoods, allowing them to recover after an incident.

The nature of the information and guidance required by the various non-specialists involved will be different in each case. Geoscientists need to understand what needs to be done, and by whom, in order to provide the right information. Just as importantly, the information needs to be presented in a way which can readily be understood *and acted upon* by each different 'target audience'. This does not just mean simplification, but it does mean avoiding the use of technical 'jargon' and avoiding any presumption of prior knowledge. The information needs to be carefully explained and focused on the specific requirements of each audience.

This paper draws upon a number of international case studies to develop general guidance on how geoscientists can contribute effectively in this way. The examples used include planning responses to karst-related subsidence, emergency response to landslides in deeply weathered tropical soils, and insurance responses to fluvial flood hazards.

EDR24-105

A Snapshot on the Economic Value of Geoscience in Malaysia

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Economic value of geoscience in Malaysia has not been studied yet. The only information available on the geoscience economic value is perhaps through the economic data statistics produced by the Department of Statistics, Malaysia. However, the statistics only covered the upstream activities of mineral production (mining) which also (fortunately) include the production of petroleum and natural gas. The gross output by these activities, grouped under the mining sector, in 2015 was RM120.41 billion (DOS, 2016). The downstream side of the mineral sector which comprises the mineral-based industries such as iron and steel industry, non-metallic mineral-based industry as well as the petroleum-based industries are grouped under the manufacturing sector thus their economic value is considered as manufacturing. Apart from the upstream and downstream activities, there are numerous geoscience-related activities not exposed by the economic statistics which prompted Lewis (2009) to consider geoscience as a deeply embedded and and hidden economy activity. ce activity to the Malaysian economy. This paper is looking into the economic value of geoscience activity in Malaysia which include other activities apart from mineral production. These activities together with mineral production will be referred here as the geoscience core-activity which include mineral and petroleum exploration, laboratories, consultancy companies, individual consultants, drilling, engineering and geotech companies, minerals and geoscience department and geoscience teaching and research. It will provide a snapshot on the economic value of geoscience in Malaysia. A more comprehensive study is proposed which should include the non-core activity such as landscaping, geotourism etc.

EDR25-138

Geohazards from the Oil & Gas Industry Perspective

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Geohazards from Oil and Gas industry perspective covers a wide topic from planning to operations, from Geoscience to Engineering. It spans from the water surface down to the hydrocarbon reservoir. One thing in common with other aspect of Geohazards is that it can be catastrophic if not being mitigated and handled properly. As safety is the utmost priority in Oil and Gas industry, Geohazards has become one of the important aspects that need to be addressed upfront in any cycle of Oil & Gas, whether it is Exploration, Development or Production. The history of hydrocarbon exploration and exploitation over more than a decade have seen many incidents took place as a result of various reasons. Incidents like Piper Alpha (1988) and Macondo Deepwater Horizon (2010), though are more related to man-made disaster has indirectly spurred the sensitivity towards safety standard. Not long after the Piper Alpha incident, Geohazards investigation survey has been made mandatory by the rig insurance underwriter prior to any well drilling activities. This is to avoid any untoward incidents resulting from Geohazard issues such as **punch through**, **rapid penetration** of the rig leg, encountering **shallow gas pocket** that could result in **gas blowout**, **drill fluid losses** and etc. To enable adequate and sufficient information is acquired, Geohazards investigation is carried out by deploying a site survey vessel which tows multi sensor equipment which collects data within the water column, the surface (seafloor) as well as sub-surface information down to approximately 1.5km below the seabed. Among the findings are bathymetry map detailing the seafloor morphology, seabed images, sub-surface channel map and shallow gas map. These findings helps determining what type of Geohazards is present and what mitigation should be in place. The data collected is then populated into a GIS database for future reference and planning.

This presentation will introduce the industry practice in Oil & Gas industry and where Geohazards investigation reside in playing an active role towards the sustainability of the operations.

EDR26-137

Peaty Sediment Distribution in the Straits of Malacca and its Potential Use as Sea Level Indicators

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Dark brown and highly decomposed peat and peaty sediment layer were encountered from 42 core samples in the Straits of Malacca. The core samples were obtained at depths ranging from 18.6 m to 63.30 m below Chart Datum (LAT) in the study area. The thickness of the peat layers ranges from 0.04 m to 1.32 m. The peat or peaty sediment layers are overlain by marine clay or muddy sediment and below them are very stiff and mottled reddish or yellowish grey clay. The peat was deposited above past sea levels and the underlying clays are continental sediment. Thus, the peat or peaty sediments could be used as a sea level indicator for constructing the palaeo sea level curve in the Straits of Malacca.

EDR27-57

Ecological Distribution of Modern Benthic Foraminifera of Kedah Coastal Waters and their Potential Use as Sea Level Indicator

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Foraminiferal assemblages can provide reliable analogues for understanding changes in the marine environment. Previous studies suggested that the modern foraminiferal assemblages are vertically zoned with respect to tidal level and can be used as analogues to predict the previous sea-level changes during the Holocene. Despite the extensive investigation of foraminifera elsewhere in the world, studies around peninsular Malaysia are limited and focused mainly on documenting the distribution of foraminifera in nearshore environments such as mangrove swamps and lagoon/estuaries. We examined the ecological distribution of subtidal benthic foraminifera on the coast of Langkawi-Kedah. Sixty-six benthic foraminiferal species have been identified from 18 sediment samples in Langkawi-Kedah waters. Of these, 25 species had >2% abundance and 10 species were common (10-20%) in the total (live + dead) dataset. Similar to Penang coastal waters, the predominance of *Ammonia tepida* in all stations can be observed from Langkawi-Kedah. Other common species include *Ammobaculites exiguus*, *Haplophragmoides* cf. *H. caraviensi*, *Textularia* aff. *T. earlandi, Quinqueloculina seminulum, Asterorotalia* cf. *A. pulchella, Nonion subturgidum* and *Pararotalia ozawai.* Calcareous-hyaline comprised 78% of foraminiferal assemblages in Langkawi- Kedah waters, followed by agglutinated (20%) and calcareous-porcelaneous (2%) groups. The total variance in data produced by CCA was 70% with eigenvalue scores for axes one and two of 0.322 and 0.141 respectively. The CCA analysis showed that dissolved oxygen, weight-percentage of clay and depth have greatest influence on the species distribution in Langkawi-Kedah waters. The assemblages off Langkawi-Kedah are related primarily to depth, dissolved oxygen and sediment characteristics. Therefore, the changes of foraminiferal species with depth, off Langkawi-Kedah coastal waters can potentially serve as indicator for sea-level reconstruction.

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

EDR28-55

The Identification of Paleotsunami Deposit Along Manjung Coastline, Perak by Trenching and Ground Penetration Radar Surveys

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Introduction

To evaluate and mitigate tsunami hazard especially in areas where historical accounts are fragmentary or cover only short periods, the onshore coastal sedimentary record provides a promising key to reconstruct impacts of tsunami waves. A research was carried out along Perak coastal plain where the 26 December 2004 tsunami inundation caused 2 deaths. The study was done by trenching, resistivity and GPR surveys to identify paleotsunami deposits.

Paleotsunami deposit description

A trenching campaign done along lines perpendicular to the coast at Manjung, revealed paleotsunami deposits mainly in low lying areas (swales) along the coast. The sequence (Figure 1) show single to multiple layer of normal grading dark coarse sand deposit which thins landward (Figure 2). The internal sedimentary structure of the deposits is not well preserved and is barely visible due to the unconsolidated state of the sediments. The tsunami deposit detected in the study area are mostly composed of quartz, broken and abraded shell fragments, wood debris as well as coal and clay or clayey sand rip up clasts. A lower sequence, interpreted as paleotsunami inflow deposit is composed of fining upward sequences of 40 cm of poorly sorted coarse-grained sand with mud clasts, The upper part of the deposit is composed of of variable thickness sandy clay with presence of sand clasts and greyish clay with mud clasts, overlain by pure clay with mud clasts attributed to outflow deposit.

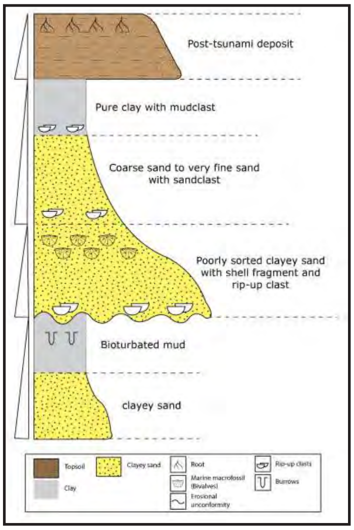

Figure 1: A log of the paleotsunami deposit at Manjung.

The upper boundary of the tsunami deposit is gradational but distinct from the post tsunami sandy and clayey deposit. On the other hand, the basal contact of the tsunami deposit are irregular as well as sharp and distinct with scouring and presence of rip up clasts near its base. Thus this deposit is distinct in character from the over and underlying sediments which are moderately to well sorted ones often with abundant shells. The nature of the pre-tsunami deposit represents calm and low to moderate energy environment, typical of lower shore face deposits indicated by presence if bioturbated mud with trace fossils. Meanwhile, the post tsunami deposit represents high energy environment typical of foreshore environment.

Description of GPR Units

On GPR profile (Figure 3) a layer about 1.4 m depth layer correlate with paletsunami layers in trenches shows internal reflections that are strong, wavy to chaotic and laterally discontinuous and approximately parallel to the upper and lower bounding surfaces. The topmost post tsunami coastal deposit exhibits a very smooth upper surface that was observed in every GPR profile. Internal reflections are typically very strong, coherent, closely spaced, and laterally continuous. The lower layer representing pre-tsunami deposit shows reflection patterns that include subhorizontal reflections that truncate overlying, inclined reflections, perhaps representing scour surfaces.

Conclusion

Similar paleotsunami deposits had been found in Pulau Langkawi. Therefore, Peninsular Malaysia had experienced tsunami prior to the tsunami of 2004. Further study will be done to determine the inundation distance, timing and recurrence intervals of the paleotsunami events for seismic hazard analysis.

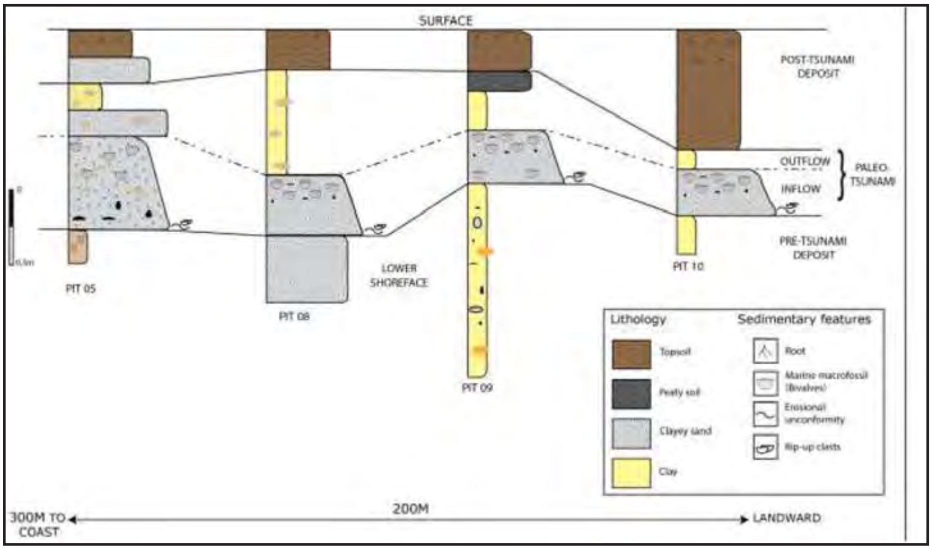

Figure 2: logs showing landward thinning of the paleotsunami deposit and influence of local topography on its thickness.

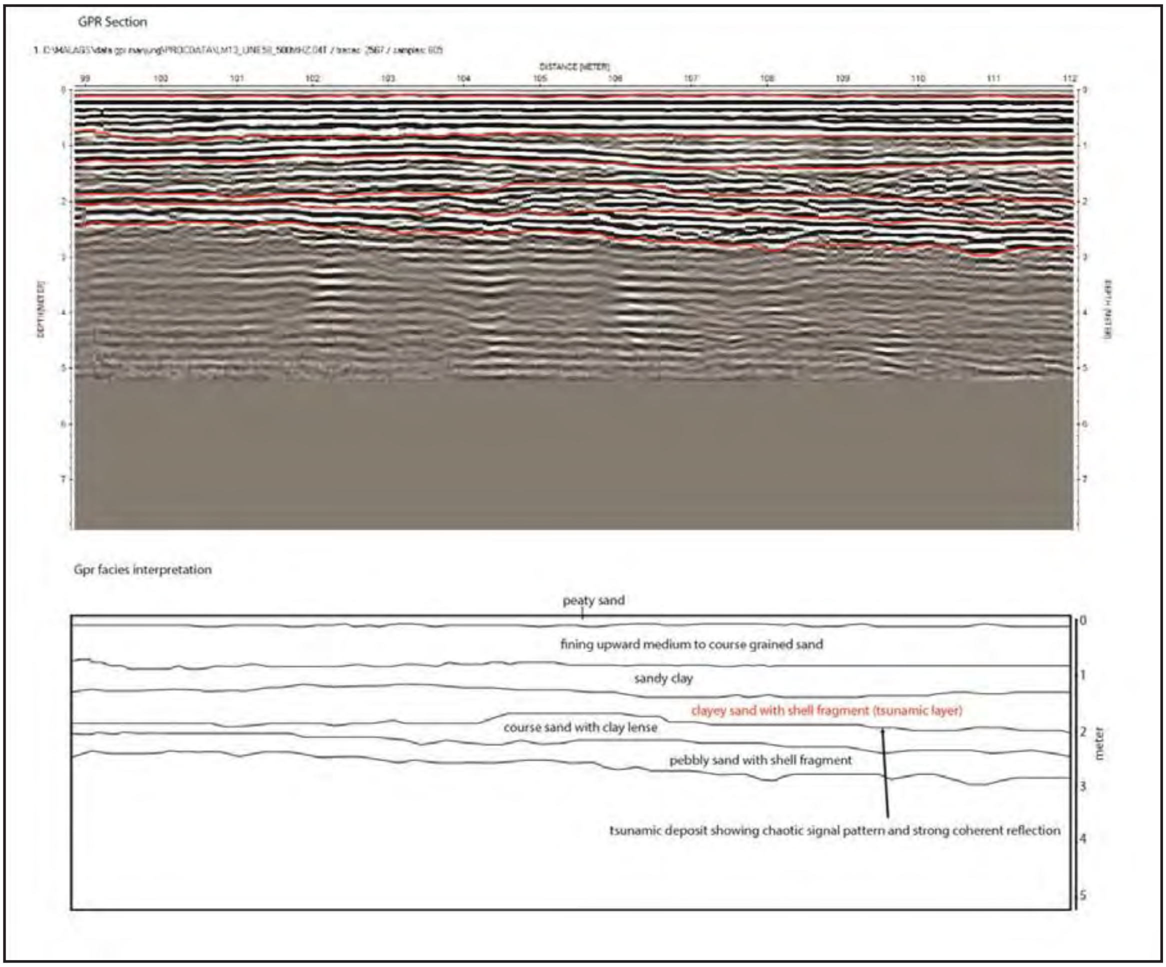

Figure 3: GPR profile showing the interpreted layers.

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EDR29-196

Numerical Analysis of Evacuation Start in Elderly Care Facility During the 2011 Tohoku Tsunami

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It is estimated that more than half of the tsunami victims did not start evacuation during the 2011 Tohoku tsunami. There were sufficient available evacuation time (more than 30 min) and warning information (e.g., tsunami warning). Therefore, analysis of evacuation start is essential for mitigating human damage due to tsunami.

In the present paper, the authors develop the evacuation simulation focusing on the process of evacuation start. In this simulation, (1) various sources (e.g., strong shaking of an earthquake, shouting evacuees, tsunami warning) create the reality of evacuation start (RES) which means the sense of urgency. (2) RES raises people's awareness level of danger (ALD). (3) People start evacuation when their each ALD reaches their own upper limit, and they create RES as a new source. These theoretical concepts are based on "Cooperative creation of social reality". We applied this simulation to reproduce the process of evacuation start of the staff members and users in the elderly care facility in Miyagi prefecture during the 2011 Tohoku tsunami.

We obtained the following conclusions. (1) The simulation results correspond reasonably well with the results of interview survey. (2) Shouting evacuees are the most effective sources for the evacuation start in the facility. (3) Most staff members could start evacuation due to hearing a voice promoting tsunami evacuation before seeing other's evacuation behaviour.

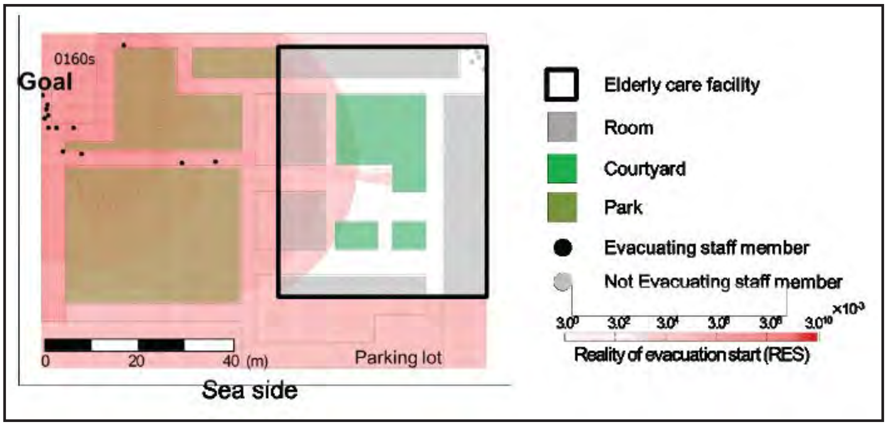

Figure. Snapshot of the staff member's evacuation behaviors and estimated RES when tsunami reached the elderly care facility.

EDR30-101

Geological and Geophysical Studies for Multiple Hazards Assessments in an Occupied Residential Area, Puchong, Selangor

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An occupied residential area in Puchong, Selangor has been badly affected by multiple-geohazards namely sub-surface erosion, ground settlement and slope failures. The multi-geohazard event was first noticed by the residents when the retaining wall and the road above it which bounded the southern-end embankment slope, failed in May 2011. The failed retaining wall and the associated road has been rehabilitated and reinstated in August-September 2011. However, ground movements (vertical and horizontal) still continue to occur. New tension cracks started to appear on the road pavement and development of new and wider dilatational cracks were widespread in the houses and other associated rigid structures (concrete walls, floors, road curbs, road-side drains, concrete walkway). Other sign of distress, such as subsided road surface, tilted lamp posts, leaked fish ponds, propagating cracks in the walls and etc, from time to time. Geological study and geophysical survey were carried out in February 2012 upon request by the residents association, in order to identify the underlying causing factors and to recommend suitable mitigation measures. Surface mapping was carried out by "walk-over" survey and mainly focused on mapping the signs of distress in the ground, such as tension cracks and other dilational cracks in the road and rigid structures, tilted posts and walls, etc. Geology of the area was compiled from the literature and field observation reveals that the fill materials used for the embankment are consisting of chaotic mixture of soils and rock boulders/blocks of variable sizes and shapes. Their lithologic types resemble much of the Kenny Hill's Formation, i.e quartzite, metasandstones, phyllite and metamudstones. Elecrical resistivity survey was also carried out to investigate and characterized the subsurface geologic conditions. A total of 6 survey lines were carried out in the residential area. Interpretation of temporal satellite images of Google Earth, dated 2001, 2004, 2007, 2008 and 2010, was also carried out in order to unravel the geomorphological and topographical changes brought about by earth- and construction-works that have been taken place in the study area. Results of these study surprisingly indicated that the housing area was actually built on a massive and thick embankment which has been placed in a valley and covered-up a stream channel. The existence of the underground stream channel was clearly depicted by the electrical resistivity pseudo section, and on the surface it appears as major springs at the lower section of the embankment slope located downstream. As a conclusion, the underlying factors for the multihazards in this residential area – namely subsurface erosions which subsequently followed by ground settlement and slope failures, are attributed to human error and ignorance. A stable and flat platform for a housing area or any other permanent engineering structures, could not be done by simply dumping rocks and earths to fill up a valley with living stream. The natural stream flow should be properly diverted or provided with sub-surface conduit prior to backfilling of the valley/channel to prevent untoward risks of geohazards. This case study served a very costly lesson that basic geological knowledge is vitally important when come to deal with the water, rocks and earth.

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EDR31-148

Preliminary Landslide Susceptibility Assessment of the Kundasang Ranau Area, Sabah Malaysia based on Information Value Statistical Method

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Landslides are the most frequent type of natural hazard that are often observed in hilly and mountainous areas. It may lead to not only loss of life but also huge economic losses due to property damage. These effects can be minimized and avoided if landslide prone areas are identified in advance.

The present study area is located in Kundasang, Ranau area (**Figure 1**). Kundasang is well known not only for its beautiful landscape and cooler climate, which is favorable for tourism destination and highland agricultural products but also because its landslide hazard problems. Large scales slow moving landslides and/or ground movements have long been known in this area and were termed as the *Kundasang Landslide Complex* (Komoo and Morgana, 1999; Komoo and Lim, 2003). Dynamic features such as cracks, bulging and tilting of building structures, houses and road surfaces and damages on some public amenities are commonly observed within the area.

The main objective of the research is to develop a landslide susceptibility map for Kundasang Ranau area based on a statistical quantitative method; the *Information Value* method. This method is also known as *landslide index* method *(Wi),* in which the weighted value for a parameter class is defined as the natural logarithm of the landslide density in the class, divided by the landslide density in the entire map *(*van Westen, 1997). *Wi* method is based on the following formula:

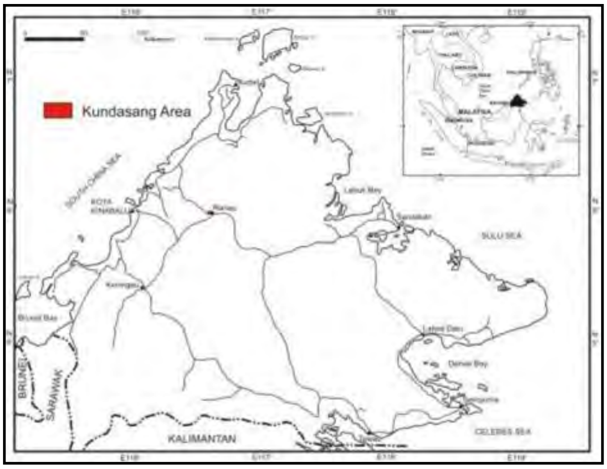

Figure 1: Location of study area area.

$$Wi = ln\frac{Densclass}{Densmap} = ln\frac{Npix\,(Si)/Npix\,(Ni)}{\sum Npix\,(Si)/\sum Npix\,(Ni)}$$

where *Wi* denotes the weight given to a certain parameter class; denotes the landslide density within the parameter class; denotes the landslide density within the entire map; denotes the number of pixels which contain landslides, in a certain parameter class and denotes the total number of pixels in a certain parameter class. The natural logarithm is used to determine the influence of a certain parameter class in landslide development within the entire map. Negative values of indicates that the presence of that particular parameter class has less effect to the landslide development, whereas positive values indicates a relevant relationship between the presence of such parameter class with landslide development (Yin and Yan, 1988; Zezere, 2002).

Landslide susceptibility map (**Figure 2**) was developed based on the analysis of spatial landslide distribution relation with five basic geo-environmental parameters i.e. geology, slope gradient, slope aspect, distance from road and distance from river.

The result shows that areas with high susceptibility to landslide are about 34.9% of the total study area. Moderately susceptible areas consist of about 39.6%; whereas relatively low susceptibility (very low to low) areas are consist of about 25.5% of the total area (**Figure 3**).

The *area under curve value* of the susceptibility map is about 0.7489, which indicates the overall *success rate* of 74.9% (**Figure 4**).

It can be concluded that the map is reasonably reliable in predicting landslide prone area and can be used by the local authority or other relevant agencies as a basic tool for landuse management and future development planning for Kundasang, Ranau area.

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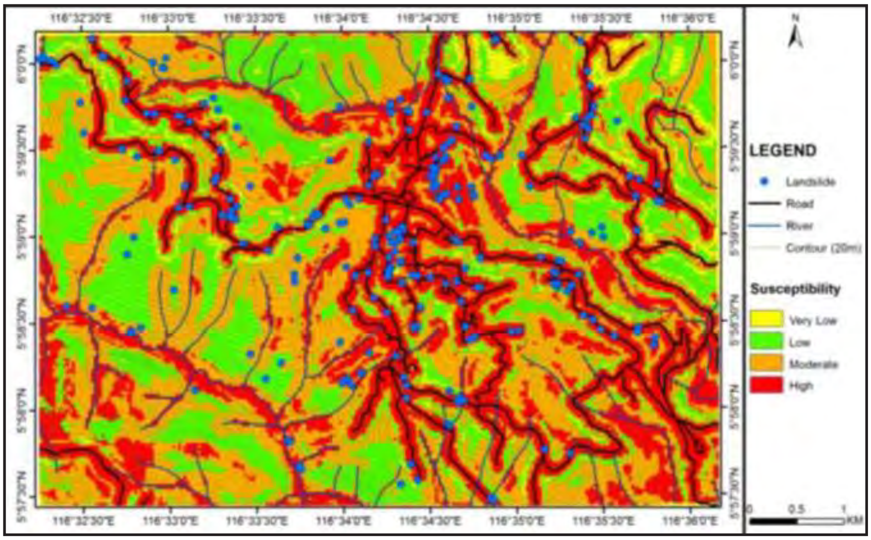

Figure 2: Landslide susceptibility class of the Kundasang, area.

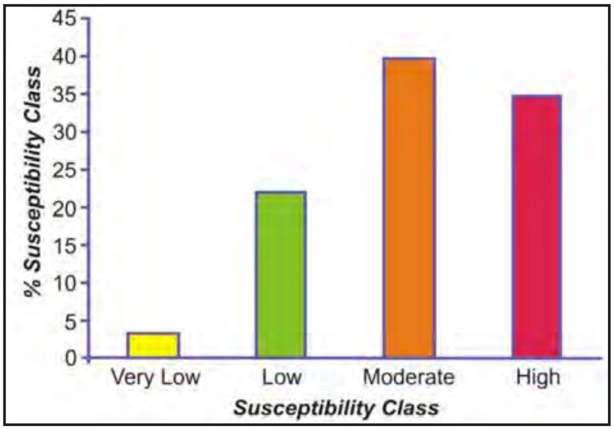

Figure 3: Histogram showing the percentage of each landslide susceptibility class.

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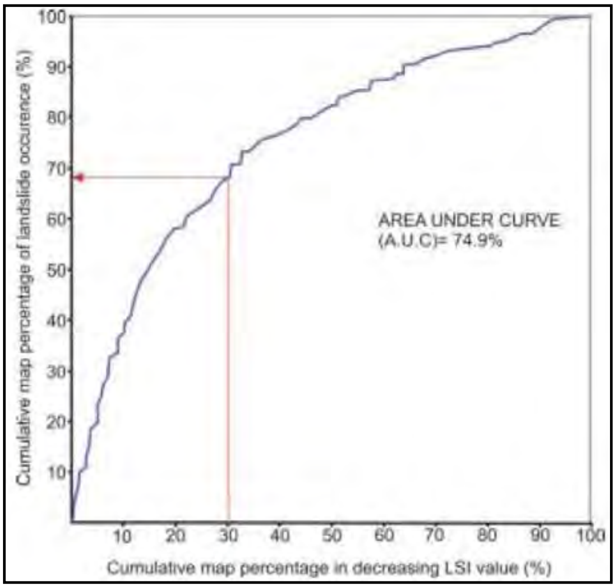

Figure 4: Validation of the landslide susceptibility map based on *area under curve.*

POSTERS

PBDG01-54

The Discovery of Phallic Rock at Jenagor, Terengganu

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Several phallic rocks pillars (Figure 1) and broken ceramic pieces (Figure 2) were discovered by locals along Sungai Terengganu at Madrasah Khairul Ihsan (MKI), Jenagor, near Kuala Berang. These discoveries may be of historical values considering that these monuments were found just about 1 km upstream from the tomb of the Shariff Muhammad Al Baghdadi, the writer of Terengganu Inscription Stone first found just 10km downstream. A study was undertaken to determine the nature and origin of the pillars and the ceramic pieces with the objectives to determine the significances of the discoveries.

The ceramics (Figure 2) were found buried in sand within a small stream. The site is situated about 12m above river level within an alluvial valley. The unique penis-shaped rocks (Figure 1) stood 2.5 meters tall above excavated ground surface. The pillars are genuine naturally sculptured moderately weathered coarse-grained granitic boulders with anthropomorphic shapes (phallus). They are buried under thick sandy gravel sediment (Figure 1). There are three pillars arranged in a triangle forming what look like a monument. The biggest of which form the tip of the triangle that point to the north. A petrological examination of the granite rock (Figure 3) shows that the rock consists of K-feldspar, quartz, plagioclase, biotite, and other accessory minerals probably apatite, zircon and secondary muscovite. The grain size ranges from 5 mm to 3 cm.

The ground where the rocks were buried consists of several layers of sandy PEBBLES soil. Each layers contain internal cross stratifications. These layers have undergone weathering giving rise to the red colourations. The layers coincide with the boundaries of the pillars' zonation. This may suggest the pillars were weathered and oxidized and corroded away within the soil layers after they were erected.

A walk over site and GPR surveys of the site showed no other granite boulders on the hill. The river bank is littered with boulders similar in shape to the phallus rocks. This suggests that there are no more buried pillars around the site and that the pillars must be carried up the hill as they are not in situ boulders. If they represent object erected in the historical time, it can be said that they are not Islamic in character and must predate the arrival of Islam in Terengganu. The tip of the triangle pointing to north may indicate they could have been used for navigation. However the phallus shaped monuments point to penis worshipping likely related to Hinduism.

The discovery of this phallic rock collection, herewith being named "Terengganu Phallic Rock" is hereby attributed to the remains of Hindu culture that further proof of the early Hinduism presence, where lingam worshipping was practised prior to the penetration of Islam into the Malay world. The ceramics suggest that Terengganu was once a trading centre along the South China Sea coast.

Figure 1: The triangularly arranged phallus rock.

Figure 2: Broken pieces of ceramic.

Figure 3: Nature of the granite.

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PBDG02-65

Pemetaan Gua di Langkawi UNESCO Global Geopark: Status dan Potensi Geopelancongan

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Langkawi UNESCO Global Geopark (LUGG) mempunyai jujukan batuan Paleozoik yang paling lengkap di Asia Tenggara. Jujukan ini bermula daripada zaman Kambrian yang diwakili oleh Formasi Machinchang, ditindih di atasnya oleh Formasi Setul, dan diikuti oleh Formasi Singa serta Formasi Chuping yang berusia Perm. Kepelbagaian jenis batuan, struktur tektonik serta proses geologi telah menghasilkan pelbagai bentuk geomorfologi berbeza di LUGG yang secara relatifnya bersaiz kecil. Langkawi dibangunkan secara lestari, sesuai dengan konsep geopark. Terdapat tiga kawasan pemuliharaan utama iaitu Machinchang Kambria Geoforest Park, Kilim Kars Geoforest Park dan Dayang Bunting Marmar Geoforest Park. Morfologi kars merupakan salah satu bentuk muka bumi atau landskap yang menarik di LUGG, yang diwakili oleh dua formasi batu kapur, iaitu Formasi Setul yang berusia Ordovisi-Silur dan juga Formasi Chuping yang terusia Perm (Rajah 1).

Formasi Setul tertabur di kawasan Teluk Kubang Badak, dari Tanjung Rhu hingga ke Kilim, Pulau Langgun, Pulau Tanjung Dendang dan seterusnya ke Selat Panchor dan Pulau Timun, hinggalah ke Pulau Tuba dan Pulau Dayang Bunting serta pulau-pulau kecil yang lain. Batu kapur adalah unit litologi utama dalam Formasi Setul, dan selebihnya ialah batuan klastik yang terdiri daripada batu lumpur dan batu pasir serta sedikit batuan berijang. Formasi Chuping pula terdapat di kawasan Kisap, di Pulau Dayang Bunting dan beberapa pulau kecil yang berhampiran. Keseluruhan Formasi Chuping terdiri daripada batu kapur dan sebahagiannya termetamorf menjadi marmar.

Landskap kars sememangnya menjadi tarikan utama pelancongan dunia dan tidak ketinggalan juga di Malaysia. Salah satu fitur geologi dalam landskap kars yang menjadi tumpuan pelancong Langkawi ialah gua batu kapur. Di LUGG terdapat lebih daripada 35 gua yang telah diketahui setakat ini (Rajah 1) dan banyak lagi yang belum ditemui kerana kawasan batu kapur ini terletak dikawasan yang terpencir dan sukar untuk dilawati. Hampir keseluruhan gua-gua yang ada di LUGG terletak dalam kawasan pemuliharaan geoforest park, kecuali di Teluk Kubang Badak dan Kisap, yang mana terdapat satu kilang simen dan kilang batu marmar yang telah beroperasi lama sebelum pengistiharan LUGG pada tahun 2007.

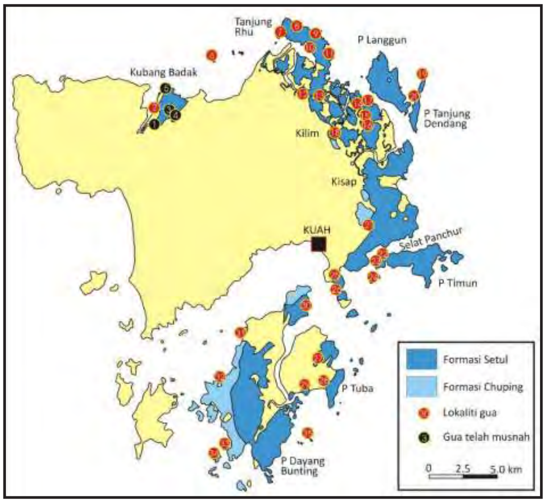
Daripada 35 buah gua yang telah dikenal pasti ini, sebanyak tujuh buah gua terletak di luar kawasan pemuliharaan, dan empat daripada gua-gua ini telah musnah secara keseluruhannya. Gua Sungai Siam, Gua Tok Sabung, Gua Layang dan Gua Balai yang terletak dalam kawasan kuari simen telah musnah secara keseluruhannya. Walau bagaimanapun Gua Pinang yang juga terletak dalam kawasan kilang simen masih terselamat (Rajah 2). Gua Bukit Putih yang terletak dalam kawasan tinggalan kilang marmar dijadikan tempat buangan sisa serpihan marmar dihadapan muka gua (Rajah 3). Gua Landak pula terletak dalam kawasan UUM dan sudah tidak boleh dimasuki kerana sudah di pagar.

Maklumat umum serta gambar gua-gua Langkawi boleh diperolehi daripada buku "*Mysterious Caves of Langkawi*, *Malaysia*" yang disediakan oleh Jabatan Saliran dan Pengaliran pada tahun 1994. Buku ini telah menjelaskan secara umum sebanyak 24 gua, termasuklah gua-gua yang sekarang ini sudah musnah oleh aktiviti kilang simen di Teluk Kubang badak. Maklumat terkini berkenaan gua-gua Langkawi telah dan sedang dikaji oleh penyelidik Program Geologi Univerisiti Kebangsaan Malaysia. Setakat ini sebanyak 17 gua telah dilawati dan dicirikan, dan daripada jumlah ini pula, sebanyak 10 telah selesai dipetakan. Pemetaan dijalankan untuk mengetahui bentuk, saiz & tinggi gua, serta jenis-jenis dan kedudukan speleoterm yang ada dalam gua. Selain fitur geologi, maklumat spesies kelawar juga dikaji kerana kelawar juga salah satu komponen biologi yang menjadi tarikan pelancong. Gua-gua yang telah dipetakan ialah Gua Pinang, Gua Buaya, Gua Kelawar (Kilim), Gua Cherita, Gua Ayam, Gua Nau, Gua Sungai Banjar, Gua Landak, Gua Wang Buluh dan Gua Kelawar (Tuba). Peta dan keratan rentas Gua Kelawar (Tuba) ditunjukkan dalam Rajah 4. Gua-gua lain, terutamanya yang telah dicirikan akan dilakukan pemetaan gua dalam masa terdekat.

Lembaga Pembangunan Langkawi (LADA) telah membangunkan enam buah gua untuk tujuan pelancongan dengan membina jeti pendaratan bot pelancong, tangga dan laluan pejalan kaki serta meletakkan papan maklumat.

Gua-gua yang terlibat ialah Gua Cherita, Gua Kelawar (Kilim), Gua Langsir (Kilim), Gua Wang Buluh, Gua Ayam dan Gua Tirai. Daripada enam gua ini, hanya Gua Kelawar (Kilim) yang menjadi tumpuan pelancong, malah bilangan pelancongnya terlalu ramai dan mungkin telah melampaui kapasiti muatan (*carrying capacity*). Jumlah pelancong ke Gua Wang Buluh, Gua Cherita dan Gua Langsir (Kilim) tidak begitu ramai, disebabkan kedudukannya agak jauh, manakala Gua Ayam dan Gua Selat??? telah terabai. Lalauan ke Gua Ayam agak sukar kerana terpaksa menaiki bot melalui anak sungai kecil dan cetek dalam paya bakau. Hanya waktu air pasang tinggi barulah boleh berkunjung ke gua ini. Gua Tirai pula sangat terpencil dan diluar laluan utama bot-bot pelancongan.

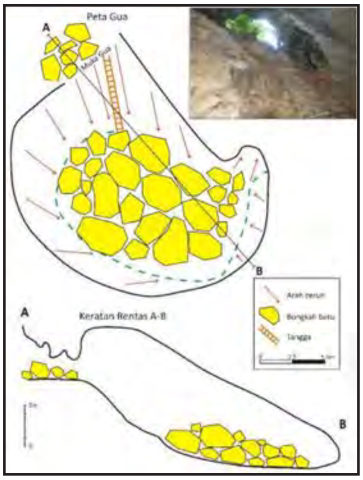
Projek pemetaan gua-gua Langkawi yang sedang dijalankan ini diharap akan dapat memberi manafaat kepada aktiviti pelancongan di LUGG. Gua-gua yang sudah dipetakan akan dibuat analisis dari segi kesesuaiannya untuk dibangunkan sebagai produk baru pelancongan. Salah satu yang paling berpotensi untuk dipromosi ialah Gua Pinang, yang mana gua ini merupakan gua yang paling besar dan juga paling banyak bilangan kelawar berbanding gua-gua lain di LUGG (Rajah 5). Walau bagimanapun, isu pemuliharaan mestilah diselesaikan dahulu kerana gua ini terletak dalam kawasan kilang simen. Setakat ini pihak kilang simen masih belum melakukan aktiviti pengkuarian di gua ini, dan diharap semua pihak terutamanya masyarakat sekitar di Kampung Kubang BadaK, pihak industri pelancongan (Persatuan Pemandu Pelancong Langkawi) serta LADA dapat mencapai persepakatan dengan pihak kilang simen supaya Gua Pinang ini boleh dipulihara daripada musnah. Pusat Penyelidikan Langkawi (PPL), Universiti Kebangsaan Malaysia telah menjalankan penyelidikan dan telah mencadangkan kepada LADA untuk menjadikan lembangan Kubang Badak (termasuk Gua Pinang) sebagai satu destinasi pelancongan baru Langkawi. Jika dipakej dengan baik, aktiviti pelancongan di lembangan Kubang Badak boleh maju seperti mana di Kilim.



Rajah 1: Taburan Formasi Setul dan juga Formasi Chuping, serta kedudukan gua-gua yang ada di LUGG.

Rajah 2: Gua Pinang yang terletak dalam kawasan kuari simen masih terselamat daripada aktiviti kuari. Diharapkan pihak pengurusan kuari akan menjadikan Gua Pinang sebagai kawasan terpulihara, iaitu tanggung jawab sosial syarikat terhadap tapak warisan bernilai tinggi.

Rajah 3: Gua Batu Putih. Pemandangan dalam gua (kiri) dan longgokan batu marmar di hadapan muka gua (kanan).



Rajah 4: Peta (atas) dan keratan rentas A-B (bawah) Gua Kelawar di Pulau Tuba. Foto menunjukkan pemandangan muka gua daripada dalam gua.

Rajah 5: Gua Pinang. Chamber gua yang besar (kiri) dan longgokan cengkerang kuno yang berusia lebih daripada 6000 tahun berhampiran muka gua (kanan).

PBDG03-150

Towards Aspiring Kinta Valley Geopark in the National Level

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Dalam pertengahan abad ke-20, Lembah Kinta di negeri Perak terkenal sebagai pengeluar bijih timah terbesar dunia, dimana aktiviti perlombongan tersebut sedikit sebanyak memainkan peranan besar dalam pembangunan awal wilayah itu. Lembah Kinta mempunyai pelbagai sumber warisan geologi semula jadi, biodiversiti dan warisan budaya dan sejarah yang perlu dipelihara dan dibangunkan melalui konsep geopark. Cadangan pembangunan Geopark Lembah Kinta telah mendapat perhatian daripada kerajaan negeri Perak dan bersetuju untuk memberi peruntukan kepada JMG Perak untuk menjalankan kajian dan penyelidikan secara terperinci. Kawasan cadangan pembangunan Geopark Lembah Kinta ini meliputi tiga (3) kawasan pentadbiran pihak berkuasa tempatan yang terdiri daripada Majlis Bandaraya Ipoh, Majlis Daerah Batu Gajah dan Majlis Daerah Kampar dengan keluasan hampir 2,000 km persegi. Lebih daripada dua puluh geotapak dengan pelbagai tapak warisan dari segi geologi, biodiversiti, budaya dan warisan serta produk tempatan telah dikenal pasti. Ciri-ciri geologi tersebut termasuklah topografi kars bukit batu kapur dan landskap gua, lata, jeram dan air terjun serta mata air panas. Dari aspek biodiversiti, kawasan Lembah Kinta ini terkenal dengan hutan simpan dan taman herba. Lembah Kinta sememangnya kaya dengan bangunan-bangunan bersejarah dan muzium yang sering menjadi tumpuan pelancong. Ianya juga sangat terkenal dengan kemanisan limau bali, kayu gaharu dan produk pertanian yang lain, kraftangan tempatan dan produk masakan yang akan dilabelkan dan dipromosikan sebagai sebahagian daripada produk geopark. Sebahagian besar geotapak-geotapak tersebut telah diusahakan sebagai tumpuan pelancongan setempat oleh pengusaha-pengusaha yang dibuat secara persendirian tanpa kaedah pengurusan pelancongan yang baik. Oleh itu, dengan wujudnya geopark ini geotapak-geotapak tersebut dapat diperkenalkan di seluruh negara dan seterusnya dapat melonjakkan ekonomi setempat. Lembah Kinta perlu diusahakan untuk mendapat pengiktirafan sekurang-kurangnya di peringkat Geopark Kebangsaan apabila melihat kepada senarai geotapak, warisan dan produk yang memenuhi ciri-ciri dan keperluan sebagai geotapak.

During the mid-20th century, Kinta Valley in Perak state was well known as the world largest producer of tin ore, hence mining activities played as a major role in the early development of the region. Kinta Valley has a variety of natural geological heritage resources, biodiversity and cultural heritage and history that should be preserved and developed through the concept of geopark. Kinta Valley Geopark development proposal has received much attention from the Perak state government and agreed to give provisions to JMG Perak to carry out details studies and research. The Kinta Valley Geopark development proposal area includes three (3) administrative area of the local authorities comprises of Ipoh City Council, Batu Gajah and Kampar Municipalities with an area of almost 2,000 square km. More than twenty geosites with a range of heritage sites in term of geology, biodiversity, cultural and heritage as well as local products have been identified. The geological characteristic includes limestone hills karst topography and cave landscapes, cascades, rapids and waterfall as well as hot springs. In term of biodiversity aspect, the Kinta Valley area is well known with its reserved forest and herb garden. Kinta Valley is well endowed with many historic buildings and museums which has always been a tourist attraction. It is also very famous for its sweetness pomelo, sandalwood and other agricultural products, local handicraft and culinary products which will be tagged and promoted as part of the geopark products. Most of the geosite has been developed as a tourist attraction by the local entrepreneurs on their own without a proper tourism management methods. Therefore, the existence of this geopark can be introduced throughout the country and can boost the local economy. Kinta Valley should be worked out to gain recognition at least at the National Geopark level when referred to the list of geosites, heritage and products that meet the characteristics and needs as a geosites.

PBDG04-152

Pengenalpastian Geotapak dalam Cadangan Geopark Jerai

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Jabatan Mineral dan Geosains Kedah/Perlis/Pulau Pinang, Malaysia (JMG) telah lama menjalankan kajian geotapak, mineral dan perlombongan di sekitar Gunung Jerai. Terkini JMG telah mengambil langkah untuk meletakkan beberapa panel berkaitan geotapak di sekitar Gunung Jerai untuk makluman umum. Pada penghujung tahun 2015, Jawatankuasa Pelaksana Geopark Kebangsaan telah mengenalpasti Gunung Jerai dan kawasan sekitarnya sesuai dibangunkan sebagai geopark kebangsaan ke-2 di Kedah. Satu Jawatankuasa Promosi dan Pembangunan telah diwujudkan untuk menggerakkan usaha untuk merealisasikan hasrat hasrat tersebut. JMG, Pusat Arkeologi Global Universiti Sains Malaysia (USM) dan Majlis Daerah Kuala Muda (MPSPK) serta Majlis Daerah Yan (MDYAN) telah berkerjasama untuk menjalankan kajian awal, khususnya mengenalpasti komponen penting untuk diketengahkan di Daerah Kuala Muda dan Daerah Yan. Aspek yang telah diberikan perhatian oleh JMG semenjak tahun 2014 ialah pengenalpastian geotapak yang perlu dibangunkan untuk pemuliharaan serta produk-produk pelancongan yang boleh diketengahkan. Terdapat sekurang-kurangnya 26 geotapak di sekitar Daerah Yan dan Daerah Kuala Muda yang terdiri daripada pelbagai jenis geotapak struktur geologi, sejarah aktiviti igneus, kepelbagaian mineral, cengkerang kuno, perubahan aras lautan, dataran paleosekitaran, tragedi geologi serta tapak arkeogeologi. Kepelbagaian geotapak yang sangat tinggi menjadikan Geopark Jerai sangat sesuai untuk dicalonkan sebagai geopark kebangsaan yang berbeza daripada geopark yang sedia ada.

PBEG01-33

The correlation of bulk density, porosity and velocity of cores from varies depth in CTW-1 Well of Kati Formation in UTP Campus, Seri Iskandar, Perak, Malaysia

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This study evaluates the effect of metamorphism on Kati Formation due to its proximity to granite bodies. A total of 16 core samples of three groups of lithology; weathered sandstone, fresh sandstone and metasandstone of varies depth from CTW-1 well were prepared for the velocity test and 8 core samples for the porosity test. The density range is between 2.275 g/cm^3 to 2.679 g/cm^3. The P-wave velocity ranges from 2168 m/s to 5232 m/s while the S-wave velocity ranges from 1454 m/s to 3050 m/s. Generally, the velocity value corresponded to the density value. The velocity increases as the density increases. The porosity range shows a low values ranging between 0.415 % and 1.062 %. Overall, the results shows a good correlation between density, velocity and porosity parameters. A low porosity sample shows a high grain to grain contact and filled pore space. Density and velocity are mainly affected by porosity. This causes the core samples to have a higher density and velocity values. In this study, the lithology after 150m depth is defined as metasandstone.

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PBEG02-34

Kajian Hidrogeologi Singkapan Granit di Lebuhraya SILK Sepanjang Kajang – Sungai Long, Hulu Langat, Selangor (Hydrogeological Study of Granite Outcrop at SILK Highway along Kajang – Sungai Long, Hulu Langat, Selangor)

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Lebuhraya Kajang SILK ialah lebuhraya sepanjang 37 km yang dibina untuk membolehkan pengguna jalan raya memintas pusat bandar, Kajang. Kesesakan lalu lintas dalam Kajang menjadi punca utama lebuhraya ini dibina. Kawasan kajian bergaris latitud 3° 0' 21.60" U dan garis longitud 101° 49' 51.60"T iaitu singkapan di antara Plaza tol Sungai Long ke arah Plaza tol Bukit Kajang yang merupakan salah satu tempat tadahan air yang popular di kalangan orang awam. Objektif kajian ini adalah untuk melakukan pemetaan geologi di kawasan kajian, melakukan analisis ketakselanjaran batuan dan seterusnya menjalankan kajian hidrogeologi di kawasan kajian. Jenis batuan yang tersingkap di sepanjang cerun ialah batuan igneus pluton. Batuan igneus pluton tersebut merupakan granit berbutir kasar. Cerapan di lapangan menunjukkan bahawa batuan bersifat felsik tersebut dikenalpasti sebagai granit biotit berbutir kasar dan granit biotit berbutir kasar berpofiri. Batuan yang tersingkap pada cerun adalah berluluhawa gred II-III dan sekitarnya ialah gred luluhawa IV-VI. Struktur yang ditemui hanyalah kekar dan sesar. Survei ketakselanjaran terhadap enam buah cerun (C1–C6) menunjukkan terdapat lima set kekar utama iaitu J1, J2, J3, J4 dan J5 dengan jurus dan kemiringan U60˚T/71˚, U287˚T/69˚, U360˚T/66˚, U110˚T/66˚ dan U305˚T/64˚. Kekar menjadi laluan utama bagi air di kawasan kajian serta membenarkannya menjadi sebuah akuifer. Analisis ketakselanjaran dilakukan untuk mengkaji corak kekar batuan. Analisis lineamen di kawasan kajian mendapat terdapat hubungan rapat dengan corak kekar di lapangan. Trend pada arah yang sama iaitu timur laut – barat daya dan barat laut – tenggara ditunjukkan oleh kedua-duanya. Analisis ketakselanjaran menunjukkan air di singkapan batuan kebanyakannya mengalir mengikuti corak retakan jasad batuan. Ketakselanjaran dengan kehadiran air menunjukkan corak arah selari dan serenjang dengan lineamen sungai. Tiub dan hos getah dipasang pada kekar-kekar tertentu bagi memudahkan penadahan air oleh orang awam. Kadar aliran paling laju yang telah dicatat ialah 1.7 x 10^2 mL/s. Air bawah tanah di kawasan kajian berada dalam julat air tawar berdasarkan jumlah pepejal terlarut dan pH air bawah tanah di kawasan kajian dicirikan sebagai asid lemah. Kekonduksian berjulat daripada 28 hingga 39 µS/cm. Kehadiran ketakselanjaran seperti kekar memainkan peranan yang amat penting bagi membolehkan batuan keras seperti granit menjadi sebuah akuifer.

Kajang SILK Expressway is a 37 km highway build to allow road users bypass Kajang. The study area covers coordinates between 3° 0' 21.60" N and 101° 49' 51.60"E which are the outcrops between the Sungai Long Plaza Toll towards Bukit Kajang Plaza Toll and is one of the popular water collection area among the public. The research objective includes geological mapping of the study area, rock discontinuities analysis and to do hydrogeological study in the area. Type of rocks exposed along the slopes are plutonic igneous rocks. Those plutonic igneous rocks are coarse grained granites. Field observations show that the felsic rocks can be classified as coarse grained biotite granite and porphyritic coarse grained biotite granite. Rocks on the outcrops show a weathering grade between II-III and surrounded by rocks within grades IV-VI. Structures found are joints and faults. Discontinuity survey on six slopes show that there are five joint sets named J1, J2, J3, J4 and J5 with strikes and dips N60˚E/71˚, N287˚E/69˚, N360˚E/66˚, N110˚E/66˚ and N305˚E/64˚ respectively. Joints are the main path for movement of water which allows it to become an aquifer. Discontinuity analysis is done to study the fracture pattern of the rocks. Lineament analysis in study area shows a close relationship with the fracture pattern in the study area. Trends in the direction of northeast-southwest and northwest-southeast are shown by both. Discontinuity analysis show that water in the rocks follow the fracture pattern of the outcrops. Discontinuities with presence of water show patterns in direction parallel and perpendicular with river lineaments. Tubes and rubber hoses are installed in certain joints for water collection purposes. Fastest flow rate recorded is 1.7 x 10^2 mL/s. Groundwater in the study area is within the range of freshwater based on total dissolved solids and the pH is characterized as weak acid. The conductivity ranges from 28 to 39 µS/cm. The presence of discontinuities such as fractures play an important role to allow hard rocks such as granite to become an aquifer.

PBEG03-44

Groundwater in Fractured Metasedimentary Rocks of Kenny Hill Formation

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Aquifer in metasedimentary rocks are not widely used because it is generally a poor aquifer. The objective of this study is to characterize the aquifer properties in metasedimentary rocks of Kenny Hill Formation. The study area is predominantly composed of interbedded phyllite and quartzite. The study is conducted by analyzing borehole logs and pumping test using constant discharge test, step drawdown test and recovery test. Borehole logs show that the area can be divided into two layers which is weathered layer on the top that acts as a confining layer and the bottom layer is fractured rock that acts as water bearing zone. Rocks in this aquifer has fractures of various depths. TW5, TW6, TW3 and TW7 is interpreted as confined aquifer and TW4 is interpreted as semi-confined aquifer. Pumping test data from five tubewells with depth ranging between 66 m to 135 m gives transmissivity, T value that ranges from 10.61 m^2/day to 10.12 m^2/day and is classified as low to moderate. Hydraulic conductivity, K value ranges from 0.02 m/day to 1.31 m/day and is classified as high. Aquifer productivity in the study area is classified as moderate based on average well yield of 5.6 m^3/hour. The presence of fractures in metasedimentary rocks in the study area makes it a relatively good aquifer.

PBEG04-45

Groundwater in Fractured Granite in Selangor

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The importance of fractured rock aquifers in the water supply issue vary according to region and depends on many factors, especially water supply and demand in the region. The study area includes factories in Selangor that use groundwater resources to meet their daily activities. This study is conducted to characterize the aquifer properties of the area. Well log and pumping test data using constant discharge test, step drawdown test and recovery test methods are analyzed to study their effects on the aquifer in study area. The interpretation made involves 16 wells with depths ranging from 16.75 m to 161.2 m. The results of this study show that the study area is predominantly composed of confined aquifer. Well log analysis indicates the presence of two major layers in the study area which are residual soil layer consisting of weathered granite material such as sandy clay and bedrock layer which is granite. This permeable layer of sandy clay acts as an aquitard which stores water that infiltrated from the surface. Meanwhile, the bedrock layer is fractured granite which acts as water bearing zone. Granitic rocks in study area is generally fractured at various depths. Pumping test analysis gives the transmissivity values, T ranged from 2.6 m^2/day to 36.1 m^2/day that are classified as low to moderate. The range of hydraulic conductivity, K is from 0.06 m/day to 4.68 m/day, which is interpreted as high. Wells in study area has a moderate productivity with an average discharge rate of 7.3 m^3/h. Granite rock aquifers generally have low water bearing potential. However, the presence of fractures in the aquifer has helped increase its productivity and efficiency.

PBEG05-62

Soil Properties and Stability of Puncak Setiawangsa and Bukit Aman Slope Failures, Kuala Lumpur, Malaysia

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Slope failures frequently occur in residual soil has negative impacts on human and the national economies. The purpose of the present study is therefore to investigate the characteristics of metasedimentary residual soil from the failed slope of Bukit Aman and adjacent slopes of Puncak Setiawangsa, to assess the stability of these slopes and to identify the causal factor contributing to the slope failures. The following tests for the index and mechanical properties were undertaken: particle size distribution, natural moisture content, Atterberg limits, specific gravity, x-ray diffraction (XRD) and Consolidated Isotropically Undrained Triaxial Tests (CIU). The results show that the main component of Puncak Setiawangsa and Bukit Aman residual soil is silt, followed by sand, clay and gravel. The range of soil moisture content for Puncak Setiawangsa is 10% to 35%, while for Bukit Aman is 15% to 35%. The plasticity index value of the residual soil from Puncak Setiawangsa is 26% to 67%, while for Bukit Aman is 37% to 68%. The range of specific gravity is 2.55 to 2.70 for Puncak Setiawangsa and 2.55 to 2.90 for Bukit Aman. The residual soil from Puncak Setiawangsa contains minerals quartz, alurgite, muscovite and kaolinite while for Bukit Aman, the minerals are quartz and kaolinite. The factor of safety for both slopes signified less than 1.5. the inherently unstable slopes, thus, effective slope remedial works were proposed for both locations. The landslides in these study areas may be attributed to a combination of several factors such as steep slope, lack of drainage system, erosion, presence of large trees and lack of ground anchors maintenance.

PBEG06-80

Kajian Keberintangan Geoelektrik di Tapak Pembuangan Lodak Sungai Jasik, Cameron Highlands untuk Melihat Struktur Subpermukaan dan Potensi Aliran Air Bawah Permukaan (Electrical Resistivity Survey in Sediment Disposal Area Sungai Jasik, Cameron Highlands for Subsurface Structure and Subsurface Water Flow Potential)

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Kajian keberintangan geoelektrik dijalankan di tapak pembuangan lodak yang terletak di antara Ringlet dan Cameron Highlands, Pahang. Terdapat dua litologi yang tersingkap dalam kawasan kajian iaitu batuan asid rejahan (granit) dan batuan metamorf seperti syis, filit, sabak dan terdapat sedikit batu kapur. Objektif kajian ialah untuk menentukan ketebalan lodak yang dibuang di tapak pembuangan, mengenalpasti kawasan yang tinggi kandungan air dan berpotensi untuk air mengalir serta mengesan kedalaman batuan dasar di tapak pembuangan lodak. Tinjauan survei ini dilakukan sebanyak 15 garis survei dengan jarak antara elektrod adalah 5m dan penetrasi sehingga 35m. Panjang garis profil adalah 200 meter dan susun atur yang digunakan adalah Wenner – Schlumberger (Rajah 1). Garis survei dijalankan secara rawak dengan mengikut kecerunan cerun bukit. Data diproses dan dianalisis menggunakan RES2DINV untuk menghasilkan imej keberintangan geoelektrik serta perisian Surfer untuk menghasilkan peta kontur. Imej keberintangan geoelektrik menunjukkan pelbagai nilai keberintangan. Berdasarkan nilai keberintangan, profil subpermukaan kawasan kajian dibahagikan kepada empat jenis; lodak atau tanah tepu air (kurang dari 100 Ωm), tanah baki (100 dan 1,000 Ωm), bongkah batuan granit yang terlulu hawa (1,000 – 2,800 Ωm) dan batuan dasar (lebih dari 2,800 Ωm). Lodak atau tanah tepu air boleh dilihat di kebanyakkan profil subpermukaan. Ketebalannya sekitar 5 m hingga 30 m. Lapisan ini terutamanya terletak di atas lapisan tanah baki atau bercampur dengan tanah baki. Manakala lapisan tanah baki paling dominan di dalam profil subpermukaan. Bagi batuan dasar ditafsirkan berada di pelbagai lokasi dan boleh dilihat pada kedalaman sekitar 10 hingga 20 meter. Berdasarkan topografi pada kawasan kajian, lodak atau tanah tepu air mengalir ke arah tenggara dan utara. Sebagai kesimpulan, lodak atau tanah tepu air yang berada di kebanyakan profil subpermukaan merupakan hasil dari pembuangan lodak dari Tasik Ringlet. Integrasi keberintangan 2-D dan data lubang gerudi menghasilkan hasil kajian yang betul dan boleh dipercayai.

An electrical resistivity imaging (ERI) study was conducted at sediment disposal area located between Ringlet and Cameron Highlands, Pahang. There are two lithologies reported in the study area which are plutonic igneous rock (granite) and metamorphic rock which is made up of schist, phyllite, slate and minor limestone. The objective of this study is to determine the thickness of sediment disposal at dumping area, interpret the location of high water content or saturated zone that has potential for water flow and to detect depth of bedrock in subsurface profile. Resistivity survey consists of 15 lines with 5.0 m spacing for each electrode and their penetration is about 35 m depth. Resistivity survey lines were conducted in length of 200 m and the Wenner – Schlumberger protocol was used for this study (Fig. 1). The survey lines were carried out at random following the slope gradient of study area. The data were processed and analyzed using RES2DINV in order to produce electrical resistivity imaging and Surface software to produce contour map. The results show the variation of resistivity. Based on the resistivity values, the materials within the subsurface profile can be divided into four types; clay or soil with high water content (less than 100 Ωm), residual soil (100 and 1,000 Ωm), highly weathered or fractured rock (1,000 – 2,800 Ωm) and fresh rock or bedrock (more than 2,800 Ωm). The clay or soil with high water content can be captured in almost all subsurface profile. The thickness is around 5 m until 30 m thick. This layer mainly overlies residual soil or mixed together. The most dominant material is residual soil. The bedrock varies based on location. Generally, it could be found around 10.0 to 20.0 m in depth. Based on topography of study area, clay or soil with high water content subsurface might flow to southeast and north of study area. In

conclusion, clay or soil with high water content that can be showed in almost all subsurface profil were resulted from sedimen disposal Tasik Ringlet. Integration of 2-D resistivity results with boreholes is successful give valid and reliable results.

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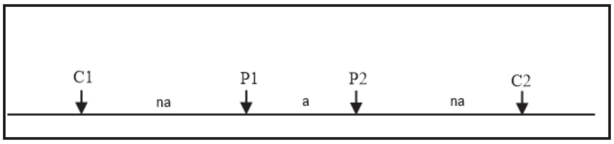

Figure 1: Wenner-Schlumberger array. The distance between electrodes is a, and the Dipole length factor is n, and n = 1 up to 6.

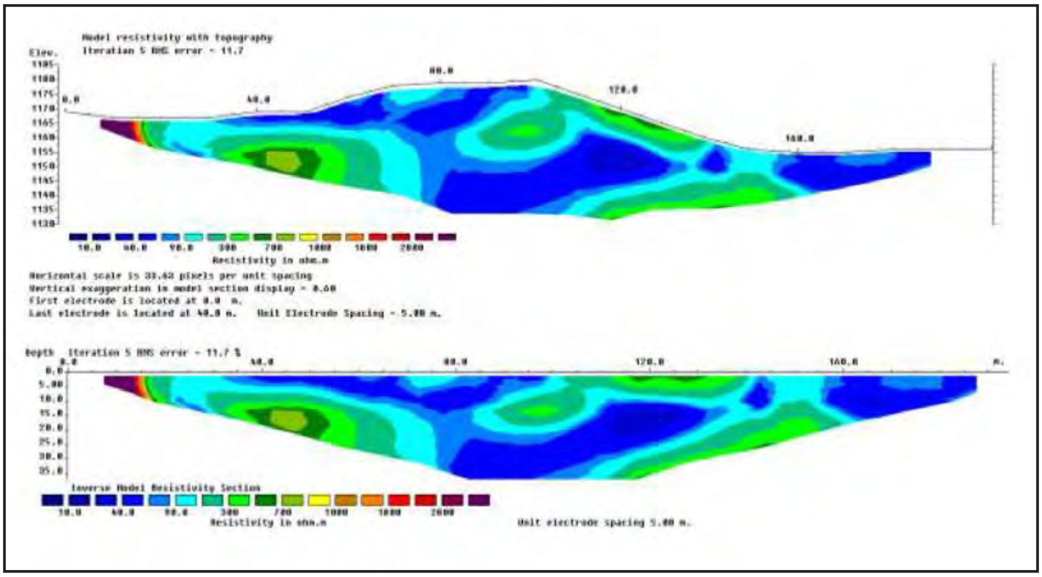

Figure 2: The interpretation model for the subsurface survey line 6.

PBEG07-83

Field Study to Identify River Plume Extension of Kerian River Discharge during Neap Tide and Spring Tide

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River flow discharge into adjacent ocean carries buoyant of sediment and nutrient which produces a unique structure known as river plume. Sediments may be load along the surface, suspended within the water column, or creeping just above the sea bed. River plume is the sediment fuel that can be associated to the formation of future delta within the estuary area. The study was performed at mouth of Kerian River that is located at the Northern part of Malaysian state of Perak and originated from Bintang ranges, Kedah. The data collection were performed twice; once during neap tide and spring tide to see the offshore extension of Kerian River plume. The data gathered in the field include salinity, temperature, turbidity, and Total Sediment Suspended, TSS. Analysis of the collected data indicate Kerian River plume extension is up to 3 km from the river mouth during neap tide and suppressed upstream during spring tide into 2 km seaward from the river mouth.

PBEG08-86

Slope Stability Assessment of Kek Look Tong Limestone Hills, Kinta Valley, Perak, Malaysia

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Limestone hills are prone to chemical weathering such as dissolution which results the formation of karst terrains. They also exhibit extensive geological discontinuities due to past tectonic history and also physical weathering. Therefore, limestone hills can pose danger to properties and human due to instability of the slopes. Unstable slopes are generally caused by the condition of the rocks and also other external factors which enhances its failure. Physical weathering results in the opening of existing geological discontinuities such as fractures. These geological discontinuities are the main factor which causes slope instability. Thus, the main objective of this study was to assess and quantify the stability of the Kek Look Tong limestone hills in Gunung Rapat, Ipoh, Perak by using Bieniawski's (1989) Rock Mass Rating (RMR) and Romana's (1985) Slope Mass Rating (SMR) system. Detailed discontinuity surveys and rock mass strength classification have been conducted on four slopes of the Kek Look Tong limestone hills for Slope Mass Rating (SMR) determination. To determine the possible modes of failure of the slopes, stereographic plotting is used and then inputted to determine the Slope Mass Rating (SMR). Based on the values obtained, all the four slopes generally have good rock quality. The values for the slopes are shown in Table 1. However, the large number of discontinuities, together with their unfavorable joint orientation and dip, results in low SMR values with a lower slope class and higher susceptibility to failure. The SMR values of the slopes are shown in Table 2.

Slope	RMR_b values
K1	65
K2	61
K3	64
K4	61

Table 1: Result of assessment of RMR_b for Kek Look Tong limestone hills, Ipoh

Slope	Mode of failure	RMR_b	F1	F2	F3	F4	SMR	Class	Stability
K1	Planar 48°/289°	65	0.70	1.00	-55	0	26.5	IV	Unstable
K2	-	61	-	-	-	-	65	II	Stable
K3	Toppling 50°/019°	64	0.15	1.0	-25	0	60.25	III	Partially stable
	Planar 77°/203°	64	1.0	1.0	-50	0	14	V	Completely unstable
K4	-	61	-	-	-	-	61	II	Stable

Table 2: Results of assessment based on SMR method

PBEG09-91

Rock Physical Properties of Kati Formation in Seri Iskandar, Perak

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This paper focuses on rock physics study on Kati formation in Seri Iskandar where the deepest on shore well in Peninsular Malaysia ever drilled. CTW-1 is the only well available with core sample and well log data for this study. A conventional petrophysical method has been implied in this study where the core sample data are analyzed using XRD, helium porosimeter and core description will justify the measurement and computation from well log data. Total of 31 core sample has been analyzed with the above-mentioned experiment. The calculated shale volume from log using linear method shows strong correlation with the XRD analysis data which gives out r2 = 0.906 and calculated sonic porosity using Wyllie-time average also gives out the same porosity range with helium porosity from core sample which is less than 1.5% in average.

The development of a quantified geological model for the Seri Iskandar area is now possible resulted from UTP – Halliburton Drilling Project in UTP campus, which cover the Kati formation. The formation is located in between 2 granite ranges i.e. Bintang and Kledang ranges [1]. A quantified geological model is not only providing the geological information i.e. depositional environment, lithology boundary, facies, it is also including the physical parameter of the rock i.e. porosity, permeability, conductivity, fluid volume, with accurate depth. The integration study between, geologist, geophysicist, petrophysicist are essential in providing the reliable interpretation.

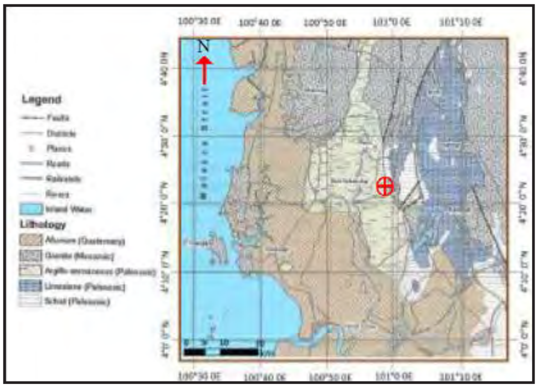

Figure above Geological map of Kati Formation and location of CTW-01 well in Seri Iskandar, Perak [1].

Depth (m)	Gamma ray (API)	BHCD (us/m)	XRD (v/v)	Grain den (g/cm3)	Vshale (v/v)	Sonic Por (%)	Helium por (%)
101.3	50.23	660	0.12		0.1454	1.091	
108	47.72	667	0.1	2.51	0.1454	1.13	
120.6	43.19	713	0.09		0.054	1.21	
133.73	49.5		0.12		0.1009		
141	47.71	718	0.03		0.0118	1.22	
146.4	48.06	709	0.1	2.6	0.1454	1.2	
152.8	62.79		0.16	2.52	0.3014		
160.2	100.34	725	0.18		0.3236	1.239	
175	101.45	897	0.22	2.64	0.23453	1.639	
182.7	100.86	885	0.11		0.2467	1.6	
191.6	78.06	655	0.12	2.59	0.1274	1.07	
200.17	89.21	615	0.18	2.66	0.1788	0.988	
212.6	128.25	695	0.27		0.3588	1.17	
215.3	83.64	480	0.15		0.1531	0.68	
229.34	78.06	596	0.12	2.54	0.1274	0.45	1.49
242.2	73.46	679	0.11	2.58	0.1273	1.134	
259.8	72.47	692	0.11		0.1017	1.164	
268	66.67	654	0.09	2.63	0.0759	1.077	1.37
275.8	66.91	783	0.08	2.58	0.0848	1.372	
279.6	100.37	691	0.2	2.63	0.2394	1.162	1.13
282.1	100.22		0.21	2.63	0.2334		
296.8	105.94		0.2	2.61	0.2657		
335	81.74		0.17	2.62	0.1635		1.31
349.5	74.38		0.111		0.1279		1.57
365	55.76		0.05		0.0378		
385.78	89.21		0.198	2.62	0.1997		
395	63.23		0.07		0.0739		0.82
396.75	70.59		0.1	2.64	0.1096		
401	66.91		0.09		0.0917		
405.7	70.59		0.11		0.1095		
407.7	89.21		0.19		0.1997		
409.12	75.27		0.13		0.1322		

Table above shows the summaries of core sample data. Both XRD and helium porosity have been loaded into the table and compare directly with other log data.

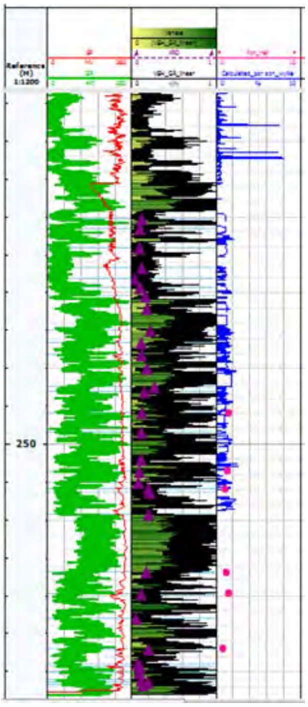

Figure shows the integrated log view layout where the triangle (XRD) and circle (helium porosity) tabulated data are the core data.

PBEG10-95

Engineering Geological Characterisation of Sedimentary Rocks at Parit to Kuala Kangsar, Perak, Malaysia

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The Parit to Kuala Kangsar area is a part of Kati Formation that consists of alternating layers of sandstone, siltstone and mudstone. The presence of sedimentary structures such as graded bedding, lamination and slumping causes these heterogeneous rocks to undergo non-uniform weathering. Field observations at the outcrop along the road A164 (N04º32', E100º56') show that the sedimentary rocks are moderately to highly weathered. Besides that, different parts of the rocks within the same outcrop exhibit different rock properties. Furthermore, the weathering grades of the rocks are difficult to identify applying the widely accepted International Association of Engineering Geology (IAEG) weathering classification, (IAEG,1981) which appears to be more suitable for igneous rock. Therefore engineering geological characterization of sedimentary rock needs to be determined to classify the weathering grade systematically by applying qualitative and quantitative techniques. In this research, the physical properties and mechanical strength of rock such as porosity, dry density, point load strength index (Is(50)) and slake durability index are determined based on the recommendation of ISRM and ASTM. Initial laboratory results based on lithology are shown in Table 1 with a preliminary weathering grade classification. Moderately weathered sandstone has the mean porosity of 11.4 %, mean dry density of 2.40 g/cm³, mean point load strength index of 0.53 MPa and mean slake durability index of 68.0 %. For highly weathered sandstone, the mean porosity is 19.1 %, mean dry density is 2.22 g/cm³, mean point load strength index is 0.15 MPa and slake durability index is 32.6 %. The completely weathered sandstone is classified as well graded sandy soil with an estimate of shear strength more than 0.45 MPa based on the pocket penetrometer test. Moderately weathered mudstone has the average porosity of 36.0 %, mean dry density of 1.77 g/cm³, mean point load strength index of 0.28 MPa and mean slake durability index of 12.5 % while highly weathered mudstone has average porosity of 39.7 %, mean dry density of 1.62 g/cm³, mean point load strength index of 0.10 MPa and mean slake durability index of 1.6 %. Apart from the sandstone and mudstone, there is also present of weathered sandstone that had undergone recementation with higher rock strength. Recemented sandstone has the average porosity of 4.5 %, dry density of 2.54 g/cm³, point load strength index of 2.30 MPa and slake durability index of 98.2 %.

Table 1. Summary of laboratory test results based on lithology.

Rock Type	Weathering State	Mean Porosity (%)	Mean Dry density (g/cm³)	Mean Point Load Strength Index (Is(50)) (MPa)	Mean Slake Durability Index, Id2 (%)
Sandstone	Moderately weathered	11.4	2.40	0.53	68.0
	Highly weathered	19.1	2.22	0.15	32.6
Mudstone	Moderately weathered	36.0	1.77	0.28	12.5
	Highly weathered	39.7	1.62	0.10	1.6
Recemented Sandstone	Moderately cemented	4.5	2.54	2.30	98.2

PBEG11-98

Slope Stability Evaluation by Geological Strength Index (GSI) on Selected Slopes of the Crocker Formation, Sabah, Malaysia

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INTRODUCTION

This study was conducted on two selected slopes, namely slope A and slope B in Menggatal, Kota Kinabalu area of Sabah. The study area is underlain by Crocker Formation of Late Eocene to Late Early Miocene ages. The Crocker Formation is a deep marine environment deposit and denoted as a flysch type.

The Geological Strength Index (GSI) system was introduced by Hoek *et al.* (1992) as an extension from Hoek-Brown criterion but its applicability only limited to "isotropic" rock masses. GSI system is never been practiced in Crocker Formation as of today. Then, this study was conducted to determine the Geological Strength Index (GSI) rating value, rock mass properties, slope stability and propose slope design for the selected slopes of the Crocker Formation in Menggatal area.

METHODOLOGY

Engineering geological mapping and discontinuity survey were conducted to obtain quantitative description of discontinuities (ISRM, 2007) as well as rock sampling based on grain sizes. GSI rating (Marinos, 2007) and disturbance factor was obtained from discontinuity survey and field observation on the slope face, respectively. Residual GSI rating was determined using empirical method by Cai *et al.* (2007) which enable the determination of residual strength of the rock mass through Hoek-Brown criterion.

Laboratory study includes point load test and dry density test (ISRM, 2007). Intact rock parameter (mi) for siltstone and shale unit was based on the suggested values given by Marinos and Hoek (2000). For sandstone, mi was obtained via empirical method by Shen and Karakus (2014). Rock mass properties such as cohesion, friction angle, tensile strength, Young's modulus and residual strength were determined by applying GSI system into the Hoek-Brown criterion which was computed using RocLab software. Kinematic analysis was done via Dips software to identify localized mode of failure.

Finite element analysis (FEA) has been conducted following Hammah *et al.* (2005) via Phase2 software for determining the safety factor or slope strength reduction (SSR) of localized mode of failure in selected slopes. Evaluation of GSI value, potential mode of failure, FOS and prescriptive measures (Yu *et al.*, 2005) were used to propose the rock cut slope designs.

RESULT AND DISCUSSION

The GSI rating obtained for slope A is 38 which consists of interbedded of thick shale and sandstone layers and 43 for slope B has GSI which consists of interbedded of siltstone and shale with similar amount. Figure 1 shows the GSI rating for slope A and slope B based on the chart for heterogeneous rock masses (Marinos, 2007).

Kinematic analysis shows slope A and slope B do not have any potential mode of failure. This result was proven by the lack of structurally controlled failure on site. The number of discontinuity plane sets of slope A and slope B as shown in the stereonet enable the slopes to be considered as "isotropic" and its slope failure will not structurally controlled by discontinuity plane. Safety factor or (shear strength reduction), SSR obtained from FEA for the slope A and slope B were 1.84 and 1.74, respectively (figure 2).

Both selected slopes can be considered as stable at the present time but become less stable in years. The installation of wire mesh, bolting, weep holes, and surface drainage are needed to prevent future failure. The main purposes of these slope protection and stabilization measures are to prevent water pressure build up within the slope since water is the main culprit triggering slope failure for tropical country such as Malaysia.

Table 1 shows the result of the parameters and rock mass properties for the selected slopes. The residual strength for the selected slopes was shown in Table 2.

CONCLUSION

GSI rating for slope A and slope B are 38 and 43, respectively. Rock mass properties are 6.91MPa and 7.82MPa, 0.135MPa and 0.166MPa, 38.25o and 39.22o, 0.28MPa and 0.22MPa and 2367.9MPa and 2216.9MPa of mi, cohesion, friction angle, tensile strength and Young's modulus for slope A and B, respectively. Both slopes can be considered as stable. Wire mesh, bolting, weep holes, and surface drainage are proposing slope design for selected slopes.

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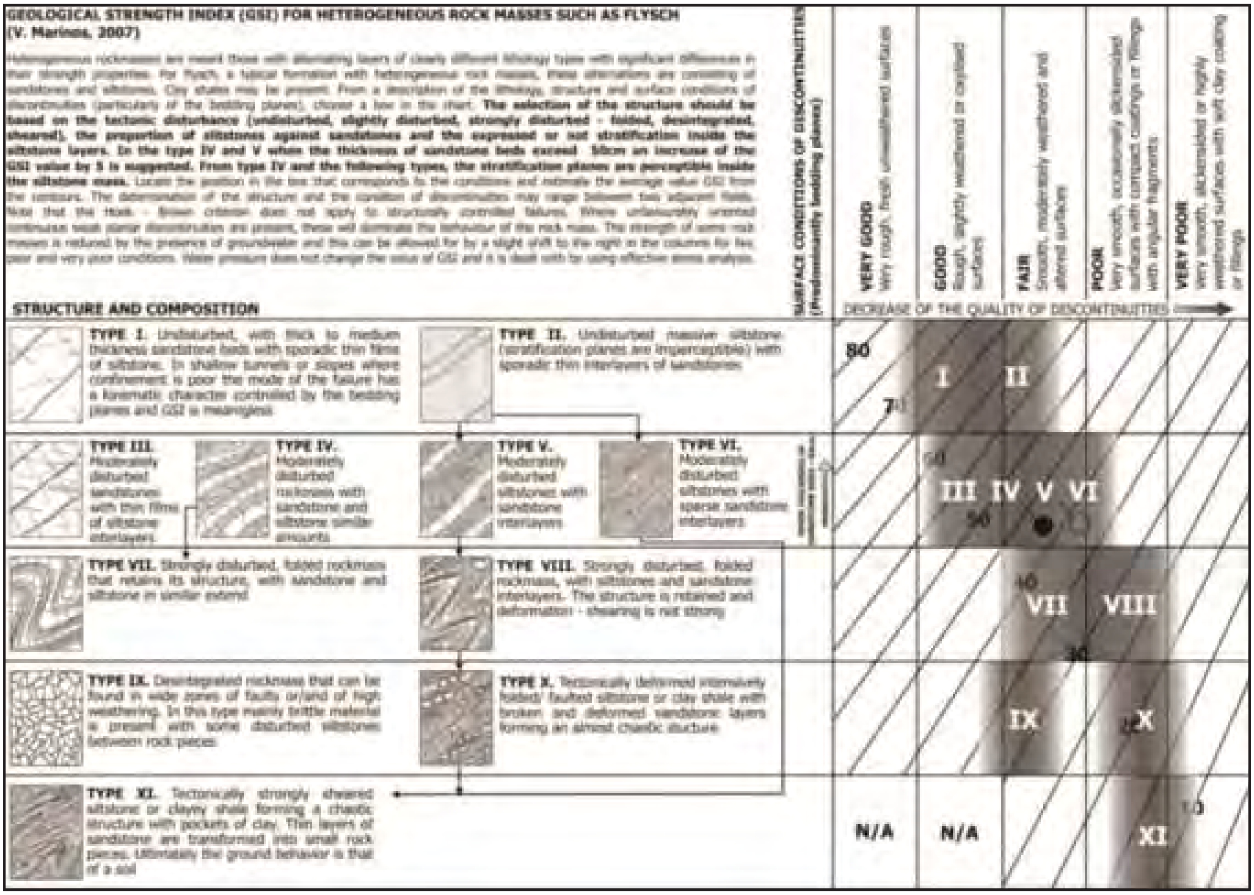

Figure 1: GSI chart (Marinos, 2007) and rating for slope A (colourless circle) and slope B (black circle).

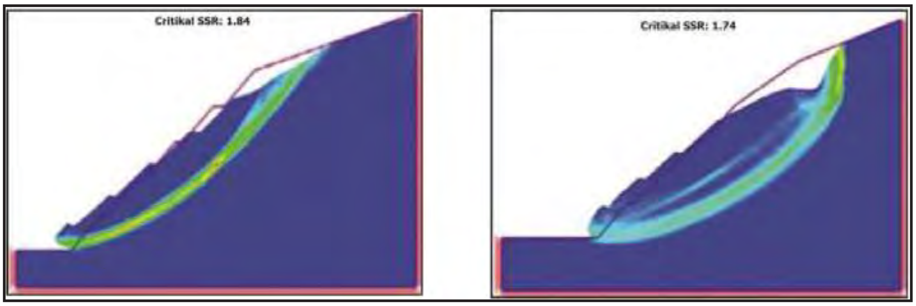

Figure 2: Cross sectional for slope A (left) and slope B (right) and mass movement acting on the slope.

Table 1: Parameter and rock mass properties for slope A and B.

Slope	Type	GSI	D	UCS (MPa)	Dry density (g/cm^2)	m_i	Cohesion (MPa)	Friction angle (°)	Tensile strength (MPa)	Young's modulus (MPa)
A	V	38	0.7	29.71	2.45	6.19	0.135	38.25	0.028	2367.9
B	VI	43	0.7	46.31	2.48	7.82	0.166	39.22	0.022	2216.9

Table 2: Residual shear properties for slope A and B.

Slope	GSI	Residual cohesion (MPa)	Residual friction angle (°)	Residual tensile strength (MPa)	Residual Young's modulus (MPa)
A	23	0.093	30.45	0.006	934.9
B	24	0.064	27.89	0.05	793.2

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PBEG12-104

Potential of Limestone Geohazard by Using GIS Analysis at Kg. Gunung Batu Melintang, Jeli, Kelantan

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Rigorous geological fissures and their connection to karst structure in tropical regions are frequently resulted with unpredictable environmental and geotechnical engineering problems. This requires an accurate modelling using modern techniques. This paper discussed about the identification of limestone karst condition at Kg. Gunung Batu Melintang, Jeli by using GIS and to mark the potential limestone geohazard in that particular area. For the determination of potential limestone geohazard, the raster multi-overlay analysis method was selected. The analysis of raster data was performed by using the ArcGIS-integrated weighted overlay tools corresponding to the specifications assessment. Based on the GIS analysis interpretation, the potential of limestone geohazard in this area is considered only moderate hazard and its potential hazard values did not exceed the value of 6.5. From thematic geohazard map analysis, the limestone geohazard that might occurring within the marked zone could be rock falls, sinkhole or land subsidence. Thus, the further precautions should be taken to avoid any misfortune and losses.

PBEG14-118

Kajian Terhadap Potensi Batuan Argilit Formasi Ma'okil sebagai Sumber Binaan Empangan di Kawasan Bukit Kepong, Muar, Johor

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Pengenalan

Lempung merupakan salah satu contoh batuan argilit iaitu yang mempunyai saiz butiran kurang daripada 0.002 millimeter dan terbentuk hasil daripada proses luluhawa dengan bantuan agen seperti air dan angin (Kamal Roslan, 2015). Batuan ini mempunyai banyak kegunaan terhadap manusia dan juga dalam bidang pembinaan terutamanya sebagai bahan binaan empangan (Humphrey & Boyd, 2011). Akan tetapi kegunaan batuan lempung bergantung kepada mineral yang terdapat di dalam batuan tersebut. Sebagai contoh mineral kaolinit sesuai dijadikan sebagai teras bahan binaan empangan isian bahan bumi kerana sifatnya yang tidak menyerap air (Didiek et al, 2014). Oleh itu, air tidak akan melalui teras tengah dan disalurkan terus ke bahagian bawah empangan bagi mengelakkan berlakunya retakan hidraulik dan sekali gus mengukuhkan lagi struktur empangan. Kawasan kajian terletak di Utara Johor dan lebih tepat lagi berada di kawasan Bukit Kepong. Keluasan kawasan kajian meliputi 16 kilometer persegi, terdiri daripada 9 lokaliti serta dibatasi oleh garis latitud 2°20'6.60" U dan garis longitud 102°50'23.76" T. Sehubungan dengan itu, kajian ini dijalankan untuk melakukan penambahbaikan terhadap data sedia ada berkaitan tentang pencirian batuan argilit di Formasi Ma'okil oleh pengkaji terdahulu agar maklumat yang lebih lengkap dan terkini dapat diperolehi. Menurut Loganathan (1977), beliau menyatakan bahawa Formasi Ma'okil terdiri daripada tiga unit batuan iaitu rudit, arenit dan argilit. Unit rudit terdiri daripada konglomerat, unit arenit terdiri daripada batu pasir (Mohd Nazly, 1995) dan unit argilit terdiri daripada batu lodak dan syal. Selain itu, kajian ini juga untuk memastikan sama ada batuan argilit di kawasan kajian sesuai atau tidak untuk dijadikan sebagai sumber bahan binaan empangan Meda yang bakal dibina dengan melihat kepada jenis mineral. Jika sesuai, ianya dapat menjimatkan kos pengangkutan serta mempercepatkan proses pembinaan dilakukan kerana kawasan kajian terletak dekat dengan empangan tersebut. Objektif kajian ini dijalankan adalah untuk mengetahui jenis batuan yang terdapat di kawasan kajian dengan mencerap segala cirian geologi yang terdapat di lapangan. Kajian juga bertujuan untuk mengenalpasti jenis batuan dan peratusan mineral yang terdapat dalam batuan secara petrografi dan melalui kaedah XRD. Semua kajian ini adalah menjurus kepada mengkaji potensi batuan argilit di kawasan kajian sebagai bahan binaan empangan Meda.

Pendekatan dan Hasil Kajian

Antara pendekatan yang digunakan dalam kajian ini ialah cerapan tangan, analisis petrografi dan analisis pembelauan sinar-X (XRD). Sebanyak 14 sampel telah diambil di lapangan dimana ianya terdiri daripada 11 sampel batuan dan 3 sampel auger. Kaedah cerapan di lapangan bertujuan untuk mengetahui litologi batuan di kawasan ini dengan mengambil segala data geologi. Sebanyak 11 sampel batuan yang telah diperolehi. Selain itu, kajian makmal telah dilakukan iaitu menggunakan analisis petrografi. Analisis ini bertujuan untuk mengenal pasti jenis mineral dengan melihat sifat-sifat optik menggunakan mikroskop pengutuban Meiji dan membuat pengelasan berdasarkan peratusan mineral yang diperolehi. Sebanyak 5 sampel batuan telah dinipiskan dalam bentuk irisan nipis. Analisis XRD juga dijalankan untuk menganalisis dan mengenal pasti kandungan dan peratusan mineral yang terdapat dalam sampel yang terdiri daripada 5 sampel batuan dan 3 sampel auger. Kaedah ini menggunakan mesin XRD model D8 *Bruker Advance* untuk menganalisis sampel.

Hasil daripada kerja lapangan menunjukkan bahawa terdapat 6 jenis batuan seperti dalam Rajah 1 yang tersingkap pada potongan bukit yang terdiri daripada batu pasir merah halus (2A1), batu pasir kelabu putih (2A2), lempung putih (5B1), lempung kelabu kuning (5B2), lempung merah (5B3) dan batu pasir merah sangat halus (5C4). Perlapisan sangat jelas dapat dilihat pada singkapan. Terdapat lempung yang berbeza warna pada 1 singkapan yang sama iaitu lempung putih yang dipercayai tidak dikotori oleh sebarang bahan kotoran semasa pengendapannya, lempung kelabu kuning ditafsir disebabkan kerana terdapat kehadiran bahan organik atau humus yang mengalami proses pereputan yang tidak lengkap manakala lempung merah pula kerana terdapatnya kehadiran oksida besi hasil daripada proses oksidasi iaitu tindakbalas kimia antara besi dan oksigen. Selain itu, terdapat juga 3 sampel auger yang diambil pada kedalaman 0 hingga 0.5 meter (T3A1 & T3B1) dan 0.5 hingga 1 meter (T3A2). Sampel ini perolehi di tebing Sungai Meda yang terletak berdekatan dengan titi.

Hasil daripada analisis petrografi bagi 5 sampel batuan yang terdiri daripada 2 sampel batu pasir iaitu batu pasir merah halus (2A1) dan batu pasir merah sangat halus (5C4), dan 3 sampel lempung iaitu lempung putih (5B1), lempung kelabu kuning (5B2) dan lempung merah (5B3). Hasil cerapan di bawah mikroskop pada magnifikasi 10x menunjukkan bahawa bagi sampel batu pasir, peratusan mineral paling dominan ialah kuarza (65%-60%) diikuti oleh pecahan batuan (25%-15%), mineral muskovit (20%-10%) dan oksida besi (5%). Selain itu, batu pasir juga mempunyai saiz butiran antara 0.180 mm hingga 0.06 mm. Butiran mineral dapat dilihat seperti dalam Rajah 2. Jenis sokongan ialah sokongan butiran kerana kurang matrik dan dominan dengan butiran. Mempunyai penyusunan butiran yang lemah dan jenis simen yang terbentuk antara butiran ialah kuarza dan oksida besi. Asingan yang sederhana baik kerana dapat dilihat perbezaan butiran yang tidak ketara. Bagi sampel lempung pula, matrik telah mendominasi dengan peratusan (80%-70%) diikuti oleh kuarza (20%-10%), oksida besi (10%-5%) dan muskovit(5%). Lempung juga mempunyai saiz berjulat kurang daripada 1/256 mm. Jenis sokongan yang ditunjukkan ialah sokongan matrik dimana matriknya terdiri daripada mineral lempung iaitu kaolinit. Penamaan batuan bagi batu pasir telah dilakukan. Hasil daripada anggaran peratusan mineral kuarza, feldspar dan pecahan batuan yang telah diplot di atas gambarajah QFL (Folk, 1974) menunjukkan bahawa sampel 2A1 ialah batuan litarenit manakala sampel 5C4 pula ialah batuan sublitarenit.

Analisis XRD terdiri daripada sampel 2 batu pasir (2A1, 5C4) dan 6 sampel lempung (T3A1, T3A2, T3B1, 5B1, 5B2, 5B3). Hasil analisis XRD menunjukkan bahawa sampel batu pasir mengandungi peratusan mineral kuarza (96.4%-65.6%) paling dominan diikuti oleh muskovit (31.2%-3.6%), kaolinit (3.2%) dan hematit (0.8%) manakala untuk sampel lempung pula, mengandungi kandungan mineral kuarza (95.1%-72.9%) yang paling tinggi diikuti oleh muskovit (15.1%-7.2%), kaolinit (5.9%-3.9%) dan hematit (7%). Rajah 3 menunjukkan peratusan yang terdapat dalam sampel batu pasir dan lempung. Berdasarkan analisis ini, dapat dilihat kehadiran mineral lempung jenis kaolinit mencatatkan peratusan agak tinggi terutama sekali di lokaliti 5. Rajah 4 menunjukkan taburan bagi mineral kaolinit di setiap lokaliti berdasarkan hasil analisis XRD.

Sebagai kesimpulannya, berdasarkan cerapan lapangan menunjukkan bahawa batuan di kawasan kajian terdiri daripada batuan sedimen iaitu lempung dan batu pasir. Berdasarkan kaedah makmal, dapat dipastikan bahawa batuan yang dijumpai di lapangan adalah memang batuan lempung kerana dapat dilihat melalui cerapan petrografi bahawa batuan mengandungi matrik yang tinggi dan dikukuhkan lagi dengan kehadiran mineral lempung melalui analisis XRD. Sama juga bagi batu pasir dimana tafsiran awal di lapangan menunjukkan sifat berbutir apabila dirasa menggunakan jari dan dikukuhkan lagi dengan analisis petrografi yang menunjukkan saiz butiran dari 1/4 millimeter bagi batu pasir halus dan bagi batu pasir sangat halus memberikan saiz butiran dari 1/8 millimeter manakala analisis XRD pula menunjukkan bacaan kuarza yang tinggi mewakili batu pasir. Peratusan mineral kaolinit dalam batu lempung yang dominan menunjukkan bahawa batuan argilit di Formasi Ma'okil sesuai dijadikan sebagai bahan binaan asas empangan kerana mineral ini bersifat tidak telap air iaitu mempunyai kekuatan regangan dan kekuatan ricih yang tinggi yang mampu menghalang daripada berlakunya retakan hidraulik.

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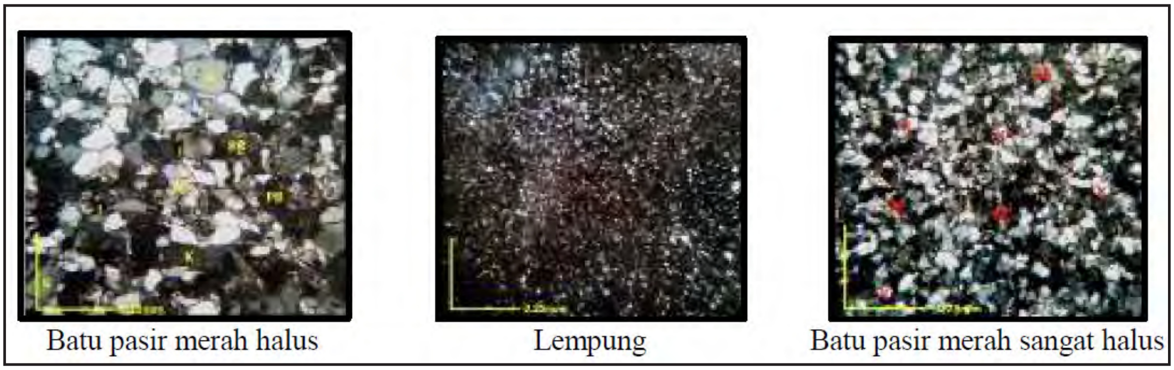
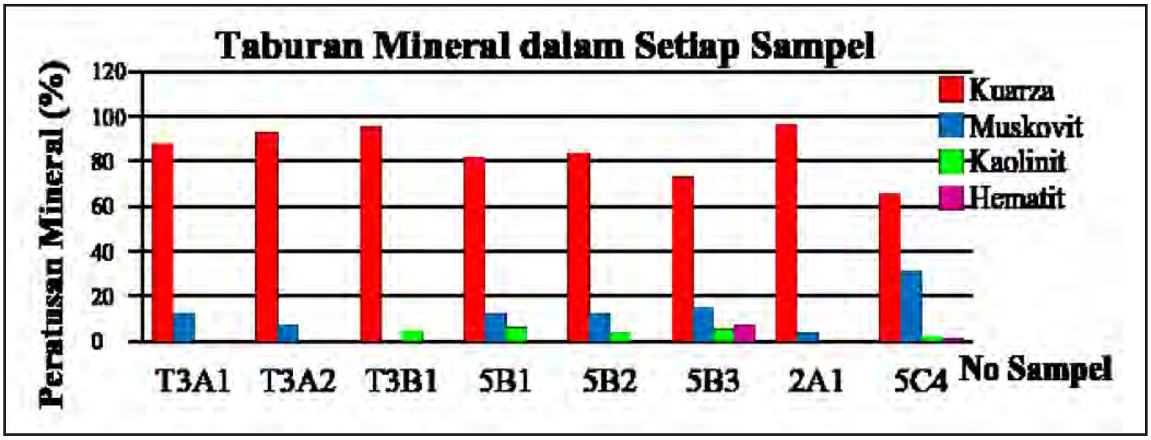
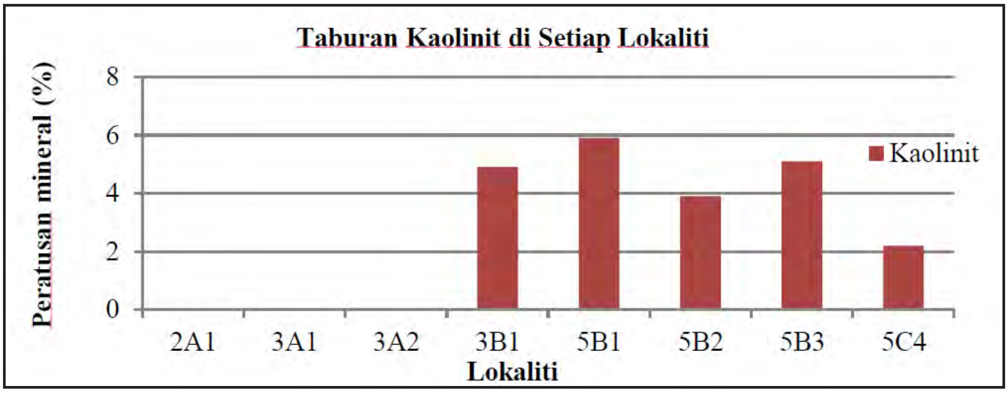
Rajah 1: Sampel batuan dan sampel auger yang dicerap dan diperolehi di lapangan.



Rajah 2: Pandangan dengan nikol silang (XPL) di bawah mikroskop bagi sampel lempung dan batu pasir.



Rajah 3: Taburan mineral yang terdapat dalam setiap sampel di lokaliti 2, 3 dan 5.



Rajah 4 : Taburan mineral lempung jenis kaolinit yang wujud di kawasan kajian.

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PBEG15-131

Preliminary Results of Engineering Geological Weathering Characterization of Interbedded Heterogeneous Siliclastic Sedimentary Rocks in Temerloh, Pahang, Malaysia

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The study of rock weathering is vital to all aspects of geotechnical engineering. Engineering properties of a rock mass can be highly influenced by the degree of weathering. Durability of rock material is one of the properties that controls the degree of weathering and this is the rationale for incorporating slake durability in the testing methodology. In this research, the interest is in interbedded sedimentary rock mass which composed of alternation of strong and weak layers, producing different weathering profiles. Thus, the standard weathering classification (IAEG 1981, ISRM 2007) may not be truly applicable to heterogeneous rock mass because it does not take lithological variation into consideration. Durability and weathering characteristics together with long-term behavior are investigated and a number of testing methodologies are being developed. 3-cycle-wetting-drying (slake durability) test that can simulate the natural condition is combined with a crystallization test to distinct hard rocks from weak rocks and further categorized the weak rocks. The study locations are mainly comprised of interbedded sandstone, siltstone and mudstone layers of the Semantan Formation with varied bedding thickness. Preliminary field observation showed that the rock masses are ranging from Type III to Type XI based on the Geological Strength Index (GSI). Point Load Index test results for two shale samples showed different strength value even though the samples are visually similar. Further laboratory tests and field investigations need to be done to study the degree of weathering and engineering geological characterization of the rock material. The final aim of this study is to enable user to adopt the innovative and practical testing method to characterize the weathering state and have a better understanding of the ground condition for any future construction works.

PBEG16-132

Seasonal Trace Elements Concentration in Domestic Groundwater Wells in Parts of Kelantan, Malaysia

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Groundwater is one of the major alternative source of fresh water supply in rural as well as in urban areas in many parts of Kelantan region. The need for groundwater has been rising day by day for irrigation purpose. The degree of trace element pollution and the suitability of groundwater for drinking purpose was assessed. Thirty-two groundwater and surface water samples were collected from shallow aquifer layers in northern part of Kelantan state and selected for the purpose of trace elements analysis. Total 15 trace elements being investigated such as As, Pb, Sr, Ba, Mn, Co, Ni, Cu, Cd, Fe, Zn, Cr, B, Se, and Al. The samples were transported to the laboratory and analysed using Inductive Coupled Plasma Mass Spectrophotometer (ICPMS) to determine the concentration of trace elements. The study reveals that most of the samples analysed contains marginally low concentrations of trace elements. Majority of toxic elements (As and Pb) are found to be in minute quantities and thus assumed to be inattentive in the wells. The trace elements concentration from most wells in the parts of Kelantan are well below the permissible limit of WHO which points to the unpolluted source of water supply in the area and thus suitable for drinking and other domestic purposes. Recommendations for the usage of water must take into consideration such as soil categories, crops developed, plantation management practises and proper drainage systems. Appropriate use of law and regulations and effective water management may perhaps make it promising to develop waters for irrigation and other domestic purposes.

PBEG17-146

Slope Stability Assessment at Gua Naga Mas, Gunung Pua, Ipoh, Perak

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Gua Naga Mas, Gunung Pua, Ipoh, Perak, is a place of worship for the religious activities of religious Buddha because there is temple which are frequented by the public. The study of the engineering aspects was carried out due to lack of consideration of some of people that rock fall will occurred without any mitigation done. Therefore, this study is to identify and evaluating the slope stability of the rock mass which include four main slope S1, S2, S3 and S4. According to SMR Rating, slope S1, S2 and S4 is in class II which is good and stable and slope S3 is in class IV which is not good and unstable. The outcomes of the study will help for further development consideration and mitigation in the future.

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PBEG18-159

Tahap Keterancaman dan Zon Bahaya Tebing Bukit Batu Kapur di Sekitar Bukit Lagi, Kangar, Perlis

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Bukit batu kapur dicirikan oleh bukit yang bertebing hampir tegak hingga tegak dan mempunyai struktur geologi khusus hasil tindakbalas semulajadi bumi seperti struktur gegua, lohong, kikisan lereng, alur pelarutan, stalagtit dan stalagmit. Kewujudan satah-satah ketakselanjaran seperti struktur kekar, sesar dan perlapisan membentuk blok-blok batuan longgar dan berpotensi untuk mengalami bencana runtuhan batuan. Faktor geologi di mana keadaan satah ketakselanjaran dan parameter geomekanik jasad batuan memainkan peranan yang penting dalam mempengaruhi kestabilan jasad batuan batu kapur. Oleh itu satu kajian dilakukan di sekitar Bukit Lagi, Kangar, Perlis yang terdiri Formasi Setul berusia Ordovisi sehingga Devon. Objetif kajian ini adalah untuk mengelaskan tahap keterancaman dan menentukan zon bahaya tebing bukit batu kapur di kawasan ini. Hasil kajian ini dapat memberi maklumat mengenai status kestabilan cerun dan membantu pihak berkuasa negeri dalam mengenalpasti cerun-cerun batu kapur yang berisiko tinggi. Seterusnya langkah-langkah mitigasi perlu diambil untuk meningkatkan kestabilan cerun dan secara tidak langsung dapat mengelakkan masalah runtuhan batuan di kawasan kajian. Disamping, dapat membantu dalam menambahbaikan satu garis panduan yang lebih sistematik dan berkesan dalam mengkelaskan tahap keselamatan tebing bukit batu kapur bagi menentukan kesesuaian zon guna tanah bagi pembangunan masa depan di sekitar bukit batu kapur di Malaysia.

The limestone hill is characterised by a hill that erupts almost upright and erected and has a special geological structure of natural earth reactions such as cave structures, holes, overhang, undercuts, stalactites and stalagmites. The existence of discontinuities planes such as joint structures, faults and layers should be formed loose rock blocks and potentially to exposed the rock fall disaster. The geological factors in which the uncontrolled plane state and geomechanical parameters of rock bodies play an important role in influencing the stability of the limestone rock body. Thus a study was conducted around Bukit Lagi, Kangar, Perlis which consisted of Ordovician-Devonian of Setul Formation age. The objectives of this study is to classify the level of vulnerability and determine the danger zone of limestone hill cliffs in this area. The results of this study provide information on the status of slope stability and assist state authorities in identifying high-risk limestone slopes. Next, mitigation measures are need to be taken to enhance slope stability and indirectly avoid the rock fall problem in the study area. In addition, it can assist in enhancing a more systematic and effective guideline in classifying the safety level of limestone hill cliffs to determine the suitability of land use zones for future development around limestone hills in Malaysia.

PBEG19-160

Pendekatan Sistematik Penilaian Kestabilan Gua Naga Mas, Gunung Pua, Ipoh, Perak

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Gua Naga Mas merupakan antara tempat ibadat yang popular di kawasan Ipoh Selatan bagi masyarakat yang beragama Buddha. Isu kestabilan gua juga kurang diberi perhatian oleh masyarakat walaupun orang ramai akan beribadat di kawasan ini. Kajian ini adalah salah satu inisiatif untuk memastikan keselamatan orang ramai dengan kajian penilaian kestabilan gua. Objektif kajian adalah menilai kestabilan gua dan dinding gua dengan menggunakan sistem pengelasan Sistem Q dan Perkadaran Jasad Cerun (SMR) dan nisbah ketebalan dan kelebaran gua. Ketinggian gua ini adalah 128 m-138 m atas paras laut. Gua terletak di 4°30’27.4”N 101°08’54.8”E. Litologi kawasan adalah batu kapur berdolomit. Kajian ketakselanjaran menunjukkan bahawa cerun C1 yang dipengaruhi oleh tiga set kekar iaitu J1, J2 dan J3 dengan arah kemiringan dan nilai kemiringan 332º/49º, 154º/37º dan 049 º/80 º manakala cerun C2 dipengaruhi oleh empat set kekar dengan arah dan nilai kemiringan bagi J1, J2, J3 dan J4 ialah 323º/44º, 125º/57º, 42º/76º, 263º/67º. Sudut puncak geseran untuk cerun satu adalah 50º manakala sudut puncak geseran untuk cerun dua adalah 55º. Nilai kekuatan mampatan sepaksi (UCS) untuk bahan batuan yang mengalami kegagalan bahan ialah dalam julat 50.5 MPa – 80.3 MPa manakala nilai untuk bahan batuan yang mengalami kegagalan bahan dan ketakselanjaran ialah 24.2 MPa – 45.6 MPa. Hubungan antara sistem Q dan kelebaran gua pula menunjukkan gua mermelukan sokongan kecuali bahagian Z di bahagian *chamber.* Kestabilan dinding gua untuk bahagian A-D, I-M, E’-J’, dan N-N’adalah tidak baik disebabkan orientasi muka dinding gua yang berbeza. Nisbah ketebalan bumbung gua dan kelebaran gua menunjukkan bahawa gua adalah stabil. Melalui kajian kestabilan gua ini, hasilnya dapat mencadangkan kaedah penyelesaian bagi tujuan memastikan keselamatan gua supaya orang ramai dan pihak berkuasa lebih berwaspada dan selamat untuk menjalankan aktiviti ibadat di kawasan ini.Analisis kinematik serta ciri geomekanik jasad batuan dalam kajian diharapkan dapat dijadikan rujukan kepada pihak berkuasa dalam mencadagkan dan merancangkan pembangunan dan pembinaan kawasan Gua Naga Mas.

PBEG20-172

Pengimejan 2D Potensi Lubang Benam dalam Batu Kapur Menggunakan Teknik Keberintangan Geoelektrik di Kampung Baru Kuala Dipang, Kampar, Perak
(2D Imaging of Potential Sinkhole in Limestone Formation Using Geoelectric Resistivity Method in Kampung Baru Kuala Dipang, Kampar, Perak)

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Lubang benam merupakan satu bencana struktur geologi yang boleh menyebabkan kehilangan nyawa dan harta benda. Bencana ini terbentuk pada kawasan berbatuan dasar batu kapur berpunca daripada hakisan pada batu kapur. Faktor utama hakisan ini ialah air hujan. Kajian dijalankan di Kampung Baru Kuala Dipang, Kampar, Perak. Kawasan yang berbatuan dasar batu kapur ini terdahulunya telah terbentuk beberapa lubang benam berpunca daripada tempias gegaran gempa bumi magnitud 8.7 skala Ritcher di Kepulauan Nias, Sumatera pada 29 Mac 2005. Kajian dijalankan bagi menentukan geometri kaviti dan potensi berlaku lubang benam di kawasan tersebut dengan menggunakan kaedah geofizik iaitu kaedah keberintangan geoelektrik menggunakan tatasusunan dwikutub (Rajah 1). Sebanyak tujuh garis survei keberintangan geoelektrik sepanjang 200 m telah dijalankan. Data keberintangan yang diperolehi kemudian diproses menggunakan perisian komputer RES2DINV bagi menghasilkan model songsangan 2D (Rajah 2 & 3). Secara umum, zon yang boleh diklasifikasikan pada model songsangan 2D di garis survei kawasan kajian terbahagi kepada tiga iaitu zon A, zon B, dan zon C. Zon A yang mempunyai nilai keberintangan kurang daripada 100 Ωm merupakan zon tepu air yang terdiri daripada tanah dan pasir hasil luluhawa batu kapur. Zon ini merupakan kawasan berpotensi untuk berlakunya lubang benam dan tanah mendap disebabkan ia terdiri daripada tanah lembut atau kurang tumpat. Zon A yang terletak di permukaan dikenalpasti sebagai zon potensi tanah mendap. Zon A yang membentuk kaviti dan mempunyai lapisan yang menindih di atasnya dikenalpasti sebagai zon potensi lubang benam. Terdapat beberapa kaviti zon berpotensi terbentuk lubang benam yang boleh dikenalpasti daripada model songsangan 2D kawasan kajian dengan anggaran saiz daripada 16 m^2 sehingga 546 m2. Zon B mempunyai nilai keberintangan dari 100 Ωm ke 1500 Ωm pada model songsangan 2D. Zon ini terdiri daripada pasir berbutir halus dan batu kapur terluluhawa. Zon C pula mempunyai nilai keberintangan melebihi 1500 Ωm. Zon ini terdiri daripada batu kapur segar yang merupakan batuan dasar kawasan kajian. Hasil daripada kajian ini membantu dalam mengenal dan menentukan kedudukan kawasan berpotensi membentuk lubang benam, geometri kaviti di dalam kawasan batu kapur, dan kawasan potensi berlaku tanah jerlus.

Sinkhole is a geological structure hazard that can cause fatalities and destruction. Sinkhole formation occur in areas with limestone bedrock due to erosion of the limestone. The studied area of Kampung Baru Kuala Dipang, Kampar, Perak is an area dominant with limestone bedrock. In 28th March 2005, sinkholes formed in the area due to the aftermath of the 8.7 magnitude earthquake in Kepulauan Nias, Sumatera. Formation of sinkholes may present risks of property destruction as well as fatalities. This study is conducted to determine the geometry of the cavities and the potential of sinkhole formation in the area using geoelectrical resistivity method. Seven geoelectrical resistivity survey lines were conducted each with 200 m length line using dipole-dipole array (Figure 1). The geoelectrical resistivity data obtained are processed using RES2DINV computer software to produce 2D inverse models (Figure 2 & 3). There are generally three zones that can be classified from the 2D inverse models which are zone A, zone B and zone C. Zone A is a water saturated zone consisting of soil and sand produced from the weathering of limestone with a resistivity value below 100 Ωm. This zone has the potential to occur either sinkholes or subsidence due to its soft or less dense soil composition. All Zone A situated at the surface is classified as subsidence potential zone whereas all Zone A forming cavities and are overlapped by topsoil is classified as sinkhole potential zone. There are several potential sinkhole zones that can be recognised from the 2D inverse models with estimated size of cavity ranging from 16 m2 to 546 m2. The resistivity value of zone B

ranges from 100 Ωm to 1500 Ωm comprising of fine sand and weathered limestone. Zone C is recognized as fresh rock or bedrock with resistivity value above 1500 Ωm. The results obtained from this study aids in recognising and determining potential sinkhole areas, the geometry of cavities in limestone areas and potential subsidence occurring areas.

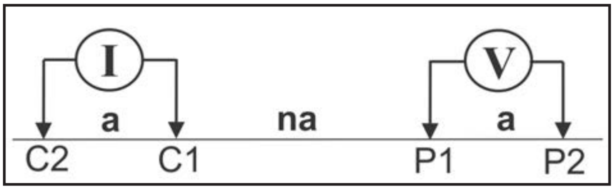

Figure 1: Figure showing dipole-dipole array. C1 and C2 are current electrodes while P1 and P2 are potential electrodes. Distance between a set of electrode, a, is constant. Distance between two sets of electrode is shifted using integer, n, which is multiplied by a.

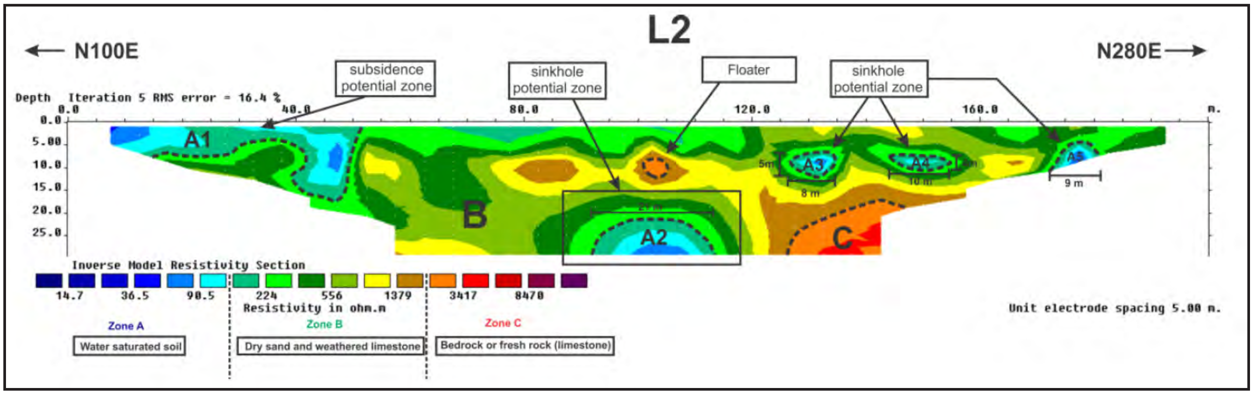

Figure 2: The interpretation model for the subsurface geoelectric resistivity survey line 2.

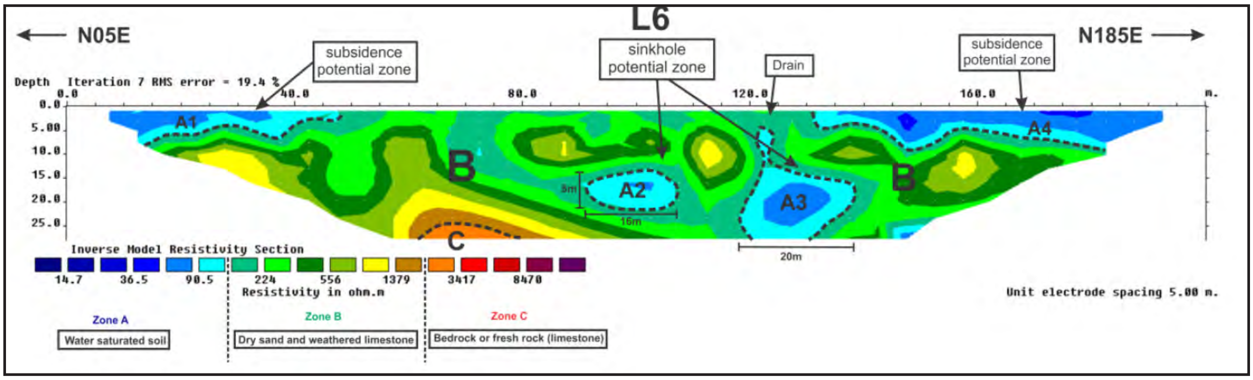

Figure 3: The interpretation model for the subsurface geoelectric resistivity survey line 6.

PCMR01(CMR08)-130

Radiogenic Heat Production of Granitic Rocks of Peninsular Malaysia: Potential for Hot Dry Rock Geothermal Resource

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Since the success of the extraction of geothermal energy from hot dry rock (HDR) at Los Alamos, US in the 1970s, and the commisioning of the first large scale commercial plant in Australia in 2013, the engineered geothermal system (EGS) has been recognized as having great potential to contribute to the global renewable energy resources. The EGS involves drilling to depth where temperature is high (>150°C) and water is circulated through artificial fractures and recovered for energy extraction by heat exchangers. One of the pre-requisite for an economic EGS is high heat flow. Direct heat flow measurement of Peninsular Malaysia is lacking but regional heat flow map indicates a high heat flow of up to 140 mW/m². High heat flow is also indicated by the common occurrence of hot springs. Analysis of radiogenic heat production (RHP) of various lithological groups by Vila at al. (2010) indicates that granitoids have high potential (Table 1 and Figure 1). Radiogenic heat is generated by the decay of ^{238}U, ^{235}U, ^{232}Th and ^{40}K isotopes. It can be calculated by: $RHP=10^{-5}\rho(9.52C_U + 2.56C_{Th} + 3.48C_K)$ (Rybach, 1988) where ρ is rock density in kg/m³, C_U, C_K and C_{Th} are concentrations of U and Th in ppm and K in %. In this study, published U, Th and K contents of rocks were compiled and RHP calculated. Most of the data are from granitoids (277), with some volcanics (20) and there is no data from sedimentary and metamorphic rocks. Statistics of RHP of Peninsular Malaysian granitoid shows that it is almost twice the global granitoid value. Granitoids of the Western Belt have highest RHP (median=5.64 μW/m³), followed by Central Belt (median=4.49 μW/m³), Cretaceous granitoids (median=4.09 μW/m³) and Eastern Belt (median=2.99 μW/m³). RHP map of Peninsular Malaysia (Figure 2) is compiled using the calculated values for granitoids, and median global values for other lithologies. It shows that the Bubu and Kledang plutons in Perak, Teris pluton in Pahang and plutons near Batu Pahat and Kluang, Johor have the highest RHP. The high background heat flow, large pluton volumes and high RHP indicates that these granitoids have potential as a HDR geothermal resource and deserve further studies.

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Table 1: Statistics of radiogenic heat production (μW/m³) of various lithological groups by Vila *et al*. (2010) and Peninsular Malaysian granitoid. No-number of sample, density in kg/m³, SD-standard deviation, Min-minimum, Max-maximum, 10P, 25P, 50P, 75P and 90P- 10th, 25th, 50th, 75th and 90th percentile respectively.

	No	Density	Mean	SD	Min	10P	25P	50P	75P	90P	Max
Earth material	2188	2750	1.59	1.75	<0.001	0.16	0.50	1.18	2.08	3.39	24.69
Igneous	1218	2750	1.76	2.07	<0.001	0.10	0.45	1.21	2.44	3.76	24.69
Igneous/plutonic	861	2750	2.08	2.27	<0.001	0.19	0.68	1.70	2.69	4.19	24.69
Igneous/plutonic/ultramafic	62	3300	0.23	0.23	<0.001	0.00	0.03	0.11	0.44	0.55	0.81
Igneous/plutonic/gabbroid–dioritoid–an-orthosite	153	2900	0.54	0.54	0.01	0.06	0.16	0.37	0.81	1.23	3.85
Igneous/plutonic/granitoid	583	2700	2.52	2.16	0.09	0.76	1.34	2.08	3.01	4.65	24.69
Igneous/volcanic	357	2650	0.97	1.13	0.01	0.07	0.20	0.57	1.21	2.57	6.55
Igneous/volcanic/basalt	166	2750	0.36	0.39	0.01	0.04	0.08	0.21	0.53	0.84	1.90
Igneous/volcanic/andesite	49	2650	0.78	0.36	0.07	0.29	0.47	0.82	1.09	1.21	1.42
Igneous/volcanic/rhyolite	56	2550	2.67	1.39	0.29	0.65	1.85	2.55	3.43	4.83	6.31
Sedimentary	464	2400	1.10	0.68	0.01	0.32	0.61	1.06	1.51	1.81	5.90
Sedimentary/detritic	395	2400	1.19	0.66	0.03	0.45	0.71	1.16	1.58	1.83	5.90
Sedimentary/detritic/mudrock	214	2400	1.39	0.70	0.17	0.57	0.97	1.44	1.66	1.86	5.90
Sedimentary/detritic/wacke	34	2400	0.98	0.54	0.13	0.32	0.55	0.99	1.21	1.81	2.18
Sedimentary/detritic/sandstone	128	2400	0.90	0.47	0.03	0.33	0.54	0.82	1.21	1.60	2.06
Sedimentary/carbonate	32	2400	0.48	0.36	0.06	0.09	0.22	0.42	0.62	0.92	1.75
Metamorphic	506	2800	1.63	1.51	0.02	0.22	0.52	1.29	2.27	3.21	12.65
Metamorphic/low grade–medium grade	327	2750	1.72	1.47	0.02	0.24	0.62	1.49	2.39	3.20	12.65
Metamorphic/low –medium grade/ metaigneous	111	2750	1.33	1.84	0.02	0.09	0.24	0.53	2.02	3.00	12.65
Metamorphic/low–medium grade/ metasedimentary	130	2750	1.99	1.01	0.11	0.69	1.21	1.84	2.77	3.13	5.10
Metamorphic/high grade	179	2900	1.49	1.58	0.02	0.09	0.46	1.03	1.97	3.37	10.64
Peninsular Malaysia granitoid	277	2600	4.28	2.13	0.08	1.92	2.61	4.06	5.65	7.03	12.98

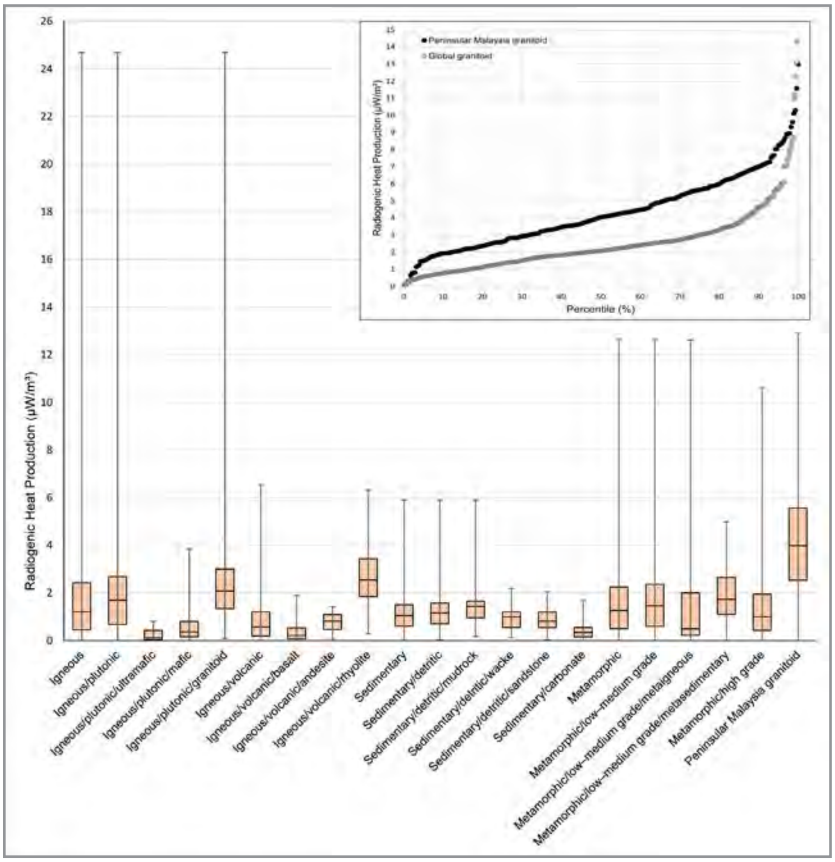

Figure 1: Whisker plot of radiogenic heat production of lithological groups (data from Vila *et al*., 2010) and Peninsular Malaysian granitioid. Inset: Cumulative frequency plot of radiogenic heat production of Peninsular Malaysian and global granitoid.

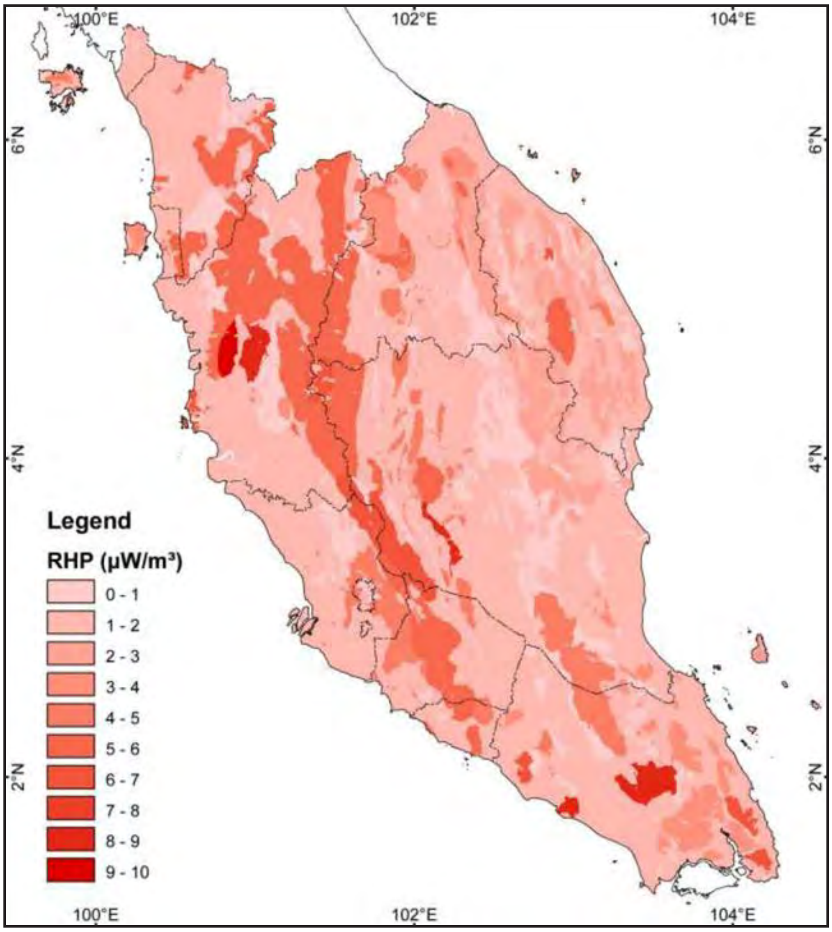

Figure 2: Radiogenic heat production (RHP) map of Peninsular Malaysia derived from geochemical data of granite plutons and median global RHP for various lithological groups from Vila *et al*. (2010).

NGC 2017 30TH NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

PDPT01-01

Prediction of Porosity and Permeability of Heterogeneous Shaly Gas Sand Reservoirs Using Neural Network Algorithm

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Analysis of shaly gas sand reservoirs is one of the most difficult problems. These reservoirs usually produce from multiple layers with different permeability and complex formation, which is often enhanced by natural fracturing. Therefore, using new well logging techniques like NMR or a combination of NMR and conventional openhole logs, as well as developing new interpretation methodologies are essential for improved reservoir characterization. Nuclear magnetic resonance (NMR) logs differ from conventional neutron, density, sonic and resistivity logs because the NMR measurements provide mainly lithology independent detailed porosity and offer a good evaluation of the hydrocarbon potential. NMR logs can also be used to determine formation permeability and capillary pressure.

The developed NN models use the NMR T2 pin values, and density and resistivity logs to predict porosity, and permeability for two test wells. The NN trained models displayed good correlation with core porosity and permeability values, and with the NMR derived porosity and permeability in the test wells. This work concentrates on determination of porosity (ϕ_{DMR}) from combination of density porosity and NMR porosity and permeability from NMR logs using Bulk Gas Magnetic Resonance Permeability (K_{BGMR}) and then using the neural network (NN) technique to predict formation porosity and permeability using NMR and conventional logging data. The NN technique has been developed and applied in several field cases and the predicted porosity and permeability values were validated from the proposed NN algorithm. Predicted porosity and permeability have shown a good correlation with core porosity and permeability in the studied shaly gas sand reservoir.

PDPT02-05

Potential of Solvents in the Study of Carbon Concentrations in the Bendang Riang Formation, Malaysia

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Western belt of Malaysia Peninsula comprises a lot of Paleozoic black shales that have the potential to be source rocks. This study focuses on twenty Paleozoic black shale samples of lower Silurian to lower Devonian from an isolated outcrop (location: 05°36'57"N, 101°01'48"E) belonging to the Bendang Riang Formation (Baling Group) [1]. This study site is located 10 km northeast of Grik, Northwest Peninsular Malaysia (Figure 1).

The preservation of organic matter in terms of quality and quantity in a black shale is the result of a complex interaction of sedimentological and oceanographic factors [2-7]. Information on the type and quantity of organic matter present in sedimentary rocks is essential, both for oil/gas exploration purposes and in-depth knowledge on geology [8, 9]. Therefore, the aim of this study was to carry out an evaluation by using Ultraviolet–visible (UV-Vis) spectroscopy to see the presence of organic matter quality and concentration in selected black shales of the Bendang Riang Formation. UV-Vis spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analytes, such as highly conjugated organic compounds. The UV-Vis analysis is this study specifically focuses on the E_4 (465 nm) and E_6 (665 nm). All samples are black in color, suggesting a high content of carbon. Different solvents were used to extract the organic fraction from the shales. In this study, methanol and dichloromethane (DCM) were used as an extracting agent. The results show that methanol has a higher potential to extract organics as compared to DCM (Figure 2). Despite this, it was observed that for each treatment, the quantity of E_4 and E_6 were very similar (Figure 3).

Figure 1: Study outcrop of the Bendang Riang Formation represented by a thick unit of grayish black shale.

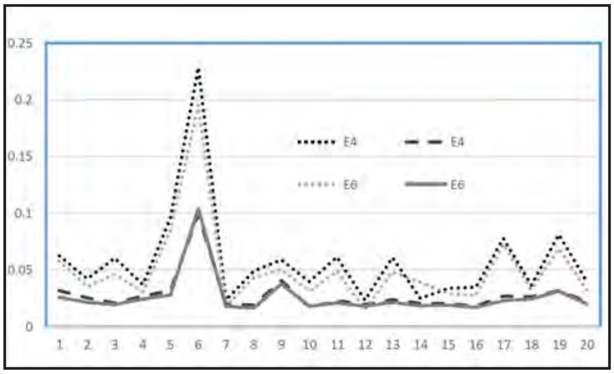

Figure 2: Comparison of DCM and Methanol for extraction of Organics.

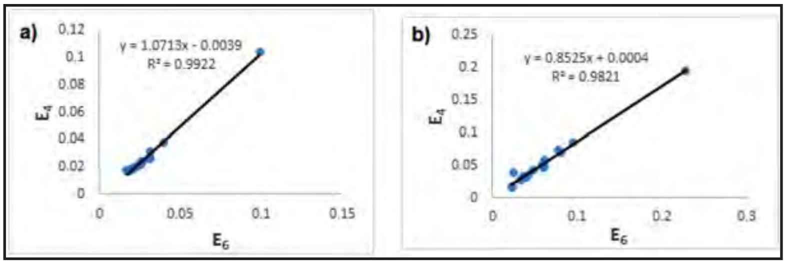

Figure 3: Relationship of E_4 and E_6 values a) Treated with DCM, b) Treated with Methanol..

PDPT03-06

ATR-FTIR Characterization of Shales from Kubang Pasu Formation, Malaysia

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Shale samples have been taken from two small hills in the Beseri area of Perlis: Bukit Chondong and Kampung Guar Jentik, Kedah, and accounted for organic geochemical properties during this study to provide an opportunity to explore the hydrocarbon distribution in these black shale. The basal unit of the Kubang Pasu Formation (Early Carboniferous) is represented by a thick unit of blackish grey shale interbedded with sandstone (Figure 1) [1, 2]. In this study shale samples were collected from the basal unit of Kubang Pasu formation. The Fourier transform infrared spectroscopy (FTIR) and Ultraviolet-Visible Spectroscopy (UV-Vis) were used in the assessment of liquid hydrocarbon present in rocks [3]. Recent advances in FTIR spectroscopy particularly in the development of ATR-FTIR has made it possible for such investigations to be carried out on both liquid and solid samples. The ATR-FTIR shows that shales from Kubang Pasu formation comprise saturated, unsaturated and aromatic hydrocarbon. The FTIR spectra of different shales exhibited similar absorption bands and characteristic absorption peaks (Figure 2). Analysis with the ATR-FTIR shows that the presence of aromatic in plane CH stretching (aromatic IPCH) hydrocarbon and aromatic out of plane CH stretching (aromatic OPCH) hydrocarbon groups (both occur in the finger print region) are found more in the Kubang Pasu Formation as compared to other functional groups. OH groups stretching vibration, alkyne C-H bending bands and alkane C-H bending band in aliphatic hydrocarbons and absorption spectrum of aromatic C=C stretching and aromatic OPCH are found in the FTIR spectra of Kubang Pasu black shales (Table 1)[4-8].

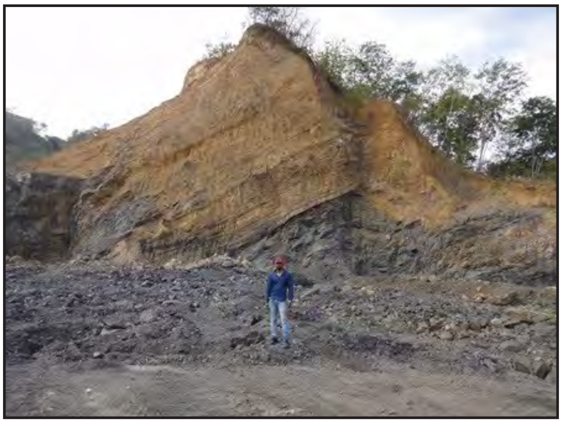

Figure 1: Study outcrop of the Kubang Pasu Formation represented by a thick unit of blackish grey shale interbedded with sandstone.

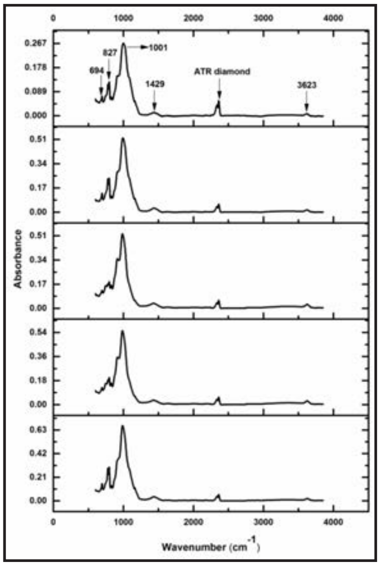

Figure 2: FTIR spectra of some shale samples of Kubang Pasu formation.

Acknowledgment

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Table 1: Functional groups identified through FTIR spectra in the Kubang Pasu Shale samples.

Sample	Aromatic C=C stretching 1430-1650 Absorbance	Alkane APH 720 C–H bending Absorbance	Aromatic bending 900–690 Out-of-plane C–H bending Absorbance	Aromatic bending 1250–1000 Out-of-plane C–H bending Absorbance	Alkyne APH 700–600 =C–H bending Absorbance	-OH Stretching 3600-3000 Absorbance
KPP-1	√	√	√	√		√
KPP-2	√		√	√		√
KPP-3			√	√	√	√
KPP-4			√	√	√	√
KPP-5			√	√	√	√
KPP-6			√	√	√	√
KPP-7			√	√	√	√
KPP-8	√	√	√	√	√	√
KPP-9	√	√	√	√	√	√
KPP-10	√	√	√	√	√	√

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PDPT04-07

E_4/E_6 Ratio Measured by UV-VIS Spectroscopy as an Indicator of Organic Matter Quality in Late Devonian Shales

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This study focus on the Devonian black shales of Sanai Formation (Late Devonian) located at Hill B in Kampung Guar Jentik, Beseri District, Perlis State of Peninsular Malaysia, just south of Timah Tasoh Dam, and roughly 10 km north of Kangar. The Sanai Formation seems to be limited in distribution, complete succession exposed on the northern side of the hill [1]. Sanai formation is composed of limestone, intercalated with dark grey to black shales. In geological literature, "black shale" is common name for a variety of fine-grained rock bodies that are rich in organic matter [2, 3]. Organic spectroscopic studies of ten Devonian black shales (Table 1) provided an insight on the hydrocarbon distribution and type of humic substances present in these black shales. Biodegradation of organic matter contributes to the formation of humic substances which are the major components of the natural organic matter in geological organic deposits such as brown coals and shales. The $E_{4/}E6$ ratio has been widely used to study the humic acid fraction and to characterize the quality of organic matter. UV-Vis results indicated that the samples comprise almost equal proportions of E4 and E6 and also the fact that humic acids were present in all the black shales. This suggests that possibly the origin of organic fraction in these shales were probably terrestrial components of Devonian in age (Figure 2). The FTIR spectra of the black shale samples from Sanai formation is divided into three zones, A) -OH groups stretching vibration, B) Alkyne Aliphatic =C–H bending in Aliphatic hydrocarbons and absorption spectrum of Aromatic C=C stretching, C) Aromatic In plane C-H bending (Aromatic IPCH) and Aromatic out-of-plane C-H bending (Aromatic OPCH) (Figure 2)[4-8].

Acknowledgment

The authors would like to acknowledge and appreciate the PETRONAS Research Fund (PRF) grant for providing financial facilities throughout the studies.

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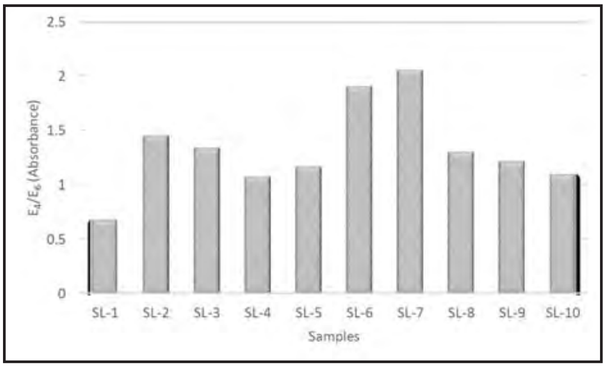

Figure 1: E_4/E_6 ratio in Black shale of Sanai Formation.

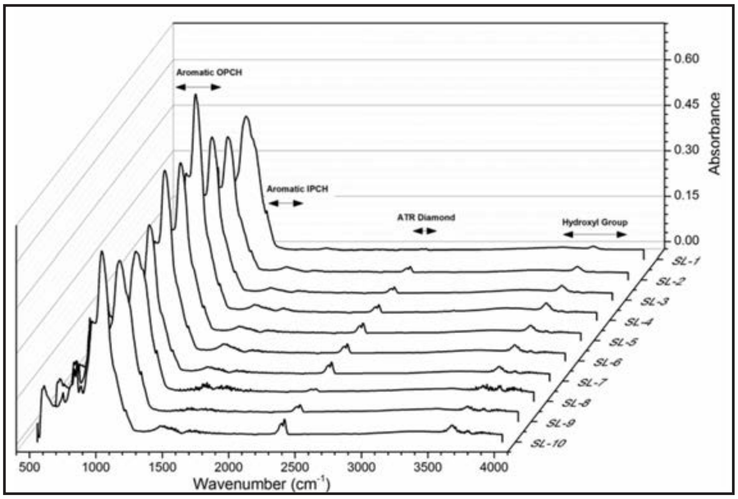

Figure 2: IR spectra of black shale from Sanai formation.

Table 1: Colour of the Sanai formation black shale samples according to the Munsell color chart

Age	Formation	Samples	Munsell Code	Color
Late Devonian	Sanai Formation	SL-1	N3	Dark Gray
		SL-2	N5	Medium Gray
		SL-3	N5	Medium Gray
		SL-4	N5	Medium Gray
		SL-5	N5	Medium Gray
		SL-6	N5	Medium Gray
		SL-7	N5	Medium Gray
		SL-8	N3	Dark Gray
		SL-9	N3	Dark Gray
		SL-10	N5	Medium Gray

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PDPT05-09

Reservoir Characterization by AVO Analysis: A Case Study in X-Block Doba Basin, Chad

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Amplitude variations with offset (AVO) is a valuable tool for extracting fluid and lithological information from seismic data, thus aiding in reservoir prediction. AVO analysis may be facilitated by the cross plot of AVO intercept (A) and gradient (B). Under reasonable geologic circumstances, A and B for brine saturated sandstone and shales follow a well-defined "background" trend. Deviations from this "background" trend may indicate the presence of hydrocarbons. Although an exploration well confirmed the presence of a 48m net pay oil, uncertainties lies within the hydrocarbon accumulation of X-Block. This study aims to delineate the lateral distribution of hydrocarbon accumulation in X-Block using AVO analysis. Integration of existing well logs, seismic and all other related data will be used to discriminate the oil reservoir from seismic section. The end results show the target reservoir in X-Block displays a strong Class II AVO anomaly at the area of interest. AVO attribute horizon data slices of scaled Poisson's Ratio change and scaled S-wave reflectivity successfully delineated the lateral extent of hydrocarbon accumulation in X-Block. Further full spectrum in- depth studies on quantitative interpretation such as pre-stack seismic inversion may be done to increase the validity of performed analysis and the level of confidence for hydrocarbon exploration in X-Block.

PDPT06-58

Surface Reservoir Analogue and Sedimentology Study of Fluvial Channel Deposits of Talang Akar Formation, Air Batu Village, South Sumatera Province, Indonesia

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Air Batu village occupies the South Sumatera basin as a back arc basin conducted to the tertiary volcanic arc. Air Batu village lies on Palembang sub-basin. Physiographically, Air Batu village located between Sunda Shelf in the eastern part and Barisan Mountain Arc in the western part boundary who consequences as provenance to South Sumatera Basin. Oligocene localized uplift fluvio-deltaic and basin sag stage marine transgressive sedimentary rocks identified in South Sumatera Basin include calcareous sandstone, quartz sandstone inserted by claystone, shale and thin layer of coal. Air Batu village stratigraphically consists of Talang Akar Formation and Gumai Formation, Air Benakat Formation and Kasai Formation. Imperative point of our study focused on Talang Akar Formation whih exposed widely in Air Batu village. Sedimentology study plays a significant role to understand the depositional environment of Talang Akar sandstone. Measuring section in Air Batu village was carried out analysis used as supplementary data for transport mechanism. Thin section analysis also employed to know the relation between mineral composition and diagenetic process related to reservoir quality. This paper provides detailed facies and variety composition of Talang Akar Formation and it's implication on reservoir quality of sandstone. Detailed measuring section shows that transportation mechanism of sandstone is laminary current in fluvial system sometimes found marine transgressive deposites including Delta. Several samples have been identified for each provenance from Air Batu village. Changing grain size composition and increasing silicification and calcification affected the diagenetic process. Generally, Air Batu village porosity ranges with classification poor-good porosity.

PDPT07-32

Evaluation of Selected Reservoir Petrophysical and Production Performance Indicators of Reservoir Analogues in the Baram Delta

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The main objective of this paper is to evaluate production performance indicators of reservoir analogues in the Baram Delta. The Baram Delta is the most productive hydrocarbon province in the Sarawak Basin. These reservoir rocks are known to be the onshore equivalents of the productive offshore reservoir sandstones in the delta. Reservoir properties measured include porosity, permeability, wettability and capillary pressure. Porosity and permeability were measured using helium porosimetry while capillary pressure was determined using the centrifuge method. Contact angle data was obtained using the drop-shape method and analyzed for wettability data. The relationship between capillary pressure, porosity, permeability and irreducible water saturation has been analyzed and presented in this paper. Porosity and permeability of the studied samples range between 15.9%-27.4% and 7.81mD-695mD respectively. The sample with the lowest porosity of 15.9% has the highest irreducible water saturation of 42.2% at 129Psi whiles the sample with the highest porosity of 27.4% has the lowest irreducible water saturation of 15.3% at 129Psi. The results show a significant influence of pore throat sizes on irreducible water saturation. Samples with bigger pores have lower irreducible water saturation compared to samples with smaller pores. Wettability of the samples range between 14.29º-17.61º indicating water wet reservoirs.

PDPT08-35

Petrophysical Analysis on Radioactive Sands for Koala Field in Termit Basin, Niger

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The neighbouring region of Termit Basin is the Niger Delta which is located on the southern section of Nigeria. Several investigations carried out in Niger Delta from 1971 to 2012 found that there is wide geological spread of radioactive sands [1]. 35-45% of the producing wells are believed to contain the anomaly. The mentioned literature, highlights the importance of identifying radioactive sand layers as it affects the volume estimation of a reservoir.

Radioactive sands are often misinterpreted as shales in petrophysical analysis specifically under the gamma ray (GR) log. Presence of clays and minerals can cause high radioactivity causing the GR log to detect shales instead of sands. This can cause potential pay zones to be overlooked unless an integration of other logs, core samples and laboratory data is used.

Based on the statement, two main objectives can be identified: 1) To identify the presence of radioactive sands and 2) To evaluate the source of radioactivity.

The best way in determining radioactive sands is by analysing thin sections but in the scenario where only well logs are available, a four-step approach can be used. Steps conducted using conventional logs are: (i) Comparison of GR log with calliper log along with density and neutron density logs. (ii) Analysing assumed layers through density – neutron (NPHI Vs RHOB) cross plots. (iii) Interpretation of radioactive source using spectral gamma ray (Uranium, Thorium and Potassium) and (iv) Identifying contributing minerals using Potassium vs Thorium cross plots (spectral gamma ray components).

The summarized phases begin with the observation of GR log and calliper log. If GR log indicates the presence of shale while calliper detects mudcake, it might indicate sandstone layer. This is because mudcake only sticks to porous and permeable layers such as sandstones, not shales. To further confirm, the crossing of NPHI log and RHOB log which is low in reading shows characteristics of sandstones while shales is vice versa as shown in **Figure 1**.

Next, density neutron cross plot is applied for the assumed radioactive sand layers. If the plots of any layers fall on the sandstone line or beneath it, there might be additional minerals present. The minerals might be the radioactive source contributors as it does not fall on the sandstone line as shown in **Figure 2** where the density and porosity value a little higher. The first two steps are to identify radioactive sands which is important as it could increase the reservoir thickness.

The subsequent steps are for the identification of radioactive source. Three common naturally occurring radioactive elements in rocks are uranium, potassium and thorium. Analysis of spectral gamma ray which consist of three spectrums whereby each individual spectrum indicates different source of radioactivity. Increase in Thorium reading indicates the presence of clay minerals and heavy minerals as shown in **Figure 3**. For example: Kaolinite, illite, smectite and chlorite for clays and monazite and/or zircon (found near granitic highlands, in unconformities or erosional surfaces) for heavy minerals. On the other hand, increase in the Potassium reading indicates minerals such as illite and sylvite and its sandstone which is high in mica minerals and K-feldspar. Uranium increment is associated with phosphates and organic compounds (shales, plants, shell fragments, euxinic environments) [2]. In addition, sometimes increase in the Uranium reading in the sandstone layer is due to the water saturated in it which was washed out from the shale layer beneath the sandstone lithology.

The final step is using Potassium Vs Thorium cross plot to identify the type of minerals found in the radioactive layers. The cross plot includes nine minerals which are kaolinite, montmorillonite, chlorite, mixed layers, illite, and muscovite which are clay minerals and the other three which are glauconite, biotite and orthoclase. **Figure 4** shows the presence of 3 minerals which are kaolinite, montmorillonite and chlorite. Mineral identification will help in choosing suitable composition for drilling mud as different clay minerals would affect the porosity and permeability of the reservoirs. Hence, the statement given does explain the importance of identifying the type of radioactive minerals.

In this paper, 8 wells from Koala Field in Termit Basin, Niger was used as an example to show the characteristics of radioactive sands using conventional logs. Identification of the radioactive sands and each different contributing source is explained as well as their importance. In conclusion, revaluation of fields for radioactive sands can increase the volume estimation as well as production rate of a field.

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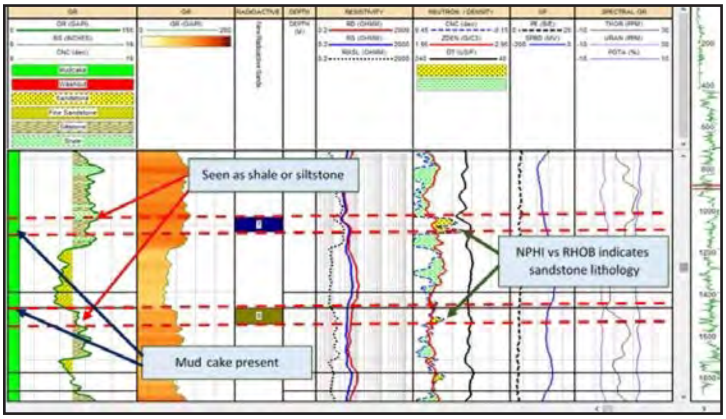

Figure 1: Radioactive sands interpretation based on present of mud cake with comparison of gamma ray results and NPHI - RHOB crossing in Koala CE-1.

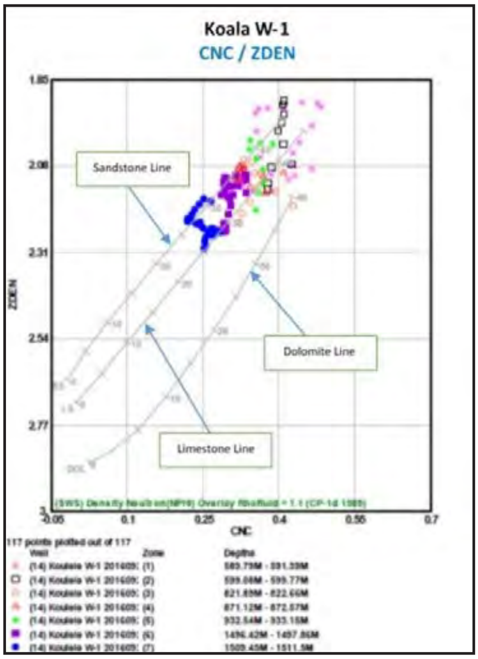

Figure 2: NPHI Vs RHOB cross plot indicating the interpreted radioactive sands as having characteristics of sandstone as there are points of interpreted zones that falls onto the sandstone line.

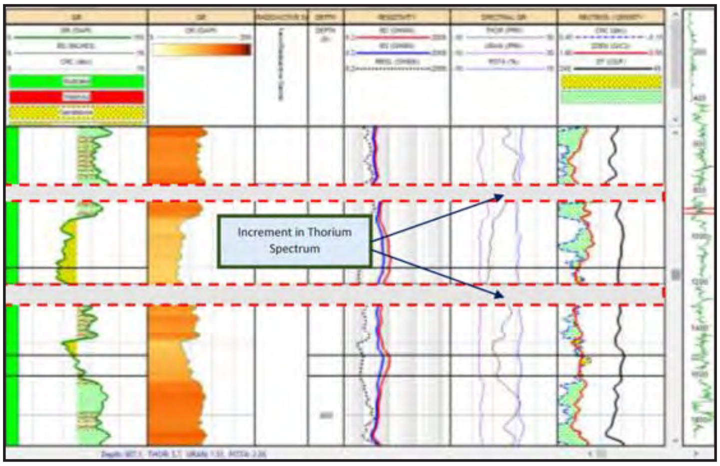

Figure 3: Spectral Gamma Ray - Thorium spectrum increase in interpreted radioactive sands layer 7 and 8 in Koala CE-1 well.

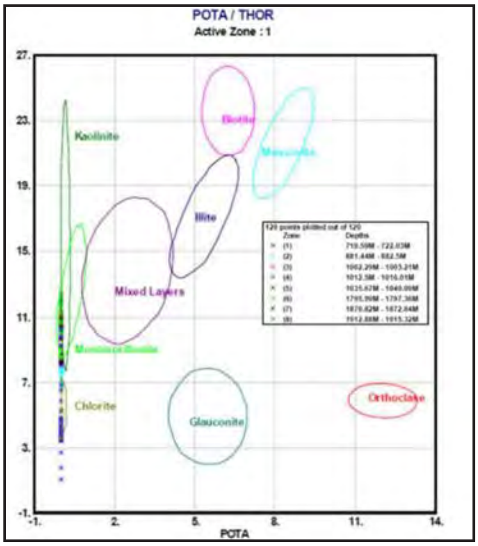

Figure 4: Potassium vs Thorium cross plot of radioactive sand zones in Koala N-1 well indicating the presence of potential clay minerals of chlorite, montmorillonite and kaolinite.

PDPT09-36

Reservoir Characteristics of Carbonates Build-ups in Southern Central Luconia Province: A Study Based on Different Scales

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This paper discusses the comparison of reservoir distribution and characteristics of different carbonate build-ups/morphologies in Central Luconia Province, focusing on two carbonate platforms in the southern part of the province. Both geological (core) and geophysical (seismic and well logs) were used throughout the study to provide different scales and resolution of the study area. The evaluation of reservoir qualities for each of the carbonate build-ups in this area focuses on Cycles III and IV carbonates. The findings showed that both fields have different reservoir distribution in terms of porosity and lithology distribution. Pinnacle build-ups has fair to good porosity with decreasing occurrence of dolomite while the flat-top platform has poor to fair porosity due to higher mud content compared to the pinnacle-type. Cleaner carbonates can be found in the pinnacle platform with lower gamma ray log. Different lithologies can also be observed in these two fields- the pinnacle platform has lithology ranging from packstone to rudstone while the flat-top platform has lithology of packstone to grainstone with a higher mud content. From the result obtained, it can be concluded that the reservoir quality of the pinnacle build-up is better than the flat-top platform, specifically accurate for the southern part of this province.

PDPT10-46

Shale Gas Reserve Potential in the Sedimentary Basins of Malaysia and South East Asia Region

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Shale gas, which is mostly methane, can be found in any sedimentary basins. The depositional setting directly controls key factors in shale gas, such as organic geochemistry, organic richness, and rock composition. Shale gas reservoir type is a source rock that has retained gas production potential. Produced gas comes from adsorbed gas in the organic matter and free gas trapped in the pores of the organic matter and in the organic portions of the matrix.

The main objective of this study is to discuss the potential of shale gas reserves in Malaysia and South East Asia sedimentary basins. Shale can actually be a game changer in South East Asia and mainly for Malaysia, China, India, Pakistan, Indonesia and Thailand. Malaysia, located within Southeast Asia, has two distinct parts. The western half contains the Peninsular Malaysia, and the eastern half includes the states of Sarawak and Sabah. This area has been identified as a potential area for unconventional gas resources in Malaysia. China has seven major onshore shale basins contain shale gas. India, various estimates put Indian reserves of shale oil and gas at large numbers. Major regions of availability are Gujarat, Rajasthan, central India, KG Basin and offshore areas in Bay of Bengal. Pakistan shale gas's assessment is restricted to the central and southern Indus basins, together called the Lower Indus. Indonesia has a number of onshore sedimentary basins which may have shale gas/oil potential. Thailand's greatest potential appears to be shale gas deposits contained in Permian and Triassic shale source rocks in the Khorat. In summary, it can be stated that the potential for shale gas as a source of energy in Southeast Asia appears to be good. However, more work needs to be carried out to ascertain the exact capacity of shale gas in each mentioned countries.

PDPT11-50

Exploration Potential for Stratigraphy Trap in Abu Field, Malay Basin

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Malay basin province has high potential of being a good lacustrine shale source and reservoir rocks. It is Oligocene - Miocene basin situated between eastern part of Peninsular Malaysia and Vietnam, in the southern part of Gulf of Thailand. Area of study located at Block PM 318, Abu Field which are 290 km north – east from the Kemaman supply base Terengganu's offshore. Several exploration wells been drilled; however were suspended for development plan due to the oil reserve calculation was under economic criteria. Abu prospect has a low structural relief so the closure is small. Therefore, the purposes is to re-evaluate the hydrocarbon potential in Abu field focusing on Early to Middle Miocene succession stratigraphic feature.

Interpretation and recognition of stratigraphic feature using 3-D seismic data requires good understanding on structural geology, geophysics and stratigraphy. Identification of prospect undergo several methods such as seismic interpretation, well log correlation, attribute analysis and spectral decomposition. Based on analysis, a huge channel deposition can be observed in Group I-50 and Group H. Structural modelling also aids the interpreter insight into the seismic image and reduce uncertainty of the field.

PDPT12-82

Estimation of Epsilon Parameter of Fracture Induced Anisotropy by In-Situ Seismic Refraction Survey

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Fractures have the ability to delay the arrival times of seismic wave. The rate of the delay depends on the direction of wave propagation with respect to fractures orientation; smallest delay parallel with the fractures and largest delay normal to the fractures. This can result in misinterpretation of true velocity of a rock mass and produce incorrect subsurface image. Thomsen's anisotropy parameters summarized this velocity variation to improve the accuracy of subsurface imaging. A seismic refraction survey was performed at a limestone quarry in Chemor, Perak, with existing outcrop showing an almost vertical fractures. The study was conducted to determine Thomsen's epsilon parameters that explain the anisotropic rate which is caused by the main fractures within the limestone. Three seismic lines were laid out on a flat surface below the outcrop; one survey line with 70 m length was laid out parallel with the strike direction; two lines were in the dipping direction where one of them crosses the fracture with 114 m length and the other one, a 70 m survey line, does not cross the fracture. Seismic refraction data were interpreted using General Reciprocal Method (GRM), Delay Time, and ABC Method. Analysis of the velocities of non-weathered layer uses the equation derived by Thomsen and indicates the epsilon parameter for the line that crosses the fracture and the one that does not cross the fracture are 0.57 and 0.08 respectively. Rock samples were collected from the study area and 1.0 x 2.5 Inches cores were prepared. Sonic measurement were performed using solid cores and later the cores were cut into two to create an artificial fracture in each cores. The epsilon value obtained from sonic measurements were much greater than the epsilon value obtain from the field because laboratory measurements are not influenced by the in-situ bulk properties of the rock mass. However, the laboratory measurement also shows the existence of anisotropy induced by the artificial fracture.

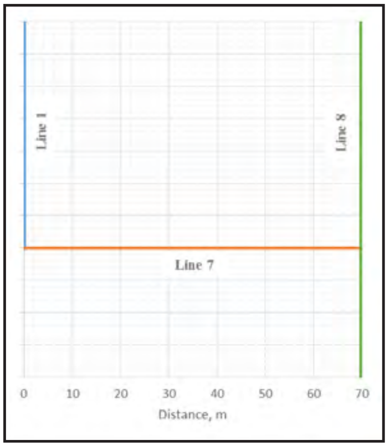

Figure 1: Orientation of in-situ seismic refraction: Line 7 is parallel with strike direction of 20° and is located directly above the fracture. Line 1 and Line 8 are perpendicular to the strike direction. Line 8 is extended across the fracture.

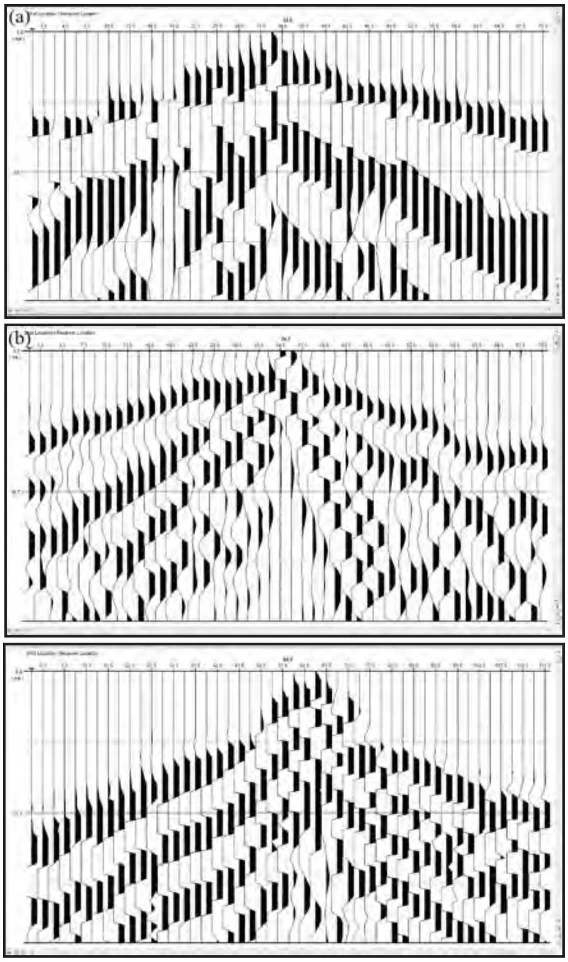

Figure 2: Recorded seismic signal of (a) Line 7, (b) Line 1 and (c) Line 8. Time arrival of the first breaks of Line 7 and Line 1 are almost similar but time arrival of the first break in Line 8 are longer. Since Line 8 is the only line that crossing the main fracture, this indicate that there is anisotropy induced by the fracture.

PDPT13-93

The Search for Stratigraphic Traps: A Case Study in X field, Malay Basin

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In petroleum industry, decision makers tend to shy away from drilling the high risk stratigraphic traps. But, as more straight forward conventional traps were drilled out, it is necessary to outline a series of pragmatic approaches to explore the potential stratigraphic traps in Malay Basin. X field, with structure is a NW-SE low-relief compressional anticline is found to have abundant channelized systems at Early Miocene Group I. The early production of X Field is predominantly from anticlinal closure at the northern part. Less exploration work has been executed on the flattish, low-relief southern area (Figure 1). However, the later production indicates it partly comes from I-35 channelized sands. Thus, it is deemed worthy to evaluate the prospectivity of these low-relief channel systems in greater details, despite the challenges face in detection and quantification. Integrated approach comprising of seismic attributes, seismic facies and wireline log analysis are employed to visualize the potential channel traps and the outcomes are indeed convincing. Variance coupled with sweetness horizon slices had successfully delineated the edges and sweetness of the channel stratigraphically. At interval I-35L, the channel complexes tend to be massive with extensive sand bodies compared to straight, low sinuosity meandering channel system in I-68 (Figure 2 & 3). Strong reflection amplitude anomalies (bright) and fining upward log signature also acts to support the presence of channelized sand packages in Group I. Plus, the decreasing dominance of sand packages from north to south had proven the origin of sediments from north. These clastic sediments could be trapped in the diverted river system and formed potential stratigraphic traps in X field. Nevertheless, the successful implication of these integrated approaches in accessing the stratigraphic traps would be beneficial for nearby fields in Malay Basin and henceforth open up a new play to boost the dwindling oil reserve.

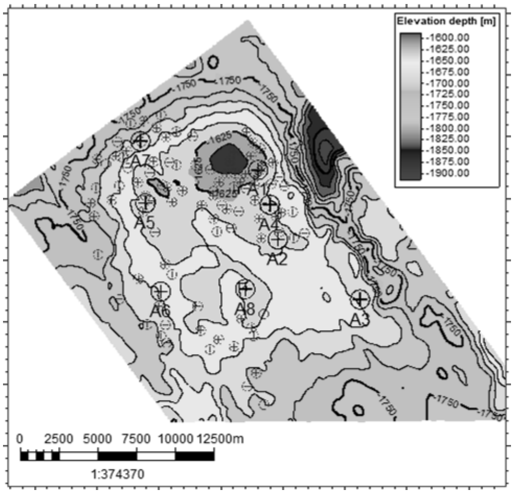

Figure 1: Top depth map of I-35L showing the early production was coming mostly from anticline at northern part rather than low-relief southern area.

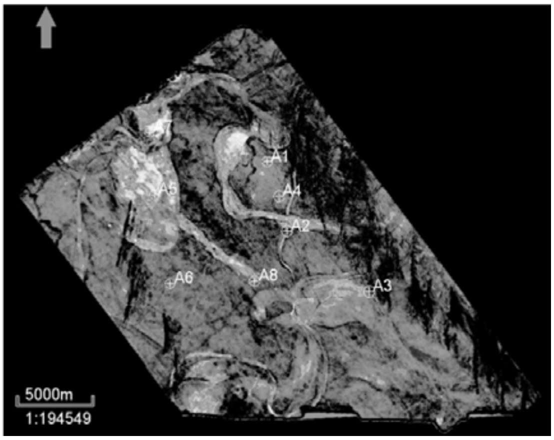

Figure 2: Application of multi-attributes (variance & sweetness) in horizon slice of 1-35L featuring massive and high sinuosity channel complexes. White color indicates strong amplitude and sweetness response with possible channel sand bodies.

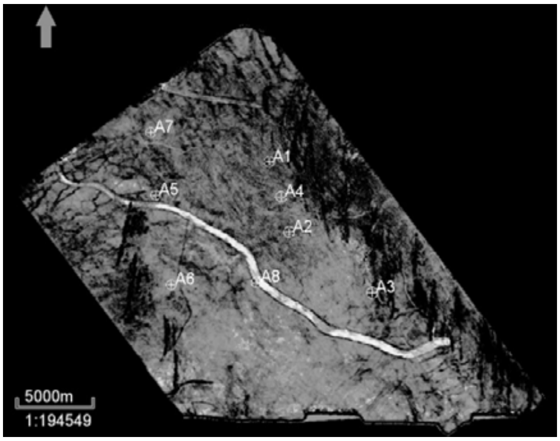

Figure 3: Application of multi-attributes (variance & sweetness) in horizon slices of I-68 featuring a contrasting straight, low sinuosity, smaller scale meandering channel system. White color indicates the potential "sweet spot".

PDPT14-102

Integrated Reservoir Characterisation with Three Dimensional Modeling in Thin Bed Low Resistivity Natural Gas Exploration

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An attempt in hydrocarbon exploration is carried out on subsurface target at a depth of approximately 3km. This subsurface structure was drilled and declared a successful natural gas discovery with significant flow and volume but four consequent wildcat wells were drilled but ended up as dry wells (no hydrocarbon discovery). This issue is further clouded by the presence of existing low resistivity pay in first success well (absence of expected high resistivity log value from hydrocarbon zone). Band pass limited seismic data could not resolve the top and bottom of formation with thickness with an average value of 20m causes thin bed effect which hindered effective seismic interpretation. The failure of wildcat wells was hypothetically believed mainly from structural complexity, the formation was deformed extensionally and inversed throughout geological ages and different local and regional faults were formed and compartmentalised the formation. Dry wells interpreted from high water saturation values might originated from highly conductive mineral affected resistivity logging tools. Less understood petroleum system with different charge and migration pathways might be another factor for less successful hydrocarbon exploration. In order to validate hypothesis, an integrated reservoir characterisation based on seismic data, petrophysical data, geological research information, rock physics calibration, and machine learning technique were researched to obtain final three dimensional model. This model is able to visualise the subsurface formation deformities, compartmentalisation, lithological distribution, porosity distribution, and other crucial reservoir information. Many important technical process were carefully applied to obtain accurate subsurface geological model, some of the significant process were neural network facies classification, machine learning well correlation, and automated fault interpretation. With the final geological model produced from integrated reservoir characterisation, the reasons of unsuccessful exploration were well understood and alternate promising target is proposed.

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PDPT15-106

Innovated PETREL Workflow for Multi-Attribute Analysis: Case Study in Malay Basin

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Petrel by Schlumberger is a commercial software designed especially for geological interpretation and modelling. Ant track workflow is part of the software application that can be applied as it is or combination with other designated workflows. Using the default ant-tracking workflow as a reference, a conceptual multi-attribute workflow is innovated to ease the process of multi attribute analysis. The conceptual workflow consists of data (frequency) filtering, attribute application and lastly attribute map generation phases. Artificial neural network (ANN) was utilized to perform the multi seismic attribute analysis. ANN is an artificial information processing model inspired from biological nervous system, and are commonly used in geoscience for facies or structural studies. From the conceptual workflow, attribute maps such as coherence-ant track attributed map, sweetness-azimuth and many more were generated. NE-SW and ESE-WNW fracture trends were identified via rose diagram plots as analyzed from the coherence-ant track map. This result is similar with fracture pattern from Anding Field in Malay basin, which indicate that the faulting was caused by regional-scaled tectonics. The conceptual workflow has no execution error as it could generate the required multi attribute maps for analysis purposes. This 3-phases conceptual workflow could be applied on other three-dimensional seismic data with potential to be coded as a PETREL plugin that benefit the community of petroleum exploration planners.

PDPT16-107

Study of Central Luconia Miocene Carbonate Buildup: Integration of Geological, Modern Carbonates and 3D Seismic Characterization

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Facies modelling of the Central Luconia carbonate build-up is a complex process due to the multi-scale heterogeneity of carbonate reservoirs in terms of facies, stratigraphy and pore structure. The objective of this research is to integrate core, modern carbonate platform and 3D seismic which will then be used for building conceptual model, then establishing carbonate buildups facies modelling workflow. The first part of the workflow builds conceptual geological model via the integration of core and modern analogue data.

The case study, TX Field is approximately 3km x 5km Miocene carbonate platform located 170km north of Bintulu, offshore Sarawak. The reservoir section is from Cycle IV to V, i.e. Middle to Upper Miocene age. The platform top is at a depth of 2800m with vertical relief of ~600m. Situated close to East of TX field is the West Baram Line that separates the field from the Baram Delta. TX Field has a flat top, overlain by a shale sequence that is most probably deposited from the nearby Baram delta. Five reservoir zones of total thickness ~323m are identified. Zone 3 and upper Zone 5 are tighter zones compared to Zone 1, 2 and 4.

The geological study begins by describing the core facies unit, then correlation to the well logs. Three lithofacies have been characterized from core TX-2 (Table 1), namely (F1) Coated grain packstone, (F2) Coral massive grainstone, and (F4) Skeletal lime packstone; interpreted as back reef, shallow lagoon and deep lagoon environments. F1 is characterized as having poor reservoir quality at about 0.1% to 8.0% porosity whereas F2 and F4 has higher reservoir quality with minimum 0.1% to 25% especially for F2.

The subsequent study of modern analogue is to laterally distribute the facies. The modern carbonate analogue selected is the Church Reef carbonate island, Semporna, Sabah, Malaysia. The analogue is suitable due to similarities in size and lithological components. Church Reef is approximately 1.8km x 2.5km and TX Field is about 3km x 5km. Both buildups compose of mainly coral and foraminifera, with windward direction from the North-east. Besides, the climate in Miocene and Holocene times are similar (Zampetti, 2010). Figure 2 shows the possible depositional facies of Church Reef, with relation to the core facies.

Table 1: The texture, component, log observation and possible depositional environment based on the core facies. Zone 2 and 4 are the porous reservoir zone with Zone 3 acting as a baffle in between.

Zone	Thickness (m)	Core facies present	Porosity range (%)	Texture	Major component	Log observation	Depositional environment (at core)
1	12 0	F1, F2	0.1 – 25.0	Packstone - grainstone	Algae, coral	GR low DEN moderate	Shallow lagoon to back reef
2	43	F2, F4	7.0 – 22.0	Packstone - grainstone	Corals (branching & platy), debris	GR high DEN very low	Shallow lagoon
3	37	F1, F2, F4	0.1 – 25.0	Packstone - grainstone	Algae	GR low DEN high	Deep to shallow lagoon
4	51	F2, F4	7.0 – 25.0	Packstone - grainstone	Corals and debris	GR high DEN low	Shallow lagoon
5	72	F1, F2, F4	0.1 – 25.0	Packstone - grainstone	Skeletal debris, algae	GR low DEN moderate	Shallow lagoon to deep lagoon

The second part of the research characterizes 3D seismic with the assistance of core and modern analogue data. Seismic interpretation distinguishes six reservoir surfaces: Top of carbonate (TOC), TZ2, TZ3, TZ4, TZ5, and TZ6. Reservoir zones from core to well correlation is used for tying the well to 3D seismic, ensuring distinct correlation. Zone 2 and 4 seismic configuration shows semi-continuity and sub-parallel. Zone 3 is very continuous and parallel. Zone 1 shows progradational pattern with local mound. Generally TX field in-builds and up-builds, with no signs of stringers that represents out-building. A sketch of the interpreted seismic is as shown in Figure 3.

Seismic attributes are applied to 3D seismic, to distinguish platform geometries and seismic stratigraphy analysis. Variance is one of the attribute useful for improving the clarity and lateral resolution of reefal structures. It also highlights seismic discontinuities caused by karst or patch reef features, and more significantly faults and fractures (Chopra et al., 2007). For example, in the analysis of Church Reef analogue, lagoonal facies are known to have patch reefs (orange). When TX Field time slice is applied with variance attributes, it shows patterns that are possibly patch reefs, while the edges shows the reef crest and back reef region. Attributes also assist in estimating the dimensions of depositional facies.

In conclusion, conceptual modelling is a crucial step which requires an extensive amount of time iterating and refining, prior to digital facies modelling. Data integration ensures better understanding of the subsurface carbonate platform and to create a geologically meaningful facies model. 3D modelling workflow is aimed at building multiple plausible realizations for each individual reservoir layers. With a wide range of alternatives, it will enable the best decisions by the reservoir engineers for robust business outcomes.

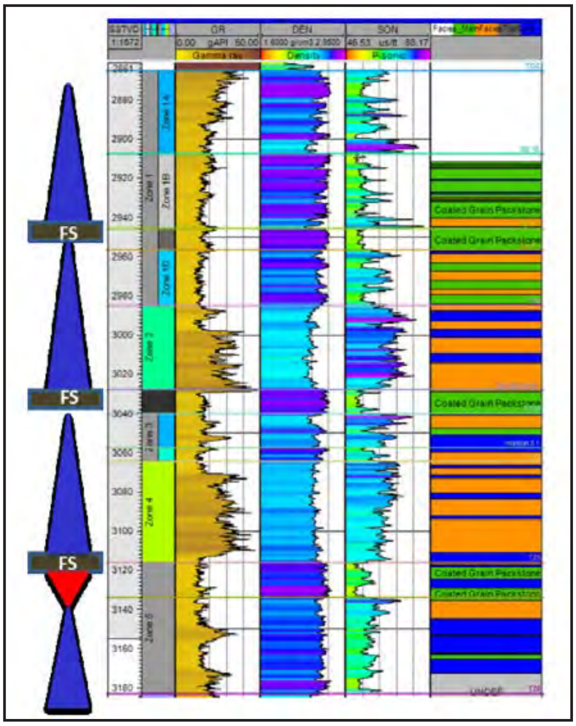

Figure 1: The TX-2 well log (left) shows the gamma ray, density and sonic, correlated with the three core facies as adapted from Janjuhah (2017). The lithofacies are F1, F2 and F4 labelled in green, orange and blue respectively.

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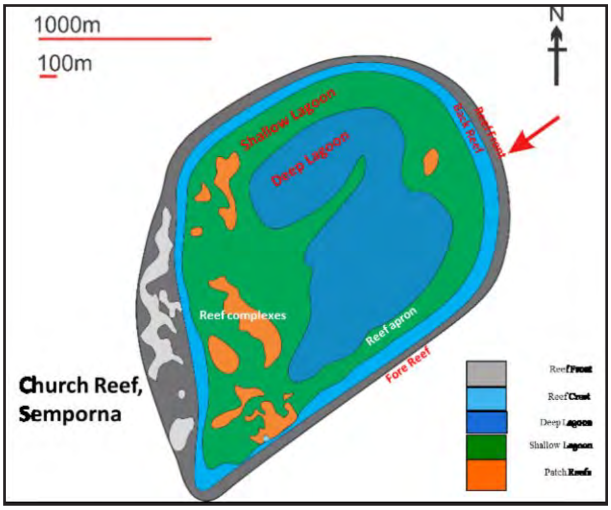

Figure 2: Sketches of the Church Reef shows the possible depositional environment, which are colored according to the core facies. The dimensions of each depositional environment are also measured to assist in later stage of digital geomodeling.

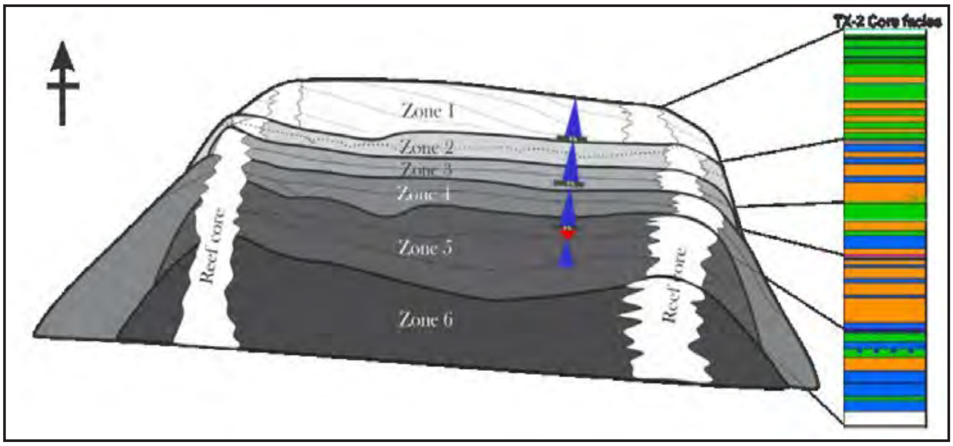

Figure 3: The sketch is drawn based on TX field cross-sectional seismic. Zone 2 and 4 seismic configuration shows semi-continuity and sub-parallel. Zone 3 is very continuous and parallel. Zone 1 shows progradational pattern with local mound. Generally TX field in-builds and up-builds, with no signs of stringers that represents out-buildiing.

PDPT17-119

Geochemistry and Bulk Kinetic Analyses of Coal-Bearing Deposit of Bongaya Formations, Northern Sabah, Malaysia

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The occurrence of coal, carbonaceous material, lignite and shaly deposit from Cenozoic sedimentary succession are widely distributed in the Bengkoka Peninsula. These organic-rich rocks, once buried at sufficient depth, could potentially charge hydrocarbon, implicitly across the Northern Sabah basin. In this study, outcrop samples from Middle Miocene – Pliocene, Bongaya Formation were collected and subsequently analysed to investigate the hydrocarbon potential and prospectivity in this area. Overall, the analysed samples show poor to excellent organic richness based on TOC content ranging from 0.41 wt. % to 70.30 wt. %. The Hydrogen Index (HI) and remaining hydrocarbon potential (S2) of coals and carbargillites from Bongaya Formation have values in the range of 73 to 303 mgHC/gTOC and 4.34 to 213.2 mgHC/gRock respectively, indicating a potential to generate gas and oil as expulsion products. The carbonaceous sandstones and shales possess mainly type III and IV kerogen as indicated by generally lower HI values in the range of 23 to 179 mgHC/gTOC, thus indicate gas prone source rock. This is supported petrographically based on common occurrence of woody plants materials and oxidized inertinite kerogen observed under reflected light microscope. Mudstone samples possess poor to fair organic richness based on TOC content ranging from 0.41 wt. % to 0.88 wt. %. with HI values from 37 to 69 mgHC/gTOC, and dominated by type III/IV kerogen. The pyrolysis Tmax and vitrinite reflectance values ranging from 371 to 439°C and 0.23 to 0.40 %Ro suggest that Bongaya Formation sediments are still within the immature to early mature oil-generation window. Bulk kinetic analysis of this immature sample predicted petroleum formation temperature of onset (TR 10%) temperature ranges from 88 to 125°C. The peak generation are ranging from 104 – 146°C, reaching approximately 40% transformation ratio.

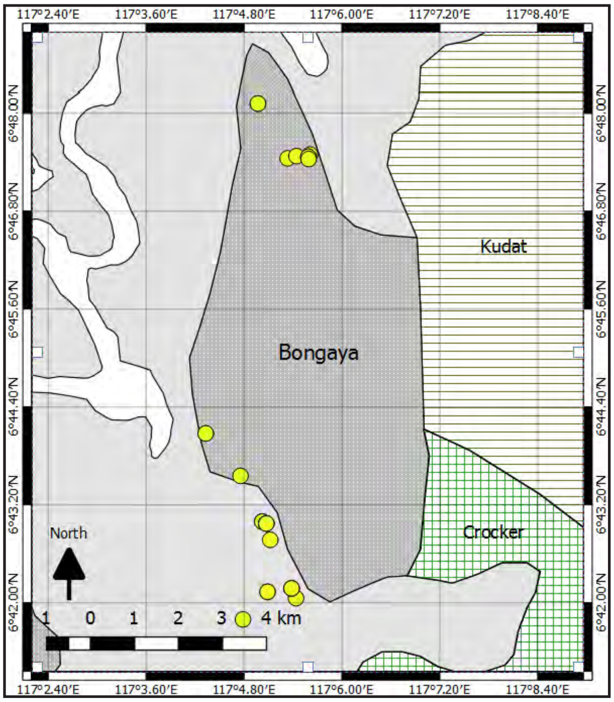

Figure 1: Base map of study area showing the outcrop localities across Bongaya Formation.

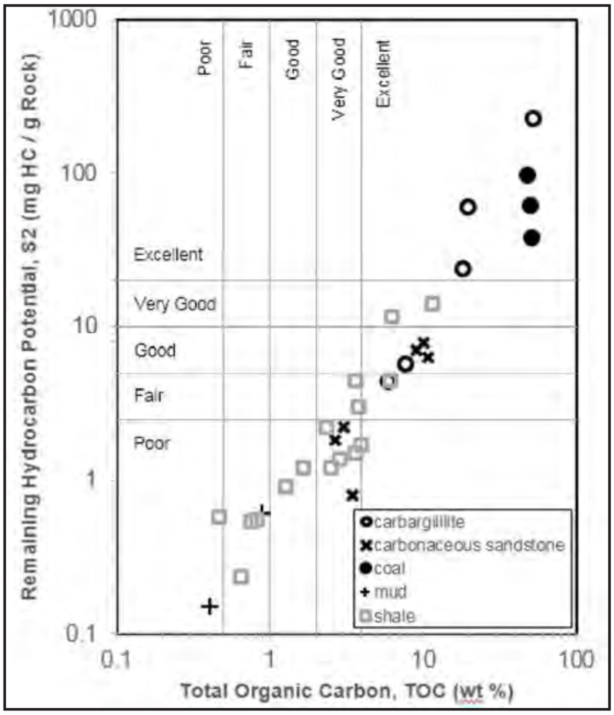

Figure 2: Plot of S2 vs TOC, Bongaya Formation.

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PDPT18-133

Application of Spectral Decomposition and Attenuation for Stratigraphy Exploration Potential in 'B' Field, Malay Basin

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The spectral decomposition technique has developed as a descriptive technique for reservoir characteristics based on frequency spectral decomposition (Li and Zhao,2014). Spectral decomposition transforms the broadband 3D seismic data into a single frequency band. Spectral components tuned to a given thickness often exhibit a high signal-to-noise ratio and thus provide the highest lateral resolution, giving clear images of channels and other stratigraphic features that otherwise might be buried in broadband data (Li et all.,2015). Seismic wave is attenuated as it propagates through subsurface formations. structure, layer thickness, lithology, and pore fluid properties. When the seismic wave travels back to the surface, it also brings back the information related to stratigraphic features, rock property changes and hydrocarbon accumulations (Tai et al.,2009). Castagna et al. (2009) showed that gas reservoirs could be identified by low-frequency shadows.

PDPT19-136

Source Rock Pyrolysis and Thermal Maturity of Early-Late Miocene Syn-Rift Deposits in Southeastern Sabah, Malaysia

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The onshore SE Sabah Basin that is extended from northern part of hydrocarbon prolific Tarakan Basin in Kalimantan are of interest in this study. This basin was filled by thick Miocene sediments, deposited in deltaic-shallow marine environment and comprised of Kalabakan, Tanjong and Kapilit formation sedimentary sequences. A total of thirty-one outcrop samples derived from these sequences were collected and subjected to Rock-Eval pyrolysis and vitrinite reflectance analysis to evaluate hydrocarbon generating potential and determine thermal maturity stage of the source rock. The collected rock samples were mainly fine-grained siliciclastic rocks and coals. Rock-eval pyrolysis indicates TOC content vary with lithology. Kapilit and Tanjong formations are dominated by coal, thus possessing very high TOC content (60.69-81.97 wt.% and 66.08-92.96 wt.%, respectively). The Kalabakan Formation which was dominated by black shales however have lower TOC content ranging between 0.50 wt.% to 1.82 wt.%. This indicates Kapilit and Tanjong formations samples have excellent source rock potential whilst Kalabakan formation have fair to good source rock potential. Pyrolysis S2 data indicates similar trend of TOC contents as shown in figure 1. The Hydrogen Index (HI) of Kapilit and Tanjong samples are in the range between 424 to 768 mgHC/gRock and 157 to 367 mgHC/gRock respectively, thus indicate the kerogens are dominated by Type II/III and capable to generate oil and gas (Fig. 2). Kalabakan samples however have lower HI values ranging from 14 to 110 mgHC/gRock, thus indicate Type III/IV kerogen and is capable to generate gas (Fig. 2). The analysed samples are varied in maturity stage as indicated by vitrinite reflectance (VR) measurements and Tmax. The analysed Kapilit Formation samples are thermally immature to early mature as indicated by VR values ranging from 0.43% R_o to 0.70% R_o. Tanjong Formation samples are interpreted to be mature to peak oil generation (0.60% R_o to 1.08% R_o) whilst Kalabakan Formation samples are post-mature and have entered gas window (1.06% R_o to 1.55% R_o). Vitrinite reflectance measurements are in good agreement with Tmax data (Fig. 3).

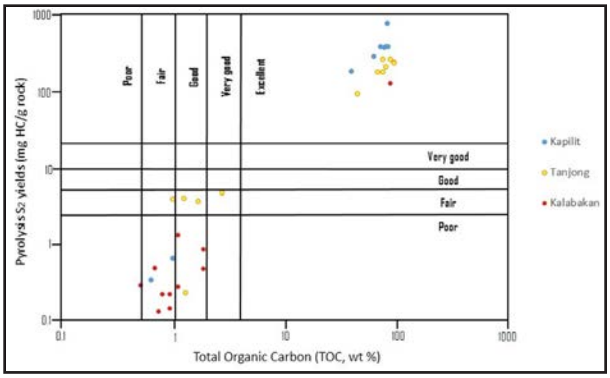

Figure 1. Cross-plot of pyrolysis S_2 yields versus Total Organic carbon (TOC) shows variation of source rock quality in the analysed samples.

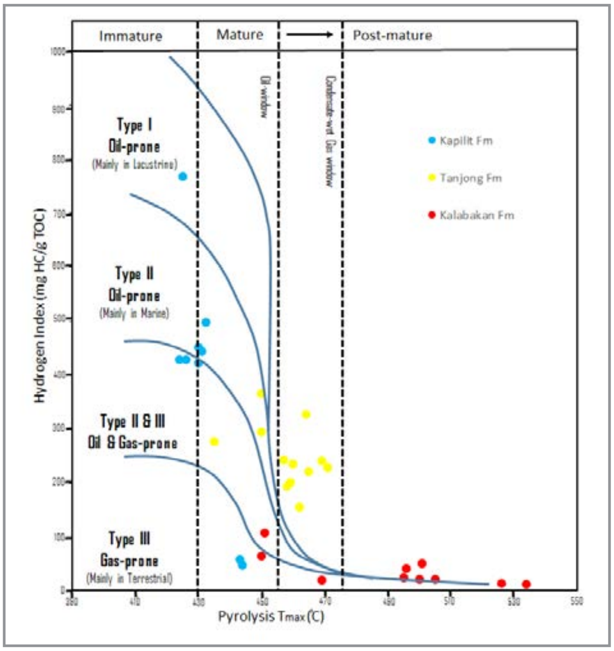

Figure 2. Kerogen type discrimination diagram of Hydrogen Index (HI) versus Pyrolysis Tmax.

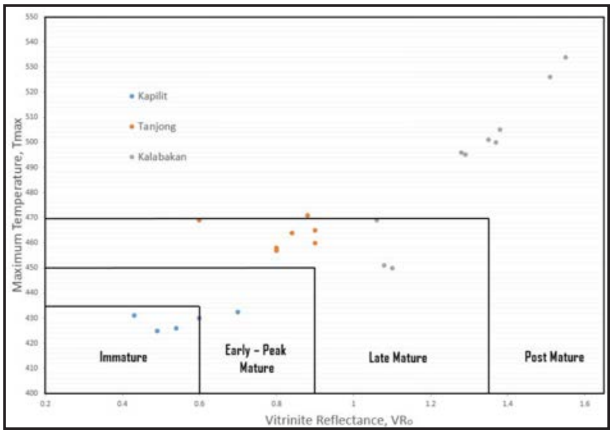

Figure 3. Cross-plot of Maximum Temperature (Tmax) versus Vitrinite Reflectance (VR_o) shows variation of thermal maturity in the analysed samples.

PDPT20-147

Pore-Pressure and Thermal Analysis for Understanding of Overpressure Mechanisms in West Baram Delta

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An accurate understanding of overpressure zone is crucial for oil and gas exploitation, especially in deep reservoirs to improve the safety and preventing the drilling hazard. Dominant factors that are affecting the generation of overpressure are mainly due to tectonics and sedimentation rate. However investigation of thermal parameters such as temperature and thermal conductivity can enhance overpressure mechanism determination for subsequent pore pressure estimation. Since those parameters are dependent on rock properties, it may reflect the changes on the pore pressure mechanisms in the sedimentary basins. This study encompassed an integration of rock physics and pore pressure trends analysis carried out within the shale and sand intervals in West Baram Delta.

Analysis of pore pressure, electric log and thermal trends with depth of several selected wells in the Baram Delta has provide insight into understanding of overpressure mechanisms prevailing in the delta. The uniqueness of relationship for pore pressure with lithostatic pressure trends in both compaction and expansion mechanisms are identified for each well. The increasing of pore pressure in reservoir due to high sedimentation rate is attributing to the disequilibrium compaction mechanisms. Meanwhile, abnormal pore pressure which is due to the fluid expansion mechanisms are related to high subsurface heat flow intervals.

Overpressure regime of West Baram Delta can be divided into two major domains that are within shelf (distal-delta) and inner shelf (medial to proximal-delta). The overpressure mechanisms are thus categorised by different tectonic and stratigraphic settings. Apparently pressure over temperature gradient distribution gradually increase towards Northwest direction in the inner shelf area dominated by the fluid expansion mechanism. Meanwhile, in the outer shelf dominated by the disequilibrium compaction mechanism, having low pressure over temperature gradients.

While using seismic velocity is a common method for overpressure prediction, however, the contribution of thermal parameters in understanding the mechanisms of overpressure would complement in pore pressure prediction. Thus, integrated of thermophysical and facies analysis technique shall compliment the velocity analysis, to provide an important parameters in investigating the overpressure mechanism. In addition, the possible inclusion of thermal effects may account for the generation of overpressure, especially the fluid expansion mechanism within deep overpressure zones. This will lead to enhancement in pore pressure estimation during oil and gas exploitation in the future.

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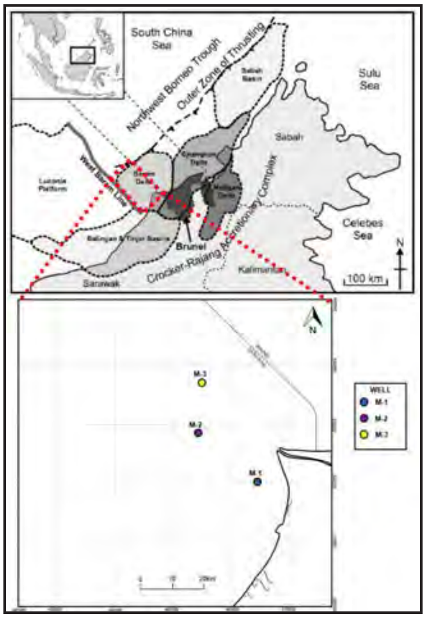

Figure 1: Map of study area. Modified from (Peter, Derek & Robert, 2015).

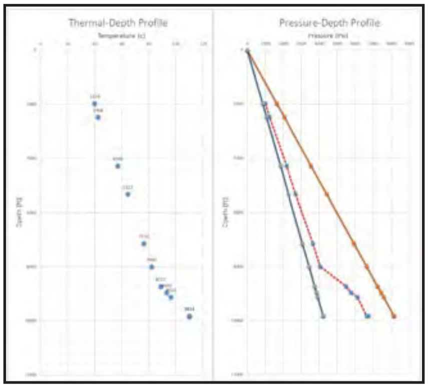

Figure 2: Thermal-Depth and Pressure-Depth profile of the well in West Baram Delta.

PDPT21-157

Cylindrical and Overlapping Technique for Better Karst Delineation

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The paper presents solutions designed to characterize the karst network for a Central Luconia carbonate gas field which has experienced unpredicted high water production and early water breakthrough. The assumption was derived that one of the main reason for unpredicted water breakthrough is strong aquifer (based on material balance analysis) and high internal carbonate reservoir heterogeneity. A decision was made to implement more comprehensive reservoir characterization practices to design reservoir models and, prevent and mitigate current and future field problems related to geologically complex carbonate field architecture. The practice includes three major components: Forward Stratigraphic Modelling (FSM), karsts network mapping, and uncertainty management. The workflow and work processes of karst mapping is discussed in this paper.

The delineation of the karsts features were carried out with several methodologies which complimented each other. Application of various seismic attributes were carried out to capture the possible locations of both the vertical karst features and lateral karst network. Observation on a flattened seismic cube was also another key method is delineating these prominent seismic anomalies for the carbonate field. The next method that was also capable in characterizing these karst features was the *Cylindrical and Overlapping Technique* which allowed the vertical karst features to be captured in the carbonate microplatform very well. After having a good estimation of where the karst features are located, karst geobody extraction was done; in order to have a 3D volume of karst geobody features.

Overall, the karst features have created a very complex diagenetic overprint on the reservoir rocks which have affected the permeability and porosity properties. With the methodology applied, the karsts network was better understood and the presence of karsts can now be predicted in other areas of the reservoir. The issues of mud-loss and early water breakthrough could also be addressed; thus, allowing better history matching scenarios and also improving the creditability of the static and dynamic model. Hence, the presence of karsts can be clearly correlated to the issues of mud-loss and early water breakthrough.

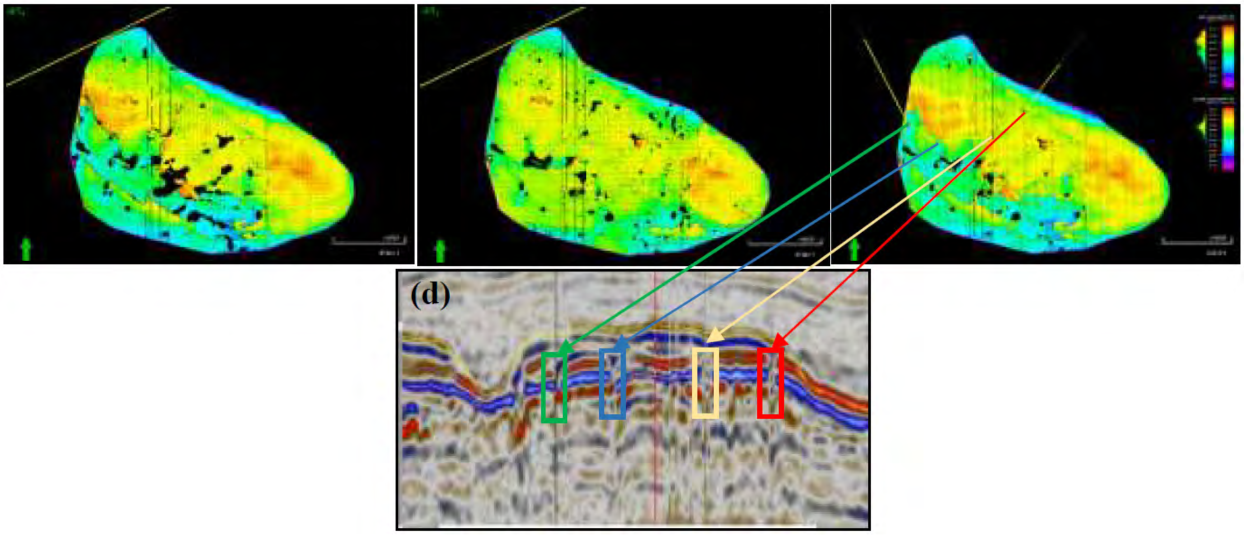

Figure: The Cylindrical & Overlapping technique employed in delineating the numerous vertical features in one of the field's carbonate microplatform.

PDPT22-173

Application of Spectral Decomposition and Seismic Attributes to Delineate the Internal Morphology of Carbonate Buildup

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Spectral Decomposition (SD) and High Definition SD technique of post stack 3D data has become a popular tool for reservoir studies. The SD technique can enhance the imaging of the internal morphology of carbonate buildup and greatly improved the reservoir delineation. The basic concept of spectral decomposition is assuming the reflection from a thin bed will give the characteristic expression in the frequency domain. It is indication of the temporal bed thickness. SD and the High Definition SD showed better visualization on carbonate buildup boundary, internal fractures and other features. This study carried out on 3D seismic data of carbonate field in offshore Malaysia to identify the most efficient technique for carbonate reservoir description and the results are presented.

PDPT23-37

The Comparison Between Central Luconia Province, Malaysia and Nam Con Sơn Basin, Vietnam: Emphasis on Tectonic Framework

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This paper will be presenting the comparison and similarities of the geological tectonic framework from the two carbonate reservoir basins in the South China Sea; Central Luconia Province at the northwest offshore Borneo and Nam Con Son Basin at the southern offshore Vietnam, which are considered to be the most seismically active and tectonically complex regions on earth. Despite the extensive exploration of oil and gas, especially in Nam Con Son basin since the late 1980s, the information concerning the geological and tectonic evolution are very lack. Some of the researches based on the tectonic framework in these respective basins have been studied for a long time ago but the information was only limited to the study area with a little consideration to surrounding geological settings. Thus, this research will conclude the relationship between the study areas in emphasising on the tectonic framework with respect to another geological event such as the formation of Cuu Long basin and South China Sea opening theories. The relevance of this research which comprises of tectonic study can be seen by judging on how beneficial it is, not only in the geology field such as the relationship of carbonate depositions but also for the oil and gas exploration for both reservoir basins.

PDPT24-28

Comparative Study of the Effect of SiO_2 And TiO_2 Nanoparticles as for Agents on Petrophysical Properties of Reservoir Rocks

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The quality of the reservoir rock is determined by its petrophysical properties which includes porosity, permeability and wettability. The use of various methods to improve these properties has been employed in the petroleum industry in order to enhance oil recovery. However, the effect of nanoparticles on petrophysical properties and EOR is still not fully understood. Although nanoparticles have been used to improve the oil recovery rate for enhanced oil recovery, the use is still relatively new, therefore a study on how a reservoir's petrophysical properties are affected by these nanoparticles is crucial to understanding the applications of nanotechnology in the petroleum industry. This study aims at evaluating and comparing the impact of TiO^2 and SiO^2 on the petrophysical properties of sandstones using onshore analogues of producing reservoirs of the Sarawak Basin as a case study. These samples have been used because previous studies have established them to be the onshore equivalent of the productive offshore sandstone units in the basin. The samples are mainly fine-medium grained sandstones with moderate to well sorted grains. Mineralogy of the samples was studied using thin sections, XRD and SEM, porosity and permeability were measured using helium porosimetry. Contact angle measurement was carried out using the drop-shape method and interpreted in terms of wettability. Initial porosity and permeability of the samples saturated with only brine solution range between 14.3%-24.3% and 218.6mD – 1588.3mD respectively while the initial contact angle ranges between 59.66º -70.34º indicating neutrally wet reservoirs. The measured porosity after nanofluid saturation remained within the same range stated above whereas the permeability decreased to a range of 209.1mD to 1322.1mD, due to the nanoparticles obstructing the pore throats. The contact angle measured after SiO2 and TiO^2 nanofluids saturation ranges from 48.9° – 60.35° and 48.03° – 56.7° respectively, indicating a wettability alteration from neutrally wet to more water wet with TiO^2 yielding better results. However, both nanoparticles show significant alteration in wettability of the samples that can yield higher recovery therefore confirming nanoparticles as an effective EOR technique.

PDRG01-22

Foraminifera Planktonik Formasi Temburong, Pulau Labuan

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Penyelidikan foraminifera terhadap enapan turbidit, Formasi Temburong yang berusia Miosen Awal yang tersingkap secara tidak berterusan di Pulau Labuan. Objektif utama penyelidikan adalah menentukan usia setiap singkapan sedimen turbidit menggunakan fosil foraminifera planktonik, selain sekitaran pengendapan bagi formasi tersebut semasa proses pengendapan berdasarkan kehadiran foraminifera bentik. Hasil penyelidikan menjadi gambaran baru biostratigrafi tempatan dan juga memberikan kaitannya dengan formasi yang sama di Sabah dari segi biostratigrafi iaitu korelasi berdasarkan kehadiran fosil dan usia. Sebanyak 35 sampel batu lumpur dan syal diambil daripada empat lokaliti berbeza di sekitar pulau dan dianalisis di makmal menggunakan Sodium Bikarbonat (Armstrong dan Brasier, 2005) dan Hidrogen Peroksida, sebagai ubahsuai kaedah pengekstrakkan fosil yang lebih bersih dan jelas, dan telah berjaya menemukan beberapa foraminifera planktonik dan bentik. Foraminifera planktonik antaranya Catapsydrax Dissimilis (N5), Globigerinoides Primordius (N4), Globigerina Praebulloides, Grobigerina Oscula, Globigerinoides Altipertura, Globigerina venezuelana, Globoquadrina tripartita, Globiquadrina Gortaanii dan Globorotalia obesa. Foraminifera Bentik pula antaranya Nodosaria longiscata, pyramidulina stainforhi, siphonodosaria annulifera, uvigerina carapitana, Nodosaria Anomala dan himpunan agglutinated bentik melebihi 60% daripada hasil penemuan.

PDRG02-23

Physical Characteristics and Distribution of Bottom Sediments from Kelantan River Delta towards South China Sea Continental Shelf, Malaysia

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The preponderance of sedimentological study in Kelantan River Delta onwards South China Sea shelf leads to the extensive work on the sediments distribution and characteristics. The sediments of the area vary from very poorly sorted to very well sorted containing a mixture of sand, silt and clay and can be divided in essence into three groups. Textural analyses of 65 surficial sediments showed that group 1 (silty) accounted for 65% to 85% of silt size, group 2 (silty sand) is dominated by sand ranging from 64% to 88% with the silt size varies between 12% to 23% and group 3 (sandy) is made up of 78% to 100% sand and 0% to 22% silt. Mineralogical analyses showed that the samples are dominated by polycrystalline sutured and straight boundaries quartz as well as monocrystalline quartz. Small amounts of feldspar, mica and lithic fragments are present with abundance amounts of organic materials. A semi-quantitative analysis of quartz grains surface texture and morphology was used to interpret the history of grains from which six types of grains have been recognized; (a) irregular shape with various angle; (b) irregular surfaces with fractured plate and long fragments shape; (c) well rounded, with V marks, oriented etches pits on surface and protruding edges; (d) irregular breakage with rough texture on planar surface, adhering particles with uneven grooves and V marks dimension of <2µm; (e) irregular shape with rounded protruding edges, rough surface with oriented etches pits and V marks with dimension <2µm and adhering particles with trail of abrasion; and (f) very rough surface with irregular shape and protruding edges, lots of cracks and detachment of small particles and etching holes, V marks > 2µm dimension. In term of distribution it can be divided into two sedimentological provinces according to the interrelationship between grain size, mineralogy, textural and morphology of sediment. Province A which covers the shallower part of water in the study area accumulated a large amount of silt and clay that could be originated from the nearby land areas brought down by the Kelantan River and deposited as recent sediments. While Province B which covers most of the outer part of the shelf area contained recent and relict materials with lesser amounts of inland sediments input. The relict sediments consist of oceanic sub-arkosic sand that were deposited circa 5000 yr. BP during the last sea-level low stand.

PDRG03-25

General Geology of Northeastern Central Gunung Semanggol, Bukit Merah: Emphasis on Tectono-Stratigraphic Development of Permian-Triassic to Recent

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Tectono-stratigraphy involves the study of rock sequences with the effects of tectonics on lithostratigrahy. The application of tectono-stratigraphy is to understand the relationships between sediment supply and generation of depositional accommodation space. In addition, sea level changes and uplifts, prograding system and late tectonic event deformation also important. While some works have been carried out in Gunung Semanggol, but there is no much about tectono-stratigraphic development of the area, thus this study would provide a new insight on the tectonic evolution and lithostratigraphy of Gunung Semanggol from Permian-Triassic to Recent by studying a new area in northeastern central Gunung Semanggol, Bukit Merah, Perak. The project combines with unpublished previous recent nearby studies observations from Farahin (2014), Rashid (2015), Aqram (2015) and Dezeree (2015).

Gunung Semanggol is part of Semanggol Formation which situated at northwestern region Western Belt in Peninsular Malaysia. The formation was termed after Gunung Semanggol (Alexandra, 1959). Burton (1973) classified this formation in Gunung Semanggol into two lithological members, namely Rhythmite Member and Conglomerate Member, whereas Foo (1990) divided into rudaceous-arenaceous facies and argillo-arenaceous facies. Semanggol Formation had undergone a deformation phase, forming the N-S trending open to asymmetrical folds and prominent ridges (Mustaffa, 1994). Besides, the formation also shows repeated and tight folding (Burton, 1973).

The Semanggol Formation is less described in Gunung Semanggol, Perak because of limited outcrops and geological data compared to those in Kedah. Therefore, this data gap would allow new findings in the field and proved the occurrence of previously hypothesized granitic intrusion (Mansor & Sokiman, NGC 2015). The depositional environment of the sedimentary units of Semanggol Formation, Bukit Merah is interpreted as marine continental shelf based on the stratigraphic log, and further no real chert is observed. Furthermore, new lithologies such as contact breccia and quartzite were identified in the area. Thus, demonstrated the inferred igneous tectonic proposed by previous studies. Also, structural elements analysis of bedding and fractures of the study area proved the presence of igneous tectonic in Gunung Semanggol. A tectono-stratigraphic development model is proposed to illustrate Bukit Merah Permo-Triassic sedimentary structuration which was influenced by end-Triassic igneous tectonic. It has significant impact on the geological events took place in Gunung Semanggol and would serve as reference for future works.

PDRG04-29

Stratigrafi di Barat Daya, Sabah

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Kawasan kajian yang terletak di Barat Daya Sabah terdiri daripada empat formasi. Formasi tertua ialah Formasi Crocker (Awal Eosen hingga Lewat Miosen) yang terdiri daripada dua unit litologi iaitu unit lapisan batu pasir tebal berselang lapis dengan syal dan unit batu pasir nipis berselang lapis dengan syal. Formasi kedua merupakan Formasi Temburong (Awal Oligosen hingga Lewat Miosen) yang mempunyai dua unit litologi iaitu lapisan batu pasir nipis berselang lapis dengan syal dan unit lapisan syal tebal. Formasi ketiga ialah Formasi Meligan (Pertengahan Miosen hingga Pliosen) yang terdiri daripada tiga unit litologi iaitu unit batu pasir nipis berselang lapis dengan batu lumpur, unit batu pasir berselang lapis dengan batu lumpur nipis dan unit batu pasir tebal. Seterusnya, Formasi termuda dikenali sebagai Formasi Liang (Pliosen) yang mempunyai dua unit litologi iaitu unit konglomerat yang disokong oleh butiran bersaiz granul ke tongkol dan unit batu pasir berkelikir yang disokong oleh matriks. Formasi Crocker dan Formasi Temburong yang merupakan endapan laut dalam mempunyai hubungan berjejari antara satu sama lain. Formasi Temburong ditindih oleh Formasi Meligan yang merupakan endapan laut cetek dengan ketakselarasan bersudut. Formasi Meligan juga ditindih oleh Formasi Liang yang merupakan endapan fluvial dengan ketakselarasan bersudut.

Kata Kunci: Barat Daya Sabah, Formasi Crocker, Formasi Temburong, Formasi Meligan, Formasi Liang, Eosen, Miosen, Oligosen, Pliosen, ketakselarasan

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PDRG05-38

Lithology and Depositional History of the Chert Unit of Semanggol Formation, Bukit Kukus, Kuala Ketil, Kedah

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The Semanggol Formation has been identified in three areas, North Kedah, South Kedah and North Perak. The age range of the formation are from Permian to Triassic. Three renowned members are the Chert Unit, Rhythmic Unit and Conglomerate Unit. The Chert unit was initially dubbed as the oldest among the three but later was found to be of relatively the same age with the other units as they are interfingering facies. The Bukit Kukus area, in Kuala Ketil, South Kedah is reported to expose the complete sequence of the Chert Unit of Semanggol Formation. Detail lithological description with depositional history for each facies of the Chert Unit are additional information required for Semanggol Formation. A study was therefore conducted with the aim of providing detail description for the lithological members of the Chert Unit and deduce the depositional history of this unit based on evidences observed and recorded during fieldwork as well as results of laboratory analysis. The findings reveal that sedimentation occurred in deep marine setting characterized by the thinly layered beds with intercalated argillaceous sediment piling up in deep and quiet environment of low energy nature with the absence of carbonate materials, indicating deposition below the Calcium Compensation Depth (CCD) level. Episodes of volcanic ashes of unknown origin has deposited volume of tuffaceous materials to the rock sequence, integrated along with the on-going in-situ sedimentation. Event of disturbances in the sequence suggest that influence of tectonic event has occurred during deposition, leaving trails of slumping structure preserved. Volcanic ashes and chert are deposited in non-parallel timeline, as such at the peak of tuffaceous influence, presence of cherty materials are rare.

PDRG07-53

Identification of Active Faults in the Quaternary South Perak Coastal Plains

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At 9.35 am on 29 April 2009, a mild tremor measuring 2.6 on the Richter scale was detected in Manjung, Perak. Prior to that the IRIS Earthquake Browser shows several earthquakes up to 4.1 on the Richter scale have its epicentres around onshore and offshore coastal areas as shown in figure 1. There is a parallelism between the trends of offshore Cenozoic grabens to the epicentres distribution. These implied that there are active faults surrounding Manjung that gives rise to the earthquakes. A study was done by remote sensing, geophysics, geomorphology and geological mapping to identify active faults that may be responsible for the tremors.

The coastal area is characterized by several major lineament sets with the NE and N-S through going faults displaying evidences for Quaternary movements (Figure 1). A NE trending fault zone passing from Bota to Manjung and a N-S fault zone passing from Segari to Telok Batik show many geomorphic, structural and stratigraphic evidences for Late Quaternary activity. These include offset streams, ridge and graben topographies, subsidence, and narrow horst and graben alluvial valley structures.

At Bota area, abandon meandering streams are cut by faults (Figure 1) forming NE trending grabens filled with 0.5 to 1.4 m thick of lumpy peaty sand, above highly jointed and faulted the grabens bedrock (figure 2). The lumps are blocks derived from the underlying fractured basement. They shows typical paleoseismites (figure 2 insert) properties. The alluvium seems to sag along each

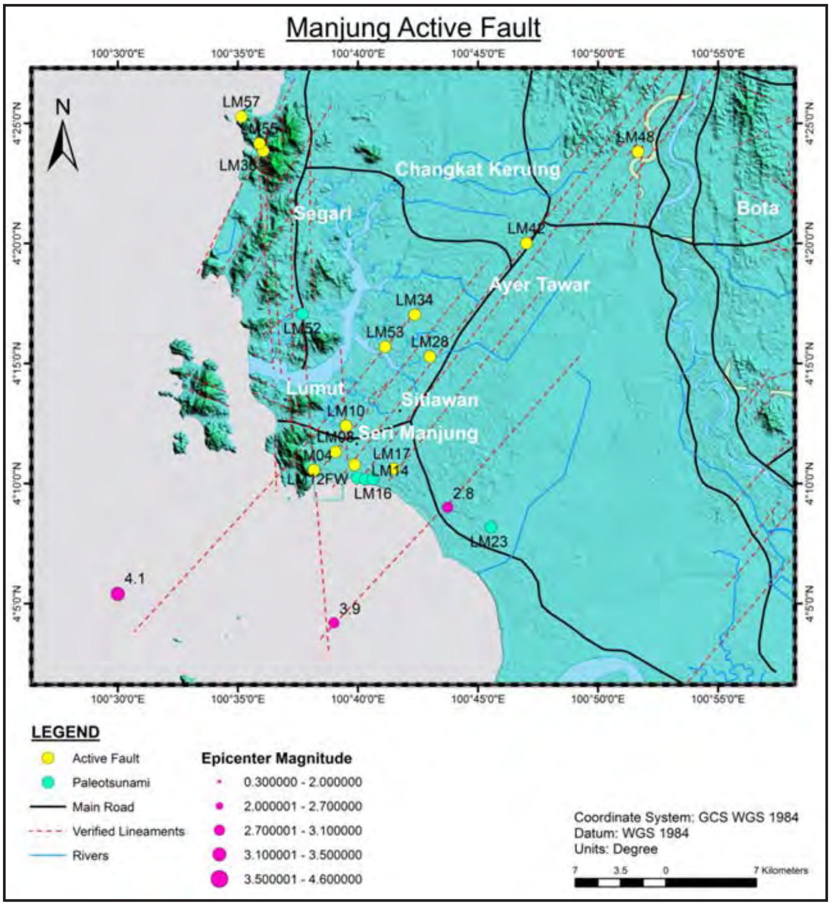

Figure 1: Active fault map showing N-S and NE lineaments representing the active fault zones and location of resistivity and GPR surveys points that shows active faulting.

graben axis and in general the area shows undulating topography.

Near Segari, field observations along A straight N-S linear alluvium-filled valley revealed the presence of N-S faulting in unconsolidated deposits (Figure 3). A 30 m wide fault zone offsetting young horizons developed in a sequence of alluvial gravels and clays in a trench. The alluvial sediments showed the presence of seismites suggesting paleoearthquake activities during sedimentation. The complex nature of faulting exposed in the trench, involving both normal and reverses faulting, suggest that movement involves a significant lateral component.

Geomorphological studies through remote sensing revealed several active fault traces. Resistivity and GPR surveys along the traces further support the active fault interpretation.

In conclusion, several N-S and NE trending active faults were delineated. It is generally believed that the south Perak Coastal Plains is characterized by NE and N-S through going active faults displaying evidence for Quaternary movements. These Quaternary active faults are considered capable of producing large earthquakes. Any seismic hazard assessments must consider these faults in their analysis.

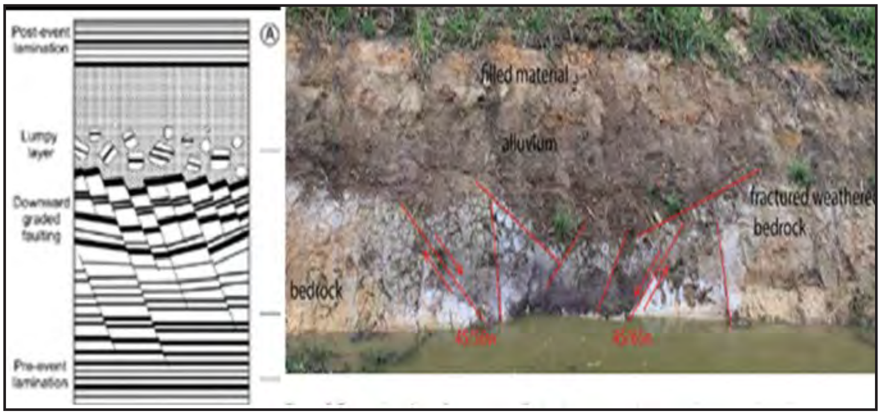

Figure2: A graben filled with alluvial sediments with faulting typicalof paleoseismites.

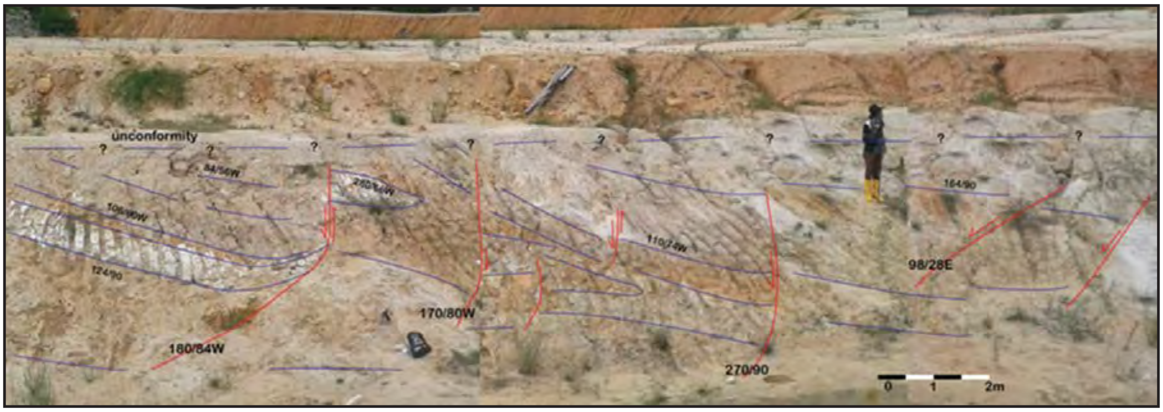

Figure 3: Deformation in Quaternary alluvial sediments within the steep N-S trending alluvial valley.

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PDRG08-59

Carboniferous Plant Fossils from the Kubang Pasu Formation, Pokok Sena, Kedah

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The Kubang Pasu Formation exposed around Pokok Sena, Kedah, comprises a thick succession of shale and mudstone with interbedded sandstone. The observed facies are characteristic of suspension, current, wave/storm and gravity flow deposition, with the depositional setting probably ranging from shelf to deep marine.

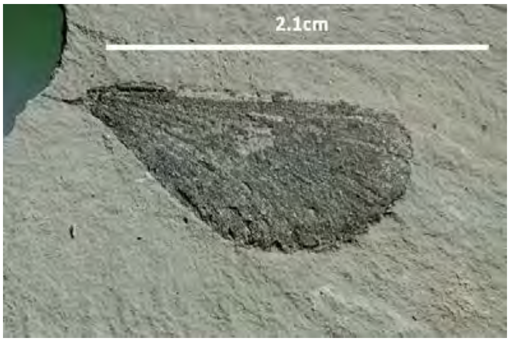

Figure 1: Sphenophyllum cf. S. miravallis from the Kubang Pasu Formation, Pokok Sena, Kedah.

Several mudstone and shale intervals contain a moderately diverse, marine fossil assemblage, which includes the trilobite *Chlupacula* (previously known as *Macrobole kedahensis*), the bivalve *Posidonia/Posidonomya becheri*, unidentified ammonoids and disarticulated crinoid ossicles. The trilobites and *Posidonia* indicate a Carboniferous (Mississippian) age and can be correlated to the Chepor Member of the Kubang Pasu Formation exposed in Perlis. Several shale intervals in the Kubang Pasu Formation of Pokok Sena contain abundant fossil plant fragments. Several fossil leaves were recovered, which are tentatively identified as *Sphenophyllum* cf. *S. miravallis*. The species is also typical of the Carboniferous. This is possibly the oldest plant fossils recorded from the Western Belt of Peninsular Malaysia. Carboniferous plant remains have previously only been reported from the Eastern Belt of Peninsular Malaysia. The close association of the Pokok Sena plant fossils with interpreted turbidites and debrites, suggests long distance transport from the land by gravity flow.

PDRG09-67

Carboniferous Plant Fossils in Teluk Kalung, Kemaman, Terengganu

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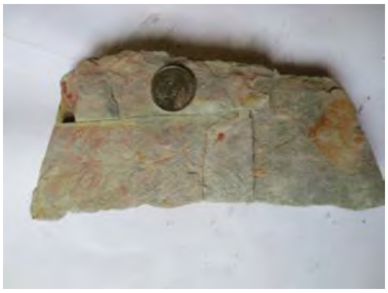
Teluk Kalung is a part of Sungai Perlis Beds with the age of 359.2 to 299 million years ago. The observed lithostratigraphy of Teluk Kalung have been divided into sandstone units, shales units, metasediments units, granitoid body and superficial deposits. The Carboniferous plant fossils found in the shales units and identified as the Pteridosperm plants which are *Rhacopteris* sp., *Sphenopteris* sp. and *Sphenopteridium* sp. These plants fossils lived in warm and humid near-shore environment. The depositional environment of Teluk Kalung is marine-environment associated with marginal setting. In this paper, we will compile the carboniferous plant fossils from Teluk Kalung as we noticed the appearance of few other species from the previous Kemaman carboniferous plant fossils from Tanjung Mat Amin.

Rhacopteris sp.

Sphenopteridium sp.



Sphenopteris sp.

PDRG10-69

Occurrence of Larger Benthic Foraminifera from the Early Miocene Limestone sediment at Batu Luang, Klias Peninsula, Sabah

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Limestone unit of Setap shale formation is exposed at Batu Luang, Klias Peninsula, Sabah. the limestone consists of well-preserved larger benthic foraminifera and its significant to study the petrography, biostratigraphy and its paleoenvironment. Klias Peninsula which located at the south-western part of Sabah. The study area underlain by Paleogene-Neogene sediment namely, the Crocker Formation, Temburong Formation, Setap Shale and Belait Formation (Dayang Nor Asyilla & Sanudin 2013). The Setap Shale consists of predominantly thick dark grey mudstone with minor sandstone intercalations. The shale is occasionally calcareous, silty and may contain carbonaceous material. The Setap Formation is unconformably overlying the Temburong Formation in Labuan Island (Basir, 2002; Basir et al. 1993; Wilson & Wong, 1964). In the study area, the contact between the Setap Shale Formation and the Temburong Formation is not exposed. Wilson and Wong (1964) reported the age of the Setap formation was Late Miocene. Basir (2002) and Basir et al. (1993) suggest that the age of the formation is Early Miocene to Late Miocene based on study at the Labuan area.

Recently we discover some significant larger benthic foraminifera from the limestone unit of the Setap Shale Formation from Batu Luang, Klias Peninsula Sabah. The significant of larger benthic foraminifera study are to give some significant age and the deposition paleoenvironment of the sediment. The purposes of this study are to classified the taxonomy of the larger benthic foraminifera species found in the limestone and to determine the age and paleoenvironment of the limestone facies.

PDRG11-75

Weathering style and geochemical (major and rare earth elements) content of granitic and basaltic soils from Kuantan, Peninsular Malaysia

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The variation of major and rare earth elements in soils is largely dependent on the type of rock or parent material from which they are weathered and are largely controlled by the mineralogical content in the rock or parent material. Minerals such as allanite, apatite, sphene, zircon, garnet and monazite are the main carriers of REE in the parent rock. During weathering, all these minerals will release rare earth elements, into the soil either by soil solution or incorporated into secondary minerals in the soil Examples of secondary minerals that can hold the rare earth elements in soils are clay minerals (e.g. kaolinite, chlorite, illite, vermiculite and smectite) and Fe-Mn oxide. This paper investigates the behavior of major and rare earth elements of rock–soil system in basaltic and granitic weathering product that occur in the same area, Kuantan, Peninsular Malaysia. The granite type is hornblende biotite granite of Permian age whereas the basaltic formation consists of alkali olivine basalt, limburgite and olivine nephlinite of early Pleistocene age. Grained size and mineralogy of both rocks is recognized as among the important factors that controlled the weathering. The basalt and granitic rocks crystallised from different types of magma, i.e. mafic and felsic magma respectively. The basalt shows more coherent soil-rock rare earth profile while the granite soil-rock profiles are more erratic. In granite profile, total rare earth elements increase with depth. Ce anomaly in granitic profiles suggested that the oxidation of Ce^{3+} to Ce^{4+} is important process during weathering where Ce^{4+} may be incorporated into zircon structure or forms a new substance such as cerianite $(Ce^{4+},Th)O_2$.

PDRG12-76

Platinum Group Elements in Proximal Impactites of the Bukit Bunuh Impact Structure, Malaysia

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The PGEs are commonly analyzed in the impact-melts and impactites from impact craters to confirm asteroid impact events. These geochemical data are considered as one of the best indicators of impactor asteroid contribution to terrestrial samples as these elements are strongly depleted in the Earth's crust. For example, the concentration of iridium (Ir) in bulk continental crust is only 0.037 ppb, whereas chondritic meteorites contain at least 300 ppb and Ir concentration in iron meteorite reaches up to 30000 ppb.

The Bukit Bunuh in Malaysia has recently been identified as an impact structure after the discovery of possible impact-melt looking rocks and impact breccias from this area. The granitic rock found in this area, also known as the Buloh Pelang unit, belongs to the Taiping pluton a large pluton member within Bintang Batholith (that makes up the Bintang mountain range). The exposed and cored granitic rock in the Lenggong area can be described as porphyritic to megacrystic with large euhedral K-feldspar; it is coarse grained, gray in colour, and contains biotite as its main mafic constituent. Various pyroxene-bearing mafic microgranular enclaves with coarse-grained rims can be found with the granite. The parent rock of the mylonite is believed to belong to the Buloh Pelang pluton because it is surrounded by this rock unit and shares similar rock texture. A total of 12 samples (three core samples of basement granites, five impactites including two impact-melt looking rocks and three impact breccia, and four mylonites) were analyzed in the present study.

The impact event is believed to have occurred around 1.34 to 1.84 Ma. Twelve impact-related rocks from this suspected impact structure were analyzed in the present study for Platinum Group of Element (PGE) contents. The sample population includes proximal impactites (two impact-melt rocks and three impact breccias) and possible impact-related rocks (four mylonites) and basement granite (three in number). The results showed no observable clear distinction between the impactites and basement granite. Compared to other asteroid impact sites in the world, the impactites and impact-related rocks in the Bukit Bunuh structure clearly contain a lower concentration of PGEs. Even though previous studies reported possible evidence of shock metamorphism in the Bukit Bunuh structure and electrical resistivity survey favored the presence of asteroid impact structure in this area as well, the absence of a clear projectile signature in our investigation on PGE hinders further discussion on the existence and nature of the impact. We suggest that the absence of any PGE signature in the Bukit Bunuh impactites could be indicative either of (1) an achondrite projectile, or (2) an oblique impact, or (3) the presence of a volatile-rich layer.

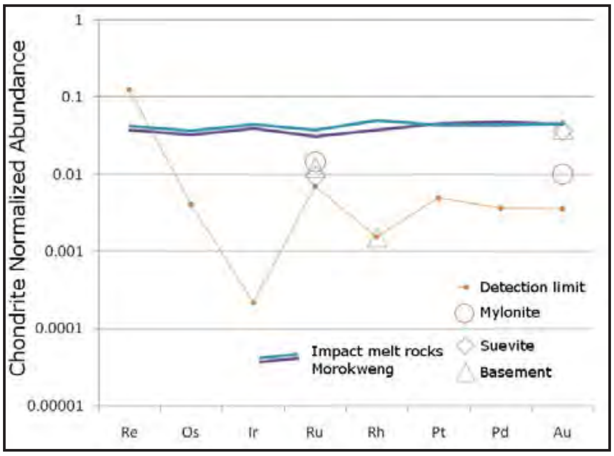

Figure (Top): Plot of platinum-group element and related metal abundances, normalized to carbonaceous-chondritic compositions. The impact melt rocks from the Morokweng impact structure, South Africa (MO-43 and MO-48), show a clear meteoritic pattern.

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PDRG13-77

Geochemistry of Ordovician to Silurian Felsic Volcanic from Gerik, Peninsular Malaysia

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Ordovician to Lower Silurian (ca. 488 to 450 Ma) volcanic rocks occur as scattered bodies in the Western belt of Peninsular Malaysia. These groups of rock have been neglected in Malaysian geology and no detailed study has been done to investigate the origin, tectonic setting and petrogenesis of the magma. This project revolves around the occurrence of volcanic rocks in Gerik, Perak originating from the Gerik Pyroclastic Member, part of the Baling Formation. The objective of this study is to investigate the petrogenesis and to propose the tectonic setting of the volcanic magma. The volcanic eruption intruded pre-existing slate formation, resulting in the slate as xenolith inclusions in the later-formed rhyolite rock. Petrographic studies exhibit a porphyritic texture along with a flow banding foliation in the volcanic rocks. The phenocrysts phase comprises of quartz, plagiocase, K-feldspar and biotite. Matrix also composed of the same material as the phenocrystic phase. The volcanic rocks also contain abundant of slate rock clasts of various sizes. The clasts size ranges from less than 1 mm to 5 cm in diameter. The volcanic rocks can be classified as rhyolite and trachydacite with SiO_2 ranging from 64% to 82%. The magma is Al-enriched and plot in the calc-alkaline series. The rocks here are peraluminous and are from 'S'-type magma, indicated from A/CNK value that exceeds 1 for both rock types (1.09-1.35).

The Western Belt of Peninsula Malaysia represents the Sibumasu Terrane before it collided with Indochina Block to form the Peninsula Malaysia during Late Permian – Mid Triassic time. The Sibumasu Terrane was a part of the eastern Cimmerian continent, believed to be separated from Gondwana margin during Early Permian in an intra-cratonic rifting event. The interaction between the late Proterozoic crust and mantle led to an early Phanerozoic arc-related magmatism along the India-Australian margin of Gondwana. This fits the result from the geotectonic plot of the Gerik Volcanic (Fig. 1) that forms a trend in the volcanic arc array field. The arc-related magmatism generated granitic bodies, derived from the mixture of mantle and Mid-Proterozoic continental crust, and the granitic bodies formed is what believed to form the Cambrian basement. Later in Silurian, an acid explosive volcanism took place at the Cambrian basement, causing the magma to intrude the pre-existing strata in the Sibumasu Terrane and produced the Ordovician to Silurian volcanism.

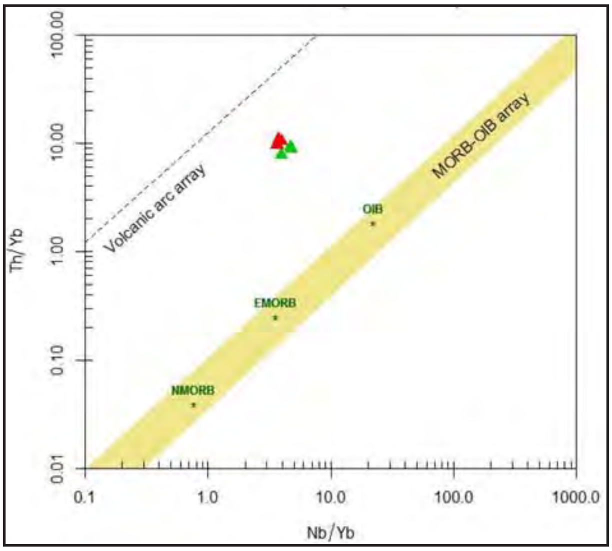

Figure 1: Geotectonic setting of volcanic rocks from Gerik, Perak. Blue and red triangles represent rhyolite and thrchydacite volcanic rocks from Gerik.

PDRG14-78

Taiping Pluton of Bintang Batholith: Example of Amphibole Bearing Melagranite in the Western Belt of Peninsular Malaysia

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The Bintang batholith is one of the biggest batholith in the Western belt of Peninsular Malaysia. The batholith consists of 4 units: Taiping, Selama, Damar, and Bubu plutons. The batholith houses several kinds of granite and the unique amphibole-bearing melagranite is one of them. The melagranite is our study main focus and it primarily resides within Taiping pluton. This particular granite deviates from the Main Range granite province typical granite facies, where amphiboles and sphene are present. The melagranite is also darker color compared to typical Main Range granite and has megacrystic to porphyritic texture. The melagranite mineralogy consists of quartz, biotite, K-feldspar, plagioclase, hornblende, orthopyroxene and clinopyroxene. Sphene, apatite, allanite and zircon are the main accessory minerals. Petrographic examination shows the amphiboles (actinolite) contain pyroxene relics or traces of pyroxene.

The range of SiO_2 of the Taiping melagranite is 58.4 to 68.3 wt. %. The value is much lower compared to the published SiO_2 content of the Main Range granite which is 65 to 77 wt. %. Differentiation Index of the melagranite samples are 7.3 to 22.0, much lower than the general Main Range granite, 17.9 to 31.7. On the AFM diagram, Taiping melagranites fall on the low FeO/MgO side of the calc-alkaline series. Compared to the typical Main Range granite the amphibole-bearing melagranites show clear deviation from the Main Range trend. The melagranite are metaluminous to weakly peraluminous (A/CNK = 0.65 - 1.06). The majority of the samples show very high potassium content and thus comparable to shoshonite series. In general, the Melagranite samples are geochemically similar to the Durbachites from Central Europe. Other ultrapotassic characters of the Taiping melagranite are (1) magnesium number (54.2 – 66.4), (2) high K2O (3.86 to 7.31 wt. %), (3) high Th/U ratio (2.38 to 12.8), (4) Rb/Sr ratio (0.82 to 6.64), (5) Cr content (233 – 568 ppm), (6) CaO/MgO ratio falls between 0.41 and 1.09. Geochemical data show that the Taiping amphibole-bearing melagranite is relatively un-evolved or primitive in character compared to the typical Main Range granite. Their geochemical variation diagram patterns are not comparable to typical Main Range type granite which is more felsic. Apatite saturation temperature for the Taiping amphibole-bearing melagranite ranges from 928.8°C to 1014.8°C. This temperature is significantly higher than the temperature of granitoid melt generated by sedimentary source.

The enrichment process of the melagranite could have been contributed by a previous subduction event. Taiping pluton itself is located at the Sibumasu plate (which subducted under the Indochina plate before the collision) and U-Pb zircon dating results (218 ± 1.3 Ma) indicate that they are emplaced during the Triassic Sibumasu-Indochina collision (200 – 220 Ma), which most of the Main Range granite province are emplaced. To fit into the current tectonic model, we believe a minor episode of extension could have occurred during early collision. As the plates continue to converge, the compressive tectonic regime will be re-established.

Lineament Study of the Semanggol Formation and Adjacent Areas from Landsat 8 Image

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This study utilises the image of Landsat 8 for lineament mapping, covering the whole Semanggol Formation and its adjacent areas. The Semanggol Formation was a continuous formation which was later separated into three areas by wrench fault (Burton, 1973; Jantan et al., 1989; Jasin, 1997). Until recent, there is no detailed lineament study in the study area using remote sensing techniques. The objective of this study is to produce a lineament map for the Semanggol Formation and adjacent areas from remote sensing data. Landsat 8 image was digitally processed which involved atmospheric correction, histogram equalization and pan-sharpening to enhance the quality of the image up to 15 m resolution. Band combination of RGB 5, 6, 7 was used to trace lineaments. Lineaments were traced based on techniques used by Komoo et al. (1990). From the lineament map produced, a total of 106 fault lines with total length of 777.13 km were mapped and 242 major fractures with total length of 731.02 km were identified (Figure 1). Nine fault lines were correlated with the Bok Bak Fault Zone which lies within the study area, trending to NW-SE direction. Two sets of faults were identified from the lineament map, trending NW-SE direction (30°-60°) and NE-SW direction (210°-240°). Based on rose diagram analysis of selected areas, the dominant direction of lineaments was NW-SE direction. A few outcrops were determined for collecting strike and dip data and were compared with data from lineament map using rose diagram analysis (Figure 2). The analysis showed similarities in terms of orientation. As conclusion, band combination of RGB 5, 6, 7 can clearly distinguish the structural features in the Landsat 8 image to produce lineament map and the lineament orientation from lineament map and fieldwork data are mostly similar.

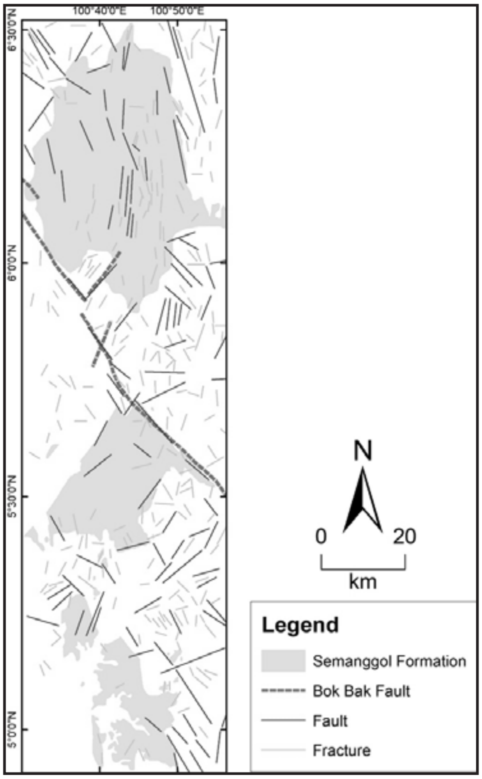

Figure 1: Lineament map of the Semanggol Formation and adjacent areas.

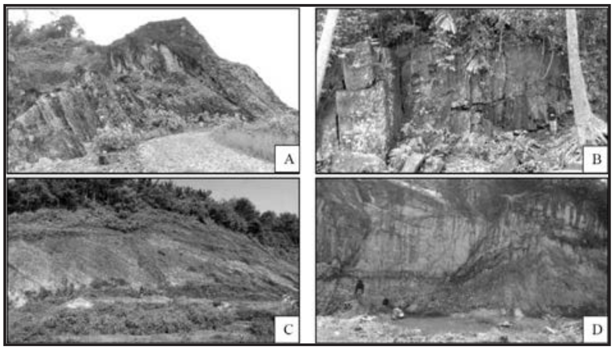

Figure 2: Selected outcrops for comparing fieldwork data with lineament map: (A) Gunung Semanggol, Perak; (B) Bukit Hijau, Kedah; (C) Kuala Ketil, Kedah; and (D) Pokok Sena, Kedah.

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PDRG16-88

Mapping Late Pleistocene-Holocene Paleo Pahang River (updated)

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The study area covers present day Pahang River basin until Penyu Basin. Paleo channels were detected in Penyu Basin from shallow seismic and 3D seismic profiles. It is postulated that these sediment filled channels were paleo extension of present day Pahang River system (Hutchison, 1989a in Hutchison & Tan, 2009; Hutchison, 2007). The paleo Pahang River basin was probably a large river basin during the Last Glacial Maximum (LGM) when sea level was approximately 123 ± 2 m lower than present-day sea level. The paleo-valleys were likely formed after few phases of regression afterwards (Rahman *et al.*, 2016).

The Penyu Basin is flanked by Pahang Platform and Tenggol Arch in the north and by the Johor Platform in the south (Madon and Anuar 1999). The basin comprises of several grabens or sub-basins which includes Kuantan, Pekan, Rumbia and Merchong grabens. The grabens created depression on the overlying sediment layers that defined the flow corridor for paleo Pahang River.

3D seismic, 2D CHIRP acoustic data and satellite images taken from Google Earth and Landsat 8 were examined for paleo channel features. The data were related to each other and mapped in order to construct the paleo Pahang River from the modern lower basin region to the Penyu Basin region. Post highstand paleo channel patterns are detectable by enhancing satellite images with SRTM topographic data. Time slices were used to investigate the evolution of submerged paleo channels on the shelf. Plan view of sequential time slices enabled better interpretation of fluvial patterns. The morphology of the paleo incised channels in Penyu Basin can be clearly seen in the time slices images they resembled present day channels.

Fluvial pattern evolved from low stand incised valley system to deltaic distributary channel system. In Fig. 1(A), meandering channels are noticeable with small feeder tributaries. Following with that, the channel separated to 2 different paths in (B) and many dendritic incised tributaries are found in (C). Some new incised rivers overlaid the big channel and the direction of the river system started to change in (D). Afterwards, deltaic river system formed following (E) and (F). The paleo channels may be connected previously to the present day Pahang River.

Acknowledgements

We thank Ministry of Higher Education Malaysia (FRGS 59332) for funding our research. High resolution CHIRP data are provided by University Malaysia Terengganu and Tongji University. PETRONAS provided 3D seismic data. Schlumberger (Malaysia) provided PETREL 2012 freely for our use. We are grateful.

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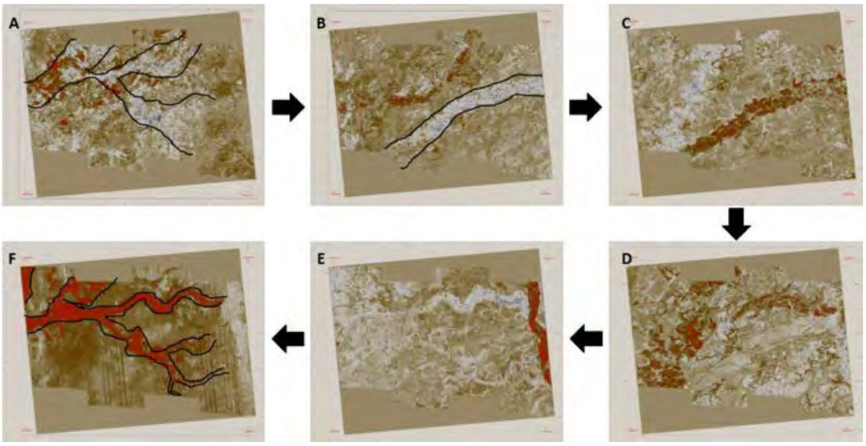

Figure 1: Morphology evolution of paleo Pahang river fluvial system in Penyu Basin.

PDRG17-108

Constraining Permian-Triassic Boundary in Gua Panjang, Merapoh, Pahang Darul Makmur

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The search of Permian-Triassic Boundary ('PTB') in Malaysia focused on limestone hills near Kuala Lipis since the 1990s. This is due to findings of Late Permian foraminifera (Lim & Abdullah 1994) and Middle Triassic cephalopod *Sibyllonautillus bamaensis* in Gua Bama (Sone & Leman 2004). In Gua Sei, Late Permian to Early Triassic conodonts were discovered in a few sections by Metcalfe (1995). However, no specific horizons in both localities were constrained to be the possible location of PTB.

The focus on PTB now shifts to Gua Panjang, Merapoh, located roughly 50 km to the north of Kuala Lipis town (Figure 1). Latest paleontological evidence has constrained the presence of PTB to be within 6.5 m to 9.0 m from the base of Gua Panjang eastern side. Late Permian foraminifera such as *Colaniella* (Figure 2) and *Palaeotextularia* were observed 6.5 m from the base, where the microfacies is characterized as bioclastic grainstone deposited within shallow open marine environment. 9.0 m from the base is highly dolomitized horizon with the presence of Early Triassic conodonts such as *Hindeodus parvus* (Figure 3) and *Isarcicella staeschi*. Between 6.5 m and 9.0 m, analysis on $\delta^{13}C$ and $\delta^{18}O$ of whole rock show slight decrease in both isotopes to 1.18‰ (VPDB) and 18.23‰ (SMOW) respectively. However, carbon isotope excursion, which is the signature signal in most PTB sections worldwide, was not observed in the study area.

Future works in the first 10 m of the eastern side of Gua Panjang is critical in order to narrowly defined the presence of PTB. This includes high-resolution sampling of 10 cm interval between height 6.5 m and 9.0 m for isotope analyses $\delta^{13}C$, $\delta^{18}O$, $\delta^{34}S$, and $\delta^{15}N$, besides age confirmation through age geochronology analysis.

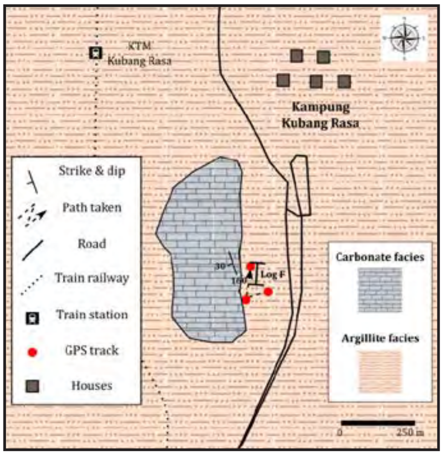

Figure 1: Geologic map of Gua Panjang, Merapoh.

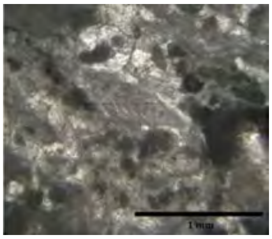

Figure 2: Late Permian foraminifera *Colaniella* sp.

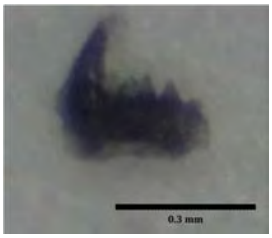

Figure 3: Basal Triassic conodont *Hindeodus parvus*.

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PDRG18-110

Sedimentary Facies of the Shoreface – Offshore Environment in Sandakan Formation, NE Sabah Basin

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Northeast (NE) Sabah basin lies on the actively tectonic plate in the Southeast Asia region, surrounded by the Sulu Sea and the Celebes Sea. The upper Miocene of the Sandakan Formation is an upper unit of this basin, and comprise a shoreface to offshore facies environment of shallow marine deposit. This deposit can be seen clearly on the exposed outcrop, which led to extensive study of the NE Sabah basin from the perspective of analogue study. Several studies have presented sedimentological data throughout Tertiary strata exposed in the region (Chung, Sum, & Rahman, 2015; Lambiase & Tulot, 2013; Noad & Harbury, 1997; Wong, 1992), but few detailed studies have been undertaken. Hence, the objectives of this study are: (1) To describe the facies characteristic of the shoreface to the offshore environment in Sandakan formation; (2) To establish facies association and interpret depositional environment of this formation.

Detail sedimentological works were carried out along the newly exposed outcrop adjacent to Sandakan town. 250 meter total of the sedimentary thickness of outcrops were described according to the standard procedure which are lithology, sedimentary structure, fossil, geometry, and paleocurrent direction. That information will give a facies characteristic and further analysis will contribute to depositional environment interpretation.

Eight facies are defined: (1) Poorly bioturbated Hummocky cross stratified (HCS) sandstone (F1); (2) Moderately bioturbated HCS sandstone (F2); (3) Well bioturbated HCS sandstone (F3); (4) Highly bioturbated HCS sandstone; (5) Bioturbated swaley cross stratified sandstone (F5); Interbedded HCS sandstone with sand-silt mudstone (F6); (7) Heterolithic sandstone (F7); (8) Heterolithic mudstone (F8). Three (3) facies association were proposed by grouping these 8 facies, which are: (1) lower to middle shoreface; (2) Offshore transition; and (3) Offshore. The facies pattern and presence of some trace fossil suggest that these facies were deposited in the shallow marine setting with storm and wave dominated influence.

The HCS sandstone primarily dominates the shoreface environment in Sandakan formation, where these repetitive facies can only be categorized by distinguishing the bioturbation index. The facies is common for high energy setting environment which related to the wave and storm processes. The presence of HCS commonly originated from storm weather, related to the presence of high energy oscillatory and combined flows (unidirectional flow and combination of oscillatory) (Cheel, Leckie, & Wright, 1993; Dumas & Arnott, 2006). The presence of trace fossils such as *Ophiomorpha* and *Skolithos* were commonly found in the high energy of shallow marine setting. Different intensity of bioturbation index (poor to high) in HCS sandstone is probably due to different in operation condition during deposition, substrate, salinity, oxygen level, sheltered environment etc. Interbedded HCS sandstone with sand-silt mudstone reflects a fluctuation and alternation of quiet water sediment fall out (low energy), with combined and pure oscillatory flows (high energy)(Buatois et al., 2012).

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PDRG19-111

The Reconstruction of 3D Geo-Lithological Model of Pekan, Pahang: A Possible Onshore Extension of Penyu Basin

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Well data from both onshore and offshore of Pekan have showed that the Quaternary sedimensts are present in both onshore and offshore Pekan unlike the Tertiary sediments which are only found offshore. This could be well explained through the paleaoenvironment of the Tertiary sediments in Penyu Basin where it starts from continental (older sediments) to marine environment (younger sediments), which may suggest that transgression had occurred causing the Pahang River delta to be located where it is today. In fact, the presence of ancient river channels found in the Penyu Basin supports the transgression claim. Thus, to proof the possible extension of the basin, this paper aims to delineate the geometry of the basement at Pekan, Pahang as well as to study the distribution of different basement rock in the area by reconstructing the geo-lithogical model of Pekan, Pahang. 30 well data from previous work, done by the Jabatan Penyiasatan Kajibumi Malaysia in 1992 and 1993 are used in reconstructing the geo-lithological model. Utilizing the Lithoblending algorithm to reconstruct the geo-lithological model, allowed us to have a greater control on the model by using nearby well data to extend the lithology laterally rather than extrapolating vertically below the borehole which may lead to inaccuracy. The outcome of the geo-lithological model revealed that basement of the area deepens towards the shoreline (Fig.1) and there are two different types of basement rocks present in the study area namely Granite and Metasediment. The termination between these two basement rocks are found to be underlying the Sungai Pahang (Fig.2), which may correspond to the opening of the Penyu Basin.

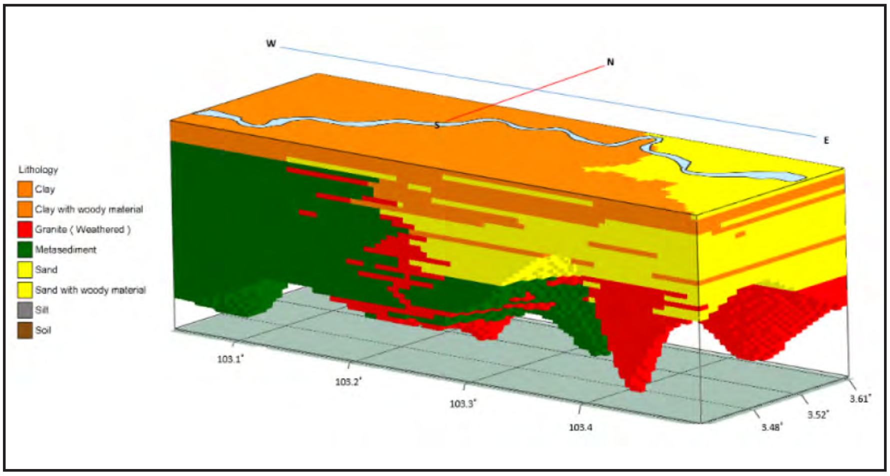

Figure 1: Geo-lithological model with W-E orientation.

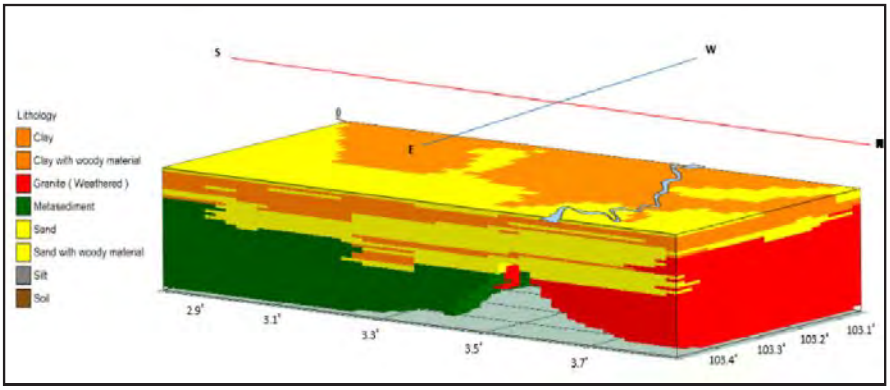

Figure 2: Geo-lithological model with N-S orientation.

PDRG20-120

Anatomy of an Isolated Carbonate Platform: Subis Limestone Outcrop, Early Miocene, Niah, Sarawak, Malaysia

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Carbonate outcrops in Sarawak, Malaysia provide invaluable information about the architecture of Neogene carbonate platforms. The Subis Platform, composed of the Subis Limestone is one of the very few outcrops in Malaysia that is large enough to reveal vertical and lateral facies relationships. The Subis Platform is a conspicuous hill that extends about 6000 m x 4000 m x 400 m. The Subis Limestone is composed of branching and massive corals, red coralline algae, benthic foraminifera, bivalves, gastropods, echinoderms and occasionally bryozoans, ostracods and serpulid worm tubes. Nine genera of foraminiferan have been interpreted confirming an Early Miocene age of the succession. Six facies from Dedeche (2012) and three facies associations have been distinguished. All these facies are all grain-dominated. FA1 is a dipping bioclastic floatstone, FA2 is a massive coral rudstone –framestone and FA3 is a is horizontally bedded mollusk packstone. These have been interpreted as reef talus (FA1), reef crest (FA2) and lagoon (FA3) forming part of an isolated platform. The lower 40 m of the outcrop are dominated by branching and massive coral rudsstone – framestone (FA2). This passes laterally into dipping bioclastic floatstone (FA1). Vertically coral framestone (FA2) is overlain by horizontally bedded mollusk packstone (FA3) and covered by a sharp 30 cm thick reddish exposure surface. The surface is covered by dipping bioclastic floatstone across the entire outcrop. This subversion is interpreted as a nearly complete transgressive-regressive sequence throughout the Debbestone Quarry. The outcrop is Early Miocene in age (Cycle II) based on benthic foraminifera. These are grain-dominated isolated platforms potentially favorable for reservoir properties.

PDRG21-121

Geologi Am di Rusila-Marang, Terengganu Darul Iman

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Kawasan kajian seluas 63 km^2 terletak dalam longitud 103˚ 8’ T hingga 103˚ 12’ T dan latitud 05˚ 10’ U hingga 05˚ 15’U, iaitu di Rusila-Marang, Terengganu, Darul Iman. Permasalahan kajian ialah kawasan ini masih kurang dikaji oleh pengkaji-pengkaji terdahulu. Oleh itu, satu kajian mengenai geologi am di kawasan ini telah dilakukan. Kajian ini dibuat untuk menentukan jenis-jenis litologi yang terdapat di kawasan kajian. Kandungan mineral di dalam batuan turut dikaji secara petrografi dan dilakukan peratusan mineral bagi penamaan batuan secara sistematik. Unsur-unsur geokimia batuan ditentukan dengan menggunakan kaedah Pendaflour Sinar-X (XRF) dan kaedah Pembelauan Sinar-X (XRD). Cerapan telah dibuat ke atas litologi yang terdiri daripada batuan igneus jenis granit dan metasedimen seperti filit dan kuarzit. Kaedah petrografi (irisan nipis) digunakan untuk menentukan jenis batuan dengan lebih terperinci. Batuan di kawasan ini berusia Perm-Karbon berdasarkan kolerasi dengan Lapisan Sungai Perlis yang terdapat di Kemaman.

NGC 2017 30th NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

PDRG22-127

Sedimentology of the Lambir Formation (Middle - Late Miocene) Northern Sarawak, Malaysia

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The Middle - Late Miocene Lambir Formation is extensively exposed along the Bekenu-Miri road near the Bukit Lambir National Park. This formation is characterized by a succession of poorly consolidated sandstone and sand interbedded with soft clay in several exposures. A detailed sedimentological study and facies analysis was conducted in order to reconstruct the paleo-depositional environment for this formation. Eight (8) stratigraphic sections of the Lambir Formation were logged at Bukit Song, Sg. Liam and Pantai Tusan, Sarawak. Thirteen (13) sedimentary facies from these sections have been identified on the basis of lithology, geometry, sedimentary structure and fossil content. These sedimentary facies are categorized as follows: F1- Trough Cross Bedded Sandstone, F2 -Herringbone Cross Bedded Sandstone, F3 - Hummocky Cross Bedded Sandstone, F4 - Amalgamated Hummocky Cross Bedded Sandstone, F5 - Bioturbated Sandstone, F6 – Well-Bioturbated Sandstone, F7 - Ripple Cross Laminated Sandstone, F8 - Flaser Wavy Bedded Sandstone, F9 -Heterolithic Sandstone, F10 - Interbedded Hummocky Cross Bedded Sandstone with Bioturbated Mudstone, F11 - Heterolitihic Mudstone, F12 - Mudstone and F13 - Lignite / coal. These facies are categorized into 2 major facies association group based on its depositional process influenced which are : storm-wave influenced facies association comprises of FA1 - lower – middle shoreface, FA2 - offshore, and tide influenced facies association comprises of FA3 - tidal influenced channel, FA4 - tidal flat, and FA5 - tidal bar. The pattern of facies and presence of ichnofossil within these facies imply that these facies were deposited in the shallow marine setting with pronounced storm, wave, and tidal influence along the paleo-margin.

PDRG23-129

Discovery of Murinae Fossils in Calcified Cave Breccia from Western Belt Caves in Peninsular Malaysia and Implications to Quaternary Palaeoenvironment

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Isolated fossil teeth of mammals from both large and small-sized taxa were found mixed together in calcified breccia remnants on the walls and roof in caves scattered in West Peninsular Malaysia. These caves are located at the foot of Palaeozoic Era limestone formation in Langkawi, Perak and Selangor and the age of some of the fossil-rich cave breccias was estimated to be Middle to Late Pleistocene (Yasamin, 2013). The identified murinae fossils were used to determine the palaeoenvironmental conditions. This is the first systematic study of murinae fossils in Peninsular Malaysia. More than 70 specimens of teeth and fragments of jaws have been identified as murinae among 350 small mammal remains recovered. Based on the dimension of the molars, the assemblages are classified into three different groups by size; small, medium and large. The identification and comparison study suggest that the rats belong to extant species that are still living in Peninsular Malaysia and adjacent countries. They are identified as *Maxomys spp*., *Leopoldamys sabanus*, *Chiropodamys gliroides*, *Niviventer fulvescens* and *Rattus spp*. Based on the specific ecological requirements relating to each of the species found, most likely the environment surrounding the caves area in Western Belt of Peninsular Malaysia during Middle to Late Pleistocene time is of lowland forest type with bamboo trees, and near to water sources such as rivers or swamp.

Figure 1: Adapted from Musser (1981), nomenclature of dental structures using left upper and left lower molars of Leopoldamys sabanus. Upper molars: cusps are numbered. Lower molars: a-lab, anterolabial cusp; a-ling, anterolingual cusp; pd, protoconid; hd, hypoconid; md, metaconid; ed, entoconid; pc, posterior cingulum; plc, posterior labial cusplet.

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PDRG24-135

Facies and Stratigraphic Architecture of the Kudat Formation, Sabah: Implications on Provenance and Tectonics

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I Introduction

A detail study of the sedimentology and stratigraphy of the Kudat Formation (Oligocene – Early Miocene), Sabah, Malaysia was undertaken to:

i) Describe and interpret the sedimentary facies of the formation,
ii) Identify facies associations in terms of sedimentary processes and environments, and
iii) Propose a depositional model taking into account the sedimentology and biostratigraphy of the Kudat Formation.

The sedimentary successions of the Kudat Formation in Sabah consist of sandstones and mudstones, commonly forming fining-upward successions, and have been interpreted to be products of turbidity currents and other related processes within a submarine fan environment. Detail facies analyses conducted on ten (10) outcrops in the Kudat Peninsula recognized: thick-bedded massive-to-graded sandstone in the northern region, while thin-bedded turbidite (Bouma units) are common in the central and southern parts of the Kudat Formation. Three major facies associations were identified: i) upper fan non-channelized proximal lobes, ii) middle fan and iii) lower fan distal lobes.

I. Upper Fan Non-Channelized Proximal Lobes Facies Association. Structureless sandstones, parallel-laminated sandstones, ripple-laminated sandstones, and graded-bedded sandstones which are dominant in northern Kudat outcrops are interpreted to be deposits of proximal lobe where flow are partially confined. However, because no other architectural elements are recognized (eg. channel-leves feature) and the outcrop extent is limited (inclined strata), the type of lobe setting cannot be determined based on its position with respect to the rest of the system involved. Sediment gravity flows are generally non-erosional immediately before deposition. However, deposition is sufficiently rapid to cause loading at bed bases and to suppress the development of primary sedimentary structures in the overlying sandstone beds (Haughton et al., 2003). The normal coarse tail grading indicates hydraulic segregation, either by turbulent sorting within turbidity current or by settling through a concentrated slurry (Marr et al., 2001). The tops of the irregular thick sandstone beds are thought to reveal some combinations of upward sand injection after liquefaction and concomitant downward foundering of the overlying breccia units into the underlying sand (Haughton et al, 2003).

II. Middle Fan Non-Channelized Medial Lobes Facies Association. Middle fan non-channelized facies associations are characterized by fining-upward and thickening-upward sequences. The beddings are commonly sheet-like, with sharp bases, great lateral extent and good continuity. This may indicate that the turbidites would have been laterally extensive and were deposited in unchannelized, unconfined environment (Walker, 1992). Only a few beds show moderately scoured bases. The facies forming this facies association are F1, F2, F3, F4, F6 and F7 and they are common in the Sikuati region (KF2, KF3, KF4, KF5, KF6 and KF7 outcrops). These outcrops show evidences of low density turbidity current due to their sand-mud ratios and sedimentary structures preserved. Localised post-depositional slumps featured in KF5 are formed with thin-bedded Bouma sequences (classical turbidites).

The fining upward succession and change in sedimentary structures are the result of waning flow velocities, gradually, leading to deposition of progressively finer-grained sediment under progressively lower flow regime conditions (Weimer and Slatt, 2006).

III. Lower Fan Non-Channelized Distal Lobes Facies Association. Lower fan non-channelized distal lobes are characterized by high proportion of mudstone, the thin bedded sandstones (not more than 50 cm thick), thus reflecting the most distal region of a lobe setting. Scouring is very uncommon and the beds are laterally extensive due to the end product of the low density turbidity currents. The beds characteristics display very thin and finest-grained deposits, reflecting the very low energy flow. By the time the flow reaches this region, most of the sediment load has already been deposited up-system and the flow becomes thinner and fully unconfined (Burgreen and Graham, 2014). This facies association is common in the southern part of Sikuati, Matunggong and Balambangan, Kudat. Bouma sequence is preserved with major divisions of Tb, Tc and Te. Only a few beds exhibit Ta and Tb divisions.

Based on Groenenberg at al. (2010), the conceptual model's distribution of lithofacies is based on their distance from the point-source and distance from a feeder distributary channel and/or scour. They explained that lobes have complex geometries and are comprised of unevenly distributed deposits, leading to heterogeneity of the lithofacies scheme present. Even though a flow has stronger energy, thicker sediments are more likely to be preserved in proximal areas but they may still be present in more distal areas. The same goes to flow with lower energy, thinner sediments are more likely to be deposited in distal area, even they might be present in proximal areas. As for bed thickness distribution, it may vary depending on the sediment source, the particular energy and size of a flow, the influence of the underlying topography, and the stochastic nature of deposition (Burgreen and Graham, 2014). Although a particular lithofacies will be more likely to be present in certain settings of the lobe, they are not necessarily being distributed in a perfectly predictive manner (Burgreen and Graham, 2014).

II Depositional Environment

The sedimentary facies of the Kudat Formation *was deposited within a* deep marine *depositional complex, from* proximal to distal lobes, basin floor fan setting. Generally, the bed thickness and grain size are useful keys to distinguish between proximal and distal environments of the submarine fans. The north Kudat part represents the upper fan of the proximal lobe system (high energy deposits) while the southern Kudat succession represents its more distal lobe system (low energy deposits). Facies distribution recognized in the Kudat Formation are marked by sand-dominated deposits (fluidized, liquefied and grain flows), mixed sand-mud and mud-dominated deposits (turbidity currents).

Thick beds and coarse-grained facies in the northern Kudat Formation (Tanjung Simpang Mengayau) are likely to be deposited in the proximal part of the fan (near the channel). They are reflected by a relatively high concentration of sediment within the flow. Common structures like vertical-escape structures (dish structures and vertical pipes) are good indicator for these deposits. Southward (Sikuati and Matunggong), the sand-mud ratios become significant. Sandy beds and medium- to fine-grained facies are dominant, interpreted to be deposited by high energy turbidity currents. Turbidity currents are normally triggered by earthquake, faulting or major floods, whereby the flows are able to carry large amount of sediment into the basinal environment. As the energy becomes weaker, turbidity currents are able to spread outwards into the basin and deposits thin sheet-like turbidites, which typifies the middle to lower fan environment. The succession in the southern part of the Kudat Formation is thus interpreted to be deposits of weak turbidity currents which carry mud and fine sands into a distal fan depositional environment.

III Provenance

Based on facies, facies associations, stratigraphic architecture and petrographic characteristics, it is interpreted that the Kudat Formation is fed at least by two different feeder systems. The petrographic study shows the immature texture of the northern Kudat Formation deposits; these are coarse-grained sandstones with abundance of angular feldspar and rock fragments, which van Hattum *et. al* (2013) proposed to have been sourced from Palawan, the nearest sediment supply, rich in large amount of granitic and metamorphic rocks. As for Sikuati and Matunggong deposits, mature medium-to-fine grained sandstones, with subrounded quartz are dominant. van Hattum *et. al* (2013) proposed a recycling of the Crocker Fan for the southern Kudat sandstones. The relationship of benthic foraminiferal assemblages to water depth is quite reliable because water mass and sedimentary parameters are commonly correlatable to water depth. Micropaleontology analysis reveals the occurrences of benthic foraminfera, contains agglutinated foraminifera assemblages. The dominant species is *Bathysiphon sp.* which can be found in almost of all the samples, *Caudamminaexcelsa sp., Rhabdammina sp. and Trochammina sp.* suggest a deep sea foraminifera assemblages. The occurrence of *Amphistegina sp., Amphisteginaradiata*, and *Ammonoidea sp.,* gastropods and fragment of corals and bryozoans are indicative of neritic environment. These samples contain mixing of deep marine and shallow marine foraminifera, suggesting from bathyal to neritic.

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Kajian Petrografi dan Geokimia bagi Sumber Granit Selaku Bahan Kuari Pembinaan Empangan Sg. Meda, Bukit Kepong, Pagoh, Johor

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Empangan Sg. Meda akan dibina di daerah Bukit Kepong, Pagoh, Johor. Tujuan pembinaan empangan ini adalah untuk menampung sumber bekalan air di sekitar utara Johor yang dijangka akan semakin berkurangan menjelang tahun 2025. Oleh itu, batuan granit diperlukan sebagai bahan kuari pembinaan empangan ini. Kawasan kajian merupakan kawasan pluton Ma'Okil yang dikelilingi oleh batuan sedimen berusia Kapur ke Trias dan dibatasi oleh enapan superfisial di sepanjang pesisir sungai yang berusia Kuaterner. Menurut Askury (1987) pluton ini telah dibahagikan kepada 3 unit granit yang utama iaitu granit berbutiran sederhana hingga kasar, granit berbutiran halus dan granofir. Kawasan kajian yang bersaiz 25 kilometer persegi ini terletak di utara negeri Johor yang meliputi daerah Gerisek dan sekitarnya. Sebahagian kawasan kajian merupakan kawasan Hutan Rizab Ma'Okil.

Kajian ini dijalankan bagi memetakan batuan dan mencari kawasan berpotensi dijadikan kawasan kuari bagi sumber granit untuk pembinaan empangan Sg. Meda. Selain itu, kajian ini bertujuan mendapatkan hasil analisis petrografi bagi menentukan jenis-jenis mineral di dalam batuan dan mengenal pasti kehadiran mineral reaktif silika seperti tridimit, kristobalit dan mikrohablur kuarza. Analisis geokimia menggunakan kaedah XRF juga dijalankan bagi menentukan peratusan unsur-unsur major dan peratusan unsur-unsur surih yang terdapat di dalam batuan. Seterusnya, kajian ini juga dijalankan bagi membuat pengelasan batuan granit yang terdapat di kawasan kajian berdasarkan kajian lapangan dan geokimia. Menurut Askury (1992) pluton Ma'Okil mencirikan granit jenis I yang berasal dari punca igneus melalui proses peleburan separa.

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PDRG26-144

Lithostratigraphy and Palaeontology of the 'Black Shale' Facies (Chert Unit) of the Semanggol Formation at Bukit Merah, Perak (Peninsular Malaysia)

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The Semanggol formation is known to crop out in Northern and Southern Kedah as well as in Northern Perak (Peninsular Malaysia). The age of the unit is traditionally considered as early Permian to Middle Triassic, based on the palaeontological contents found in the chert unit in Kedah (Hutchison & Tan, 2009). During our recent work in the latter area – at the Bukit Merah 1 section (BM1), located at the old quarry of Bukit Putus – 'black shale' and other associated facies have been identified at the lowermost levels of the chert unit, containing trace and body fossils which are the main object of our study (Fig. 1). Previously, studies in the Northern Perak outcrops of the Semanggol formation have been particularly scarce until some recent contributions: Drahman and Gámez Vintaned (2016) identified the Permo-Triassic bivalve genus *Claraia*; Mansor & Sokiman (2016) described some petrographical aspects of the chert unit; and Drahman and Gámez Vintaned (2017) challenged previous assumptions that the chert unit in Perak had been deposited in a deep marine, oceanic setting – which were based on observations from the unit in Kedah (Hutchison & Tan, 2009) – after an integrated palaeoichnological-stratigraphical study which showed the presence of nine ichnogenera (being represented the *Cruziana* and *Skolithos* ichnofacies), cryptobioturbation, the bivalve *Claraia* and also microbial mats.

However, open questions still remain about the 'black shale' facies of the chert unit, particularly its depositional palaeoenvironment, palaeoxygenation history and biochronological age (assumed to be as old as early Permian, according to Hutchison & Tan, 2009). Thus the aim of this study is to answer those open questions.

In this paper, we have further described the lithostratigraphic and palaeontological contents of the 'black shale' facies of the chert unit, and applied some sedimentological, palaeobiological – specially palaeoichnological –, petrographical and geochemical analyses in order to ascertain the palaeoenvironmental conditions. The age of the 'black shale' facies has been refined in base of the bivalve contents.

The ichnoassemblages identified at the section BM1– comprising twelve ichnogenera – belong to the *Cruziana* and *Skolithos* ichnofacies. The *Cruziana* ichnofacies represents the background palaeocommunity and corresponds to a shallow marine – probably distal deltaic – sublittoral setting, located above the storm wave base but below the action of the fair weather wave base. The *Skolithos* ichnofacies developed during shorter intervals of higher energy.

Summarising the palaeoichnological and sedimentological results obtained from the section BM1, it is revealed a marine shelf environment, showing a coarsening and thickening-upward regressive trend, which is compatible with a prograding, distal deltaic succession undergoing the influence of storm events and fluctuating energy levels. Overall, we confirm herein the views of Drahman & Gámez Vintaned (2017).

As it is well known, 'black shales' are often associated with anoxic conditions at the moment of their deposition, which makes the marine bottom an unsuitable habitat for the immense majority of animals. In contrast with this, the presence of trace and body fossils in a majority of intervals of the 'black shale' facies at Bukit Merah (Perak) suggests that deposition occurred – most of the time – under oxygenated conditions, allowing an invertebrate benthic fauna with aerobic metabolism to populate the seafloor. Those intervals are separated by others which lack palaeontological remains – likely reflecting anoxia at the seafloor – and by some others, more frequent, which reveal episodic sedimentary processes which may have played a role in the oxygenation of the bottom waters of the basin.

Two sources of additional free oxygen (O_2) have been identified, namely the episodic storm events and the presence of microbial mats. They have regularly replenished the oxygen levels at the surface of the seafloor. Hence, the marine bottom was unlikely to have been either dysoxic or anoxic during most of the time recorded by the studied rock interval. Instead, deposition occurred mostly under well-oxygenated conditions. Still, some 'black shale' levels found to be deprived of both

Figure 1: The 'black shale' facies exposed at the section Bukit Merah-1 (BM1). It appears to constitute the lowermost stratigraphic interval of the chert unit at Bukit Merah. The section is divided into 17 stratigraphic levels for sampling purposes. (A human figure at the right side –arrowed – is used as graphic scale).

ichnofauna and shelly body fossils implying that periods of anoxia did exist at some particular time intervals.

From the point of view of the biochronology of the section BM1, the findings of the bivalve *Claraia* cf. *intermedia* Bittner, 1901 at several levels of the succession – stretching from the lower to the upper ones – are relevant (Fig. 2). The genus *Claraia* is a cosmopolitan, Permo-Triassic form with its acme at the Early Triassic. Despite their poor preservation, the specimens of *Claraia* cf. *intermedia* provide an indication of the Early Triassic (Induan) age.

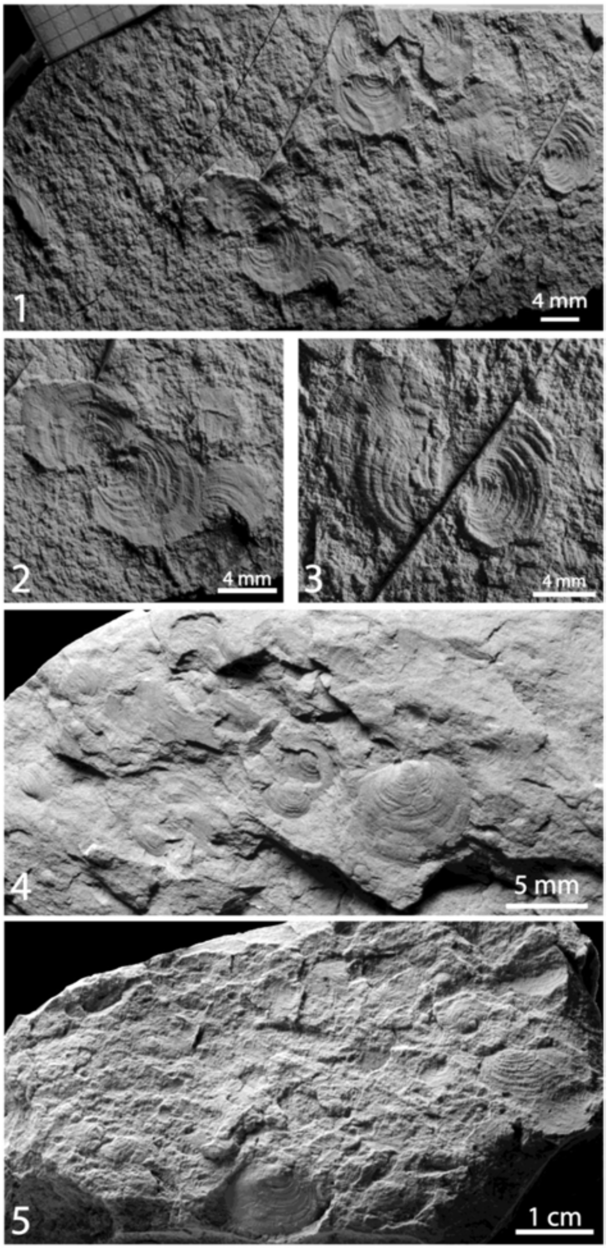

Figure 2: Some specimens of the bivalve Claraia cf. intermedia collected from the studied area; (1) articulated specimens from level BM1/5; (2), (3) close-up of the specimens in (1); (4), (5) two samples showing a continuous size distribution in disarticulated specimens collected from the levels BM1/6 and BM1/16 respectively.

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PDRG27-145

Geologi Am Bukit Besi, Dungun, Terengganu

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Kajian telah dijalankan di sekitar kawasan Bukit Besi, Dungun, Terengganu khususnya mengenai geologi am kawasan. Kawasan ini telah dibangunkan dan telah menjadi tempat perlombongan besi bermula dari penjajahan askar jepun zaman dahulu dan sehingga kini. Kawasan kajian meliputi keluasan 100km^2 yang terletak di sempadan latitud 103°8'T hingga 103°13'T dan longitud 4°42'U hingga 4°47'U. Permasalahan kajian ini adalah kawasan kajian masih kurang dikaji oleh pengkaji-pengkaji lepas khususnya tentang geologi am. Kajian ini dilakukan bagi menentukan jenis-jenis litologi yang wujud di kawasan kajian. Cerapan petrografi bagi mengenalpasti kandungan mineral dan peratusannya dilakukan untuk menentukan penamaan batuan secara sistematik. Bagi mengenalpasti unsur-unsur yang terdapat di dalam batuan, kaedah geokimia Pendaflour Sinar-X (XRF) dan Pembelauan Sinar-X (XRD) dijalankan. Secara keseluruhan, litologi yang terdapat di kawasan kajian ini ialah batuan rejahan igneus iaitu granit dan batuan metasedimen yang telah mengalami proses metamorfisme darjah rendah. Usia batuan metasedimen sekitar kawasan kajian ini telah ditafsirkan berusia Karbon berdasarkan penemuan fosil tumbuhan dan juga korelasi Perlapisan Sungai Perlis (Chand, 1978) manakala batuan igneus pula ditafsirkan berusia Perm-Trias (Hill, 1962). Kebanyakkan metasedimen mempunyai warna merah jambu hingga keperangan akibat luluhawa oksida besi.

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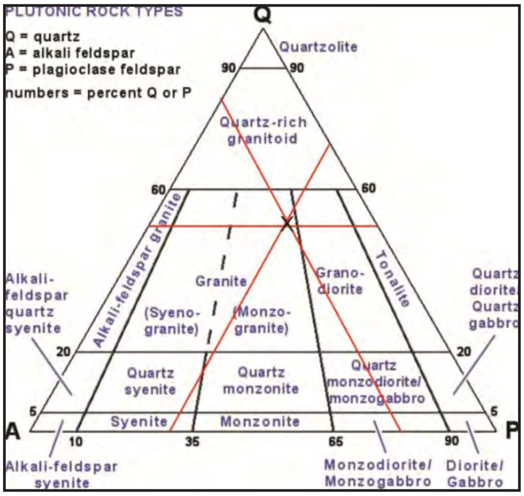

Rajah 1: Gambar rajah QAP bagi penamaan batuan granit berbutir sederhana.

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Kajian Batuan Arenit Formasi Ma'okil dengan Kaedah Petrografi, PSD dan XRD

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Formasi Ma'okil terletak di barat laut Johor merupakan klastik merah yang tebal dan menindih Formasi Semantan.Sedimen ini dinamakan Formasi Ma'okil (Loganathan,1977). Beliau telah mengenal pasti tiga unit yang menghalus ke atas daripada unit rudit yang paling tua kepada unit arenit berusia pertengahan dan unit argillit yang paling muda. Jumlah ketebalan formasi ini ialah melebihi 6700 meter. Unit rudit terdiri daripada lensa yang tebal dan konglomerat berferum berselang lapis dengan batu pasir berpebel dan lava andesitik. Konglomerat terdiri daripada saiz klasta dari pebel-kobel dan jenis klasta terdiri daripada kuarza, kuarzit dan rijang. Di Bukit Lop, lebih kurang 40 meter ketebalan konglomerat masif hingga berlapis tebal yang menindih batuan andesit dan dilombong kerana kaya dengan kandungan ferum. Ferum ini datang dari klasta jenis hematit yang besaiz pebel-kobel yang membentuk jasad lentikular dan tebal sehingga 2.3 meter pada dasar batuan konglomerat (Mohd Shafea & Zakaria 1995). Ferum ini dipercayai datang dari batuan volkanik yang berada dibawah. Selain daripada lapisan konglomerat ada kehadiran jasad batu pasir berbentuk struktur palung yang mengandungi pebel hematit. Unit arenit jenis batu pasir yang dominan ialah ortokuarzit dan subgreiwak (sedikit). Struktur sedimen yang ada ialah perlapisan,laminasi silang dan lapisan silang. Unit argillit dilaporkan adalah yang paling tebal berwarna merah,kelabu-ungu dan syal berwarna maroon serta batu lodak dan selang lapis batu pasir dengan lava andesit hingga trakit.

Loganathan (1978) mencatatkan bahawa strata Ma'okil dan Semantan terlipat dalam beberapa siri lipatan kearah barat laut-tenggara. Beliau pada mulanya mencadangkan formasi Maokil merupakan 'discomformable' terhadap Semantan kemudian ditafsir hubungan sentuhan sebagai 'paraconformity'. Tiada fosil ditemui tetapi dia mengkorelasikan dengan Kumpulan Tembeling. Di bahagian paling atas Formasi Maokil terpangkas oleh sesar, sebahagian besarnya berjurus timur laut-tenggara, timur laut - barat daya. Melalui imej 'RADARSAT' jelas lineamen ini berjurus barat laut - tenggara, pada selatan lembangan Ma'okil. H.D Tjia mentafsir lineamen ini 'dextral strike-slip fault'. Di selatan Formasi Ma'okil terdapat lapisan merah yang tebal merujuk kepada Formasi Payung. Kawasan kajian penulis di terletak di Bukit Kepong dan Lenga. Objektif kajian ini adalah untuk mengenal pasti taburan saiz partikel di dalam sampel tanah dengan menggunakan kaedah Taburan Saiz Sedimen (PSD). Selain itu, kajian juga bertujuan untuk menentukan kandungan geokimia batuan dengan menggunakan kaedah Spektrometer Belauan Sinar - X (XRD) serta membuat kajian petrografi untuk mengenal pasti jenis-jenis mineral dalam batuan.

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PDRG29-171

Geochemistry of Bangka Granites, Bangka Island, Sumatera Indonesia

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This study will provide new petrography and geochemical data of the granites from Bangka Island, Indonesia. The Bangka island is located just east of Sumatera, Indonesia. Bangka is famously known to be south extension of Peninsular Malaysia Main range granite and also a producer of Tin. The Peninsular Malaysia Main Range granite province was known to have dominated by S –type collisional granite based on I and S type granitoids classification. However recent studies show that the Peninsular Malaysia Main Range granite is not exclusively S-type granite. The main minerals that present in the Bangka island granites are megacrystic K-feldspar, quartz, plagioclase, biotite and less common hornblende. The accessories minerals include the zircon, apatite, allanite and ilmenite. The granite from Bangka island have SiO_2 content range from 68.8 wt. % - 77.7 wt. %, Na_2O content range from 2.25 wt. % – 3.6 wt. % , weakly metaluminous to peraluminous (A/CNK = 0.98 – 1.13). The Bangka granites are also high-K calc-alkaline to shosonite series and depleted in Ba, Nb, Sr, Zr, Eu and Ti in multi-element variation diagram. Granites from Bangka Island show evidences of mixed source of greywacke and amphibolite and they are formed within syn-collision tectonic setting. This is evidence from $CaO/(MgO+Fe_2O_3+TiO_2)$ vs $CaO+MgO+Fe_2O_3+TiO_2$ plot. Geochemical data shows that the Bangka island granite are comparable to the Peninsular Malaysia Main Range granite although the granites shows within overlap fields between Peninsular Main range and East Malaya - Sukhotai granite. We suggest that the Bangka Island is southward continuation of Main Range granite province from Peninsular Malaysia.

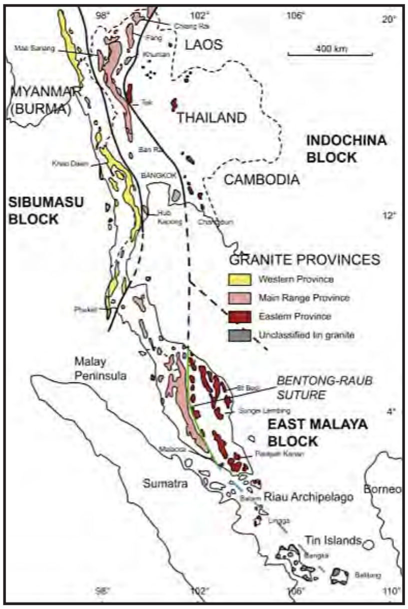

Figure 1: Map shows the distributions of Southeast Asian granites (after Cobbing et al. 1986, 1992).

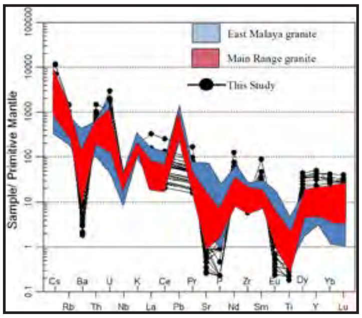

Figure 2: Multi-element variation diagrams of rock samples from Bangka island (this study), Main Range and East Malaya. All sample are normalized to primitive mantle (after Sun and McDonough, 1989). Note the granite from Bangka Island shows depletion in Ba,Nb,Sr,P,Eu and Ti.

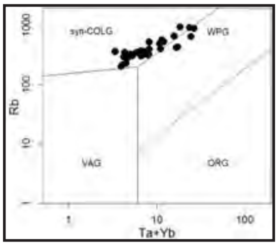

Figure 4: Tectonic discrimination diagram after Pearce et al. (1984). Note that most of the Bangka Island granites are plotted into syn-collisional field.

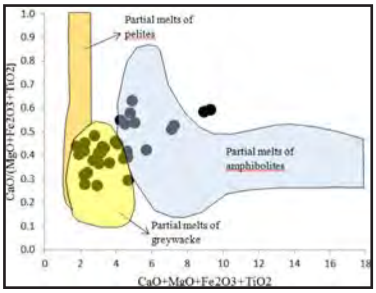

Figure 5: Binary diagram of $CaO/(MgO+Fe_2O_3+TiO_2)$ against $CaO+MgO+Fe_2O_3+TiO_2$. The fields are from Patino – Douce and Harris (1998), Sylvester (1998).

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PDRG30-174

Pencirian dan Tafsiran Paleo-Sekitaran Stromatolites dan Thrombolites pada Jujukan Batu Kapur Setul di Kawasan Langkawi dan Perlis

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Endapan mikrobial dalam jujukan Batu Kapur Setul diwakili oleh endapan lapisan stromatolites dan thrombolites. Setiap struktur yang dibentuk oleh mikro-organisma ini menunjukkan ciri-ciri fizikal berbeza sebagai berstruktur linear, selari, beralun, turus serta jaringan kompleks. Hasil cerapan log sedimen pada jujukan batu kapur (Ahli Setul Bawah dan Ahli Setul Atas) di kawasan Pulau Langgun dan Perlis menunjukkan jujukan ini terbahagi kepada beberapa pengelasan fasies mikrobial antaranya seperti fasies batu kapur stromatolites berstruktur linear (Fsl), fasies batu kapur stromatolites berstruktur alunan (Fsa), Fasies batu kapur onkolit (Fso), fasies batu kapur berstruktur kolumnar (Fsk), fasies batu kapur thrombolites berstruktur jaringan kompleks (Ftk), fasies batu kapur stromatolites berstruktur selari (Fss) dan fasies batu kapur berfosil (Fbf). Walau bagaimanapun, pembentukan struktur stromatolites dan thrombolites ini tidak wujud pada lokaliti yang sama. Struktur stromatolites yang bersifat linear, beralun dan kolumnar adalah terbentuk di kawasan Perlis, manakala jujukan batu kapur di kawasan Pulau Langgun adalah didominasi dengan struktur thrombolites dan stromatolites yang bersifat selari dan jaringan kompleks. Pola taburan serta corak petumbuhan hidupan yang berbeza pada dua kawasan yang berlainan ini dipercayai dikawal oleh faktor persekitaran yang melibatkan tiga proses utama iaitu hidrodinamik, biologi dan kimia. Oleh itu, di dalam konteks tafsiran paleo-sekitaran, jujukan batu kapur ini dipercayai terendap di persekitaran karbonat berlaut cetek yang melibatkan zon subtidal hingga supratidal. Taburan hidupan serta corak pertumbuhan hidupan ini menandakan jujukan perlapisan batu kapur adalah semakin cetek ke arah daratan. Ianya dibuktikan dengan pendominasian struktur thrombolites dan stromatolites yang bersifat jaringan kompleks di kawasan Pulau Langgun dan diikuti dengan pendominasi oleh struktur stromatolites yang bersifat kolumnar, beralun dan linear di kawasan daratan Perlis. Selain daripada itu, pengelasan fasies batu kapur yang menunjukkan perubahan butiran daripada batu bebat ke batu lumpur serta kehadiran butiran alokem seperti bioklas, intraklas, peloid dan mikrit juga menandakan jujukan ini terendap di persekitaran karbonat berlaut cetek.

PDRG31-175

A Dendroid Hydrozoan from the Uppermost Cambrian of Pulau Langkawi, Malaysia

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During the last decades, the presence of fossiliferous Cambrian strata was established in northwestern Langkawi Island, State of Kedah, Peninsular Malaysia (Lee, 1980, 2006; Mohd Shafeea Leman, 1997; Gámez Vintaned *et al*., 2016). The siliciclastic Machinchang Formation embraces a similar Cambrian interval – in base of its close sedimentological and palaeontological similarities – to the one recorded by the Tarutao Formation at Tarutao Island, Thailand (Kobayashi, 1957; Shergold *et al*., 1988), which is ascribed to the uppermost Cambrian Stage 10 of the Furongian Series. Despite of a fragmentary preservation of the fossils, the trilobites *Prosaukia*? sp., *Hoytaspis*? sp., *Lichengia*? *tarutaoensis*, "*Eosaukia*" *buravasi*, *Lophosaukia* sp., and *Quadraticephalus* sp., as well as nisusiid, billingselid, and strophomenid brachiopods, are identified from the middle Chinchin Member of the Machinchang Formation.

Besides, delicate sessile dendroid fossils are distinguished within the same assemblage. The fossil is tubular and, probably, postmortem flattened; thus, tube margins are swollen and reach 0.034 to 0.096 mm. Tubular segments vary in diameter from 0.13 to 0.45 mm and the largest segment is over 24 mm long. Common tube bifurcations – trifurcations do also exist – were probably produced by budding, with new tubes arising at an acute angle; but some minute tubes are attached to the surface of a larger one by a holdfast and are deviated at a right angle to it. The fossil displays a high phenotypic plasticity producing either polygonal encrusting colonies on trilobite carapaces in high energy (sandy) microfacies or erect branching freely standing ones in low energy (silty) microfacies. SEM studies revealed a pure organic (carbon only) composition of tubes.

Among Palaeozoic fossils, archaeoplastid algae, colonial hydroids, and pterobranchs including graptolites possess a similar habit, size range, and sometimes composition. However, neither colonial nor siphonous algae do produce propagules with holdfasts, while pterobranch tubaria show a fusellar structure of the wall (Maletz, Steiner, 2015; LoDuca *et al*., 2017). Hydrozoans only have a similar set of features. Among them, *Marcusodictyon* Bassler, 1952 from the Furongian and Tremadocian of Baltica (Vinn, 2016; see also Taylor, 1984, for a challenge of previous interpretations of the genus as an early bryozoan) and *Sinobryon* Baliński *et al*., 2014 from the Floian of South China are identical to the Langkawi dendroid fossil: *Marcusodictyon* to individuals encrusting on trilobites and *Sinobryon* to erect ones. Also, some Furongian erect branching forms from Baltica, ascribed to *Sphenothallus* Hall, 1847 (Stewart *et al*., 2015), can actually belong to *Marcusodictyon*. The only difference is in the phosphatic composition of the Baltic specimens, but all of them have been studied as encrusters of phosphatic brachiopods, while Chinese ones are pyritized. Thus, Malaysian specimens reveal a synonymy of *Marcusodictyon* and *Sinobryon* and their probable primary organic (chitinous?) composition.

PDRG32-176

Structural Evolution and Basin Development of the Rukwa Rift Basin, Southwest Tanzania

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The Rukwa rift basin is situated in southwest Tanzania and lies within the Western Branch of the East African Rift System (EARS). The main debate over the years relate to the opening dynamics of the rift and its significance to the evolution of the EARS. Two main models have been proposed in many studies: (a) an orthogonal to oblique-slip rift basin and (b) a strike-slip to oblique-slip pull apart basin. This study utilizes recently acquired, high resolution shallow infill grid seismic data combined with vintage seismic to evaluate and propose the extension direction under which the Rukwa rift was formed. The main control on sedimentation and depocentre distribution in the rift is the southwest dipping Lupa border fault, a Karroo-aged fault following the inherited trend of the Palaeoproterozoic Ubendian fabric. Subsequent reactivation of the border fault led to the deposition of the Karroo Supergroup during the Late Carboniferous-Permian, the Red Sandstone Group during the Cretaceous-Palaeogene and the Lake Beds Sequence in the Late Cenozoic relating to the EARS. The basin geometry of the Rukwa rift varies considerably along-strike. To the southeast, a classic half graben geometry exists with overall thickening of sediments onto the Lupa fault and deposition concentrated in a narrow zone adjacent to the border fault. To the northwest, the basin widens with relatively shallow dipping beds dipping to the southeast towards the Lupa fault and thins onto the margin to the northwest, forming a full graben geometry. The central portion forms a transfer zone where displacement is accommodated by high frequency synthetic and antithetic faults as well as flower structures adjacent to the border fault. It is suggested that initial rift development occurred under orthogonal rifting from the Karroo (Late Carboniferous) to early Tertiary. The rift continued to develop in a pure extensional setting during the Late Cenozoic; however experienced a late stage localized dextral strike slip deformation.

PDRG33-178

The Late-Quaternary Sedimentary and Sea-Level History of Shelf Paleo Valleys, Sarawak (Northwest Borneo), Malaysia

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We interpret the late Quaternary sedimentary and sea-level history of three paleo-valleys on the Sarawak continental shelf (off NW Borneo) based on extensive seismic, piston core and radiocarbon age data. Paleo valleys were incised by the Lupar, Rajang and Bintulu river systems during the last glacial maximum (LGM) when relative sea level more than 120 m below present. Approximately 180 km of seismic profiles extend to depths of around 70 m below MSL and were run both across and along paleo valleys. Water depths range from 20 to 50 m. Piston cores penetrated up to 5 m below the seafloor. Paleo-valley fill is dominated by mud. Where cores penetrate the pre-Holocene transgression surface, underlying deposits are dominated by mica-rich, quartz sand and interpreted to represent delta deposits. Preliminary examination of ostracod and foraminifer from piston cores provide a detailed history of climate and environmental change over the last 7000 years. As research progresses and additional ages are obtained, a more complete picture of the post-LGM flooding history and potentially regional variability is expected.

PDRG34-185

Measured Section for the Possible Stratotype of the Miri Formation, at Miri Hill, North Sarawak, Malaysia

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The Miri Formation is continously studied by many researchers in various aspects and disciplines in geology due to the important petroleum reservoir since the period of production in 1920-1941. Same goes to this article, the aim of this study is to analyse a basic principle of postulated stratotype (type section) found in Miri region. A complete sequence of outcrop (measured section) is exposed at Oil Well road which is related to the Miri Formation. The rock formation is displayed as fully equipped of complete sequence bedding by showing numerous facies established for the Miri Formation. It consists of facies 1: planar cross stratified (PcS), facies 2: swaley cross stratified (ScS), facies 3: swaley-Hummocky cross stratified (SHcS), facies 4: Hummocky cross stratified (HcS) and shelf facies. Those facies are believed to have been deposited within a range from shelf to foreshore setting. This measured section found stands by itself without referring to another rock unit either lateral or vertical distribution except the information reported by former researchers that they used sub surface data to evaluate other formation related to it.

PDRG35-187

Taburan Mineral Lempung di Sepanjang Sungai Muar, Johor

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Kajian ini membincangkan tentang taburan mineral lempung di sepanjang Sungai Muar. Kawasan kajian melibatkan singkapan tebing sungai yang terdiri daripada 14 lokaliti yang terletak di sepanjang Sungai Muar, bermula dari Bandar Maharani, Muar sehingga sekitar kawasan Gerisek. Hasil daripada kajian lapangan mendapati jenis batuan di kawasan kajian ialah sedimen jenis lempung yang terbentuk secara semulajadi, terdiri daripada mineral berbutir halus kurang daripada 2 mikrometer. Kajian ini dijalankan bagi menambah maklumat pencirian mengenai jenis-jenis dan taburan mineral lempung yang terdapat di sepanjang Sungai Muar. Objektif kajian adalah memetakan kawasan di sepanjang Sungai Muar bagi mengenalpasti jenis batuan yang terdapat dalam kawasan kajian, mengenal pasti taburan dan jenis mineral lempung yang terdapat di sepanjang Sungai Muar melalui kaedah XRD, menentukan kandungan geokimia sedimen lempung di sepanjang kawasan kajian melalui kaedah XRF serta mengenalpasti struktur mineral lempung secara mikroskopik melalui analisis SEM. Hasil analisis XRD terhadap 14 sampel menunjukkan kebanyakan sampel lempung terdiri daripada komposisi mineral yang hampir sama iaitu kuarza, kaolinit, illit, montmorilonit dan muskovit. Hasil analisis XRF terhadap tujuh sampel lempung menunjukkan 10 unsur major dapat ditentukan iaitu (53.74%-76.80%), (17.47%-32.12%), (1.69%-2.42%), (0.14%-3.05%), CaO (0.04%-0.31%), MgO (0.48%-2.35%), (2.20%8-10.51%), (0.84%-1.06%), MnO (0.01%-0.09%) dan (0.14%-0.27%). Manakala 16 unsur surih yang dapat dianalisis ialah Ba (0.03%-0.10%), P (0.05%-0.09%), Zn (41ppm-0.02%), Rb (100pm-0.01%) , Br (87ppm-0.02%) , Zr (93ppm-0.03%), Ni (24ppm-50ppm), S (0.2%-0.79%), Sr (23ppm-53ppm), Cl (0.03%-3.64%), As (11ppm-67ppm), Ga (29ppm-36ppm), Nb (14ppm-15ppm), Cu (26ppm-76ppm), V (0.02%) dan Co (3ppm) . Hasil daripada analisis SEM terhadap lima sampel lempung mendapati sampel lempung A3, A8 dan A9 ada menunjukkan kehadiran unsur Al yang tinggi iaitu A3 (10.19%), A8 (9.39%) dan A9 (10.27%) serta kehadiran unsur Mg iaitu, A3 (1.17%), A8 (0.38%) dan A9 (0.64%). Sampel lempung A12 dan A14 menunjukkan kehadiran unsur Al yang tinggi iaitu A12 (10.50%) dan A14 (4.95%) tetapi tidak menunjukkan kehadiran unsur Mg. Walaupun unsur Si dan O ada menunjukkan peratusan yang tinggi, kedua-dua unsur Si dan O ini tidak signifikan dalam mengelaskan sedimen lempung kerana unsur silika sememangnya didominasi oleh mineral lempung. Hasil daripada analisis SEM ini, dapat disimpulkan mungkin sampel A3, A8 dan A9 mengandungi mineral lempung jenis Montmorilonit, manakala sampel A12 dan A14 mengandungi mineral lempung jenis Kaolinit.

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PEDR01-04

General Geology and Assessment of Extraction of Drainage Pattern in Jelawang River, Dabong, Kelantan

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This study was about the general geology and assessment of extraction of drainage pattern in Jelawang, Dabong, Kelantan. The purposes of this research were to produce a geological map of the study area, to extract the drainage pattern from the study area and to evaluate the accuracy of drainage pattern extraction from Digital Elevation Model (DEM). Field observation and mapping at the study area were done. Rock samples were collected for laboratory studies. The drainage pattern is extracted from two methods: (1) topographic map at scale 1:25000 and (2) Digital Elevation Model (DEM) extracted from SRTM data using ArcHydro tool. The study area consists of rocks from Permian until Triassic. The rocks included are marble, volcanic origin rocks and sandstone. An acid intrusive granite is the igneous rocks that formed from the cooling of magma below the earth surface. By the finding of hornfel, marble and quartzite nearby the Stong Migmatic Complex, it can be the evidence of metamorphism that occurred due to the intrusion of granite. The obtained results of drainage pattern extracted by the two methods were evaluated using GPS points and visual interpretation. The results show that the drainage pattern extracted from the previous DEM using ArcHydro tool was more accurate comparing to those extracted from topographic maps at scale 1:25000 as this was proved by GPS points.

PEDR02-31

Mobility of Cadmium in Granitic Soil Using Batch and Mini Column Tests

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Introduction

Geotechnical centrifuge have been widely used to study the migration of contaminant in soils (Alshaebi, Zuhairi, & Samsudin, 2010; Antoniadis & Mckinley, 2000; Kumar, 2006). Centrifuge leaching test have shown great prospect to be used as an experimental study for reactive contaminant transport process in fine grained soils. This paper highlights the chemical-physical properties of granitic residual soils and the effectiveness of using batch and column test to study the migration and sorption of heavy metal (Cadmium) through a compacted soil layer.

Materials and Methods

This study was conducted using granitic residual soil (BGR) taken from Broga, Selangor. Physical-chemical tests were analyzed according to British Standard Method, BS1377 (1990). While sorption, batch and mini column infiltration tests were conducted according to USEPA (1992a) and Antoniadis et al. (2007) methods; respectively.

Result and Discussions

Physical characteristic of granitic residual soil is presented in Table 1. Granitic residual soil has highest percentage of sand ranging between 54%-63% and least percentage of clay (1%-6%). It also shows high value of specific gravity ranging from 2.50-2.59. Table 2 indicates the chemical characteristics of granitic residual soil. The pH values of BGR are acidic generally ranged between 5.35-5.85. Other chemical tests are organic matter, specific surface area and cation exchange capacity ranged between 0.22%-0.34%, 17.96m^2/g -21.93m^2/g and 0.79 meq/100g - 1.35meq/100g respectively.

Granitic residual soil was also tested using mini column infiltration test and results are presented in measured breakthrough curves as shown in Figure 1 and Figure 2. All breakthrough curves showed similar trends. The relative concentration of Cd increased with the increasing of pore volumes and then became constant. In higher G-force, the relative concentration of effluent became higher due to less interaction time with the soils surfaces. The results from this study show similarity with the work published by Antoniadis and Mckinley (2000). According to Yaacob et al. (2008), high adsorption capacity was observed at lower Cd concentration. The sorption capacity in all gravity forces can be ranked as; 230G>520G>920G>1440G. Table 3 also indicates the Kd values obtained from mini column infiltration and batch tests. For mini column infiltration test, the Kd values in mix solution showed that an increasing of G-force reduces the Kd values. Result also showed that Kd in batch tests (single and mix solution) gives higher values of Kd (6.2 L/kg and 2.2 L/kg; respectively) compared to all Kd values from mini column infiltration test. However in specific case, Kd value in mini column infiltration test (single solution and the G-force; 520G) showed higher value of Kd compared to Kd in Batch test. This observation was due to the presence of the cracks in 'mudcakes' layer.

Conclusions

This research reveals that granite has good retention to absorb Cd. Physical-chemical test and sorption test using mini column infiltration and batch tests have strong relationship to characterized granite soil and mobility of Cd through compacted soil layer. The study also concludes that the partition coefficient (Kd) values from batch experiment is about 5 to 30 times higher than the mini column. The speed of centrifuge (G-force) is greatly controlled the Kd values from mini column experiment.

Acknowledgement

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Table 1: Physical Characteristics of adsorbent/ residual soils.

Physical Characteristics	BGR
Particle size distribution:	
Sand (%)	54-63
Silt (%)	32-42
Clay (%)	1-6
Atterberg Limit:	
Plastic Limit (%)	38.01-38.69
Liquid Limit (%)	48.50-50.00
Plasticity Index (%)	9.90-11.99
Specific Gravity	2.50-2.59
Max Dry Density (g/cm^3)	1.64-1.71
Permeability	2.08 x 10^{-06}

Table 2: Chemical Characteristics of adsorbent/ residual soils.

Chemical Characteristics	BGR
pH	5.32-5.54
Organic Matter (%)	0.39-0.50
SSA (%)	17.96-21.93
CEC (meq/100g)	0.79- 1.35
SSA: Specific Surface Area; CEC: Cation Exchange Capacity	

Table 3: K_d value obtain from Mini column infiltration test and Batch test.

	Mini Column Infiltration Test				Batch Test			
Weight (g)/ Thickness (mm)	Velocity (RPM)/ G-Force	K_d in Single Solution (500ppm), L/kg	K_d in Mix Solution (500ppm), L/kg	Single Solution		Mix Solution	
				K_d (L/kg)	R^2	K_d (L/kg)	R^2
10	1000 /230G	0.514	0.777	6.2	0.913	2.2	0.838
	1500/520G	23.449	1.079				
	2000/ 920G	0.793	0.420				
	2500/ 1440G	0.981	0.417				

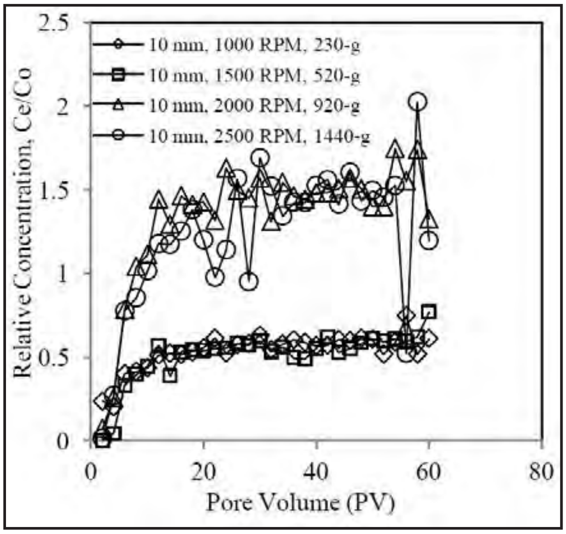

Figure 1: Breakthrough curve for mini column infiltration test by using Cadmium single solution (500ppm) with different G-force.

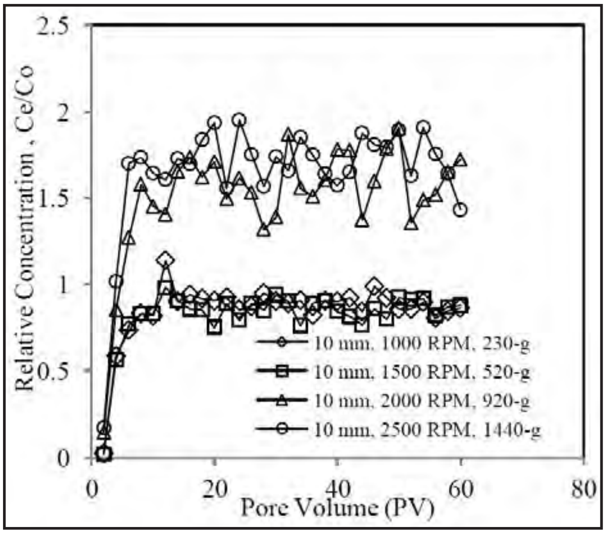

Figure 2: Breakthrough curve for mini column infiltration test by using Cadmium mixture solution (500ppm) with different G-force.

PEDR03-52

The Effect of Physical and Engineering Properties of Stabilization of Burnt Tropical Lowland Peat in the Banting Area, Selangor

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Peat soil is a representative material of soil and well known as highly organic, high compressibility and low shear strength. These soil occur in many countries and formed naturally the decomposition of plant and animal matter. When prolonged drought occur peatlands become dry and can become a tinderbox resulting in fires. When peat forest fires happen, it leads to burn soil and also humic acids as a dominan organic matter contained in peat soil as well as the forest. The impact of the peat fire on peat soil from Banting, Selangor Peninsular Malaysia were investigated through the physical and engineering properties through burnt peat site. The physical properties of the peat samples were determined through natural moisture content (NMC), loss of ignition (LOI), ash content and pH value. The engineering properties of the peat was performed by shrinkage limit of untreated and treated peat and unconfined compressive strength test to determine the strength gain after 14 and 28 days of curing period. The unconfined compressive strength result show the peat soil gained in strength that strongly related to the binder and filler dosage, moisture content of peat and curing time. The UCS value of stabilized burnt peat samples range 106.87 – 245.30 kPa (14 days curing) and 121.48 – 412.17 kPa (28 days), respectively.

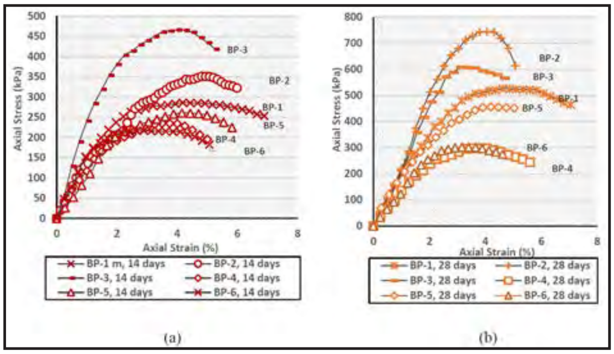

Figure 2: Unconfined Compressive Strength test result of stabilized burnt peat samples (BP-1 – BP-6), a) 14 days; b) 28 days, by using the same composition of mineral soil filler (m.s.f) and Ordinary Portland Cement (OPC).

The value of UCS strength increased with the gain of moisture content of peat samples but the strength tends to be decrease when the moisture content exceed 400%. The UCS strength value tend to be increased but seem to be a slower rate of strength gain after 14 days of curing. The most important geotechnical aspect of peat that have effect on stabilization process are natural water content, humification grade and pH value. The strength of burnt peat can be considerably improved by stabilization.

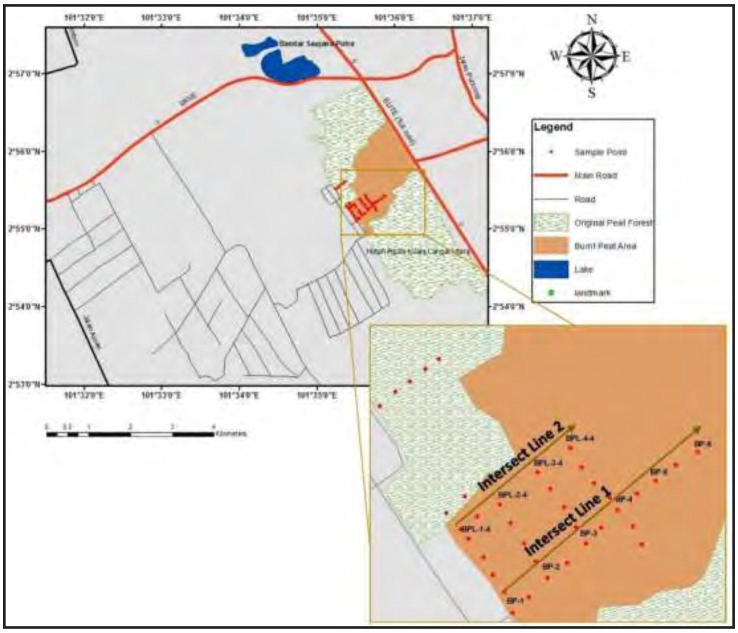

Figure 1: Base map of project area showing the sampling location of burnt peat soil samples.

PEDR04-66

Heavy Metal Distributions and Contamination in Top Soils of Penang Island

FATIMAH AZ ZAHRA' ABDUL HAMID, AHMAD FARID ABU BAKAR & NG THAM FATT

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This study analyse heavy metal distribution concentration in surface soil at surrounding of Penang Island. Thirty-one top soil samples were collected at different type of land uses. Concentration of arsenic (As), lead (Pb), cadmium (Cd) and nickel (Ni) in soil samples were analysed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The As content ranging from 67.92 mg/kg to 2942.08 mg/kg with mean value of 366.61 mg/kg. Pb content ranging from 42.14 mg/kg to 7019.60 mg/kg with mean value of 422.89 mg/kg. Cd content ranging from 0.16 to 16.67 mg/kg with mean value of 1.58 mg/kg. Ni content ranging from 6.48 mg/kg to 1049.24 mg/kg with mean value of 51.71 mg/kg. Spatial distribution maps of selected heavy metals. Indicated that the highest concentration of all heavy metals were found in North East district which has more development and urbanization compared to South West district. In soil contamination factor (CF) assessments, all heavy metals showed higher average of CF in North East district than in South West district. These high average of CF values have classified As as no element enrichment, Pb as considerable contamination, Cd as no element enrichment and Ni as moderate contamination levels.

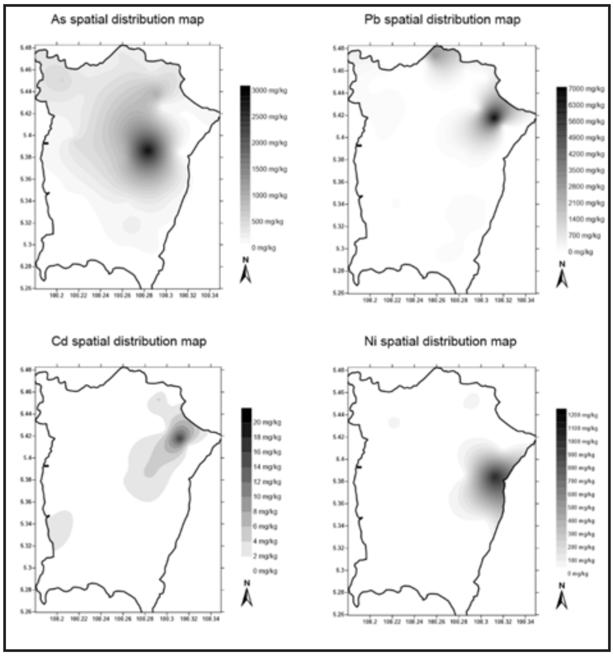

Figure 1: Spatial distribution maps of heavy metal in top soil of Penang Island.

Table 1: Soil contamination factor (CF) assessment results of North East and South West districts of Penang Island.

	As	Pb	Cd	Ni
Contamination factor (CF)				
NE district				
Min.	0.111	0.338	0.126	0.276
Max.	4.253	38.576	6.803	35.555
Mean	0.801	4.201	0.993	3.050
SW district				
Min.	0.098	0.232	0.064	0.220
Max.	0.755	1.172	1.512	2.030
Mean	0.276	0.564	0.317	0.536

PEDR06-89

Comparison Study on the Adsorption of a Synthetic Textile Dye Using Bentonite and Surfactant Modified Bentonite

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Abstract: Dyes entering waterways are less focused on since there are more reports of heavy metals, organic and inorganic compounds pollution.The main aim of this paper is to evaluate the adsorptive potential of Natural Bentonite (NB) compared to Cetyltrimethylammonium bromide modified bentonite (CTAB-Ben) and Cetylpridium bromide modified bentonite (CPB-Ben) on an anionic azo dye. The materials used for adsorption of Acid Blue 25 (AB 25) dye from an aqueous solution was identified using physical characteristics and various test effects.

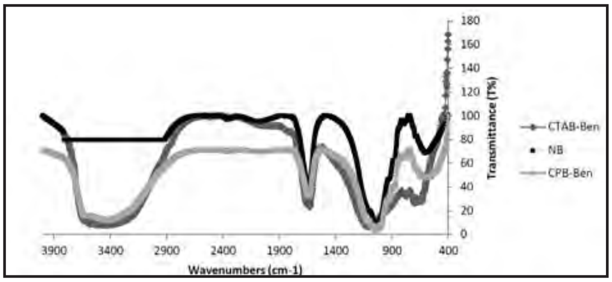

Figure 1:FTIR pattern of NB, CTAB-Ben and CPB-Ben.

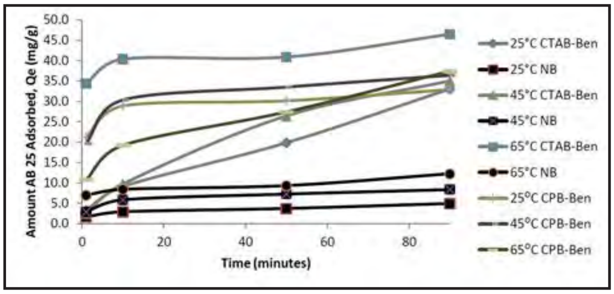

Figure 2: Batch test effect of temperature and time on the adsorption of AB 25 on CTAB-Ben, CPB-Ben and NB.

Table 1: Isothermal equation parameters of the adsorption of AB 25 on CTAB-Ben, CPB-Ben and NB.

Adsorbent	Langmuir			Freundlich		
	q_{max} (mg/g)	b (L/mg)	R^2	K_f (mg/g)	n	R^2
Bentonite	6.8	0.03	0.94	51.29	10	0.89
CTAB-Ben	73.9	0.13	0.96	4677	5.56	0.96
CPB-Ben	59.7	0.01	0.93	3981	7.14	0.92

PEDR07-96

Implications of Climate-Related Hazards on a Coastal Landfill in Selangor, Malaysia

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More than half of the landfills in Selangor are exposed to climate-related hazards in the form of slope failure, flood and coastal erosion (Yahaya et al., 2016). Climate-related hazards at landfills often result in remobilization of wastes that lead to insidious impacts on communities and natural resources (Flynn et al., 1984; Hwang, 2001; Young et al., 2004; Blight, 2008). Early identification of possible implications of waste mobilization on exposed communities and natural resources is crucial to prioritize adaptation measures for affected areas. The implications of coastal hazards has been investigated in a landfill in Sabak Bernam using the source-pathway-receptor-consequence (S-P-R-C) model. The S-P-R-C model is an effective means of visualizing risks from climate-related hazards and is commonly applied in studies related to risks from coastal erosion and flooding (Sayers et al., 2002; Narayan et al., 2011; Horrillo-Caraballo et al., 2013). The model portrays the interaction of systems and processes that lead to a particular consequence through identification of sources, exposure pathways and receptors in the area at risk (Holdgate, 1979). In Sabak Bernam, potential pathways were identified using information on local hydrogeology, surface hydrology and existing protection measures at coastlines. Field inspections were made to verify the characteristics of the pathway and to supplement missing data. Several surface water quality parameters were also measured directly from the field (*in-situ*) and lab analysis was conducted to determine the pollution status and its spatial variation. Potential receptors were identified using land-use information and field observation. There is a risk of release of contaminants due to flood and coastal erosion at the landfill in Sabak Bernam, which is capable of widespread impact on the surrounding community and environment. Waste transportation through surface and subsurface pathways during coastal erosion and flood events may cause widespread degradation of natural resources including surface water, groundwater and the arable soil. The need for integrative adaptation measures at exposed landfill sites is crucial to protect the landfill and receptors in the vicinity and to improve the resilience of landfills towards the hazards.

ACKNOWLEDGEMENT

The research is funded by grants from the Asia Pacific Network for Global Change (APN) (XX-2014-008) and DPP-2015-097 led by Prof. Dr. Joy Jacqueline Pereira. The authors acknowledge the support of various agencies for sharing of data.

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PEDR09-99

Climate Change and its Implications on the Coastal Zone of Kuala Selangor, Malaysia

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Climate change influences on hydrological components pose substantial threats to natural resources in coastal zones. The changing climate accelerates the rate of sea level rise and this has been observed since the mid-19th century (IPCC, 2013). Sea level rise could result in higher occurrence of inundation and saltwater intrusion (Klein et al., 2001; Nicholls & Cazenave, 2010; Wong et al., 2014) that lead to negative impacts on coastal zones and its natural resources. A study was conducted to analyse the impacts of climate change on the coastal zone of Kuala Selangor, which hosts significant agricultural produce and groundwater resources. The analysis was carried out by comparing the simulated data for historical and future periods generated for four climate variables namely surface temperature, rainfall, land water storage, and sea-level. By using Geographic Information System (GIS), contour interval of 0.5 m in the study area is interpolated to identify areas exposed to inundation. The inundation map is then developed to analyse the risk of inundation especially on agriculture areas and groundwater resources. By the year 2100, surface temperature in the study area is projected to increase by 1.3-1.8°C with higher maximum and lower minimum precipitation. Under 0.5 m rise in sea-level, 3,640.32 ha of agricultural areas is at risk of inundation while a 1.0 m sea-level rise would nearly double the area at risk to 7,010.55 ha. Both scenarios indicate that agriculture areas of Kuala Selangor is most at risk to inundation. Inundation from 1.0 m rise in sea-level could result in seawater intrusion is certain parts of Kuala Selangor. Vertical seawater infiltration through the geological layer is not expected to impact the aquifer significantly due to the presence of impermeable clay layers. However, certain areas are at risk from lateral intrusion of saltwater through subsurface. Population growth and urbanization are already threatening the coastal ecosystem in Kuala Selangor. Climate change and sea level rise is expected to further exacerbate the risks posed to its valuable natural resources.

ACKNOWLEDGEMENT

The research is funded by grants from the Asia Pacific Network for Global Change (APN) (XX-2014-008) and DPP-2015-097 led by Prof. Dr. Joy Jacqueline Pereira. The authors acknowledge the support of Mr. Jasni Yaakub and Dr. Saim Suratman as well as various agencies for sharing of data.

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PEDR10-109

Evaluation of Mean Annual Soil Loss: A Case Study from Gua Musang, Kelantan

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Soil erosion is a hazard traditionally associated with agriculture and occurs in tropical and semiarid climate regions which experience high rainfall intensity over the years. It also causes sedimentation when the eroded soil is washed away by water and enters water bodies resulting in river shallowing. This sedimentation downstream reduces the capacity of rivers and drainage channels, increasing the risk of flooding, blocking irrigation canals and shortening the design life of reservoirs.

The Gua Musang area in Kelantan has been affected by severe soil erosion and was chosen as a study area for this research. This study focuses on the application of the Universal Soil Loss Equation (USLE) parameters which are rainfall erosivity (R) factor, slope length (LS) factor, soil erodibility (K) factor and crop management (C) factor. In order to estimate the annual Soil Erosion Loss, numerical values were established for all the factors. In this paper, the emphasis is on the soil erodibility (K) parameter as well as the slope length (LS) parameter. These parameters are directly influenced by the bedrock geology; however, the other factors in soil erosion are also evaluated.

Analysis of soil samples derived from the weathering of granite bedrock records soil erodibility (K) factor values from 0.36 to 0.48 and the slope length (LS) parameter values ranging from 2.07 to 6.00. Soils derived from the weathering of the metasedimentary rocks gave soil erodibility (K) factor values from 0.55 to 0.89 and slope length (LS) parameter was from 0.10 to 2.07. These results indicate that soils from weathered metasediment bedrocks are more erodible compared to weathered granite soils if only the soil erodibility factor, K, is considered. It was supported by particle size distribution analysis result where weathered granitic bedrock are more sandy while the weathered metasedimentary bedrock are more silty. Larger particles are more resistance to transport because of the greater force required to entrain them compared to the finer particles. The least resistance particles are silt and fine sands. Thus soils derived from weathering of metasediment bedrock with high silt content are the most erodible. However, the topography of granite bedrock areas is much steeper as reflected by the higher LS factor. Hence, the values of LS x K were calculated; the values for the weathered granite rocks ranging from 0.75 to 2.88 and the weathered metasediment rocks ranging from 0.06 to 1.84. The multiplication of these two factors show that areas underlain by granite rocks in this study area are more prone to erosion.

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PEDR11-141

Landslide Susceptibility Maps to Support Urban Landuse Decision-Making: Case Study of the Langat Sub-Basin, Selangor

NURFASHAREENA MUHAMAD[1], MOHAMMAD IMAM HASAN REZA[1] & JOY JACQUELINE PEREIRA[1]*

[1]Southeast Asia Disaster Prevention Research Initiative (SEADPRI), Universiti Kebangsaan Malaysia
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The integration of multi-dimensional information using Geographical Information System (GIS) is useful to support landuse decision-making in urban areas. The development of a landslide susceptibility map using GIS will serve as a powerful tool to support informed decision-making to reduce the risk of landslides through appropriate landuse planning. The effectiveness of such a tool would depend on the scale of the information, which should ideally match the needs of the decision-maker. Built-up areas in the Langat sub-basin have expanded rapidly since the 1990s. Over the past two decades, landslides have been widely reported in such areas. The study employed four main methods. These include compilation of landslide incidences to establish a disaster inventory, content analysis to identify the criteria that contributes to landslide occurrences, expert elicitation to provide weightage of the criteria and GIS overlay analysis to process and derive thematic maps. The landslide inventory reveals that landslides are most common in Mukim Kajang, which has the highest expansion of built-up areas. The contributing criteria to landslides were categorized as topographic factors, geological structures and geomorphologic features, and then weighted according to expert input. The Landslide Susceptibility Map for Langat sub-basin was derived from the spatial integration of the weighted multi-dimensional input into the GIS environment. Areas with low susceptibility of landslide dominates at 49.3 km^2 followed by high susceptibility at 212.7 km^2 which was the highest in the sub-basin. Most of the low susceptibility areas are located in flat areas at the center of sub-basin adjacent to the river. The high susceptibility areas covered almost the entire of Mukim Kajang and most of Mukim Cheras which have large tracts of built-up areas. About 48% of past landslides have occurred within these areas. Spatially explicit data at the relevant scale is essential to provide better information to facilitate and expedite the decision-making process for reducing landslide risks. GIS serves as a useful decision support tool in managing disasters in built-up areas and the method employed in this study can be expanded to other regions.

CERAMAH TEKNIK TECHNICAL TALK

The Ordovician Radiation in Reef Ecosystems

Dr. Qi-jian LI
Nanjing Institute of Geology and Palaeontology, Academia Sinica
Date: 18th July 2017
Venue: Geology Department, University of Malaya

Dr. Qi-Jian Li is a geologist and biologist. His main interest focuses on the origin of metazoan 3D reefs in the Early Ordovician. He has just started his new project with Dr. Masatoshi Sone (Geology, UM) on Malaysian Ordovician sedimentology. This project is funded by the Chinese Academy.

Abstract: The Ordovician Period (438–443 million years ago) witnessed the most important diversification event of marine life in Earth history — the so-called Great Ordovician Biodiversification Event (GOBE). The event had a significant influence in level-bottom communities as well as reefs. It was thought that a unique transition from microbial to metazoan-dominated reefs took place in the Middle Ordovician. However, although Early Ordovician reefs were still mainly microbial-dominated, sessile metazoans already began to occupy shallow reef communities. This is documented by lithistid sponge-*Calathium* reefs of the Upper Hunghuayuan Formation (early Floian) from South China. These reefs have a three-dimensional skeletal framework that is mostly produced by *Calathium* and lithistid sponges. *Calathium* had a critical role in reef construction, as demonstrated by well-developed lateral outgrowths, which connected individuals of the same species and with lithistid sponges. Bryozoans, stromatoporoids and microbial components were secondary reef builders. Morphological, constructional and functional analyses provide evidence that *Calathium* was a hypercalcified sponge rather than a receptaculitid alga as previously thought. At the dawn of the Ordovician Radiation, these small-scaled patch reefs thus represent the initial rebound of metazoan-dominated reefs after the late-Early Cambrian archaeocyath reef crisis.

We also discovered the oldest labechiid stromatoporoid (*Cystostroma*) in one of the lithistid sponge-*Calathium* reefs at Zhangzhai, South China. *Cystostroma* occurs as dome-shaped coenosteum with undulating thin laminae. The stromatoporoids and cryptic sponges attached on the walls of *Calathium* as encrusters and cryptobionts. *Cystostroma* might have originated in intraskeletal crypts and later expanded their habitats to open surfaces. Beyond the oldest *Cystostroma*, keratose sponges, *Pulchrilamina* and bryozoans also benefited from the microhabitats provided by *Calathium*. This finding supports that increasing topographic complexity contributed by novel metazoan builders promoted the diversification of reefs and ultimately of the whole benthic fauna. It also implies that hypercalcified sponges may have played a more important role in Early Ordovician reefs than usually assumed.

Late Ordovician reefs from southeast China offer another piece of evidence for tracing the trajectory of reef development after the main pulse of the radiation. In the nearshore areas, coral-stromatoporoid reefs are exposed in the Xiazhen Formation (late Katian) at Zhuzhai (Yushan, Jiangxi). The reefs have a combined thickness of 7.4 m and are metazoan-dominated with most reef builders in growth position. Stromatoporoids and tabulate corals constitute the framework of the reefs. Stromatoporoids dominate the first unit, whereas tabulate corals are the main reef builders in the second unit where stromatoporoids are rare. We attribute this change to a greater tolerance of tabulate corals to turbidity allowing them to thrive in the muddy facies of the upper unit. This facies change is probably related to the increasing terrigenous input from the northwestward expansion of the Cathaysian Land during the late Katian.

The Cathaysian orogeny also led to a short-term exposure of the sea floor in the study area, which terminated the reef growth. We conclude that the waxing and waning of the reefs in South China was strongly controlled by this regional tectonic event.

In the offshore areas, we found the oldest sphinctozoan-coral-microbial reef from the Upper Sanqushan Formation (late Katian) of southeast China, which is also the first report of Ordovician sphinctozoans from South China. Paleogeographically, the studied site belongs to the north margin of Zhe-Gan platform, which developed in a deep-subtidal setting. This is not the preferred habitat of most metazoan reef-builders. The sponges occur in a >120m thick reef that is mainly constructed by calcimicrobes with a low abundance of in situ metazoans, predominantly sphinctozoan sponges and rugose corals. In contrast to the shallower coral-stromatoporoid reefs from the nearshore areas, this sphinctozoan-bearing reef possessed a low diversity of metazoans, indicating that the first reef-building sphinctozoans might have had a larger fundamental niche but were competitively inferior to many other colonial organisms during the Late Ordovician. The detrital input derived from the weathering of volcanic rocks might have been a crucial factor to boost the formation of thick and abundant microbialites on the Zhe-Gan platform during late Katian.

By using sampling-standardized occurrence data from the Paleobiology Database, the results support that the Ordovician Radiation might have been an extension of Cambrian diversification dynamics. The Cambrian diversification was halted by a prolonged greenhouse episode. And high temperatures might have played a critical role in inhibiting metazoan reefs, creating an ecological bottleneck during the middle and late Cambrian.

CERAMAH TEKNIK TECHNICAL TALK

The early evolution and diversity of the Chondrichthyes (cartilaginous fishes - sharks, rays, etc.)

Dr. Gilles Cuny

Date: 26th July 2017

Venue: Department of Geology, University of Malaya, K.L.

Dr. Cuny is the Professor in Vertebrate Palaeontology at the Université Claude Bernard Lyon 1 - Laboratoire de géologie de Lyon, terre, planètes et environnement. He is a renowned researcher in the palaeontology of fossil sharks, and is one of the chief organizing members for the ***7th International Meeting on Mesozoic fishes*** to be held in Mahasarakham, Thailand in early August (https://immf7.msu.ac.th/).

Abstract: It is often said that sharks are "living fossils", that is, they have not changed much since their emergence in the early Silurian (ca. 430 million years ago). This short review of Palaeozoic chondrichthyans aims at demonstrating that this is not the case and that modern chimaeras, sharks, skates and rays show a disparity and a diversity, which is much more reduced than the one of their Palaeozoic ancestors. The phylogenetic relationships of the Chondrichthyes with the rest of the jawed vertebrates (Gnathostomata), which accounts for more than 90% of all living vertebrates, is currently in a state of flux, and the relationships of the fossil forms remain sometimes difficult to decipher. This is mostly due to a poor fossil record of articulated specimens, although a consensus phylogeny seems now to emerge. Finally, the cartilaginous skeleton of the chondrichthyans is not a plesiomorphic (primitive) feature, and sharks do not represent a proxy for plesiomorphic conditions among gnathostomes.

CERAMAH TEKNIK TECHNICAL TALK

Geobiology and Geomicrobiology: Frontier areas in Earth System Science

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Guru Jambheshwar University of Science and Technology,Hisar 125001, Haryana, India
Date: 7th August 2017
Venue: Department of Geology, University of Malaya

Summary of the lecture:

One of the greatest exciting moments in Science during this century will be the discovery of life on another planet (Nealson & Ghiorse, 2001). The recent surprising discoveries of microbes in extreme environments (such as hydrothermal vents/deep ocean floor) have improved our understanding about origin of life on earth, and have strengthened the perceived probability that similar kinds of microorganisms/life forms may exist on other planets. Such grand scientific goals and exciting scientific discoveries are now within reach, because of rapid advances in the fields of geobiology (the study of the interactions that occur between the biosphere and the geosphere) and geomicrobiology (the interaction between microorganisms and their metabolic processes with geological and geochemical processes) during the last two decades. Geomicrobiology requires varied expertise in subjects ranging from geology, geochemistry, mineralogy to microbiology, and microbial ecology. Current and future geobiological investigations will improve our ability to understand the relevant records, interpret them and make predictions, and thereby have a more detailed understanding of the complete history of the earth.

As a matter of fact, the science of geomicrobiology, *per se* is not a new field, as investigations on these aspects began as early as 1838 (Ehrlich, 2002), and has been conducted in various disciplines (microbial ecology, low temperature geochemistry, environmental engineering, economic geology, chemical oceanography). However, this subject did not receive formal recognition until the MSA short course and volume by Banfield and Nealson in 1997 (Fowle *et al.*, 2007).

It is well known fact that the Earth's physical and biological processes continuously interact and influence one another, but we have classified the geological and biological sciences as separate entities in the academic world. There is no doubt that both the disciplines have grown and matured independently but certainly lack of geobiological approach has led to poor understanding of the coupled earth-biosphere interactions. It is only in the past decade that geologists, microbiologists, geohydrologists and geochemists have recognized the significance of these microbial activities. At present, there is general agreement about the importance of microbiological activities in shaping the earth's hydrosphere and atmosphere. Microbes affect and are affected by virtually all geochemical processes that occur at the earth's surface, as well as deep within its subsurface. Microbes have lived at the earth's surface for most (about 85%) of the time since the earth was formed.

There are many potential practical and scientific benefits that might arise from the study of geobiology, some of which are outlined below:

Understanding Biogeochemical cycles: Microorganisms are an essential part of the bio-geocycling of elements (example C, N and S) between the surface of the earth and the surrounding atmosphere.

Waste cleaning: Bacteria are used to clean up oil spills and polychlorinated biphenols in water/soil.

Metal mobility/ Bioleaching: Certain microbes have proven ability to transform toxic, soluble metals into insoluble ones by their mediation by affecting the redox process. *Bioleaching* is a biochemical process by which specific metals in the ores can be concentrated.

Enhancing understanding the Science of Climate Change: Some part of the puzzle relating to global warming are likely to lie inside microbial cells, since multitudes of these tiny organisms emit and deplete enormous amounts of gases (e.g. carbon dioxide and methane) that trap heat around the earth.

Cave geomicrobiology: This field deals with the microscopic life that resides in caves and its interactions with minerals, including mineral dissolution/ precipitation (Baskar, S., Baskar, R. & Barton, H.A., 2009).

Possible solutions for achieving Energy security: Microbes in the organic-rich sediments beneath the ocean floor produce huge amounts of methane gas, which exists in crystalline form; combines with water in the form of methane hydrates.

Extraterrestrial matter: Biosignatures discovered in earth may be important tools in astrobiological studies.

Viewing the earth processes through geomicrobiological lens has changed some of our perceptions. Some examples are discussed, which are by no means exhaustive.

For example, banded iron formations (BIFs) are one of the most abundant chemical precipitates from the Precambrian period. The unique feature of BIFs is that these sedimentary rocks are no longer formed like during the Precambrian period, and consist of repeated thin layers of iron oxides with bands of shale and chert. Some geochemists believe that BIFs could form by direct oxidation of iron by autotrophic (non-photosynthetic) microbes. The conventional concept is that the banded iron layers are the result of oxygen released by photosynthetic cyanobacteria, combining with dissolved iron in the earth's oceans to form insoluble iron oxides.

Another example of such a geological puzzle is the mineral dolomite. There was a time in geological history, when dolomite was formed on the earth in great quantities, e.g. the Dolomite Mountains in the Italian Alps. Dolomite precipitation is mediated by a group of sulphate-reducing bacteria. Currently, dolomite is formed in only a few selected locations such as salt flats and lagoons. Its mineral composition includes magnesium, calcium and carbonate ions, which are common enough in sea water, but the conditions necessary for arranging these components in the ordered, alternating layers that form dolomite are not common today. These conditions and the group of sulphate-reducing bacteria may once have been far more prevalent.

Another important contribution by geomicrobiology, is the recognition the role microbes play as geochemical agents in cave ecosystems. Cave environment being relatively free from weathering and erosional processes, make apparent the subtle chemical changes made by microorganisms. Cave geomicrobiology has also contributed in understanding the pathways of microbial metabolism and biotransformation in geochemical environments. It has helped in understanding the roles microbes play in the formation of caves. It can be as subtle as the generation of CO_2, which forms the carbonic acid that is responsible for the formation of the vast majority of the world's carbonate caves, to sulphuric acid from sulphate reducing bacteria, a mechanism recently reported that can form caves, hundreds of kilometers in length (Engel *et al*., 2004).

The action of corrosive agents in chemical weathering of rock has been long appreciated by geologists but it still remains unappreciated that microbes can play an important role as weathering agents or its ability to act as catalysts in the weathering process. Microbes are known to excrete chemical agents that corrode the rock through chemical interaction/ by oxidizing/ reducing a rock component that leads to mineral diageneis or dissolution.

In the Western world, rapid advances are taking place in the field of geobiology/geomicrobiology. There are many institutions where geobiological and geomicrobiological research has been given prime focus. There are many Universities where formal courses in geobiology/ geomicrobiology are offered and many centers of research in geobiology/geomicrobiology are established (Baskar, S. & Baskar, R., 2009).

In many Asian countries, geologists are not trained in microbiology and vice versa. This pioneer field should be recognized as a thrust area and should be strongly supported as one of the new, important frontier areas of knowledge. There is also an urgent need to offer formal programs in geobiology/geomicrobiology at the postgraduate level, so that the Asian students have the opportunity to explore this frontier area of research. New discoveries can be expected from such cross-disciplinary approaches, which can lead to advances in basic research, of course with huge possibility of applied outcome.

We may conclude that geobiology is a tool which can be applied to address fundamental questions in geology, biology, microbiology, ecology with vast applications in earth and beyond. Formal courses in geobiology and geomicrobiology should be launched. We should ensure that the casual dating between geology and biology (microbiology) should be solemnized into a solid marriage, without any further delay.

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Mapping and Monitoring of Landslide Hazards Using LiDAR Technology

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Remote sensing technologies are indispensible for hazards mapping and monitoring and they have advanced over the decades from aerial photography, satellite optical and radar, terrestrial and aerial LiDAR scanning to UAV Photogrammatery. Malaysian geoscientists were provided with an overview of the latest techniques at the Workshop on LiDAR for Landslide Hazard Mapping and Monitoring, which was held on 11-13th of July 2017 in The Everly, Putrajaya. The Workshop was jointly organized by the Department of Minerals and Geoscience (JMG) and project partners of the Newton-Ungku Omar Fund (NUOF) under the administration of Malaysian Industry-Government Group for High Technology (MIGHT) and Innovate-UK.

The Workshop commenced with officiating remarks by YBhg. Dato' Sri Azizan bin Ahmad, Secretary General, Ministry of Natural Resources and Environment Malaysia (NRE). In his speech, YBhg. Dato' emphasized on the reinforcement of disaster risk reduction strategies and improvement of the preparedness before a disaster strike. YBhg. Dato' also mentioned that a project of this kind is essential in the present day where climatic issues are prevalent, apart from being in line with the National Blue Ocean Strategy (NBOS) envisioned by the NRE to encourage the sharing of skills, knowledge and capacity building. A total of 44 participants comprising technical and academic representatives including risk assessors, engineers, geologists and researchers from different states in Malaysia attended the Workshop. A total of 11 papers were presented by the invited speakers including the NUOF Project Members from Malaysia and United Kingdom. The Workshop began on the 11th of July 2017 with the keynote paper presentation on the Role of Geoscience in Disaster Risk Reduction by Dr. Helen Reeves from British Geological Survey (BGS). Her presentation provided an overview of BGS's role in geology in context of the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction (DRR) and its' priorities. The Natural Hazards Partnership was also explained. Three elements from the 17 Sustainable Development Goals endorsed by the United Nations were also highlighted in the matter of Disaster Risk Reduction; Sustainable Cities and Communities, Climate Action and Partnerships for the Goals.

The first session shed light on the subject of Light Detection and Ranging (LiDAR) application and its practice both in tropical and cold climate land. The presenters for this session shared their insights on their methods, approaches and challenges when conducting geological risk assessments and mentioned the benefits of utilising remote sensing in landslide hazard mapping. This session also highlighted the various uses and pros of using LiDAR specifically in the field of hazard assessment along with some case studies in Malaysia and UK.

The Workshop continued with the field demonstration of Terrestrial LiDAR Scanning (TLS) on the 12th of July 2017 at Bukit Permai, Cheras. Parts of Bukit Permai are classified as critical slopes and the characteristics of the slopes were explained by the facilitators followed by a fruitful discussion on the effectiveness and life-span of the remedial actions taken on the slopes. Participants got to see how the TLS instrument scans and collects data of a slope and were also exposed on its' processing and analysing using a computer.

The last session of the Workshop on the 13th of July 2017 started off with the demonstration of the SIGMA Mobile/Geovisionary which was proven to be useful for hazard mapping in terms of data acquisition and storing. This session was then followed by a dialogue on the Reflections and Way Forward. Issues were highlighted in this dialogue concerning local universities fresh graduates' preparedness to conduct site investigation and perform basic geological tasks at the field and the short-term remediation plan applied in Malaysia. The importance of LiDAR application and ways to fully optimize its' benefits in many fields was also discussed. A better outlook was obtained on new approaches to apply LiDAR technology for the geoscience industry.

A token of appreciation was presented by Tuan Haji Shahar Effendi bin Abdullah Azizi (**middle**), Director General of JMG to YBhg. Dato' Sri Azizan bin Ahmad (**left**), Secretary General of Ministry of NRE, who delivered the officiating remarks.

Various participants attended the Workshop in The Everly, Putrajaya.

Parts of Bukit Permai, Cheras are classified as critical slopes and ranked as very highly hazardous. It poses a risk to the adjacent residential areas. The mitigation measures adopted along the slope consists mainly of wire mesh, shotcrete and rock bolting.

Guided demonstration of the Terrestrial LiDAR Scanning (TLS) instrument next to a critical slope in Bukit Permai, Cheras.

A group photo of the participants at the Workshop.

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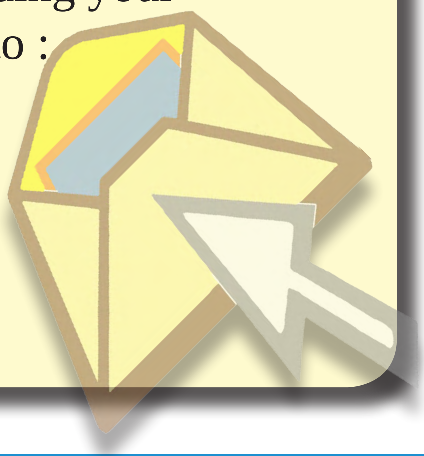


UPCOMING EVENTS

October 26-27, 2017: GSL (Geological Society of London) Conference: Ground Related Risks to Transportation Infrastructure, London. More information at: www.geolsoc.oorg.uk/infrastructure17

October 31-November 2, 2017: GSL (Geological Society of London): Fold and Thrust Belts: Structural style, evolution and exploration. London. More information at: http://www.geolsoc.org.uk/PG-Fold-and-Thrust-Belts-Structural-style-evolution-and-exploration

November 6-7, 2017: Janet Watson Meeting 2017, The Future of Contaminated Land Risk Assessment; stakeholder perspectives. Burlington House, London. For more information visit: www.geolsoc.org.uk/jwatson17

November 7-21, 2017: Puzzling out Gondwana, Bangkok, Thailand. For details, contact: SecretaryGondwana.16@gmail.com

November 13-14, 2017: 2nd Offshore Mexico Congress 2017, Mexico. Contact Email: maisiec@szwgroup.com for further details.

November 15-18, 2017: 1st International Congress on Earth Sciences in SE Asia at Bandar Seri Begawan, Brunei Darussalam, organised by the Physical and Geological Sciences of the Faculty of Science at UBD. Visit http://fos.ubd.edu.bn/foscon/ for details.

November 20-21, 2017: Asia Petroleum & Geoscience Conference & Exhibition (APGCE 2017), Kuala Lumpur, Malaysia. Email: apgce@icep.com.my for details.

November 28-29, 2017: MSGBC Basin Summit & Exhibition. Location: Senegal. Visit http://www.oilandgascouncil.com/conference/msgbc for details.

November 28 – December 1, 2017: The CWC 18th World LNG Summit & Awards Evening, Lisbon, Portugal. More information at: http://world.cwclng.com

December 4-8, 2017: Course on Applied Subsurface Geological Mapping. Kuala Lumpur, Malaysia. Call 60(3) 21471111 for enquiries.

December 6-7, 2017: Geosciences Technology Workshop AAPG, Oil and Gas Resources of India: Exploration and Production Opportunities and Challenges, Mumbai, India. Contact: Adrienne Pereira, Programs Manager, AAPG Asia Pacific Region, +65 96536728.

December 11-13, 2017. Kurdistan-Iraq Oil & Gas Conference, London. Contact KIOG@thecwcgroup.com for further details.

January 3-5, 2018: Tectonics Studies Group & Metamorphic Studies Group joint meeting, hosted by the University of Plymouth. Contact TSG2018@plymouth.ac.uk for queries.

January 4-9, 2018: 5th Biennial Structural Geology and Tectonics Forum, Arizona State University, Tempe. Visit the initial 2018 SGTF website: https://sites.google.com/view/sgtf2018

February 27 - March 1, 2018: Janet Watson Meeting 2018: A Data Explosion: The Impact of Big Data in Geoscience, Burlington House, London. Visit www.geolsoc.org.uk/events for details.

March 15-16, 2018: Alpine Folded Belts and Extensional Basins Geosciences Technology Workshop, Granada, Spain. Website: https://europeevents.aapg.org/ehome/255320/homegranada/

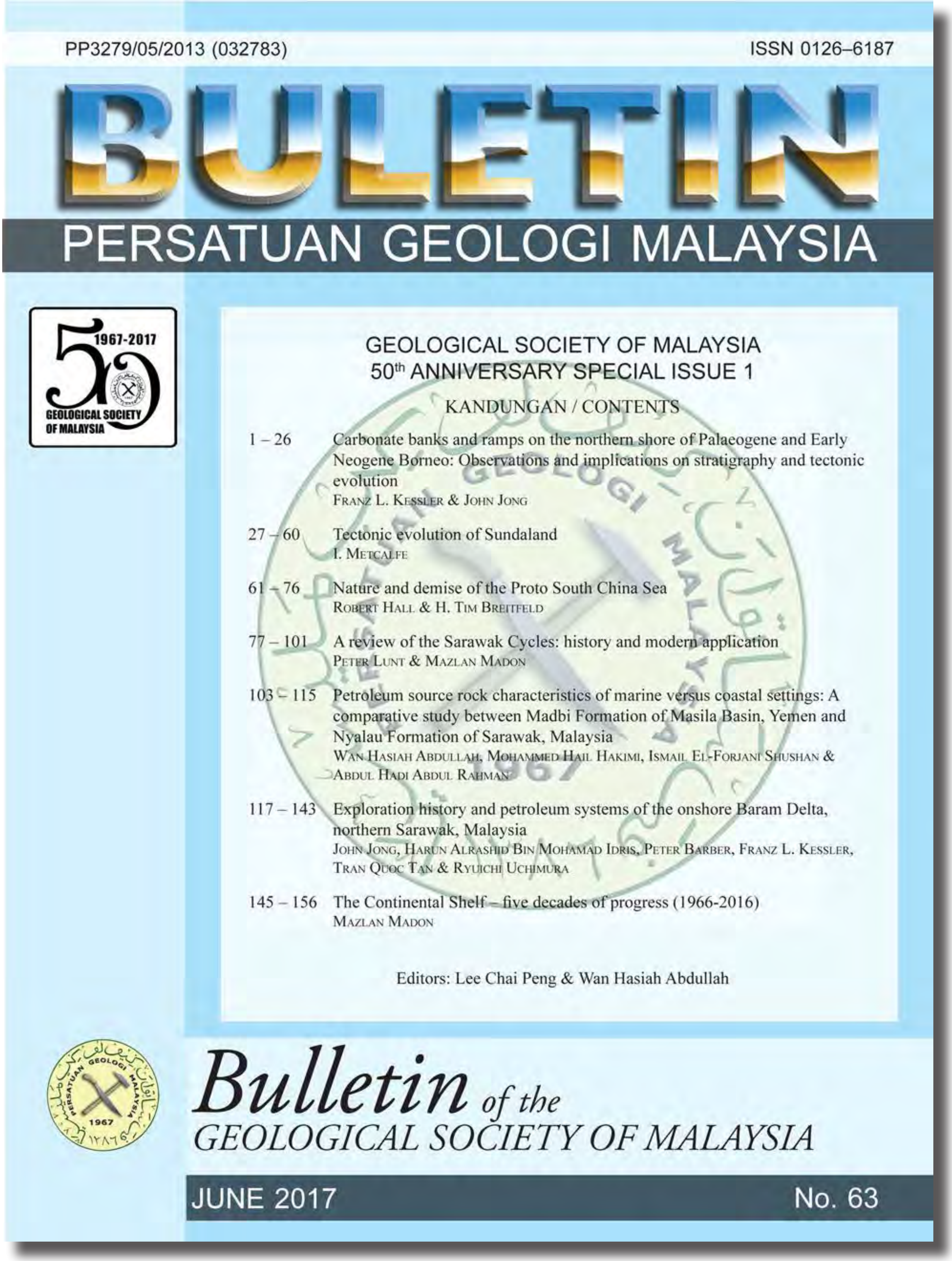
March 20-23, 2018: Offshore Technology Conference Asia (by AAPG), Kuala Lumpur, Malaysia. Website: http://2018.otcasia.org

April 11-12, 2018: EAGE-HAGI First Asia Pacific Meeting on Near Surface Geoscience and Engineering. Yogyakarta, Indonesia. Details at www.EAGE.ORG

June 6-7, 2018: Geosciences Technology Workshop - Pore Pressure and Geomechanics: From Exploration to Abandonment. Perth, Australia. Contact Programs Manager, AAPG Asia Pacific Region +65 96536728 or visit www.aapg.org website for further details.

July 10-13, 2018: Granulites & Granulites 2018 Conference, by the Mineralogical Society of Great Britain and Ireland, Ullapool, NW Scotland. Contact: Tim Johnson, tim.johnson@curtin.edu.au

September 11-14, 2019: 9th "European Conference on Mineralogy and Spectroscopy 2019". Prague, Czech Republic. Preliminary information can be found at http://ecms2019.eu.



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