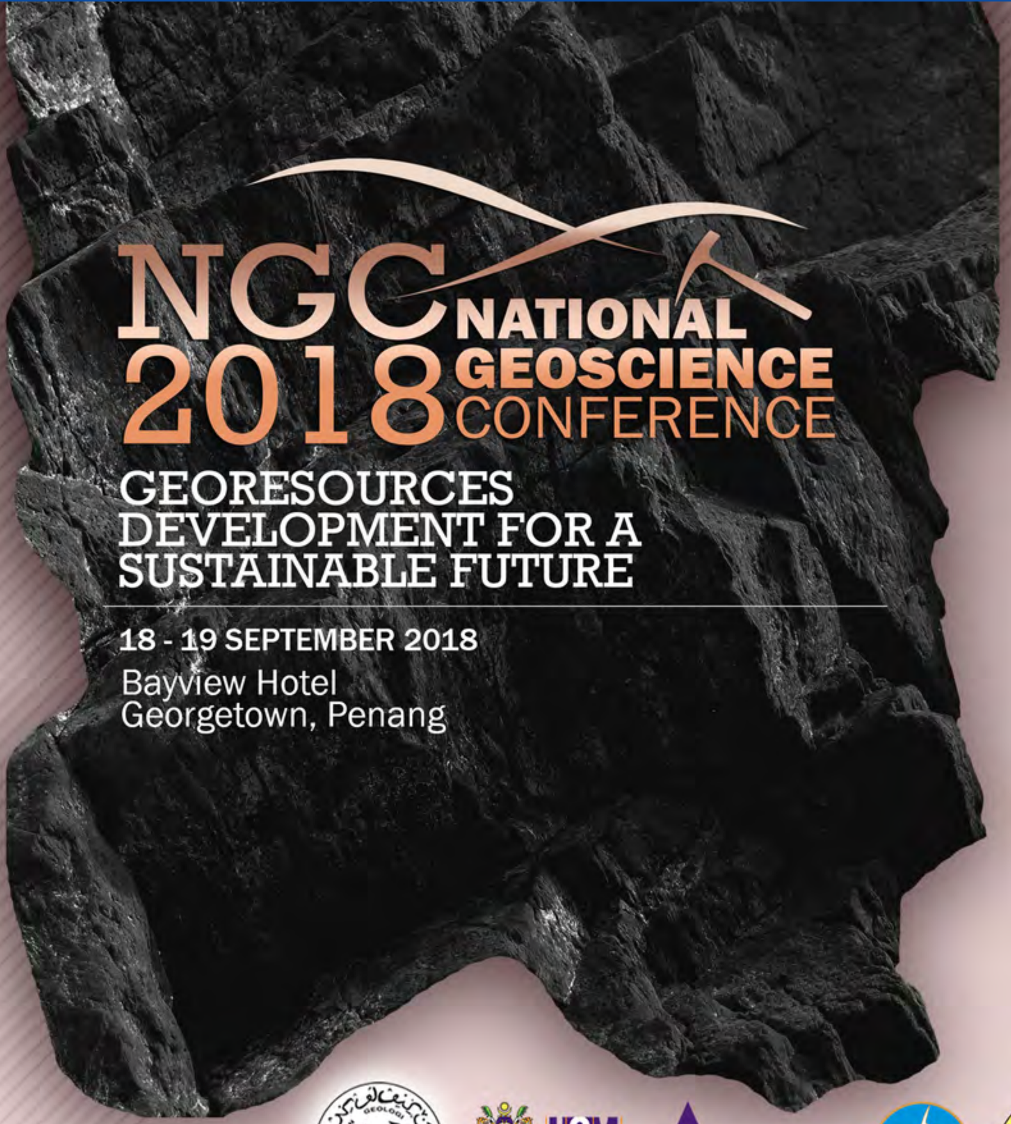
PERSATUAN GEOLOGI MALAYSIA

WARTA GEOLOGI

NEWSLETTER of the GEOLOGICAL SOCIETY OF MALAYSIA



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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:

The Editor
Geological Society of Malaysia
c/o Department of Geology,
University of Malaya,
50603 Kuala Lumpur, Malaysia
Tel: 603-79577036 Fax: 603-79563900
Email: geologicalsociety@gmail.com

NGC 2018 NATIONAL GEOSCIENCE CONFERENCE

31ST NATIONAL GEOSCIENCE CONFERENCE & EXHIBITION

"Georesources Development for a Sustainable Future"

Bayview Hotel, Georgetown, Penang
18th – 20th September 2018

Officiated by:
YB Zairil Khir Johari
Penang State of Executive Councillor (EXCO) for Public Works, Utilities and Flood Mitigation

Jointly organised by:

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Foreword by Chairman of NGC 2018 Penang

It is a great pleasure to Universiti Sains Malaysia **(USM)** and Geological Society of Malaysia **(GSM)** to welcome you to the 31st National Geoscience Conference, Penang, Malaysia **(NGC 2018)**. The Conference is a premiere Geoscience event in Malaysia dedicated in promoting and sharing the development of geoscience fields and research in Malaysia and region.

Annual National Geoscience Conference **(NGC 2018)** is an occasion and platform for academia, geoscientists, government's bodies, research institutes, engineers, individual to share their expertise and research findings. **NGC 2018** is co-organised with the support of Mineral and Geoscience Department Malaysia **(JMG)**; with the involvement of multidisplinary geosciences bodies and institutes i.e. School of Materials and Mineral Resources Engineering **(SMMRE)**, Geophysics program, Global Archaeology Centre of Universiti Sains Malaysia **(USM)**, Institute of Mineral Engineering Malaysia **(IME)**, as the main organiser and host to **NGC 2018** with the involvement of Southeast Asia Disaster Prevention Research Initiative **(SEADPRI- UKM)**. Thus, encourage collaboration in promoting and networking of academicians and professionals in sharing of common knowledge, facilitating exchanged of ideas and to keep abreast with the latest development under the Mineral, Geological and Georesources field.

"Georesources Development for a Sustainable Future" is the theme of **NGC2018**. Knowledge of the earth's systems and processes, together with the application of technology has improved our quality of life through the utilization and management of the earth's natural resources such as rocks, minerals, petroleum, natural gas, groundwater and geoheritage are priority nowadays. The use of technologies and innovation in sustainable resource exploration, mining, processing, exploitation and preservation are essential elements of today's industries and practices. The technical program of **NGC2018** has accepted over 80 working papers that encompassed areas of interests in Petroleum Geology, Engineering Geology/Geomechanics, Geoheritage/Archaeology, Mining/Quarrying and Mineral Processing, Hydrogeology, Remote sensing, Mineralogy/Petrology and other aspects of geoscience discipline either as oral and poster presentation. A one-day short course on Advanced Blasting Technology and a post-conference fieldtrip to Gunung Jerai Geoparks, Fort Conwallis, Guar Kepah, Sg. Batu (Geoheritage) are amongst the attraction of **NGC 2018**.

We would like to express our sincere thanks to Universiti Sains Malaysia **(USM)**, Geological Society of Malaysia **(GSM)** secretariat, Department of Mineral and Geoscience **(JMG)**, Institute of Mineral Engineering Malaysia **(IME)**, sponsors, donors and individuals for their trust and support given for organising and making this event successful. This year an online editorial system platform technology has been adopted in manuscripts and payment process, and last but not least, we thank the USM Committee, GSM secretariat and individual for their support and effort that make **NGC 2018** a successful event that manifested the smart corporation, collaboration and networking.

I am very confident, **NGC 2018** will provide a platform and avenue that promote networking and benefit the community i.e. scientist, academicians, management, consultants, government agencies and interested individuals to keep abreast with the latest development in Geological and Geo-resources field and industries. Last but not least, I would also like to extend my gratitude to the members of the organising committee, editorial sub-committee, reviewers, sponsors and individuals for their dedication, hard work, commitment and support, in planning and ensuring the success of this **NGC 2018**.

Thank you and all the best,

ASSOC. PROF. DR KAMAR SHAH ARIFFIN
Chairman, Joint Organising Committee
NGC2018
18-20 September 2018

PROGRAMME

DAY 1
18 SEPTEMBER 2018 (TUESDAY)

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<tr><th>TIME</th><th colspan="3">EVENT</th></tr>
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Assoc. Prof. Dr Kamar Shah Ariffin (Universiti Sains Malaysia)</td></tr>
<tr><td>8.40–9.20</td><td colspan="2">PL1:

YBhg. Dato’ Yunus Bin Abdul Razak (Board of Geologists Malaysia)

Background to Geologists ACT 2008 - ACT 689</td></tr>
<tr><td>9.20–10.00</td><td colspan="2">PL2:

Mr. Zaidi Harun (Selinsing Gold Mine Sdn Bhd)

Finding Large Scale Metallic Deposit in Malaysia. Have We Exhausted Our Effort?</td></tr>
<tr><td>10.00–10.30</td><td colspan="3">COFFEE BREAK/POSTER SESSION</td></tr>
<tr><td rowspan="2"></td><td>Sri Mas Ballroom</td><td>Sri Perak 1</td><td>Sri Perak 3</td></tr>
<tr><td>Marine Geology/Geoenvironment/ Hydrogeology

Chairperson: Dr Mohd Hazizan Mohd Hashim (USM)</td><td>Geophysics

Chairperson: Mr Syahrul Salehudin (Consultant)</td><td>Geo-archaeology

Chairperson: Dr Suhaina Ismail (USM)</td></tr>
<tr><td>10.30–11.00</td><td>SK1 – Abdullah Sulaiman (JMG)

Offshore Sand Resources and Mining in Malaysia</td><td>SK2 – Assoc. Prof. Dr Rosli Saad (USM)

Resistivity and Magnetic Response on Seulawah Agam Geothermal System</td><td>SK3 – Dr Nasha Rodziadi Khaw (USM)

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<tr><td>11.00–11.15</td><td>S1-90 – Habibah Hj Jamil

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<tr><td>11.15 – 11.30</td><td>S1-82 – Fatihah Binti Azmi

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<tr><td>11.30–11.45</td><td>S1-26 – Hazimah Haspi Harun

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Ground Motion Seismic Surface Wave of the 2015 Shallow Strong Earthquake at Ranau Central Zone Seismically Active Region, Sabah, Malaysia</td><td>S3-99 – Ratnah Wati Rapi

Scientific Application on Bricks from Sungai Batu Monuments</td></tr>
<tr><td>11.45–12.00</td><td>S1-85 – Zaidulkhair Jasmi

An Evaluation of Groundwater Reserve Potential in the Mid Miocene Aquifer System in Miri Basin, Sarawak</td><td>S2-43 – Muhammad Nazrin Rahman

Groundwater Potential Assessment Using 2-D Resistivity Method in Kluang, Johor (Malaysia)</td><td>S3-69 – Naizatul Akma Mohd Mokhtar

The Contribution of Technical Ceramic to Iron Smelting Production at Sungai Batu, Bujang Valley</td></tr>
<tr><td>12.00–2.00</td><td colspan="3">LUNCH</td></tr>
<tr><td rowspan="2"></td><td>Sri Mas Ballroom</td><td>Sri Perak 1</td><td>Sri Perak 3</td></tr>
<tr><td>Mining & Quarry/Mineral Processing

Chairperson: Dr Ismail Ahmad Abir (USM)</td><td>Regional Geology

Chairperson: Assoc. Prof. Dr Habibah Hj Jamil (UKM)</td><td>Geohazards and Disaster Risk Reduction</td></tr>
<tr><td>2.00 – 2.30</td><td>SK4 – Ir. Dr. Mior Termizi Mohd Yusof (IME)

Challenges in Exploration and Mining for Gold</td><td>SK6 – Askury Abd Kadir

Comparison on Geochemical Properties of Andesite from Pos Betau, Pahang with Malay Basin's Volcanic: An Overview</td><td>SK7 – Dr. Alan Thompson

(Cuesta Consulting Ltd.)

Communication of Geohazard Information: An overview of examples from S.E. Asia</td></tr>
<tr><td>2.30 – 2.45</td><td rowspan="2">SK5 – Prof Muhammad Nurdin (Universitas Haluoleo, Indonesia)

Mineral Exploration Potency in Southeast Sulawesi Indonesia: an Opportunity for Research Collaboration</td><td>S5-79 – Syahrul Salehudin

Dry Hole Analysis on Caravel-1 Well, Offshore Canterbury Basin, New Zealand</td><td rowspan="4">SPECIAL SESSION:

Geohazards and Disaster Risk Reduction</td></tr>
<tr><td>2.45 – 3.00</td><td>S5-40 – Abd Alsalam Abduh Saeed Ali Almasgari

Seismic and Sequence Stratigraphy Study of the Central Part of Taranaki Basin Deposits, New Zealand</td></tr>
<tr><td>3.00 – 3.15</td><td>S4-16 – Kanok Kuntawang

Upgrading of Waste from Construction Sand Process: Case Study of Lamthamenchai Deposit Nakornratchasima, Thailand</td><td>S5-66 – Muhammad Murtaza

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<tr><td>3.15 – 3.30</td><td>S4-42 – Ismail Ibrahim

Physical and Physico-chemical Processing of Malaysian Sulphide Iron Ore</td><td>S5-84 – Ilyah Abd Aziz

Geology Exposure for Younger Generation in Malaysia for a Sustainable Future</td></tr>
<tr><td>3.30 – 4.00</td><td colspan="3">COFFEE BREAK/POSTER SESSION</td></tr>
</table>

<table>
<tr><td>4.00 – 4.15</td><td>S4-92 – Abd Rahim Harun

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3D KL</td><td rowspan="4">SPECIAL SESSION:

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<tr><td>4.15 – 4.30</td><td>S4-18 – Ros Sochea

Study on Beneficiation of Silica Sand by Wet High Intensity Magnetic Separators (WHIMs) and Reverse Flotation Technique for Glass Application: A case Study in Sihanoukville, Cambodia</td><td>S5-28 – Najiatun Najla Mohamad

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<tr><td>4.45 – 5.00</td><td>S4-4 – Tagwai Gregory Mathew

Gold Potential Mapping in Kelantan (Malaysia) Using ArcGIS and Excel Applying Frequency Ratio Model</td><td>S5-71 – Maame Adwoa Maisie

Evaluation of Provenance and Clay Minerals of Shales from the Belaga Formation in Central Sarawak, Malaysia.</td></tr>
<tr><td>5.00 – 7.00</td><td colspan="2">END OF DAY 1</td><td>Science Communication for Geoscientists</td></tr>
<tr><td>8.00 pm</td><td colspan="3">Conference Dinner & Official Opening Ceremony

(Grand Ballroom)</td></tr>
</table>

DAY 2
19 SEPTEMBER 2018 (WEDNESDAY)

TIME	EVENT	
8.30 – 9.10	Plenary Keynotes Sri Mas Ballroom (LEVEL 4) Chairperson: Assoc. Prof. Dr Hashim Hussin (USM)	PL3 **Prof. Dato' Dr. Mokhtar Saidin (Centre for Global Archaeological Research (CGAR), Universiti Sains Malaysia)** Geoarchaeology in Malaysia
9.10 – 9.50		PL4 **Mr. Sam Habib (Olympus)** The Applications of Portable XRF and XRD in Geological Settings
9.50 – 10.30		PL5 **Mr. Elysio Campos Neto (Carl Zeiss)** Advances in Geological Microanalysis: Correlation and Machine Learning
10.30 – 10.45	COFFEE BREAK/POSTER SESSION	
	Sri Mas Ballroom	**Sri Perak 1**
	Geo-hazard/Geo-mechanic Chairperson: Dr Ismail Ibrahim (PPM)	**Geophysics/Petroleum Geology** Chairperson: Dr Nor Shahidah Mohd Nazer (UKM)
10.45 – 11.15	*SK8 – Prof. Dr. John Kuna Raj (Engineering Geology Consultant)* Lithologic Map Units and Anticipated Method of Open Excavation (<20m high) in Peninsular Malaysia	*SK9 – Dr. Mazlan Madon (Member of UN Commission of Continental Shelf)* Geoscience Capability Development in the Petroleum Industry: Challenges and Opportunities
11.15 –11.30	*S7-59 – Abdul Ghani Rafek* Geomechanical Characterisation and Rock Slope Stability Analysis, Bukit Kledang, Perak	*S8-48 – Mohd Asraf Khamis* Conventional Core to Outcrop: A Comparison Study of Deepwater Depositional Environment and Implications on the Reservoir Potential
11.30 – 12.00	*S7-109 – Ismail Abd Rahim* Tunnel Support by Rock Quality Index (Q) System for Ultrabasic Rock: A Case Study in Telupid, Sabah, Malaysia	*S8-33 – Seyed Yaser Moussavi Alashloo* Application of VTI PSDM for Imaging Carbonate Structures
12.00 – 12.15	S7-94 – *Frankie Cheah* Strength and Stiffness Parameter Study of Kenny Hill Formation with Consideration of Constitutive Soil Model in for a Finite Element Analysis	*S8-5 – Satyabrata Nayak* Linking Shelf to Deep Water: Understanding Deep Water Sedimentation in Above Grade Slope Setting using Near Surface Seismic Data. A Case study from Sabah Deep Water
12.15 – 12.30	*S7-95 – Mohd Farid Abdul Kadir* Landslide Susceptibility Assessment of the Cameron Highlands, Pahang, Malaysia Area Based on Combined Spatial Analysis Model – Frequency Ratio and Logistic Regression.	*S8-45 – Douglas Law* Delineation of Fracture Zone using 2D Electrical Resistivity and Induced Polarisation Methods
12.30 – 12.45	*S7-78 – Mohd Faiz Mohammad Zaki* Assessment of Geological Condition for Tunnels Analysis using Inverse Distance Weighting Method (IDW)	*S8-53 – Abubaker Alansari* High Resistivity Reservoirs (Causes and Effects): Sahara Field, Murzuq Basin, Libya
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1.00 – 2.30	**LUNCH**	
	Sri Mas Ballroom	**Sri Perak 1**
	Mineral Exploration/Geochemistry Chairperson: Dr Nordiana Mohd Muztaza (USM)	**Geophysics/Petroleum Geology** Chairperson: Dr Nurul'Ain Jabit (USM)
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2.45 – 3.00	*S9-25 – Esther Boateng Owusu* Mineralogical Analyses of Belata Black Shale, Peninsular Malaysia	S10-54 – *Nur Hazira Hamsan* Seismic Anomaly Identification in Pliocene Stratigraphy, BG Field, Malay
3.00 – 3.15	*S9-89 – Teuku Andika Rama Putra* Zero Mercury Implementation Management of Artisanal Gold Mining at Geumpang Mountain, Pidie - Aceh, Indonesia	*S10-39 – Walaa Elnasir* Geological Interpretation of Spectral Gamma Ray (Sgr) in Nyalau Formation of Black Shale and Mudstone of Central Sarawak, Malaysia
3.15 – 3.30	*S9-3 – Shaib Abdulazeez Shehu* Preliminary Assessment and Optimization of Blasting Cost and Cycle Time of Load-haul Unit of Obajana Cement Quarry	*S10-47 – Md Yazid Mansor* Malay Basin Upper Pliocene Shallow, Low Pressure Gas Potential: Its Implication Towards Onshore Peninsular Malaysia Deltas Hydrocarbon Prospectivity
3.30 – 4.00	COFFEE BREAK/POSTER SESSION	
4.00 – 4.15	*S9-70 – Ali Yaraghi* Geochemical Assessment of REE Associated With Weathered Crust of Malaysian Granite Profile	*S10-44 – Ismailalwali Babikir* Seismic Geomorphology Analysis of Coal-Bearing Reservoirs using Waveform Classification: A Case Study from the Northern Malay Basin
4.15 – 4.30	*S9-70 – Sharan Kumar Nagendran* Application of UAV Photogrammetry for Quarry Monitoring and Assessment	*S10-63 – Nik Nur Anis Amalina Nik Mohd Hassan* Seismic Geomorphology of Channels in X-Block, Penyu Basin
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2	PGE27	Fitri Akhir, Aida Saad and Azazi Zakaria	Desulfurization of Groundwater Using Marble Filter
3	PGE51	Siti Aisyah Ramli, Askury Abd Kadir	Physico-chemical Characteristic of Black Shale from Sungai Perlis Bed around Kijal, Terengganu
	GEOPHYSICS		
4	PG8	Nordiana Mohd Muztaza, Muhammad Taqiuddin Zakaria, Tajudeen Olugbenga Adeeko	Slope Investigation Using Integrated Geophysical Methods
5	PG9	Hazrul Hisham, Nordiana Mohd Muztaza, and Muhammad Taqiuddin Zakaria	The Study Of Chepor Member Facies At Bumita Quarry, Perlis Using Seismic Refraction and Electrical Resistivity Method
6	PG29	Nur Azwin Ismail, Iffah Zalikha Roslan and Kalai Vani Thirmalingam	2-D Resistivity and Time Domain Induced Polarization (TDIP) for Shallow Subsurface Characterization
7	PG50	Afiq Farhan abdul Rahim, Mohd Farid Mohd Dali, Mustapha Atta and Abd Rasid Jaapar	Observations on Comparative Geological Interpreta-tion of Two Different Resistivity Surveys for the Same Landslide Prone Area
8	PG57	Hamzah Hussin, Mohd Hariri Arifin, Tajul Anuar Jamaluddin & Nadzari Ismail	Pencirian Jasad Batuan Terlindung Shotcrete Meng-gunakan Survei Tomografi Keberintangan Geoelektrik
9	PG86	Nurulamani Rosman, Aisah Abdullah, Ismail Ahmad Abir	The Effect of Land Reclamation on Water Clarity in Tanjung Tokong using Remote Sensing
10	PG87	Dwiky Pobri Cesarian, Ismail Ahmad Abir, Muhammad Isa	Identifying Geothermal Potential Sites in Jaboi Field, Sabang Using Satellite Data
	GEO-ARCHEOLOGY		
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12	PGA75	Norhidayahti Mohd. Muztaza, Mokhtar Saidin and Hamzah Mohamad	Mineralogical Analysis to Identify Ancient Furnace Structure in Jeniang, Kedah
13	PGA76	Wani Maler, Suprayitno and Mokhtar Saidin	Perbandingan Terhadap Batu Nisan Khas Barus dan Batu Nisan Plak-Pling: Berdasarkan Analisis Motif Ragam Hias
14	PGA77	Nurazlin Abdullah, Nor Khairunnisa Talib and Mokhtar Saidin	Mineralogical Evidence from Bukit Bunuh Impact Crater and its Contribution to Prehistoric Lithic Raw Materials
15	PGA91	Noridayu Bakry, Jeffrey Abdullah, Mokhtar Saidin and Shyeh Sahibul Kara-mah bin Masnan	Kapak Genggam Bukit Bunuh, Lenggong, Perak: Isu Dan Perdebatan Teori Movius Line Di Asia Tenggara
16	PGA100	Siti Nurul Siha Mohamad, Mokhtar Saidin and Goh Hsio Mei	Sungai Batu As a Geosite In Jerai Geopark And Its Contribution to The Geoarchaeo-Tourism Industry in Malaysia
17	PGA101	Mohd Hasfarisham Abd Halim and Mokhtar Saidin	XRD, XRF and SEM Analysis of Pottery from Jetty and Administrative Sites, Sungai Batu Complex's, Bujang Valley, Kedah

	GEOPHYSICS/PETROLEUM GEOLOGY		
18	PPG14	Mazshurraiezal Nasir, Abdul Hadi Abd Rahman, Zainey Konjing and M Azfar Mohamed	Tertiary Palynomorph from The Lambir Formation (Middle – Late Miocene), North Sarawak, Malaysia
19	PPG35	Amir Abbas Babasafari, Deva Prasad Ghosh, Seyed Yaser Moussavi Alashloo, Yasir Bashir, Chico Sambo and Ahmed M. A. Salim	Seismic Reservoir Characterization in a VTI Anisotropic Media: Case Study in Malay Basin
20	PPG46	Nur Khalisa Binti Abdul Hamid, Numair Ahmed	The Effect of Shale Content to Reservoir Properties Using Synthetic Core Plug Analysis
21	PPG49	Zainey Konjing, Abdul Hadi Abd Rahman	Facies and Stratigraphic Architecture of Fluvial to Tidal Transition in a Mixed Tide-Wave-Influenced Estuarine Deposits; an Example From Nyalau Formation, Central Sarawak, Malaysia
22	PPG114	Choong Chee Meng, A Previna, Sean Lee Cheong Heng, Ooi Wei Chian, Nik Azfar Azwanis Nik Aziz, Muhammad Noor Amin Bin Zakariah, Khairul Arifin Bin Mohd Noh	Geological Modelling using Gravity Anomaly Data: Lumut – Gua Musang Transect, Malaysia

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24	PME32	Siti Nadzirah Nazri, Azman Abd Ghani	Major Element Geochemistry of Soil Produce from Felsic Volcanic Rock in Teluk Ramunia
25	PME36	Ahmad Fauzan Yusoff, Jasmi Hafiz Abdul Aziz	Mineralogy and Geochemistry of Iron-Copper in Mengapur Project, Sri Jaya, Pahang, Peninsular Malaysia
26	PME38	Nur Nadwa Syahirah Ai Zamruddin, Jasmi Hafiz Abdul Aziz	Trace Elements Composition of Iron at Pulai, Kelantan
27	PME41	Anuar Othman, Azli Sulaiman, Ismail Ibrahim and Mohd Syahrir Mohd Rozi	The Effectiveness Study of Calcium and Magnesium Oxides in Acid Mine Drainage Treatment
28	PME103	Mohd Hazizan Mohd Hashim, Khairul Shazwan Pelawang and Shaib Abdulazeez Shehu	Prediction of Blast Induced Vibration at Lafarge Quarry in Kanthan, Ipoh, Perak
29	PME104	Syed Mohd Syafiq Idid, Suhaina Ismail and Nurul 'Ain Jabit	A Preliminary Characterization Study of Copper Dross (CD) and Roasted Copper Dross (RCD) as a By-Product in Tin Smelting
30	PME105	Khong Ling Han, Hareyani Zabidi & Kamar Shah Ariffin	Textural and Morphological Properties of Aplitic Kaolin from Kinta Valley
31	PME108	Mohd Haikal Rosli, Mohammad Hafizuddin Mohd Safri, Hareyani Zabidi, Nurul Ain Jabit & Suhaina Ismail	Mineralogical Characterisation of Complex Sulphide Gold Ore from Pahang, Malaysia
32	PME110	Hud Mohamad Muzaffar, Suhaina Ismail, Nurul Ain' Jabit & Hasliza Mat Saad	Physical and Chemical Characterisation of Malaysian Sulphide Gold Ore from East Peninsular Malaysia
33	PME113	Shafinaz Saad & Syed Fuad S. Hashim	Effect of grinding additives in dry grinding of mica in planetary mill

	REGIONAL GEOLOGY		
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35	PRG55	Nabilah Mohamed Zainuddin, Siti Nur Fathiyah Jamaludin, Choong Chee Meng, Mohd Suhaili Ismail	The Geology of Kudat Peninsula, Sabah: New Insights from Field Geology and Subsurface Interpretation
36	PRG65	Abdul Hadi Hashim, Habibah Jamil, Zainey Konjing, Ramlan Omar	Quaternary Biostratigraphy of Borehole Sample (BH1) from Pontian, Western Johor, Peninsular Malaysia
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Olympus
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Prof. Dr. John Kuna Raj
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PLENARY KEYNOTES

Background to Geologists Act 2008 - Act 689

YBhg. Dato' Yunus Bin Abdul Razak

Board of Geologists Malaysia

The Geologists Act was initiated way back in the 1980s by a concerned group of geologists as a result of a number of natural incidents which resulted in a loss of lives, such as the Gunung Cheroh landslide in Perak, and the Genting Sempah landslide in Selangor. The need of this Act arose because there was no control over unqualified people who were free to prepare geological reports and to make any recommendations without fear of consequences. The impetus of this Act was realized as a direct result of the collapse of Highland Towers on 11 December 1993 which resulted in a loss of more than 50 lives.

Following a Cabinet decision, Kementerian Perumahan dan Kerajaan Tempatan (KPKT) set up a committee to review and strengthen the Akta Jalan, Parit dan Bangunan 1974 (Akta 133). Several recommendations were put forward to the Cabinet in June 1994, among which was a guideline on the development of highland areas. In early 1996, the guideline were further reviewed, and it was expressly required that any geotechnical and geological reports have to be prepared and certified by qualified professionals. However, at that time there was no law to define who is a qualified geological professional, and hence the Geologists Act was enacted to register professional geologists and to control geological practices.

The essence of this Act was intensely debated, discussed and amended by members of Institute of Geology Malaysia since it was first proposed. In 1998, a meeting was held between the Legal Advisor of Ministry of Primary Industries (KPU), Mr. Peh Suan Yong, and officials from KPU, JMG and IGM to review a draft of the proposed Act. In August 2001, a discussion was held at the Attorney-General's Chambers (AG) between the Legal Advisor of the AG's Chambers, officials from KPU (including Mr. Peh) and IGM. However, there was a delay in finalising the proposed Act when the person-in-charge in the AG's Chambers was transferred and thereafter Mr. Peh himself was transferred.

Discussion on Geologists Act was revived in mid 2002 when a new officer from the AG's Chambers, Mr. Bhupinder Singh, and a desk officer from JMG, Mr. Seet Chin Peng, were assigned to handle the proposed Act. A discussion was held between Mr. Bhupinder and officials from the IGM Council on 11 September 2002 to finalise the proposed Act, and subsequent to this discussion, the Act was sent to KPU for approval. The proposed Act was returned to JMG on 30 Oct. 2002 and following this a Cabinet Paper was submitted to Cabinet on 3 January 2003. After a break of more than 4 years, the proposed Act was approved by the Cabinet on October 2007. The proposed Act was then tabled to Parliament in May 2008 and was approved on July 15. It was consented by the King in early August and gazetted on August 27 2008 as Geologists Act 2008 – Act 689. It finally came into force in December 2014 when a Board of Geologists was set up.

The Board of Geologists (BoG) comprised 14 members, a Chairman, a representative from IGM, 5 members from the public sector, 5 members from the private sector and 2 Minister's nominee. The board members serve a maximum of 2 terms, each term of 3 years. The primary role of BoG is to enforce the Geologists Act and to control the practice of geology.

Finding large scale metallic deposit in Malaysia. Have we exhausted our effort?

ZAIDI BIN HARUN

Monument Mining Limited, Canada
Email address: zaidi.harun@selinsingmine.com

Abstract: Since the collapse of the tin industry in mid-80's, there were hardly any systematic exploration for hard rock tin deposits in Peninsular Malaysia. A few exploration programmes were carried out by foreign companies but did not yield and meaningful results (Yeap, 2000).

Sg Lembing tin mine were consider a large hard rock system that were mine in the late 19th century. From 1880 to 1987, underground tunnelling (shaft and adits) methods yielded about 8,472,750 tons of ores averaging of 1% for a total ore contained 86,717 tonnes of tin metal.

The Sungai Lembing mine had produced large amount of metal over the century however the site is hardly seen any systematic re assessment study to determine the true size of the deposit.

Within the central gold belt, despite a large exploration campaign conducted by Geological Survey Malaysia and foreign exploration companies in the 80s and 90s, there is no major discovery of large metallic metal deposit outside the known hard rock gold occurrence at Selinsing, Buffalo Reef, Raub, Penjom and at Ulu Sokor in Kelantan.

Selinsing, Penjom and Raub were all an historical site which were discovered and operated intermittently through history for more than 100 years. The introduction of block system in the 90s attracted foreign capital to re assess the site led to expansion of the known resources.

The Penjom gold mine was developed by Avocet Mining plc in 1996 with a reserve of 223,000 ounces of gold and by the end of 2013, Penjom had produced approximately 1.4Moz and remaining resources are <u>21mt at 1.63g/t</u> or 1.2Moz.

Monument acquired the Selinsing and Buffalo Reef property in 2007 from the previous operator and commenced commercial production in 2010 and since produced a total of 280,000 Ounce of gold with a remaining resource of 764Koz including reserve of 279koz Au at 1.4g/t.

At Raub gold mine, operated intermittently since 1889 had produced more than 1mOz. Peninsular Gold Ltd, of UK announced 180,000 ounces of proven reserves in a large tailings deposit immediately adjacent to its existing processing plant in Pahang. Additional resource were declared by the company at its Tersang-Tenggelan-Chenua project areas estimated to contain about 579,000 ounces.

At Ulu Sokor, Kelantan CNMC of Singapore identified a total measured, indicated and inferred gold resources for the Sokor project are 13.8mt at 1.6g/t gold for a total of 724,000 ounces. A total of approximately 120Koz were produced till end of 2017.

Mengapur base metal project is the first major metallic metal discovery from a grassroot exploration activity in central gold belt. The deposit was first identified by geological survey Malaysia from a reconnaissance drilling program carried out in 1979 and subsequently via an agreement signed between the government of Pahang and Malaysia Mining Corporation in 1983. MMC completing a drilling program from 1983 to 1988 and a definitive feasibility study in 1990, MMC did not pursue development of Mengapur and the land reverted back to the Government of Pahang sometime after 1993. Monument Mining Limited acquired Mengapur project in 2011 and since then completed additional 58,000m of drilling and currently finalising the NI 43-101 resource reporting for Mengapur project. Historical report showing Mengapur hosting 762,000 tonnes of copper, 1.1mOz of Au, 64mOz of Ag and 45million tonne of magnetite.

In Sarawak, the Bau gold field has been intermittently mined since the mid-19th century with historic production of more than 3M oz gold. Besra in their technical report update 2012, showing Measured and indicated resource of 21.3mt @ 1.64g/t Au and inferred resource of 51.3mt @ 1.32g/t from 34 prospects along 15km long and 7km wide mineralisation corridor.

In 2018, the Sabah state government in a historic event after the closure of Mamut copper mine in 1999, permitted the operation of open cast gold mining activities at Mantri, Tawau. The project reportedly hosting a gold resource between 1.5 to 1.8mt of at 4.5g/t to 4.6g/t for total ounces between 242,000 to 263,000 ounces.

In recent years, the main challenges faced by the mining and exploration industry in Malaysia today are the lack of available land for mining, the short period of mining lease, as well as the small area of mining tenement granted by the state authorities. These situation does not encourage large scale exploration activities nor attracted investment from major companies. The prolonged depress investing environment had not auger well for major discovery of metallic metal. The window is closing down rapidly with urbanisation especially within the Kinta and Klang Valley and opening of land for other land used.

Both combined tin field had produced most of world tin production over the century from placer mining activities but lacking hard rock exploration initiative that can led to its revival.

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PL-3

Geoarchaeology in Malaysia

MOKHTAR SAIDIN

Centre for Global Archaeological Research (CGAR),
Universiti Sains Malaysia, 11800 Pulau Pinang.
Email address: mmokh@usm.my

Abstract: Geoarchaeology represents the interface of the geosciences with archaeology, where geological approaches and techniques are used to answer anthropological questions about the human pasts. Therefore, geoarchaeology is the application of concepts and method of the geology, especially geomorphology, geophysic, geochemistry, petrology, sedimentology and pedology. The geoarchaeological research approach is truly multidisciplinary, and can be a subfield of geology, earth sciences or anthropology. It is focus on the use of palaeoenvironmental reconstructions, the analisis of sediments and stratigraphy, raw material sourcing, geochronology, geography and mapping, geophysical and geochemical techniques, paleontology and geomorphology. These applications are important to archaeologists because they provide information about human interactions with their prehistoric environments and allows geoarchaeologists to locate archaeological sites and artifacts, and estimate by the quality of soil how "prehistoric" they really are. Also, it will provides evidence for the development, preservation and destruction of archaeological sites, and for regional scale environmental change and the evolution of the physical landscape, including the impact of human groups.

Beside all of the contributions of geology to archeology in "geoarchaeology", we cannot deny the facts that archaeology contribute directly to the geological Quaternary knowledge. World archaeological evidence shows human only present began at early Pleistocene period. Therefore, the more archaeological researches done in one country the more we knows about the Quaternary record of that country. In short, the collaboration of archaeology and geology was a natural step in the common goal of research documenting the antiquity of man and the earth history. The popularity and diciplines of geoarchaeology has expanded exponentially to understanding the human past.

In Malaysia, scientific archaeological research was done by CGAR since 1987. After more than 30 years, our prehistory and civilization chronological sequence much more complete compared to before 1987 (Figure 1). We have an evidence since 1.83 Ma, from time to time until today. Beside chronology that covered Pleistocene and Holocene in Malaysia, Figure 1 also shows that we have an evidence from open and cave sites that covered from Palaeolithic, Neolithic, Metal Age and Civilization. Each sites showed their stratigraphy that represent their own environment. The material cultures found in every sites revealed the surrounding "geology" of the sites. All of these geoarchaeological data contributes to the knowledge of Quaternary period of Malaysia.

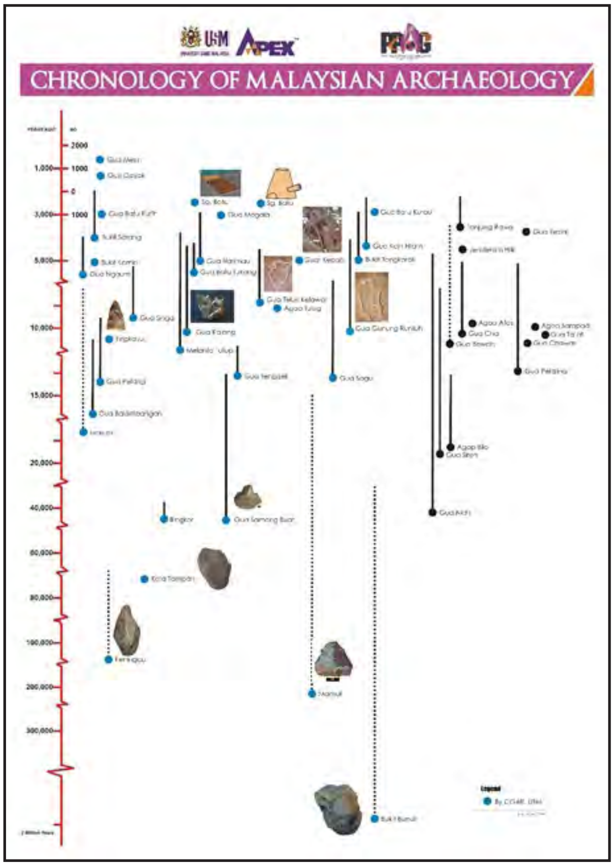

Figure 1: Chronological Sequence of Malaysian Archaeology.

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PL-4

The use of the hand held XRF and portable XRD in geological settings

SAM HABIB

Crest Olympus

Abstract: With the rapid portable analytical technology there have been two techniques that have been readily adapted by the global geoscience community that stand above the rest of infield analytical techniques. The handheld XRF and the portable XRD. There is a reason for this high adoption, we explore in this presentation why these two key technologies where successful and what was key to their success and what we have learned in the 5 to 10 years. How they have changed the industry, what is the future directions of these products?

In the second part of the presentation we look at the technology from global regulatory approach, what is required from users perspective to do in order for their data to be admitted with the Canadian and Australian mineralogical governing bodies. Can they meet compliance regulations for financial reporting? Can we produce lab quality data with these instruments?

Advances in geological microanalysis: Correlation and machine learning

MATTHEW ANDREW[1] & SHAUN GRAHAM[2]

[1]Carl Zeiss X-ray Microscopy, Pleasanton, California, USA
[2]Carl Zeiss Microscopy, Cambridge, UK
Email address: matthew.andrew@zeiss.com; shaun.graham@zeiss.com

Introduction

Techniques such as Light Microscopy (LM), Scanning Electron Microscopy (SEM), Automated Mineralogy (AM) and Laser-Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS) (are often viewed in isolation; there has been limited functional development on the correlation and integration of these techniques to advance geological microanalysis. This is required, as geological structures are highly heterogeneous, and so the resolution required to image fundamental microstructures frequently comes at the expense of a field of view representative of that heterogeneity. Even more critically, no single tool gives complete information about the sample, and frequently analyses are complementary.

In this paper we will show how these techniques can be integrated together using machine learning and advanced data science to generate unique insights into the geological processes in question, with specific application to multiscale characterization of shales, trace geochemical indicators for ore deposits and mineralogical characterization of hydrothermal vents.

Multiscale characterization of shales

Unconventional reservoirs have transformed the energy industry, but a detailed understanding of their structure and flow behavior at the micro and nano scale remains a challenge. Reservoir rocks exhibit strong structural heterogeneities spanning length scales ranging from the km down to the nm or even sub-nm scale (Ringrose *et al*., 2008). An understanding of mineralogy is critical to understand reservoir flow behavior and geomechanical response (Oliver *et al*., 2016). Recent developments in high throughput automated digital petrography digitization allow for entire thin sections to be fully digitized in a matter of minutes. Local microfacies can then be identified using machine learning based image classification. These locations can then be used as the targets for high resolution Automated Mineralogy analyses through a common (sample centric) control system. By maintaining the relationship between local microstructure and macroscopic heterogeneity, data can directly upscaled to the pore to core scale.

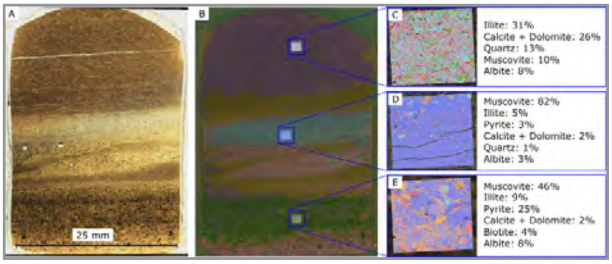

Figure 1: Multiscale analyses of shale rock, with high throughput automated light microscopy (A), classified into local microfacies using machine learning (B). This multimodal classification is then used to define locations for high resolution analyses (C).

Geochemical indication of ore deposits

Trace element geochemistry of specific minerals can be used as a vector to locate and understand the genesis, evolution and distribution of ore deposits (e.g. Garnet in diamond exploration, Epidote in porphyry copper exploration and magnetite in Ni Sulphide exploration)

Figure 2: Automated mineralogy overlay of type 1 and type 2 magnetite, imaged using high throughput automated digital petrography, then used to locate regions for LA- ICP-MS analyses.

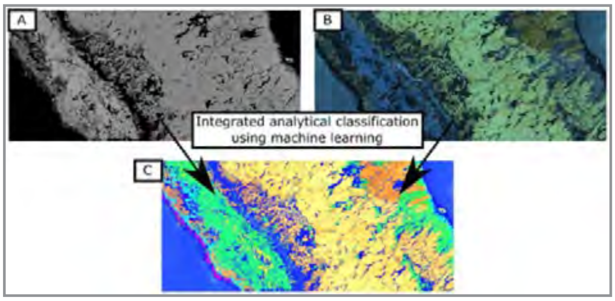

Figure 3: Automated mineralogy overlay of type 1 and type 2 magnetite, imaged using high throughput automated digital petrography, then used to locate regions for LA- ICP-MS analyses.

(Ward *et al.*, 2018). Automated Mineralogy gives reliable, high throughput, quantitative analyses of major element geochemistry at a high spatial resolution, but if more detailed analyses of trace element geochemistry are required, targeted LA-ICP-MS is required.

By integrating these two techniques together, driving locations for trace element analyses from high throughput automated techniques, it is possible to contextualize the results of LA-ICP-MS a large area. This can allow for a large number of grains to be screened rapidly for damaging effects (such as fractures or mineralogical defects), give information on the textural setting of the grain (Figure 2), or even act as an internal geochemical standard for trace element geochemistry.

Multimodal analysis of hydrothermal vents using machine learning

One of the principal challenges associated with detailed microanalysis is that of data scale and analysis. With the advent of high throughput, automated mapping technologies, we need equally powerful analytical tools to allow for the interpretation of the resulting data. The last 10 years have seen a transformation in a broad group of technologies frequently grouped together as "machine learning". By integrating and spatially registering disparate datasets acquired on different tools, and feeding the resulting data into a machine learning algorithm (Breiman, 2001), it is possible to automatically classify mineralogical variations over extremely large areas at high resolution extremely rapidly (Figure 2).

When applied to subsurface hydrothermal vent samples, this analysis reveals the spatial variation of Chalcopyrite-Bornite alteration, governed by the variation of (and heterogeneity in) fluid flow fields within the vent. This is true both in the center of the central vent flow pathway, where flow and alteration is concentrated, but also within the vent matrix, where flow appears to be strongly concentrated in targeted banded regions.

Conclusions

The integration of microanalytical techniques across modalities and length-scales leads to unique insights into the geological processes associated applied to unconventional hydrocarbon reservoir analysis, trace-element vector mineralogy and the analysis of alteration within hydrothermal vents. By integrating correlated tools with novel machine learning technology, it is possible to scale previously localized, manual or time intensive analyses across extended areas, contextualizing results and allowing for more quantitative and representative approach to geological microstructure.

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ORAL PRESENTATIONS

MARINE GEOLOGY/ GEOENVIRONMENT/ HYDROGEOLOGY

Offshore sand resources and mining in Malaysia

Abdullah Sulaiman[1,2,*], Noran Alwakhir Shaarani[1], Mohd Rais Ramli[1], Amin Noorasid Abdul Jalil[1] & Ling Nan Ley[1]

[1]Department of Mineral and Geoscience Malaysia, Technical Services Division, Jalan Sultan Azlan Shah 31400 Ipoh, Perak
[2]Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu
*Corresponding author email address: abdullah@jmg.gov.my

Abstract: Offshore sand mining activity, if improperly managed, can result in economic loss and environment degradation. This is because the range of activities involved in offshore sand mining, such as dredging, extraction and transportation of the sand, all have a potentially deleterious effect on the hydrodynamics and biological environmental of the mining site and adjacent areas.

The National Offshore Sand Resource Study is a major effort by the Government to ensure that the mining of the offshore sand resources is carried out in a systematic and sustainable manner with least environmental impacts to the marine living resources and coastline. This comprehensive study that is undertaken by the Department of Mineral and Geoscience Malaysia (JMG) comprises geophysical survey, seabed sediment sampling, hydraulic and environmental assessment of the offshore sand resources. Towards this end, a comprehensive ranking methodology was developed to enable the offshore sand resources are ranked according to the potential impacts of their exploitation. The development of an appropriate ranking framework is of fundamental importance in guiding the overall mining of the sand reserve. Thirteen (13) environmental criteria (ranging from water quality, living resources, habitats, and non-living and man-made resources) are used to rank the sand reserve. The ranking involved two primary tiers in which sand resources were categorized as Non-Exploitable and Exploitable. Based on the study, the vast amount of sand reserve in Straits of Malacca and Sarawak offshore that amounted to about 9.67 billion m^3 and 17.1 billion m^3 respectively were categorized as exploitable. Based on the current royalty rates of RM0.70/tonne, the total potential Federal Government revenue that can be generated by the sustainable mining of these offshore sand reserves would amount to RM18.8 billion.

The study also indicated that the distribution of exploitable sand in offshore was greatly controlled by the environmental impact criteria that mainly comprised of coral reefs, marine protected areas, cables and oil pipelines, oil platforms, and to a smaller extend artificial reefs, living aquatic resources and turtle landing sites.

Impacts of the sand mining activities in Malaysia were first studied by JMG at Ramunia Shoal since it was actively dredged from 1996 to 2010. A multi-disciplinary scope was undertaken in this study such as bathymetry, sediment sampling, coastal mapping and hydraulic modelling. The multibeam data analysis indicated the shoal was cut through at two parts due to the sand mining activity. The sediment sampling data has further confirmed that the sediment at the two parts of the shoal has changed from sandy to muddy sediments. Coastal mapping data showed severe coastal erosion at south of Tg. Punggai and several significant erosion signs observed in other study sites. However, the hydraulic modelling results showed that there is an insignificant current speed change at the coastal locations which is less than 0.02m/s. Thus, sand resources can still be mined at Ramunia Shoal but needed to be mined at a sustainable manner.

Keywords: Offshore sand resources, sand mining, sand ranking, hydraulic modelling, environmental impact assessment

Alluvium geochemistry and groundwater aquifer of Kg. Tiram Burok, Tanjong Karang area, Selangor

Habibah Jamil[1,*], Norsyafina Roslan[1], Abdul Manan Abdullah[1], Tan Pei Shi[1] & Mazatul Akmar Binti Aros[2]

[1] Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Malaysia
[2] Mineral and Geoscience Department of Malaysia
*Corresponding author email address: bib@ukm.edu.my

Introduction

In response to the increasing demand of public water supply in Selangor, studies on hydrogeology and groundwater potential have been carried out by the Mineral and Geoscience Department of Malaysia in the alluvial plain of Tanjong Karang, Selangor (Bachik, 2000; Habibah & Iszaynuddin, 2004).

Geologically, the area is covered by unconsolidated marine alluvium sediments of Quaternary age (Bosch, 1988), and the groundwater aquifer is made up of 20-30 meters thick of sand and gravels mixed with clay lenses, at 30 to 70 meters depth (Bachik, 2000). According to Islam *et al*. (2000), reservoir water quality could be influenced by the type of local bedrocks and soils. In the case of Tanjong Karang area, the groundwater might be influenced by rainfall (as main recharge source) and by the alluvium deposits. Based on previous studies, alluvium aquifers are commonly of type IV (Na_2SO_4 or NaCl) due to its proximity to seawater (JICA, 2002; Tan, 2018). The groundwater would also influenced by relict seawater within the aquifer system (Umar *et al*., 2007) or salt water intrusion (Igroufa *et al*., 2010).

Despite of its significance to the groundwater quality, study on the influence of alluvium to the groundwater quality has yet to be done in this area. Thus, this study aims to establish the alluvium constituents and geochemistry of Tanjong Karang area, and its influence to the groundwater quality.

Materials and method

Alluvium samples have been collected at two localities in Kg. Tiram Burok, the AM1 (359100m E, 378000m N) and AM2 (360400m E, 379200m N), at 0-0.5, 0.5-1.0, 1.0-1.5 and 1.5-2.0 meters depth. The alluvium constituents (type of sediment and mineral content) and alluvium geochemistry (pH value, organic matters content, cation exchange capacity (CEC), redox condition, major elements, and heavy metals) are determined in the samples. The groundwater aquifer is characterized based on secondary borehole data at KSE08, KSE13 and BKSTW4 and pumping test analysis.

Results and discussion

Alluvium constituent and geochemistry

Alluvium in the study area is dominated by mud, of silty clay soil texture. The alluvium constitutes a mixture of montmorillonite, kaolinite, goethite and quartz minerals. The percentage of major elements in the decreasing following order are SiO_2 (59.82-65.62%) > Al_2O_3 (15.64-20.66%) > Fe_2O_3 (1.32-2.91%) > K_2O (1.32-2.14%) > Na_2O (0.95-2.88%) > MgO (0.31-1.66%) > MnO (0.03-0.82%) > TiO_2 (0.72-0.82%) > CaO (0.12-1.08%) > P_2O_5 (0.08-0.14%). Silica (SiO_2) in sediments denotes the silicate minerals (kaolinite, montmorillonite and quartz) in the silt and sand size fractions, Al_2O_3 is contributed by aluminosilicate minerals (kaolinite and montmorillonite), and Fe_2O_3 indicates the presence of goethite and ferrihydrite in alluvium (Habibah *et al*., 2014). Other major elements would occur as amorphous materials in alluvium.

Heavy metals content in the decreasing following order are Zn (113-154 ppm) > Pb (82-108 ppm) > Cr (12-65 ppm) > Cu (37-57 ppm) > Ni (20-23 ppm) > As (16-21 ppm). According to Khairiah et al. (2009), heavy metals in alluvium paddy soils are mainly distributed in residual fraction, followed by acid reducible or organic oxidizable fractions. Bioavailable heavy metals in soils are very low, suggesting minor impact to the environment. Brownish (10YR) to yellowish (7.5YR) alluvium colour, and the presence of brownish (7.5YR) mottles denotes the repeated oxidation and reduction condition due to the exposure and submergence of alluvium due to shallow water table fluctuation (1.5 meters depth) in the area. The sediments are very acidic (pH 3.15-3.78), and the organic matters content and CEC values are low to moderate.

Groundwater characteristics

Based on subsurface geology and pumping test, the groundwater aquifer (sand, sandy clay and gravel layer) of the study area is classified as leaky aquifer. In this area, the overlain unconsolidated mud aquitard permitting water infiltration during groundwater recharge. The groundwater is classified as Na-Cl facies, ranging from fresh to brackish waters (Table 2). Except for Fe and Mn, all of the heavy metals studied are in permissible level for drinking water (WHO, 1985). The influence of heavy metals from aquitard is minimal due to its low bioavailability in alluvium. Iron (Fe) and manganese (Mn) are ubiquitous elements in alluvium soil. In aerated condition, these elements mainly occurred as precipitates or mottles of Fe-Mn oxides (Habibah *et al*., 2014). However, in anoxic condition such

Table 1: The alluvium characteristics in AM1 and AM2 samples.

Characteristics	AM1				AM2			
	AM1a (0-0.5 m)	AM1b (0.5-1.0 m)	AM1c (1.0-1.5 m)	AM1d (1.5-2.0 m)	AM2a (0-50 m)	AM2b (0.5-1.0 m)	AM2c (1.0-1.5 m)	AM2d (1.5-2.0 m)
Colour	Pale brown (10YR 6/3), with reddish yellow (7.5YR 6/8) mottles	Light brownish gray (10YR 6/2)	Light brownish gray (10YR 6/2)	Light brownish gray (10YR 6/2)	Very dark brown (10YR 2/2)	Dark yellowish brown (10YR 3/6), with strong brown (7.5YR 5/8) mottles	Dark yellowish brown (10YR 3/6), with strong brown (7.5YR 5/8) mottles	Dark yellowish brown (10YR 4/4)
Soil texture	Silty clay	Silty clay	Silty clay	Silty clay	Silty clay	Silty clay	Silty clay	Silty clay
Type of sediment	Mud	Mud	Mud	Mud	Mud	Mud	Mud	Mud
Clay	52.17	55.78	54.15	51.42	51.53	49.37	53.58	51.57
Silt	46.99	43.21	44.68	46.31	47.63	49.53	44.98	45.77
Sand	0.84	1.01	1.17	2.27	0.84	1.10	1.44	2.66
Total	100	100	100	100	100	100	100	100
Mineralogy	Kao, Mont Goethite	Mont	Kao, Mont, Goethite	Kao, Mont, Quartz	Kao, Goethite	Kao, Goethite	Mont, Goethite	Kao, Mont, Quartz
Cation exchange capacity (CEC) (meq/100g)	58.14	73.11	67.50	68.32	4.00	5.97	6.58	10.87
pH value	3.78	3.70	3.67	3.59	3.31	3.18	3.16	3.15
Organic matters (%)	2.15	2.78	3.34	2.41	7.61	5.19	3.80	2.74
Major elements								
SiO_2	59.88	59.82	62.22	63.53	58.62	63.05	64.13	65.62
TiO_2	0.82	0.80	0.80	0.80	0.72	0.79	0.77	0.73
Al_2O_3	20.66	20.06	19.72	19.08	15.79	17.41	17.24	15.64
Fe_2O_3	2.26	2.91	2.85	2.86	1.32	1.97	1.93	1.77
MnO	0.04	0.05	0.05	0.82	0.03	0.03	0.03	0.03
MgO	1.39	1.66	0.31	0.32	0.80	1.00	0.99	1.40
CaO	0.26	0.32	1.08	0.04	0.12	0.16	0.17	0.22
K_2O	2.06	2.14	2.12	2.10	1.32	1.62	1.77	1.80
Na_2O	2.82	2.74	1.61	1.61	1.00	0.95	0.95	2.88
P_2O_5	0.10	0.08	0.09	0.09	0.18	0.14	0.11	0.11
LOI	10.20	9.08	9.12	8.88	20.43	13.09	11.67	9.99
Total	100.48	99.67	99.96	100.12	100.33	100.20	99.76	100.18
Heavy metals								
As	16	16	16	16	21	19	17	18
Cu	42	37	44	44	57	40	40	39
Cr	13	58	14	65	13	57	54	12
Ni	21	21	23	22	23	21	20	20
Pb	84	82	82	84	108	102	94	98
Zn	148	150	154	148	117	114	113	115

Mont=Montmorilonite, Kao=Kaolinite

as groundwater aquifer, these elements occurred as Fe^{2+} and Mn^{2+} ions rendering high metal values in the water.

Acknowledgements

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Table 2: Groundwater characteristics and concentration of elements of boreholes water samples.

Parameters	KSE8*	KSE13*	BKSTW4#
Longitude (E)	368500	364600	367600
Latitude (N)	377500	377300	379300
Depth of well (m)	38	62	35
Static water level (meter below ground level)	0.33	3.12	1.5
Total dissolved solid (TDS) (mg/l)	412	2629	948
Cation (mg/l)			
Na	3.3	58	303
Ca	1.8	35	12
Mg	3.3	58	0
K	143	890	47
Anion (mg/l)			
Cl	147	1445	361
SO_4	3	3	<3
CO_3	0	0	278
HCO_3	6.7	27	305
Heavy metals (mg/l), and the WHO (1985)			
Fe (<0.3)	2.4	18	6
Mn (<0.1)	0.1	0.9	0.2
Cu (<1)	0.1	0.1	0.1
Pb (<0.01)	0.1	0.01	0.1
Zn (<3)	0.1	0.1	0.1
As (<0.01)	-	-	0.005
Cr (<0.05)	-	-	0.1
Ni	0.1	0.1	-

Source *Bachik (2000) and #Habibah and Iszaynuddin (2004)

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S1-82

Baseline water quality data of mines in Kelantan

FATIHAH BINTI AZMI

Mineral Research Centre, Jalan Sultan Azlan Shah, 31400 Ipoh, Perak
Email address: fatihah@jmg.gov.my

Introduction

Kelantan is a state that is rich with mineral resource such as gold, feldspar, manganese, granite, marble, barite and et cetera (Anonymous, 2014). In year 2017, Kelantan is being selected for auditing activities under Sustainable Development Indicator (SDI) project, which required involvement of all JMG offices and divisions in Malaysia. JMG was auditing a total of 24 mines and 13 quarries in Kelantan.

One of the components in the auditing activities is to collect baseline data of water quality, air and noise throughout the auditing period. Regarding to this matter, Minerals Research Centre (MRC) was assigned to conduct and collect baseline water quality data at all mines in Kelantan. Sampling activity was held from April to September 2017.

Sampling and analysis

A total of 24 mines has been selected for sampling points. Duplicate raw mine water samples were collected from the sampling points by grab sampling into high-density polyethylene bottles. In-situ analysis was carried out using Thermo Scientific Orion Star A329 portable multiparameter meter Hach TSS Portable Hand-held meter. Metal analysis was conducted using Perkin Elmer Inductively-Coupled Plasma (ICP-OES) spectrometer to measure concentration of selected metal elements. Anion and hardness analysis were conducted using DR2800 Hach Spectrophotometer to measure concentration of selected anions.

From the ICP analysis, it shows that elements namely Ag, Al, B, Ba, Cd, Cr, Ni, Se, Sn and Zn do not exceed the limits at all 59 sampling points, while 5 elements namely Hg, Mn, Cu, Fe, Pb and As exceeded the limits at a few sampling points.

Arsenic (As)

At Tanah Merah and Jeli area, only SP5 exceeded the value of As limit (0.1 mg/L) which is 0.220 mg/L. As for Gua Musang area, the value of As for all sampling points are within the limit.

Copper (Cu)

The concentration of Cu for SP7 which is located at Tanah Merah and Jeli area is 0.845 mg/L and exceeded the allowable limit of 0.2 mg/L. As for Gua Musang area, a total of 8 out of 41 sampling points have exceeded the allowable limit. SP57 recorded the highest value, 4.899 mg/L.

Iron (Fe)

Only SP12 exceeded the allowable limit of Fe (1.0 mg/L) and recorded the highest concentration of Fe at 6.319 mg/L at Tanah Merah and Jeli area. Meanwhile, a total of 6 out of 41 sampling points at mine sites around Gua Musang exceeded allowable concentration limit of Fe. The highest Fe concentration was recorded at SP26 with the value of 13.610 mg/L, followed by with the value of 8.374 mg/L.

Mercury (Hg)

A total of 13 out of 17 sampling points that are located at mine sites around Tanah Merah and Jeli were recorded containing more than allowable limit of Hg value (0.01 mg/L). Based on Figure 1, SP3 recorded the highest Hg value, 0.284 mg/L and followed by SP5 with Hg value of 0.282 mg/L. The Hg value might be higher for the mines because of mostly those mine sites are gold mines. In gold mining industry, the utilization of Hg is to amalgamate and concentrate precious metals (de Lacerda & Salomons, 1998).

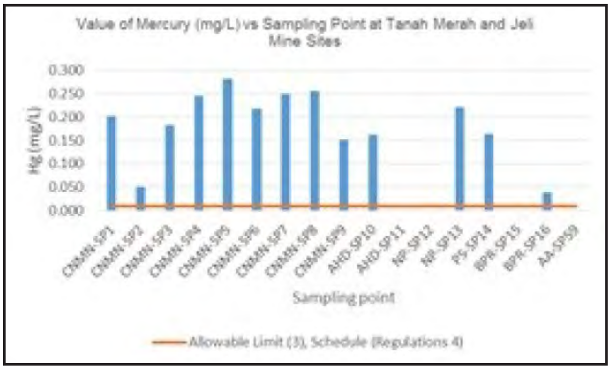

Figure 1: Graph of Hg values at Tanah Merah and Jeli sampling points.

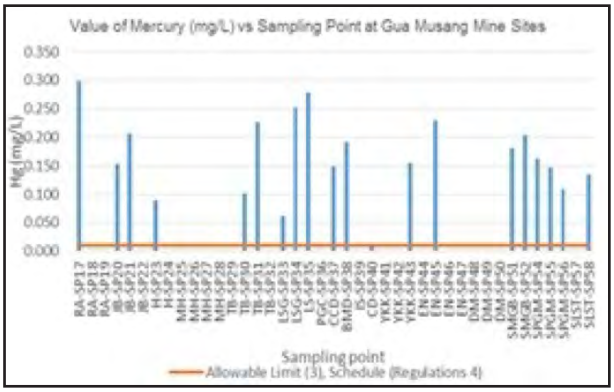

Figure 2: Graph of Hg values at Gua Musang sampling points.

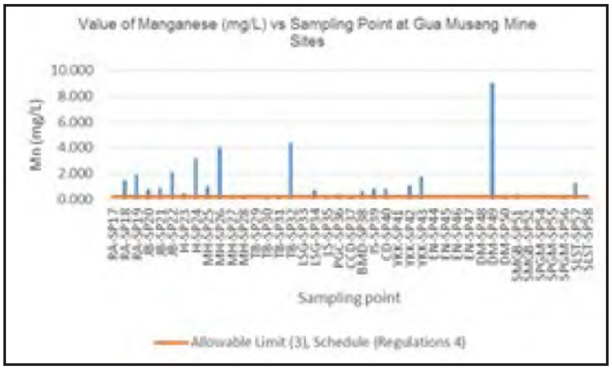

Figure 3: Graph of Mn values at Gua Musang sampling points.

Referring to Figure 2, at mine sites around Gua Musang**,** there are 14 out of 41 sampling points were recorded exceeding the allowable limit of Hg. SP17 recorded the highest Hg value, 0.298 mg/L, followed by SP35 with Hg value of 0.282 mg/L.

Manganese (Mn)

There are 3 out of 17 sampling points that located at mine sites around Tanah Merah and Jeli were recorded exceeding the allowable limit of Mn (0.2 mg/L). SP2 recorded the highest Mn value, which is 4.379 mg/L.

In the meantime, 22 sampling points out of 41 has exceeded allowable concentration limit of Mn at mine sites around Gua Musang as shown in Figure 3. The highest concentration value was recorded at SP49 with the value of 9.041 mg/L. The values of Mn have exceeded allowable limit as most of the mines are manganese mines.

Lead (Pb)

Only SP2 which located at Tanah Merah and Jeli mine sites have exceeded the concentration limit. The concentration of Pb at SP2 is 0.108 mg/L, while the actual limit of Pb should be 0.1 mg/L and below.

Conclusion

In conclusion, in-situ data have shown all sampling points have fulfilled all values that within Limit (3), in the regulation stated. There are 6 element concentrations that exceeded maximum allowable concentration limit. The overall data have shown that the major elements of concern are Hg and Mn, followed by Cu, Fe, As and Pb. At Tanah Merah and Jeli mine sites, the major element of concern is Hg, as majority of the mines are gold mines. Meanwhile, in Gua Musang, the major element of concern is Mn, as majority of the mines are manganese mines.

Acknowledgement

The authors would like to thank and also pleased to acknowledge the support of Director of Mineral Research Centre, Department of Mineral and Geoscience Malaysia and fellow staff especially to the staff of Section of Mining and Quarrying Technology for their assistance of this research.

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Limit (3), Schedule (Regulation 4), Parameter and Limit of Effluent, P.U. (A) 338, Mineral Development (Effluent) Regulations 2016.

S1-26

The influence of seawater to groundwater in Kuala Langat, Selangor

HAZIMAH HASPI HARUN[1,*], MOHAMAD ROSLAN MOHAMAD KASIM[2], FARADIELLA MOHD KUSIN[3], SITI NURHIDAYU ABU BAKAR[4] & ZULFA HANAN ASH'AARI[5]

[1] Dept. of Forest Management, Faculty of Forestry, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia

[2] Dept. of Environmental Sciences, Faculty of Environmental Studies, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

*Corresponding author email address: hazimah77@gmail.com

Abstract: The groundwater characteristic in Banting, Kuala Langat Selangor is influenced by the criteria of aquifer types and the geomorphology of the areas. Thirteen monitoring wells were selected in this study, and are scattered at different stations in the study areas. There were eight parameters selected for this study, i.e. salinity, electrical conductivity, pH, total solids, phosphate, magnesium, strontium and turbidity.

The principal components analysis used as tools to see the correlations between parameters and reduce the dimension among the parameters selected. Normality testing was performed before proceeding to the principal components analysis to obtain the homogenies and representative data.

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S1-85

An evaluation of groundwater reserve potential in the Mid Miocene aquifer system in Miri Basin, Sarawak

JASMI, ZAIDULKHAIR & RAJALI, ROSLAN

Geoscience Unit, Hydrogeology Activity
Minerals and Geoscience Department Malaysia Sarawak, 93712, Kuching, Sarawak, Malaysia
Email address: zaidul.jasmi@jmg.gov.my; roslanra@jmg.gov.my

The El-Nino phenomena awareness is well spread globally. The long dry season ultimately affects the surface water supply in many states and countries. Many countries through their government agencies are taking it into account to mitigate the risk and effect of the natural phenomena to the industries and mainly to the economic growth. So does Malaysia. El-Nino was threatening various sectors in Miri, Sarawak circa 1997-1998 (LAKU report 2007). The shortage of surface water supply from nearby rivers brought many issues to the public, socioeconomics and environmental sustainability. Previously, the groundwater exploration had been studied in the early 1980s but only focusing at the small area of Kampung Lusut and Kampung Tunku Abdul Rahman up to the foothill of Lambir Hills which was covered 60 square km. In this project, the study area has been expanded up to 560 square km, covering the entire area of Miri's Mid Miocene catchment area.

ORAL PRESENTATIONS

GEOPHYSICS

Resistivity and magnetic response on Seulawah Agam geothermal system

MUHAMMAD SYUKRI[1] & ROSLI SAAD[2]

[1]Department of Physics, Faculty of Sciences, Syiah Kuala University Darussalam, Banda Aceh, 23111, Indonesia
[2]Geophysics Section, School of Physics, Universiti Sains Malaysia
11800 Minden, Pulau Pinang
Email address: rosli@usm.my; rosli28260@gmail.com; m.syukri@unsyiah.ac.id

Introduction

Resistivity is a common parameter used for delineating geothermal system while magnetic used in delineating the geothermal fluid flow system. Hydrothermal alteration depends on temperature distribution and forms various clay minerals with various conductivity properties (Wright *et al.*, 2009). Clay minerals formed at high temperatures are more resistant than lower temperature (Figure 1).

Most geothermal systems within active volcanic regions show low resistivity value (1-5 Ω.m) surrounding an inner core of higher resistivity value (Hjalmar *et al.*, 1994). Magma flows from earth crust through thinned and fractured area as lava while trapped magma heats underground rocks and groundwater (Figure 2). Crustal rocks lose their magnetization at the Curie point temperature. Geothermal region is characterized as high temperature gradient with heat flow and the region will be associated with Curie point isotherm. Almost all volcanic rocks are magnetic because they contain small amounts of primary magnetic minerals (Byerly & Stolt, 1977; Bhattacharyya & Leu, 1977).

Data acquisition

The 2-D resistivity and ground magnetic methods were conducted at Seulawah Agam (Aceh) and its vicinity. Seulawah Agam is an active volcano with geothermal sources indicator such as hot spring, hot mud/fumaroles/steam located at Herzt, Ie Jue and Ie Seu'um, flowing from south-east to north-west from Seulawah Agam. Two 2-D resistivity lines, L1 and L2 were conducted crossing the suspected geothermal flow using ABEM SAS4000 system with 10 m minimum electrode spacing and Pole-Dipole array. Ground magnetic data was acquired in line mode (L2 and G) consisting of few stations crossing the suspected geothermal flow using GEM-GSM19T system with 30-50 m station spacing and ~500 m line spacing (Figure 3). The 2-D resistivity data are process using RES2Dinv and surfer 8 software while the ground magnetic data are process using Microsoft excel and surfer8 software.

Result and conclusion

The 2-D resistivity results interpreted the study area as three layers; top layer with thickness up to 20-80 m and resistivity value of >60 Ω.m, second layer of impermeable cap-rock layer with depth of 20-80 m and thickness of 20-220 m indicated by resistivity value of 6-50 Ω.m and the third layer of bedrock with depth of 40-240 m. Few fractures and low resistivity regions (<5 Ω.m) were identified in the cap-rock and bedrock interpreted as geothermal flow (Figure 4).

Magnetic results indicated the study area consist of two main zones; magnetic residual of 0-110 nT interpreted as hot water, flowing from west to east and north-west to

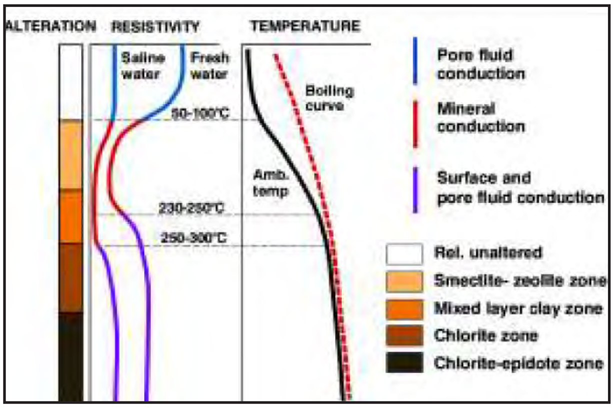

Figure 1: Electrical conduction vs. temperature and hydrothermal alteration (Flóvenz *et al*., 2005).

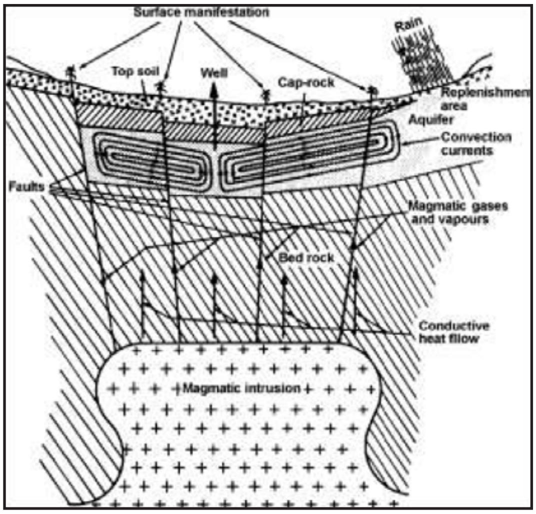

Figure 2: Conceptual model of hyper-thermal field (Berktold, 1983).

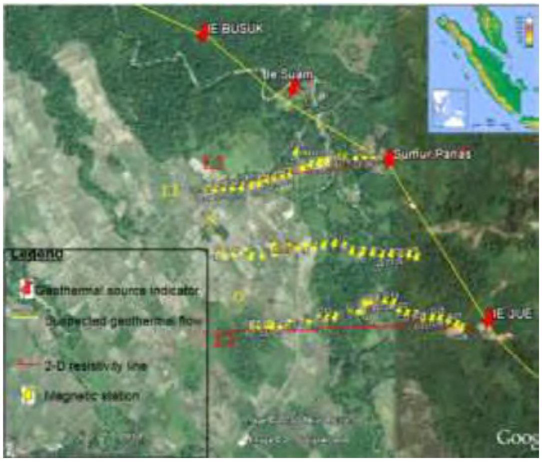

Figure 3: Study area and its vicinity with 2-D resistivity and ground magnetic surveys (Google, 2015).

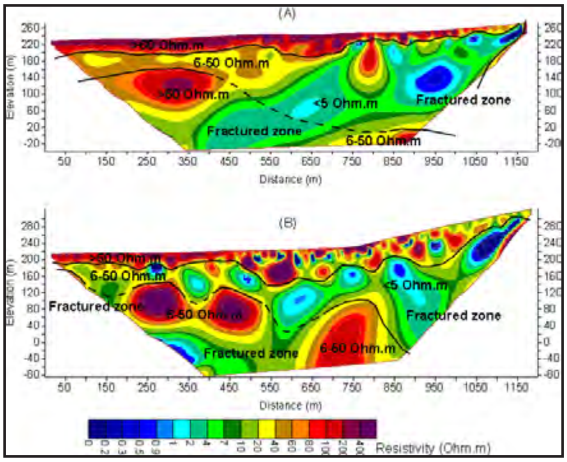

Figure 4: 2-D resistivity model of the survey lines at study area; (a) line L1 and (b) line L2.

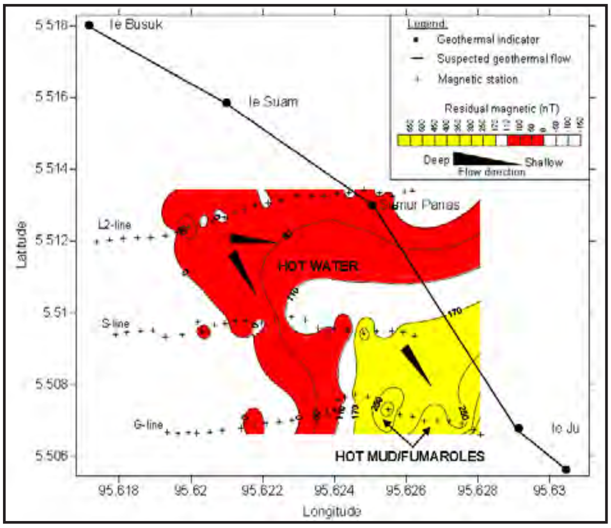

Figure 5: Magnetic residual map of the study area shows the flow of hot water and hot mud/fumaroles flow.

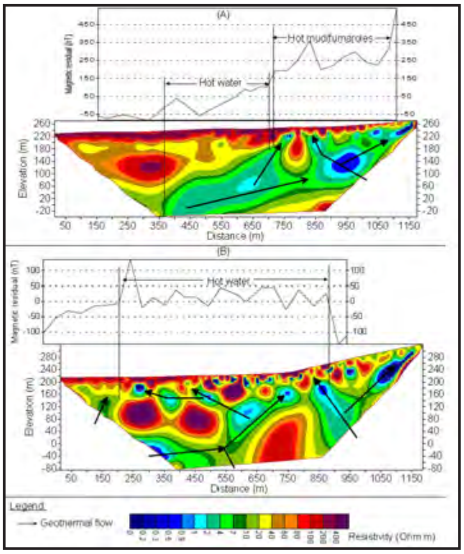

Figure 6: Magnetic residual respond towards depth; (A) magnetic residual of line G plotted against distance overlaid with 2-D resistivity of line L1 and (B) magnetic residual of line L2.

south-east, and hot mud/fumaroles with value of >170 nT flowing from north-west to south-east (Figure 5).

This study concluded that the 2-D resistivity method capable in delineating cap rock and geothermal fluid flow while ground magnetic method show magnetic residual of hot water and hot mud/fumaroles generally decreases with depth (Figure 6).

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Enhanced depth imaging for subsurface faults, fracture and karst: Application in Malaysian carbonate field

Yasir Bashir*, Deva Prasad Ghosh, Seyed Yaser Moussavi Alashloo, Amir Babasafari & Chow Weng Sum

Centre of Excellence in Subsurface Seismic Imaging & Hydrocarbon Prediction (CSI)
Faculty of Geoscience Department, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Malaysia
*Corresponding author email address: Yasir.bashir@utp.edu.my

Introduction

Seismic Depth Imaging (SDI) is the most glamorous step of seismic data processing because it transforms the raw data into a final image that is considered as an accurate structural description of the earth. in this regards, our expectation of the accuracy of structure imaging is higher, robustness and reliability. In the past, we have seen migration moves from its heuristic roots to mathematically sound techniques with enhancement of methods, novelty and workflows. All of the techniques continually improve and borrow from each other, so one technique may never dominate to be a constant method. Diffraction imaging (DI) is a novel technology that uses diffractions to image with super-resolution of small subsurface elements. Diffractions are the seismic response of small elements (or diffractors) in the subsurface of the earth, such as faults, fractures, karst, salt flanks, pinch-outs, scattering objects. In general, all these objects which are small compared to the wavelength of seismic waves. Since diffraction is, by definition, smaller than the wavelength of seismic waves, diffraction imaging provides super-resolution information, which consists of image details that are beyond the classical Rayleigh limit of half a seismic wavelength.

The Carbonate contains important hydrocarbon which is explored in East part of Malaysia, with its Middle Miocene pinnacle reefs and platforms of cycle III-IV and with its post-carbonate clastics playing an important role in hydrocarbon exploration. However, cycles I and II pre-carbonate clastics are considered to be the future potential targets.

A 3D data set from the Sarawak Basin is used for diffraction imaging to resolve the small-scale events. The data set provided for this project was unprocessed offset stack data starting from 80 m to 4730 m with an interval of 75 m offset. The 3D data was acquired by Petroleum Geo-Services (PGS). Data acquisition was conducted in 2006 with the configuration of two guns and six streamers resulting in 12 subsurface lines per boat pass. The data recorded length was 5.7 seconds with a 2 ms sample interval.

In this paper, a Seismic Diffraction depth Imaging is used to complement the structural images produced by conventional processing by generating an additional image volume of high-resolution unconformities using diffractions. We present the several examples from the synthetic (Marmousi, Sigsbee GOM, Fractured model) and real field data (Sarawak basin) a carbonate field in which there are issues of karst imaging. DI is a success for these types of discontinuities problems which making an image complex for interpretation. The results demonstrate the accuracy of diffraction modeling, separation, and imaging for a high-resolution imaging. By identifying the areas with increased natural fracture density, the reservoir engineers can design an optimal well placement program that targets the sweet spots, areas with increased production, and minimizes the total number of wells used for a prospective area.

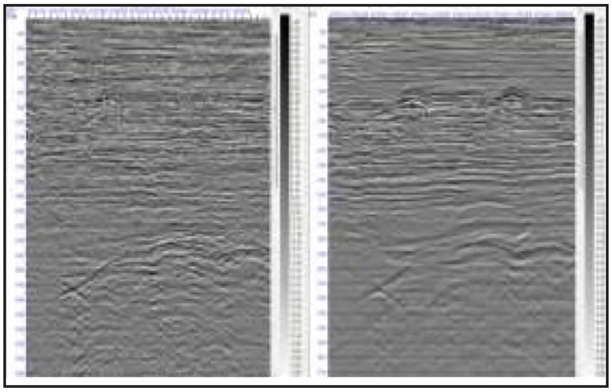

Figure 1: Partial stack seismic with a near stack (left), and far angle stack (right).

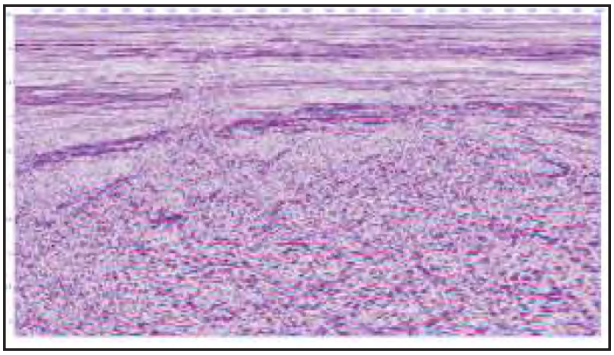

Figure 2: An accurate imaged with enhancing structural description using SDI and DI methods.

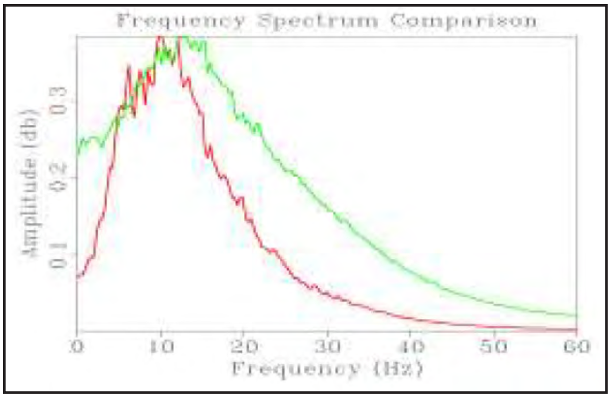

Figure 3: Frequency spectrum using conventional SDI and SDI using DI.

Discussions and conclusions

We present the significance and importance of careful seismic processing and depth imaging by utilization of diffraction in complex Earth, like fractured zones, fault edges, small-scale events, and pinch-outs. In processing, plane-wave destruction filters with an improved finite-difference design added the value for preserving diffraction. Figure 1 shows the processed near and far stacked data, in which a diffraction response does not appear in near but the far angle stack show better diffraction preservation. Figure 2 shows a final migrated data using SDI technique in which an improvement can be seen as the faults, fractures and karsts are illuminated with high resolution. A comparison of legacy seismic data and improved imaging is shown using frequency spectrum in Figure 3. However, an enhancement in the amplitude of lower frequencies 0-5 Hz and higher frequency from 15-60 Hz data is preserved in the final imaged section.

Acknowledgements

We are thankful to Universiti Teknologi PETRONAS (UTP), Geoscience Department and the Centre of Seismic Imaging (CSI) for providing the facilities for this research work. We would also like to thank PETRONAS for funding this work and providing data for research and publication. This research work is funded by PETRONAS Group Research & Technology (PRSB).

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S2-19

Soil characterization using integrated geophysical methods at Sungai Batu, Kedah

MUHAMMAD TAQIUDDIN ZAKARIA[1], NORDIANA MOHD MUZTAZA[1,*], MOKHTAR SAIDIN[2], ROSLI SAAD[1] & SHYEH SAHIBUL KARAMAH MASNAN[2]

[1] Geophysics Section, School of Physics, 11800 Universiti Sains Malaysia (USM), Penang, Malaysia
[2] Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800 Penang, Malaysia
*Corresponding author email address: mmnordiana@usm.my

Abstract: Heterogeneity and variations in subsurface environments necessitated detailed geological and geotechnical investigation in order to provide a useful and comprehensive information. This alluvial material characterized by loose, unconsolidated soil/sediment that commonly investigated by the conventional geotechnical method. The conventional method such as borehole provided an excellent measurement of the soil characteristic of particular location however due to heterogenous of fractured rock system with a greater volume it may not possible to extrapolate with a single measurement. The geophysical approach is needed to overcome this problem for the large area besides decrease the environmental damage, time, and cost (Muztaza *et al*., 2012; Abu Samah *et al*., 2016). The paper briefly introduced the applied geophysical method in subsurface characterization with validation of geological and geotechnical information. Generally, this area is underlain by Mahang Formation with the rock unit comprise shale, red slate, grey slate and black slate (Jamil *et al*., 2004). Granitic intrusion causes the rocks of surroundings area to become metamorphose to produce schist rocks with formation formed in Middle Ordovician to Early Devonian age (Bradford, 1970). Six survey lines; L1, L2, L3, L4, L5 and L6 with length of 800 m, 400 m, 540 m, 1400 m, 200 m, 200 m respectively were conducted with utilizing SAS4000 system for data acquisition while two lines, L1 and L2 of seismic with length of 200 m and 230 m are recorded using seismograph ABEM Terraloc MK8 with 24 unit of vertical geophones as a detector. The resistivity data were processed using Res2Dinv and Surfer8 software for inversion process and data imaging. The first arrival of seismic waves was picked, and 2-D profile is generated using SeisOpt@2D. A region with low resistivity values of 50-150 Ωm was interpreted as the clay and sand while saturated zone was identified with resistivity values of <100 Ωm. A region with resistivity of >100 Ωm was interpreted as loose and dry alluvium while high resistivity value of >800 Ωm interpreted as shale layer as closed agreement with geology information. The seismic refraction result identified the first, second and third layers with a velocity of 400-1400, 2000-3400 m/s and >3600 m/s respectively. A top layer shows a high velocity as SPT-N values increase with depth. A layer with a velocity of 2000-3000 m/s interpreted as the compacted material is closed an agreement with borehole record which shows at depth 5-15 m the lithology consists of hard clay, quartz pebble, and also shale layer. The correlation with the borehole, BH 1 record which is in line with profile line of L1 shows at depth <5 m the stratigraphy shows clay dominated as it is stiff and plastic with the presence of fine grain sand. This shows the velocity recorded at this layer are higher at <1400 m/s and resistivity of <30 Ωm with the SPT N- values of 6-7. Cross-correlation of 2D resistivity and seismic refraction shows the lithology of this locality is being dominated by the clay deposit with the shale layer represent as hard layer as SPT-N values reach up to 70 blows with resistivity and velocity values >800 Ωm and >3600 m/s respectively. Table 1 shows the summary of standard resistivity and seismic values for this locality.

Table 1: Standard resistivity table in Sg.Batu.

Soil types	Resistivity, ρ (Ωm)	Velocity, V_p (m/s)	SPT-N
Clay	<30	400-1400	6-60
Saturated clay	50-150	2000-3400	9-27
Shale	800	>3600	26-70

Keywords: Sungai Batu, 2-D resistivity, seismic refraction, geotechnical, borehole

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S2-62

Ground motion seismic surface wave of the 2015 shallow strong earthquake at Ranau central zone seismically active region, Sabah, Malaysia

BAILON GOLUTIN

Geoscience Unit, Department of Mineral and Geoscience Malaysia, Sabah
Locked Bag 2042, 88999 Kota Kinabalu, Sabah
Email address: bailon@jmg.gov.my

Introduction

Ranau is situated in the central zone of Sabah, Malaysia which is seismically an active region and is well known by shallow earthquakes with historical moderate magnitude of earthquake. The first moderate local earthquake recorded in Ranau region was in 1966 with a magnitude 5.3M_w and depth of 52 kilometer. The ground shaking due to the 1966 earthquake was reported by Jacobson (1970). Twenty-five years later, another moderate earthquake jolted Ranau in 1991 with a magnitude of 5.1M_w and 5.4 M_w. Based on Lim (1992) technical report; a 4-storey teacher's quarters had suffered considerable structural damage and many buildings in the Ranau region had appeared with minor cracks. On 5th June 2015, Ranau region was jolted by strong earthquake with 6.0M_L magnitude.

Objective

The main objective of this analysis is to construct the preliminary isoline of surface wave ground acceleration, ground velocity and seismic hazard amplification map encircling the areas radiated by earthquake wave of 6.0 magnitude in Richter scale which occurred in the Ranau region on 5th June 2015.

Seismic ground motion acceleration and ground velocity by series of light aftershocks (4.0M_L, 4.2M_L and 4.3M_L on 5 June 2015, 4.8M_L on 6 June 2015, 4.0M_L on 17 June 2015 and 4.3M_L on 23 June 2015) and moderate aftershock (5.1M_L on 12 June 2015) was also analyzed.

Methodology

Historical seismicity rates that was gathered from United States Geological Survey and Met. Malaysia will be the primary source of recurrence information. The weighted parameters to produce this geometric mean of ground acceleration and velocity isoline map are by using real time value of ground acceleration and recorded by accelerometer installed by MET Malaysia and data provided by the United States Geological Survey. Model in microzonation by Barounis *et al*. (2007) was also referred.

Geology and tectonic setting

Sabah mainland is considered to be seismically active caused by the local active faults and intermittently produced strong earthquake tremors (Ismail *et al*., 2016).

Results

The data from the Ranau earthquake (6.0 M_L) revealed some common features of ground motion. The nearest "strong" station which recorded the acceleration (cms^{-2}), g-value and velocity (cms^{-1}) was in Lawa Mandau at Kota Kinabalu, which is located 43.40 km from the earthquake epicenter. Other nearby strong stations are Bakun (456.22 km from epicenter), Kudat (106.28 km from epicenter), Lahad Datu (229.21 from epicenter), Sibu (625.75 km from epicenter), Sapulut (143.49 km from epicenter) and Tawau (235.75 km from epicenter).

The result of peak ground acceleration and peak ground velocity as analysed by the United States Geological Survey (http://earthquake.usgs.gov/earthquakes/map/) shows highest peak ground acceleration in Tuaran area with 0.1452g. The result of acceleration in other areas show some tendency of wave amplification in the alluvium plain, fill area and thick residual soil such as in Menggatal, Teluk Salut, Kampung Kolopis Penampang and at Kota Kinabalu Airport.

Conclusions

Based on real time value of ground acceleration and velocity recorded by accelerometer that was installed by MET Malaysia and data provided by the United States Geological Survey shows amplification of seismic ground motion surface wave in the area underlain by sensitive geological material and loose sediment such as Pinosuk Gravel, slump breccias, peat deposit, coastal alluvium and riverine alluvium. Man-made slope particularly fill slope and reclaimed area could also generate ground motion surface wave amplification. The effect of ground motion amplification cause substantial damage to buildings sitting on it.

The strong ground motion acceleration is able to trigger massive landslides and rock falls in the rocky mountain and steep slope if the epicenter is located below or nearby the mountain as was shown by incident of massive occurrence of landslide at steep slope of Mount Kinabalu, Ranau, Sabah, Malaysia.

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Groundwater potential assessment using 2-D resistivity method in Kluang, Johor (Malaysia)

NAZRIN RAHMAN & ROSLI SAAD*

Geophysics Section, School of Physics, 11800 Universiti Sains Malaysia (USM), Penang, Malaysia
*Corresponding author email address: rosli28260@gmail.com

Abstract: Water is an important element in life. Increasing population in Malaysia subsequently caused increase in water demands. Clean water can be obtained from two main sources; water treatment and RBF. However, these methods cannot accommodate the water demand in Malaysia as it is greatly influenced by factors such as cost, pollution and drought. The existing clean water sources which mostly originates from surface water is decreasing due to unplanned waste system which leads to pollution. RBF cannot work effectively when initial extraction is contaminated. During dry seasons, the amount of rainfall is reduced, simultaneously reducing the amount of water accumulated. Hence, a need for a new water source arises. Confined aquifer is an imperative solution for clean water resource as the water is safe from pollution and is unconnected to potentially contaminated surface water (Nolan *et al*., 1997). When a well is drilled into confined aquifer, the water will automatically flow upward under influence of high pressure of subsurface. Hence, no pump is needed thus saving expenses. The deep aquifer is also unaffected by seasonal changes, making it vital for clean water source of all time. The most qualified way in delineating groundwater potential is electrical resistivity method because it is economical and effective (Anomohanran, 2103). This technique is able to map resistivity distribution of subsurface, estimate aquifer properties and classify resistivity of different lithologies effectively. The study took place in Kluang, Johor. The study area is elevated about 40 m to 70 m from sea level in the northwest towards southeast direction. Geology of Kluang consist of sedimentary rocks which come from Semberong Ridge of Jurassic to Cretaceous age. The rocks are dominated by mudstone, siltstone, sandstone and partly tuffaceous (Said *et al*., 2003). The study area however, located within undifferentiated acid intrusive region close to the border of sedimentary formation and the topsoil is dominated by clay and sand. This study implemented 2-D resistivity imaging method where a total of five survey lines were successfully conducted using ABEM SAS4000 system. Pole-dipole electrode arrangement was chosen in this study specifically for deeper penetration (Loke, 1999). The field survey data were processed by using RES2DINV to produce true resistivity subsurface images. Then, the result was exported to Surfer8 software to produce contour maps for a better presentation and a clearer perspective of the subsurface. Results show that the subsurface distribution is not uniform. Generally, the study area is made up of granitic rocks covered by thin topsoil which consist of clay and sand. Below the topsoil, the subsurface is dominated by weathered granite with resistivity value of 300 – 1000 Ωm. Unconfined aquifer can be observed from resistivity sections, indicated by resistivity values of 0 – 100 Ωm at depth of <50 m. Some fractures can be observed at resistivity lines of R1, R2 and R3, indicated by resistivity values of 50 – 200 Ωm. The fractures are suspected saturated with water since the resistivity values are very low. Granite rocks are indicated by high resistivity value of >3000 Ωm. From the overall results, confined aquifer can be seen at 2 different zones which flows through lines R1 to R3. Gunung Lambak hills that is located 6 km from the study area in the southwest direction is suspected to be the recharge area for the confined aquifer. Hence, the water movement inside the aquifer is predicted to flow from R1 to R3, in the southwest to northeast direction (Figure 1). The hard rock aquifers are highly recommended to be drilled because they contain a large amount of fresh water that can be extracted for further usage. The overall results are classified in Table 1.

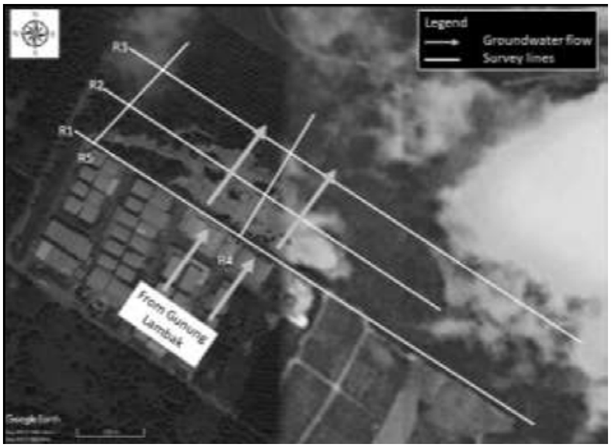

Figure 1: Predicted groundwater flow in Kluang.

Table 1: Generalized resistivity values in Kluang study area.

Lithology	Resistivity (Ωm)
Granite	>3000
Weathered granite	300 – 1000
Saturated fractured granite	50 – 200
Unconfined aquifer	0 – 100

Keywords: Groundwater, 2-D resistivity, Kluang, confined aquifer, granitic

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ORAL PRESENTATIONS

GEO-ARCHAEOLOGY

The archaeological survey of Bukit Choras: A preliminary study

NASHA RODZIADI KHAW, SHYEH SAHIBUL KARAMAH & NINIE HAVELA DISHONG

Pusat Penyelidikan Arkeologi Global, Universiti Sains Malaysia, 11800 USM Pulau Pinang
Email address: rnasha@usm.my; shyehsahibul@usm.my; ninihavela1994@gmail.com

Abstract: Ancient Kedah was one of the centre of international trade and iron production of the Straits of Malacca from the 5th Century B.C.E to the 14th Century C.E. Being located in the Bujang Valley, numerous archaeological remains were unearthed which give insight into its history and culture. Among the most important aspect of discovery in the Bujang Valley is the Hindu and Buddhist shrine, one of them being the Site of Bukit Choras. Bukit Choras is located in the northernmost limit of Bujang Valley, and is relatively large and well preserved complex. Despite of its importance, the site had been understudied. On July 2018, archaeological survey was done on the site to review its potential for future studies. During this preliminary survey, the surface findings, distribution of cultural mounds, and the geomorphological features of the site were observed. This research had given some insights into how the geological formation of the area influenced the ancient society to build the monument there. The indication regarding the correlation between the orientation of the site with the landscape of the area area also postulated.

Keywords: Bukit Choras, archaeological survey, Buddhist shrine

Magnetic and 2-D resistivity imaging prospecting of shallow buried archaeological remains structure at Sungai Batu, Lembah Bujang, Kedah

NURINA ISMAIL[1], NORDIANA MOHD MUZTAZA[1,*], MOKHTAR SAIDIN[2] & I A ABIR[1]

[1]Geophysics Section, School of Physics, University Sains Malaysia, 11800, Penang, Malaysia
[2] Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800, Penang, Malaysia
*Corresponding author email address: mmnordiana@usm.my

Abstract: In an archaeological study, geophysical method becomes important tools for the scientific investigation and also can be applied to map shallow subsurface structures at the archaeological site. The main purpose of the research is to locate the shallow buried archaeological remains structure in the area of Sungai Batu, Lembah Bujang, Kedah using magnetic and 2-D resistivity methods. The magnetic survey was performed using G-856 proton magnetometer and the spacing between stations was 1 m gridding. The magnetic data revealed high residual zones causing the magnetic anomalies using Surfer8 software. The results of high magnetic values (-65-75 nT) indicated the anomaly features within the study area. These anomaly features are detected according to the magnetic contrast (clay bricks) and the surrounding, mainly sandy clay. In order to provide further data on the site, 2-D resistivity technique was carried out at the same area of SB1 site. Resistivity surveys have been applied using Pole-dipole arrays with 13 survey lines and by 0.75 m electrode spacing. The survey used ABEM SAS 4000 and the data was processed using Res2DINV and Surfer8 software. The 2-D resistivity profiles obtained some high anomalies (≥5000 Ωm) at a depth ranging from 0-1.5 m study area. For being recognized as an area that have great archaeological potential, it must have two main characteristics which are mound area and exposed clay bricks on the surface. Based on the interpretation, the high resistivity value indicates the interesting anomaly which is clay bricks due to the effect of heat at high temperature.

Keywords: Magnetic, 2-D resistivity, shallow buried, archaeological, mound area

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Two-step filtering of ground magnetic data for archaeological investigation at Sungai Batu, Kedah, Malaysia

SABIU BALA MUHAMMAD[1,2,*], ROSLI SAAD[1], MOKHTAR SAIDIN[3], RAIS YUSOH[1], MUSTAPHA ADEJO MOHAMMED[1,4] & YAKUBU MINGYI SAMUEL[5]

[1] Geophysics Section, School of Physics, Universiti Sains Malaysia, 11800 Pulau Pinang, Malaysia
[2] Department of Physics, Usmanu Danfodiyo University, Sokoto, Nigeria
[3] Centre for Global Archaeological Research, Universiti Sains Malaysia
[4] Department of Physics, Federal University, Lafia, Nigeria
[5]School of Science and Technology Federal Polytechnic, Damaturu, Yobe State, Nigeria
*Corresponding author email address: sabiubala@gmail.com

Magnetic survey measures combined primary magnetic field intensity of the different components of the Earth; core, mantle and crust, as well as secondary field induced in geological units, utilities, archaeological remains and other forms of objects buried in the subsurface. The method provides a means for probing the Earth's subsurface in a non-destructive manner, by taking advantage of the contrast in magnetic susceptibility of underlaying materials (Muhammad *et al*., 2014). Techniques are now available to acquire magnetic data on land (Suleiman *et al*., 2014), at sea and in air (Ajana *et al*., 2014).

Difficulty associated in dealing with dipolar nature of magnetic anomalies is well known in geophysics. This often makes interpretation difficult as an anomaly is not usually placed exactly over its source. The location of the source object cannot therefore be completely determined using the anomaly it produced. Furthermore, regional-residual separation is typically performed to remove long wavelength background field due to deeper regional sources to boost anomalies of shallow local structures. Sometimes, the background effect persists after the separation. A couple of techniques can be used to mitigate some these problems. Data reduction to the equator (RTE) for areas closer to the equator can be applied to place anomalies almost exactly above the causative bodies. Automatic gain control (AGC) filter can be used to enhance signal in regions of low magnetic variability and subdue signal in regions of high background magnetic field. In this way, signals of all important anomalies are equalized and thus treated evenly across the study area.

In this study, ground magnetic data was acquired, analysed and interpreted for shallow archaeological investigation at Sungai Batu, Lembah Bujang, Kedah, Malaysia. The objective is to locate buried archaeological remains, typically in the form of backed clay bricks in the surveyed area. Magnetic field intensity data was acquired using G-856 proton type magnetometer at 1 m minimum grid spacing. During the data acquisition, suitable base station was established at 50 m from the study area to take readings at 1-minute interval for diurnal data correction and regional-residual separation. Residual field intensity values obtained were in the range of -25 to 177 nT. The values were generally divided into two main classes; low magnetic (< 38 nT), and high magnetic (> 38 nT). The data was gridded and contoured using Oasis Montaj software to obtain the magnetic residual field intensity map (Figure 1). The gridded data was reduced to the magnetic equator to shift anomalies directly over their sources (Figure 2). Automatic gain control filter was then applied to enhance the signal in regions of low field variations and to supress the signal in regions with very high field variations (Figure 3). Post-processing of the grid using hierarchical combination of RTE and AGC filters refined the shape, location, orientation and extent of the anomalies of interest. The major anomalies, located in regions B and C were generally rod-like, running in the west-east direction. Few other anomalies were also identified in region A, presumably due to fragments of the suspected clay bricks shattered as

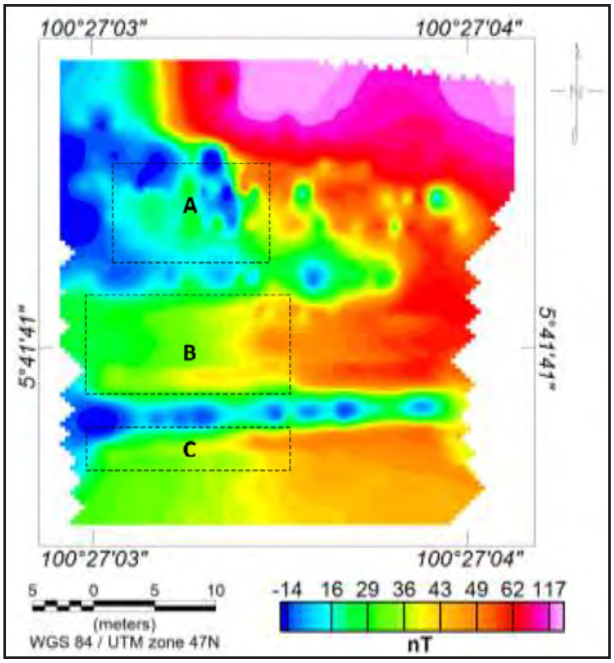

Figure 1: Residual magnetic field intensity map of the study area.

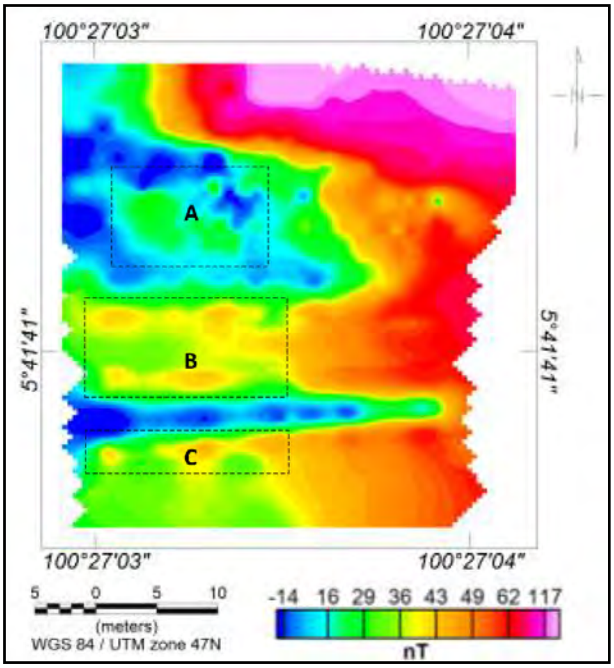

Figure 2: Residual magnetic field intensity map after reduction to equator.

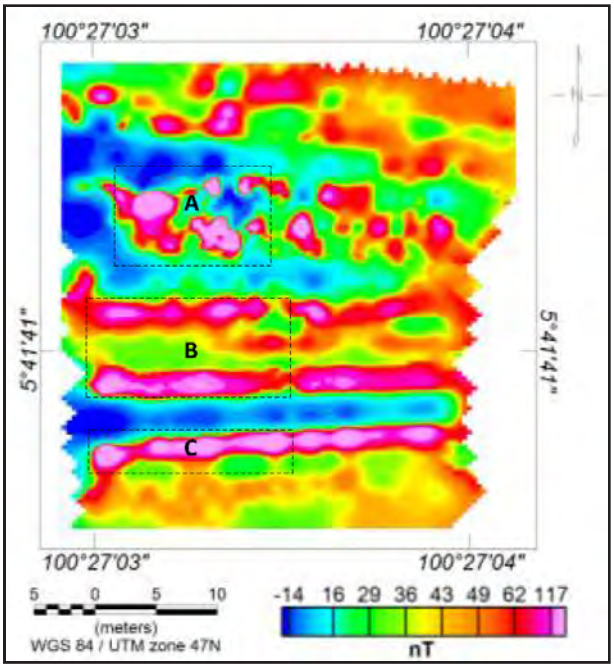

Figure 3: Two-step filtered image from obtained from RTE-AGC.

a result of heat or other weathering agents. The two-step filtering has revealed sharp anomalies suspected to be signatures of the baked clay bricks.

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S3-99

Scientific application on bricks from Sungai Batu monuments

RATNAH WATI MOHD RAPI, AHMAD FADLY JUSOH & MOKHTAR SAIDIN

Pusat Penyelidikan Arkeologi Global, Universiti Sains Malaysia, 11800 USM Pulau Pinang
Email address: ratnah1986@gmail.com; ahmad_fadly@usm.my; mmokh@usm.my

Abstract: Evidence of Kedah Tua Kingdom since 6th Century BC was found by USM through excavation in Sungai Batu Complex. The evidences are proved by the sites of iron smelting workshops and monuments. There were 54 sites excavated and 33 of them are monuments functioned as ritual sites, jetties and administration buildings. Monuments showed an evidence of floor, stair, wall and corridor structures that are entirely built from brick material. A total of 24 brick samples from eight monument sites was analysed by XRD and XRF to knows their composition. The X-ray Diffraction (XRD) and X-ray Fluorescence (XRF) techniques can determine the mineral content and trace elements in qualitative and quantitative values. The results will allow us to know whether they used the local materials or conversely. The samples are from site SB1B (ritual site), SB1H, SB2B, SB1A (jetty sites) and SB1M, SB1N, SB1X, SB2ZY (administrative building sites). The results showed that they used local material to made the bricks. Therefore, the people in Sungai Batu Complex already have the skills and knowledge to find the locality and quality raw materials for making their bricks.

Keywords: Sungai Batu Complex, Bricks, XRD and XRF Technique

S3-69

The contribution of technical ceramic to iron smelting production at Sungai Batu, Bujang Valley

NAIZATUL AKMA MOHD MOKHTAR & MOKHTAR SAIDIN

Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800 USM Pulau Pinang
Email address: naizatulm@gmail.com; mmokh@usm.my

Abstract: Iron smelting sites at Sungai Batu, Bujang Valley are dated from 535 BCE until 15th Century CE. The evidence of 17 sites found with abundance of iron slags and other artefacts clearly show that a large scale iron-smelting industry existed in Bujang Valley. The technical ceramics are one of the dominant discarded material in smelting process besides iron slag. The term 'technical ceramics' refers generally to any ceramics used in metallurgical or other high-temperature operations. Technical ceramics are essential tools for almost all metallurgical processes and were routinely exposed to a variety of conditions that they had to cope with. The technical ceramic found in archaeological sites can be classified as furnace, tuyere and brick. They were made by clay and play different roles in iron smelting process. Clays have the ability to withstand temperatures up to around 1,100°C without melting. This article will discuss the significance of technical ceramic regarding the impact of iron production. The methods consist of collecting sample from archaeological site, auguring sample and scientific analysis such as X-ray fluorescence (XRF), X-ray diffraction (XRD) and scanning electron microscopes (SEM-EDX) analysis. The following discussion will further explain the selection of material and particular shapes in enhancing the iron smelting process in Sungai Batu. The result demonstrates that the technical ceramics were made from locally available supplies with some organic material and sand as temper. The site which was located in the vicinity of natural resources required in iron production such as water, ore and clay made the Sungai Batu Complex a strategic location for iron industry.

Keywords: Iron smelting, technical ceramic, Sungai Batu site

ORAL PRESENTATIONS

MINING & QUARRY/ MINERAL PROCESSING

Challenges in exploration and mining for gold

Mior Termizi Mohd Yusof

Institute of Mineral Engineering Malaysia

Abstract: The state of Kelantan is known for a long time for its resources of gold. The author was a general manager of a gold mining company in Kelantan for seven years. The author met several challenges, amongst others are to get ample fund to keep the company running, the thick jungle with wild elephants that trampled on pitting samples, infighting among the staff and the most unfortunate was misunderstandings with the state authorities. This was the time where the mineral legislations were being tested for the first time, whereby the interest of the miners were being protected. With that the company managed to recover on the losses within two years.

Mineral exploration potency in Southeast Sulawesi Indonesia: An opportunity for research collaboration

MUHAMMAD NURDIN[1,*], I. ILHAM[2], M. MAULIDIYAH[1], DWIPRAYOGO WIBOWO[1], MUH. NATSIR[1], MUH. ZAKIR MUZAKKAR[1] & ABDUL HARIS WATONI[1]

[1]Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Halu Oleo, Jl. HEA Mokodompit Kampus Hijau Bumi Tridharma Aduonohu, Kendari 93232 – Southeast Sulawesi, Indonesia

[2]Faculty of Engineering, Universitas Halu Oleo, Jl. HEA Mokodompit Kampus Hijau Bumi Tridharma Aduonohu, Kendari 93232 – Southeast Sulawesi, Indonesia

*Corresponding author email address: mnurdin06@yahoo.com

Abstract: The high mineral exploration in Indonesia has become pay attention to foreign investors. Especially, in Southeast Sulawesi Province has attended many foreign companies (China, South Korea, and America) to explore and exploit the minerals. There are 16 foreign companies that have obtained a permit from the government based on a decree mining license 2010's. Total of mining area exploration in Southeast Sulawesi achieve 328,291.37 Ha or 8.61% of the total land area. The metal mineral deposit content has abundant and consists of Ferronickel (iron, nickel, cobalt, chrome, manganese, molybdenum, titan), precious metals (gold, silver, platinum), base metals (zinc, copper, lead, lead, mercury), and rare metals (bauxite and monazite). One of the minerals abundant in Southeast Sulawesi is laterite as a source of nickel.

Mining activity and nickel industry in Pomalaa area have affected the environment. It is expected that the implementation of good mining practice, industrial ecology, and social responsibility (CSR) will balance the mining and industrial activities with the sustainability of environment. The problems caused by the mining activity and nickel industry are the changes of environmental quality. This work aims to analyze the environmental conditions of the community as well as creating a balanced model of the sustainable mining area and nickel industry. The balanced model of the mining area and sustainable nickel industry can be realized by implementing the concept of good mining practice, industrial ecology, and CSR in a balanced manner. The products have been exporting to abroad for high purification of Ti, Fe, Ni, etc.

Keywords: mineral, purification, exploration, Southeast Sulawesi, Indonesia

S4-16

Upgrading of waste from construction sand process: Case study of Lamthamenchai Deposit Nakornratchasima, Thailand

K. KUNTAWANG[1], S. SOMSAK[2] & A. NUMPRASANTHAI[3]

[1] Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Phayathai Rd, Pathumwan, Bangkok 10330, Thailand
Email address: kanok.kuntawang@gmail.com[1] , Somsak6931@gmail.com[2] , Apisit.nu@chula.ac.th[3]

Abstract: The research presents an upgrading of waste of construction sand process from Lamthamenchai Deposit in Nakornratchasima, Thailand. This research focuses on the mineral processing of silica sand to reduce the iron impurities from silica sand by physical and chemical process and analyze the characteristic of the silica sand by X-ray fluorescence.

First, the sample from deposit are divided into 6 parts by using spiral concentrator, half of each of them are scrubbed by scrub machine. Next, shaking table has been used for upgrading the low-grade silica sand and the result shown that 91.3 % of SiO_2 and 0.51% of Fe_2O_3 is the best result, compared with the silica sand obtained by wet high-intensity magnetic separator (WHIMS) 94.1% of SiO_2 and 0.42 % Fe_2O_3 was achieved which cannot respond the standard of the glass- grade silica sand. After that, Flotation method has been used to help for reducing the iron impurities from WHIMS samples 0.3% Fe_2O_3 and 97.6% of Silica sand were achieved by using 100 ml collectors (AOA and Nanza) which higher than minimum standard for glass sand. After finished all the process of removing the impurities minerals, the cost was taken into consideration. Therefore, Wet High Intensity Magnetic Separator technique combined with Flotation process is recommended to apply for this study area.

Keyword: silica sand, glass sand, sand process

Physical and physico-chemical processing of Malaysian sulphide iron ore

ISMAIL IBRAHIM, NAZWIN AHMAD, SALMAH BAHARUDDIN & ROSHAIDA ARBAIN

Mineral Research Centre, Department of Mineral and Geoscience,
Jalan Sultan Azlan Shah, 31400 Ipoh, Perak, Malaysia
Email address: is.ibrahim@jmg.gov.my; nazwin@jmg.gov.my; sal@jmg.gov.my; roshaida@jmg.gov.my

Introduction

Iron ores are rocks and minerals from which metallic iron can be economically extracted. The ores are usually rich in iron oxides and vary in colour from dark grey, bright yellow, deep purple, to rusty red. The iron itself is usually found in the form of magnetite (Fe_3O_4), hematite (Fe_2O_3), goethite (FeO(OH)), limonite ($FeO(OH).n(H_2O)$) or siderite ($FeCO_3$). Iron ore is the raw material used to make pig iron, which is one of the main raw materials to make steel. 98% of the mined iron ore is used to make steel (Shitarashmi Sahu, 2009).

In the future it is expected that there will be strong growth in iron ore demand. Hence, the production of local iron concentrate is expected to increase too. It happens either by expanding existing mines or exploring new areas to intensify the activity of iron ore mining. However when we look back at Malaysia iron ore mining scenario, some of the processing activities were carried out with simple processing method and hence by only taking lump of iron (LOI). Consequently, only low grades of iron concentrate are exploited and slightly less intent on removing impurities. As a result, the Fe grades produced are considerably low (Ismail *et al*., 2017).

Materials and methods

Sample and sample preparation

Rock sample used in this experimental works was obtained from a local iron ore mine in Malaysia. First, the rock sample was crushed using crushers and mixed thoroughly. Then, grinding of crushed material was performed on the oversize (+600 μm) portion for 3 to 7 minutes in a laboratory ball mill with 10 kg of mixed steel balls (5 kg of 5 cm, 3 kg of 3.75 cm and 2 kg of 2.5 cm diameter) to achieve a particle size in which this particle size corresponds to the liberation size as confirmed by mineralogical analysis, and followed by sieving. Then, the sieved materials (-600+45 μm) from batches were mixed together and was passed through spiral, double disk magnetic separator (DDMS) and flotation to get rid of sulphide content. Sample characterizations by x-ray fluorescence (XRF), x-ray diffraction (XRD) and then Fe and Sn content by titration method while carbon and S analysis were employed by carbon-sulphur analyzer.

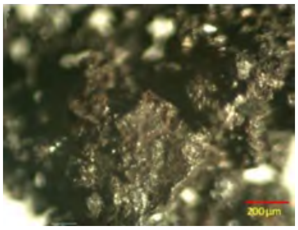

Figure 1(a): Image microscopic shows sink product which contains magnetite as dominant.

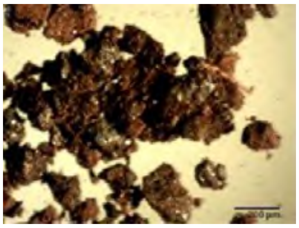

Figure 1(b): Image microscopic shows float product of pyrite as dominant.

Results and discussions

Characterization of sample

The results of XRF analysis reveals the presence of chemical composition of iron ore in their respective compositions of Fe_2O_3 (34.0477%), SiO_2 (35.0817%) and Al_2O_3 (14.3570%) and SO_3 (8.2663%). XRD diffractogram of iron ore sample contains the major minerals were magnetite (Fe_3O_4), hematite (Fe_2O_3), goethite (FeO[OH]), quartz (SiO_2) and pyrite (FeS_2).

During the grinding period of 3 to 7 minutes, the grinding process was selected at 3 minutes in order to liberate the iron oxide from other associated minerals and to avoid over grinding materials.

Physical and physico-chemical processing

Table 1 shows the magnetic separation results on spiral concentrate. The results shows that total Fe for 0.2 amp and 0.4 amp products from spiral concentrate were increased from 51.65% to 68.62% and 60.43% respectively, while the Fe content in non-magnetic product was 22.72%. Meanwhile the distribution of Fe in 0.2 amp and 0.4 amp and non-magnetic gave 64.57%, 33.97% and 1.46% respectively. It shows there were good separations occurred at both 0.2 amp and 0.4 amp discs. Due to the dominant Fe content of the 0.2 amp product, it indicates that many magnetite has been collected from this product.

The purpose of conducting flotation test is to get rid of carbonaceous and sulphide minerals. Therefore, the material to be floated shall contains a lot of carbonaceous and sulphide minerals. While sink material should contain low C and S and high Fe as it represent final iron concentrate and ready for commercialization.

From flotation test at pH 2 the carbon content in float and sink were 0.3326% and 0.2407% respectively. However the distribution of C were 7.89% (float) and 92.11% (sink). Whereas the content of S were found to be 2.53% (in float) and 0.4673% (in sink) and the

Table 1: Magnetic separation by DDMS on spiral concentrate fractions.

From Product	Magnetic intensity (amp)	% wt	% Fe	% S	% C	% Dist of Fe	% Dist of S	% Dist of C
Spiral Conc (Fe = 51.65%)	0.2 (Disc 1)	60.18	68.62	0.6418	0.1375	64.57	49.78	57.83
	0.4 (Disc 2)	35.73	60.43	0.9780	0.1509	33.97	45.09	37.68
	Non Mag	4.09	22.72	0.9735	0.1574	1.46	5.13	4.50

distribution of S were 25.08% and 74.92% in float and sink respectively. Since C and S content is less than 0.5%, to some standard it has achieved a target grade for iron concentrate commercially.

The microscopic study has been carried-out to know the colour, the morphology and size of the particles of float and sink from flotation process. Based on the images shown in Figure 1(a), it can be seen that the magnetite particles are dominant in sink products. This indicates that magnetite particles can be liberated from other minerals such as quartz, alumina, pyrite and other minerals as a result of grinding for 3 minutes previously carried out. Figure 1(b) demonstrates pyrite particles as dominant were collected from float products.

Acknowledgement

The authors would like to thank and also pleased to acknowledge the support of the Director of Mineral Research Centre, Minerals and Geoscience Department and fellow staffs of the Centre especially to the staffs of Mineral Processing Technology Section for their assistance and laboratory works in making this research successful.

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Generation of target areas for further mineral exploration studies from airborne geophysical survey in East Coast Economic Region (ECER)

Abd Rahim bin Harun & Ahmad Zulkifli Kamaruzaman

Department of Mineral and Geoscience Malaysia

Abstract: Department of Mineral and Geoscience Malaysia had been awarded a task to manage an airborne geophysical survey over the East Coast Economic Region (ECER), Malaysia. The objectives of the survey were to; outline the various geological units and tracing the major faults/structures, and to define the best targets for the mineral exploration ground follow up study. Requirements included to; recognize and delineate magnetic anomalies caused by igneous and mineralised bodies and delineate basement structure that may assist in the recognition of features favourable for base metal mineralization. Map the gamma-ray activity of the surface rocks and soils for the purpose of; recognizing radioactive mineral deposits of possible economic significance, and mapping lithology boundaries, possibly delineating igneous bodies.

The acquisition and processing of the airborne geophysical data was undertaken by GPX Surveys Pty Ltd. It was then merged with an existing airborne geophysical survey acquired in 1980 over the Central region.

Interpretation of the large airborne geophysical dataset within the Central and Eastern Belts has provided new insight into the geology and geological history of the region. There has been continuous sedimentation, volcanic and intrusive activity in the Central and Eastern Zones of Peninsular Malaysia from Carboniferous age through to very recent.

The present study involved the interpretation of new airborne magnetic and radiometric data acquired in 2016 as part of the East Coast Economic Region (ECER) initiative merged with existing data, and existing geology maps and publications.

The airborne radiometric and digital topographic data map the surface geology very well in Peninsular Malaysia. This has enhanced the existing geological map through the correlation of geological formations across the area, subdivision of units due to differences in composition and recognition and classification of intrusive bodies. These intrusives are known to be important fluid and heat sources for the known mineralisation in the areas.

The geology can be extended to the subsurface using the airborne magnetic data. The geological evolution of Eastern Peninsular Malaysia has been proposed through the identification of the surface and subsurface geology and structures affecting the sequences in the area. One key finding has been the recognition of more extensive sequence of highly magnetic Permian andesitic volcanics than previously known. These are considered to be potential hosts for base metal mineralisation.

Structural mapping is particular difficult in tropical regions, as the faults will often weather preferentially and so are not exposed. A regional structural framework has been compiled in this study. Of particular interest, is the recognition of several major faults, subparallel to the known Bentong-Raub Suture Zone and the Lebir Fault Zone. These structures appear to be long-lived and significant for controlling important mineral districts.

Mineralisation is present throughout the area, including tin, iron, gold, barite and basemetal mineralisation. Extensive small scale mining has generally focussed on the shallow or alluvial deposits. A key outcome of this project is the generation of target areas for further mineral exploration studies. The target areas include; Isolated magnetic highs (of interest for iron and tin);broad areas of increased thorium response (for monazite); and areas considered to have favourable lithologies and structures to host gold, tin and base metal mineralisation.

This work should be considered a regional review of the airborne geophysical data. It provides a comprehensive and consistent dataset on which to base further geological studies. These may include, but not limited to; a more detailed assessment of the geophysical data over areas of interest;further understanding of the intrusive systems in the region, by reviewing existing geochemistry, geochronology and petrology data in light of the classifications of the intrusives provided here; Fieldwork focussed to resolve areas of discrepancies, or to get further information on the target areas.

S4-18

Study on beneficiation of silica sand by Wet High Intensity Magnetic Separators (WHIMs) and reverse flotation technique for glass application: A case study in Sihanoukville, Cambodia

R. SOCHEA[1], S. SOMSAK[2] & A. NUMPRASANTHAI[3]

[1] Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Phayathai Rd, Pathumwan, Bangkok 10330, Thailand

Email address: ros.sochea@gmail.com; somsak6931@gmail.com; apisit.nu@chula.ac.th

Abstract: White silica sand samples were collected from Steuong Hav district area. The samples mixed and quartered to obtain a representative sample for physical and chemical characterization. Silica (SiO_2) and iron oxide (Fe_2O_3) content were measured by XRF. The results showed silica and iron oxide content 94.83 wt.% and 0.189 wt.% representatively. In this study, shaking table, WHIMs and reverse flotation technique was undertaken to remove mainly iron oxide. The collectors AOA, NANZA, pine oil and depressant H_2SO_4 were used to optimize the froth performance. The Iron Oxide content was removed from 0.189wt.% to 0.062 wt.% and the silica content was upgraded from 94.83wt.% to 98.6 wt.% after the process.

S4-34

Cassiterite recovery from mine tailing dump in Myeik, Tanintharyi Division, Myanmar

K. THI THAW[1], S. SOMSAK[2] & A. NUMPRASANTHAI[3]

Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Phayathai Rd, Pathumwan, Bangkok 10330, Thailand

Email address: kaythaw7@gmailcom[1], Somsak6931@gmail.com[2], Apisit.nu@chula.ac.th[3]

Abstract: The research aimed to recover cassiterite ore from mine tailing dump at the Ngwe Gabar mine in Tanintharyi Division, Myanmar. The tailing dump contains 0.05% Sn, 0.002% Nb, 0.001% Ta. Wet sieve technique was primarily used to separate the sample into three sizes including +30#, -30+100# and -100#. XRF and Frantz Isodynamic Magnetic Separator were employed to measure the Sn% content. Shaking Table, WHIMs and Electrostatic Separator were employed to concentrate tin from the tail dump. The results have shown that the tin was recovered up to 72% after process. The profitability of the project was measured and reported in term of the Modified Internal Rate of Return.

Keywords: Cassiterite, Shaking Table, WHIMs, electrostatic

S4-4

Gold potential mapping in Kelantan (Malaysia) using ArcGIS and Excel applying Frequency Ratio Model

Tagwai Gregory Mathew & Kamar Shah Ariffin

Mineral Resources Engineering
School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
Email address: tgm15_min031@student.usm.my; kamarsha@usm.my

Introduction

Mineral exploration activities include the securing of mineral resources that have the potential to be economically developed. Generally, since geological, geochemical and geophysical factors mainly control the formation of mineral deposits such as gold mineralization, it is, therefore, a geological belief that the ‘spatial integration of all related gold occurring factors produced excellent prediction maps.’ (Carranza, 2017; Joy *et al.*, 2012). The acquisition of geochemical and geophysical data for GIS predictive mineral mapping are usually expensive compared to geological factors with an open-access data source (satellite imagery). This current work aims to determine the prediction rate of potential gold maps produced by the spatial integration of geological factors using Probabilistic methods (frequency ratio based-model) in respect to regional gold predictive mapping in Kelantan, Malaysia. So far, no studies have managed to determine the success rate of integrating only geological evidence for potential gold mapping in Malaysia.

Study area

The study area is part of the Kelantan State bounded by latitudes 4^{o}38’20”- 4^{o}56’40” and longitudes 101^{o}49’50” – 102^{o}1’55”E. The study area occupies approximately 593km^{2}. This region was selected because a similar study (Yosuff *et al.*, 2015) had applied a different approach to produce a potential gold map of the area. Thus, the choice of the region allows the comparison of the prediction accuracy of the current studies with the previous research.

Methodology

In total this study considered five factors (lineament NE-SW, lineament NW-SE, host rock, heat source and alteration of clay and iron) and eight gold deposits. These five (5) factors were obtained from historical geological maps and open source satellite imagery. The research applied the geographical information system (GIS) of frequency-based model and Excel spread-sheet Software to generate a potential gold.

Results and discussion.

The contribution of each factor used in generating the final predictive maps was statistically determined and their pairwise calculated values (Table 1). The results suggests gold mineralization is majorly control by the selected analysed factors for instance, incorporating geochemical or geophysical data for the predictive mapping will have no or insignificant effect on the final map.

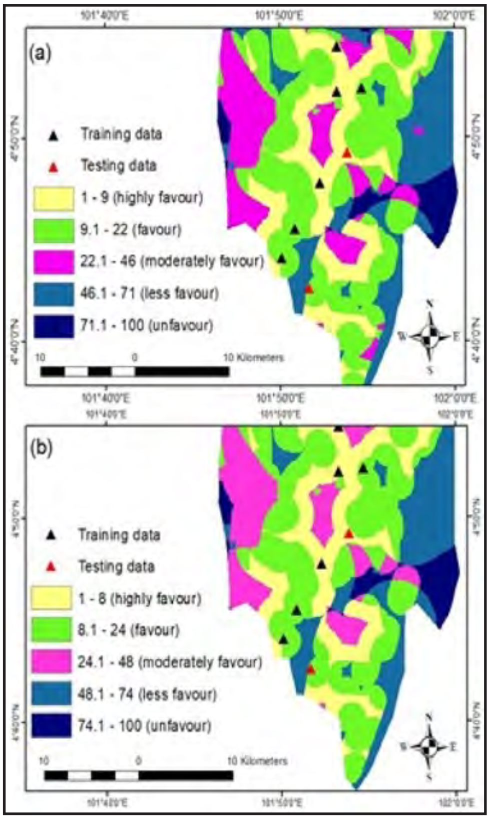

Figure 1: Potential gold Map (a) based on FRPR (b) based on FRPI.

Table 1: Frequency ration prediction rate (FRPR) Prediction and Frequency ratio Pairwise (FRPI).

Factors	*Frequency Ratio Prediction Rate*	*Frequency ratio Pairwise*
Alteration	*42.8039*	*32.26322*
Heat source	*102.2369*	*77.06054*
Host rock	*122.7767*	*92.54231*
Lineament NW-SE	*161.9133*	*122.0413*
Lineament NE-SW	*233.6236*	*176.0926*

Conclusion

This study shows a high prediction accuracy of 92.50% and highlight regions with high gold prospectivity. Mineral exploration industries can now depend on geological evidence for predictive mapping. Thus this study presents a new phase of research in regards to Landsat 8 OLI imagery application for gold mineral target and exploration in Malaysia.

Acknowledgements

The authors expressed our profound gratitude to all staff and Ph.D. students of Universiti Sains Malaysia who in one way or the other had contributed to the success of this work.

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ORAL PRESENTATIONS

REGIONAL GEOLOGY

SESSION KEYNOTE SK-6

Comparison on geochemical properties of andesite from Pos Betau, Pahang with Malay Basin's Volcanic: An overview

Syazwan Zainal Abidin & Askury Abd Kadir

Geoscience Department,
Universiti Teknologi PETRONAS
32610 Bandar Seri Iskandar, Perak Darul Ridzuan
Email address: bayernean@gmail.com; askury_akadir@utp.edu.my

Abstract: This paper reviews the geochemical properties of andesite outcrop exposed along Jelai to Pos Betau. It aims to compare the geochemical properties of andesite and fracture pattern with the Malay Basin basement. The updated version of geological map of transect area compared to published geology of Peninsular Malaysia will be suggested through the lithological changes. The relationship between them to Anding Utara fractured basement reservoir are the main focus on this study. The geological analysis suggested that the observed serpentinite and chert represent remnant of Palaeo-Thethys sea that has been closed when Sibumasu collided with Indochina block. Fractured and sheared serpentinites indicate the compressional forces acted, or by convergent plates. Partly, the serpentinites altered to soapstone. As for structural analysis, the andesite outcrops have fracture system in direction of NW-SE with minor fracture system aligning in NNE-SSW direction which is closely related with the tectonic evolution of Peninsular Malaysia. For the geochemical properties analysis, the plotting of normative mineral calculation results on the International Union of Geological Sciences (IUGS) volcanic rock classification indicates that the andesite in Pos Betau falls in quartz andesite type. Based on previous study, the Anding Utara volcanic basement reservoir rock also have the same composition which is andesite shows that both of the rocks originate from the same magmatic composition which is andesitic and intermediate lava.

Keywords: Andesite, Anding Utara, fractured basement

Dry hole analysis on Caravel-1 Well, offshore Canterbury Basin, New Zealand

SYAHRUL SALEHUDIN

SSC Sdn Bhd
A-8-13, D'Alamanda, Jalan Pudu Impian, 56100 Kuala Lumpur, Malaysia
Email address: syahrulsyam@hotmail.com

Introduction

The offshore Canterbury Basin has been explored for its hydrocarbon potential since the 1960s (Figure 1), unfortunately only three wells have gas and condensates discovery from a total of six exploration wells, but all were uneconomic (Salehudin, 2017, in press).

Source rocks occurrence was discussed in great length by Sahoo *et al*. (2015) and these source rocks has been evaluated for its richness, maturity and ability to yield hydrocarbon from various available raw data (Salehudin, 2017; in press). The occurrence of hydrocarbon shows and uncommercial discoveries in this region may be contributed by the localized granite intrusions in some part of the basin (Sahoo *et al*., 2015; Salehudin, in press).

The failure of Caravel-1, recently drilled in 2014, to discover hydrocarbon in its primary target is still a question.

Reservoir

The primary target of the Cretaceous clastics reservoir rock was reported to be absent at the well location (Blanke, 2015) which is in contradiction to the findings by Sahoo *et al*. (2015).

Source rocks

There are no reported source rocks within the Caravel-1 well location since it was located on a horst. However, within 15km Southeast of the location, coals and coaly mudstones were observed through seismic amplitude response in the graben. These rocks were the main source rocks that supply the hydrocarbon to Galleon-1. Unlike Galleon-1, there was no indication of igneous intrusion in this area which suggest even if there were source rocks, it would be still immature.

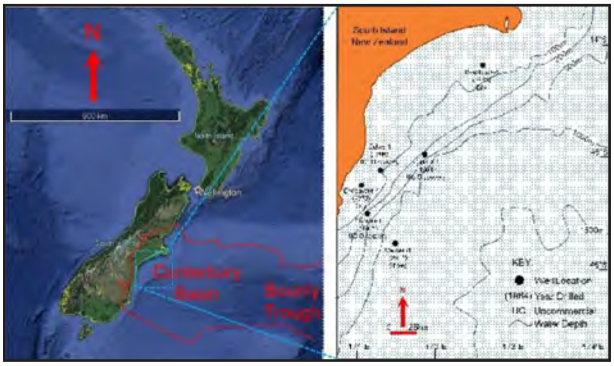

Figure 1: Location map of Canterbury basin and some wells drilled offshore.

Migration and seal

Salehudin (2017) speculated that the migration had taken place outside the structure or a possibility of the hydrocarbon was never charged into the structure which explains the absence of any show in the Cretaceous primary target rocks. Assumption was made that the faults bounding the graben next to the horst was sealing and therefore prevented hydrocarbon from migrating into the Caravel-1 structure (Figure 2).

However, minor shows in the Paleogene clastics may be due to migration from elsewhere particularly a spill over from Galleon-1 which was located approximately 35km to the Northwest of Caravel-1.

It is assumed from regional data that the top seal within the post Eocene was intact. The main structures were developed completely within the Early Tertiary which was the timing for migration took place.

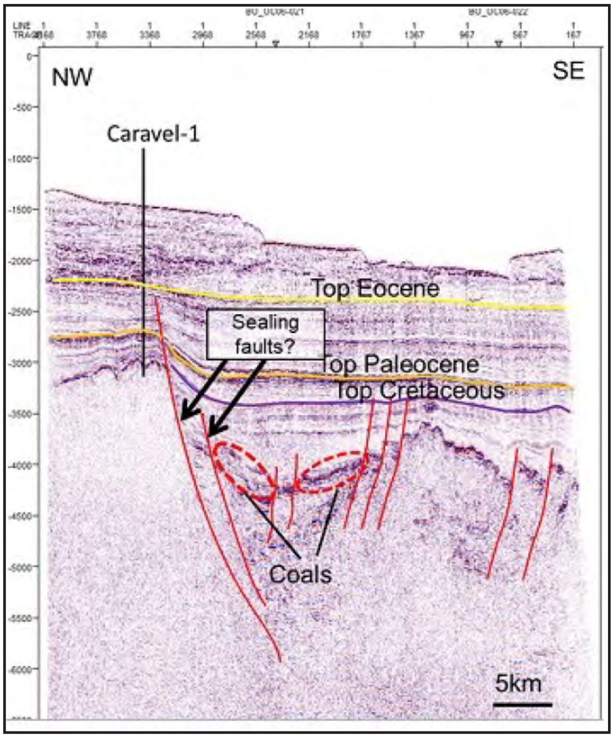

Figure 2: Seismic cross section along OC06-12 line showing an approximate Caravel-1 location on a horst next to the graben with potential source rocks occurrence.

Conclusions

It is well noted that the failure to observe significant amount of hydrocarbon in this basin currently lies from several factors and all of which can be related to the infavourable results of Caravel-1 as follows;

1) Selected maturity on source rocks exposed near to igneous intrusions;

2) Some bounding faults within the source rocks graben were sealing;

3) Immature nature of most of the source rocks in the region.

4) Absence of reservoir rocks within the drilled well locations.

Acknowledgements

The raw data and most of the reports for this study were obtained through the GNS Science Data Series which are open to public through its website and were gratefully thanked.

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S5-40

Seismic and sequence stratigraphy study of the central part of Taranaki Basin Deposits, New Zealand

ABD ALSALAM ALMASGARI[1,2,3], DEVA PRASAD GHOSH[1,2] & ABDUL HADI BIN ABD RAHMAN[1]

[1]Department of Geosciences, Universiti Teknologi PETRONAS (UTP), 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia
[2]Centre of Excellence in Subsurface Seismic Imaging & Hydrocarbon Prediction (CSI)
[3]Department of Geology and Environment, Faculty of Applied Science, Thamar University, Yemen
Email address: abd_16005741@utp.edu.my; drdeva@utp.edu.my; hadi_rahman@utp.edu.my

Introduction

The interpretation of the seismic sequences boundaries, seismic facies and system tracts from seismic reflections was very crucial in hydrocarbon, of in establishing the potential hydrocarbon accumulation. Previous researchers have widely and generally studied the Taranaki Basin in New Zealand. However, detail study on sequence stratigraphy in Central Taranaki Basin has yet to be done. Figure 1 shows the study area of Taranaki Basin, the main structural elements and the location of the wells.

Some detailed investigations have been undertaken on the Giant Foresets Formation by several researchers (Hansen & Kamp, 2002), while in the current study giant and Parasequence sets have been delineated. By interpreting the seismic facies, depositional environment, before establishing the delineation of the system tract within the study area in the basin. Consequently, modified sequence stratigraphy of the basin, and potential hydrocarbon reservoirs were proposed.

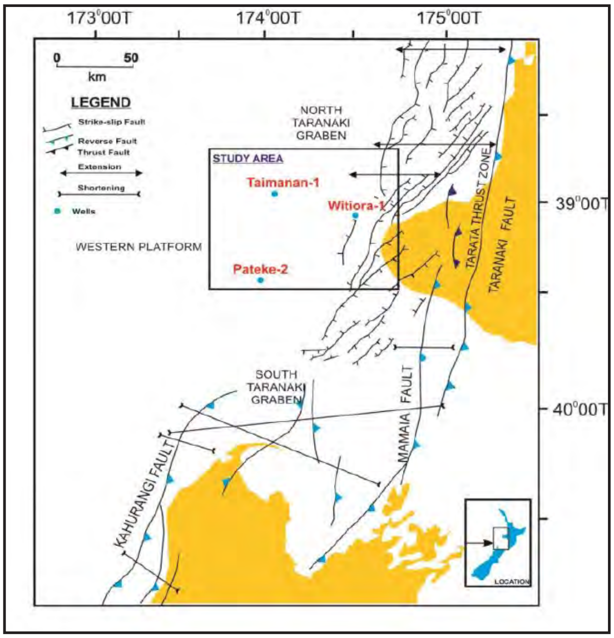

Figure 1: Map of Taranaki Basin showing the study area, the main structural elements and the location of the wells, after King & Thrasher, 2010.

A total of ten 2D seismic lines from Taranaki Basin and a well log (exploration Witiora-1) were used in this study, covering the area of 217 km^2.

Sequence boundaries were picked from synthetic seismogram which was previously developed by tying the seismic lines with the well data. The seismic facies and system tracts (LST, TST, and HST) were determined by identifying the internal seismic reflection seismic reflection terminations, and gamma-ray log data.

The morphology of each for each sequence and structures were presented as the line structure maps, developed by using Kingdom and Petrel software. In this study, eight regional seismic sequences (SEQ1, SEQ2, SEQ3 SEQ4, SEQ5, SEQ6, SEQ7, and SEQ8) and eight boundaries representing unconformities (H1, H2, H3, H4, H5, H6, H7, and H8) have been identified based on reflection terminations and supported by well logs information.

A new horizon named (SA-Middle Giant Formation) was detected between the upper and lower Giant formation based on newly found onlapping feature towards the land in the seismic section indicating a period of seawater encroachment.

Various of seismic facies have been identified in most of the seismic sections and categorized as continuous, to sub-continuous, parallel to sub-parallel, free-reflection, high amplitude-frequency to high amplitude-low frequency, chaotic and wavy.

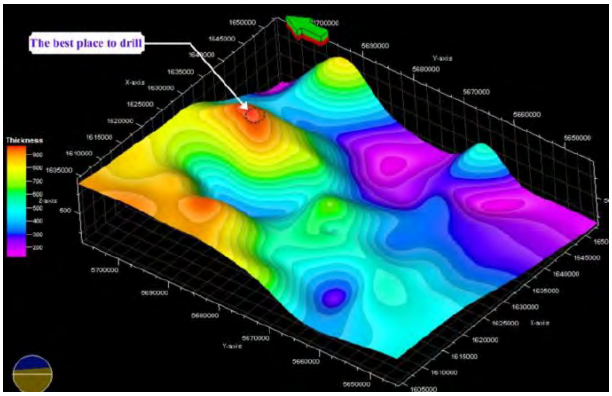

Figure 2: The 3D view of isopach map showing the thickness variation in depth of Kapuni Group (SEQ8).

Different types of system tracts such as low (LST), transgressive (TST) and high (HST) were successfully determined in the seismic sections and its Para-sequence and Para-sequence set representing short-term sea level changes were determined by analyzing the gamma ray log patterns of three well.

Based on the system tract and seismic facies analysis, the sediment sequence was deposited on the faulted (horst and graben) basement rock. Based on this study, the potential hydrocarbon layers were anticipated at Kapuni Group (SEQ8) and Giant Formation (SEQ3). Figure 2 represents the 3D view of isopach map showing the thickness variation in depth of the potential anticipated hydrocarbon layers of Kapuni Group (SEQ8).

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The depositional evolution of the Kayan Formation, Lundu area, Sarawak

Muhammad Murtaza*, Abdul Hadi Abdul Rahman, Chow Weng Sum, Mazshurraiezal Nasir, Najiatun Najla & Zainey Konjing

Faculty of Geosciences and Petroleum Engineering
Universiti Teknologi PETRONAS.Bandar Seri Iskandar, 31750 Tronoh, Perak Malaysia
*Corresponding author email address: murtaza_k@hotmail.com

Introduction

The Kayan Sandstone Formation outcrops in Gunung Undan area in the north, while Penrissen and Lundu area marks the western exposures. It is composed of variant of massive and cross-stratified sandstone and conglomerates interbedded subordinately by thin beds of black, red and grey mudstone (Wilford, 1955). The mud-stone beds are generally silty while carbonaceous shales and thin coal seams occur at Gunung Undan area. The succession was interpreted to be fluvial to deltaic environment (Tan, 1984). Well preserved exposures of the Kayan succession along the Bau-Lundu road provided a good opportunity for facies analyses.

This work presents the detailed facies analyses and petrographic evaluation of the Kayan Formation with emphasis on the probable provenance. The Kayan succession in the Lundu area provides exclusive outcrops analogues of the interacting processes and depositional pattern. Twelve (12) individual facies belonging to Kayan Formation were grouped into three (03) facies association: FA1-Tide influenced facies association, FA2- fluvial channel facies association and FA3- Floodplain facies association.

Depositional environment

The Kayan Formation at Lundu and adjoining areas are dominated by fine to coarse sand-stone units interbedded with less frequent mudstone deposits. The described facies and facies association suggest a higher flow velocity and flow turbulence that is consistent with channelised deposition.

The upper part is dominated by very thick, mostly coarse grained sandstone units interbedded with very occasional floodplain deposits. The floodplain deposits are also characterized by the sediment from main channel during flooding seasons.

The lower part of the Kayan exposure especially outcrop S-1 show a slight difference in the overall depositional pattern, having slightly bioturbated sandstone at one horizon. This suggests some brackish conditions would have also prevailed during the course of deposition. The palynological studies integrated with the sedimentological data also suggest brackish conditions prevailed during the course of deposition.

The Kayan Formation is interpreted to represent fluvial dominated depositional environment from base to top with having some tidal influence in the base. The facies and facies association and overall sequence suggest that the channel belt was characterized by high sandy sediment input, variable accommodation space while transforming the vertical and lateral succession rapidly (Figure 1). The mineral assemblages from the Kayan Formation represents probable provenance of recycled Orogen-Quartzose field (Figure 2).

Acknowledgements

We are very thankful to Universiti Teknologi PETRONAS (UTP) for the financial support. We are also grateful to Mr. Wan Zawawie bin Wan Akil (CEO) and Mr. Mohammad Faisal bin Abdullah (Exploration Manager) Sarawak Coal Resources Sdn. Bhd. for their

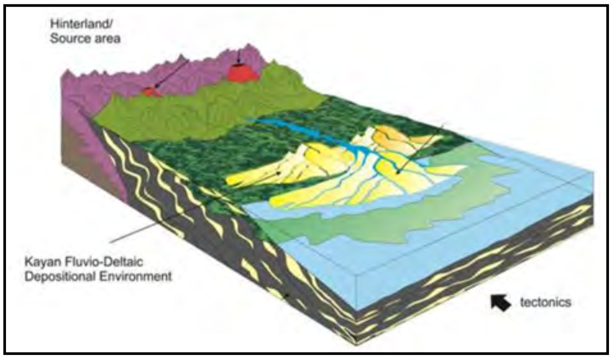

Figure 1: Reconstructed depositional model of Kayan Formation depicting fluvial setting.

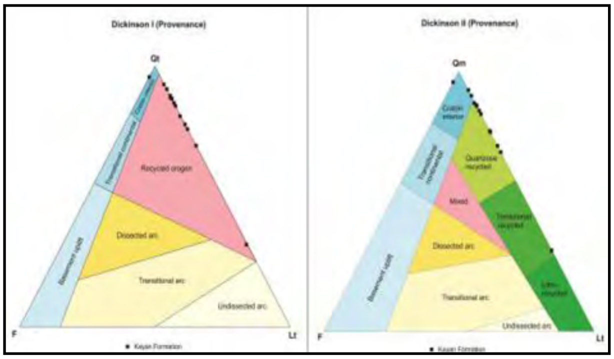

Figure 2: QFL and QmFLt diagram for provenance after Dickinson *et al*. (1983).

help. We are indebted to Leonardo Bazzano (Customer Relationship Manager, Endeeper) for lending us Petroledge (c) license.

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Geology exposure for younger generation in Malaysia for a sustainable future

Ilyah Abd Aziz

Level 14, Tower 3, KLCC, 50088, Kuala Lumpur, Malaysia
Email address: ilyah.abdaziz@hess.com

Introduction

Geology is an unknown subject to most primary and even secondary school children in Malaysia. It is the study of the earth and it's process which also is a subject that could help to build foundations or locate natural resources for the future.

A lot of natural disasters such as floods, landslides, earthquakes, and volcanic eruptions can either be prevented, or preparations can be made beforehand if an understanding of Geology is at verse.

Malaysia is a country that has a lot of Geology resources and happenings around it. Cultivating Geology at an early stage of mind will help younger generations appreciate Malaysia more and develop love towards the country.

With a diverse understanding of Geology at an early stage, the younger generations would be the able to sustain the country while developing the natural resources for economic growth.

Exposure

To nurture Geology into younger children, exposure is needed from a younger age. There is no minimum age in introducing Geology to children and it could happen as soon as they are born.

Children love to explore and exploring the earth around them could be a good learning platform to broaden their knowledge on it.

Home

Parents can introduce simple Geology at home. Starting with letting the children play in different settings such as in the backyard of the house or the beach and even try to bring them to places to view and understand about streams and the hills that form the scenic environment.

Correlate everyday life with Geology and watch documentaries with children on Geology related matters will enhance their knowledge in it without them knowing they are learning.

School

Most primary school children are enthralled by the world around them. They have a spirit of enquiry and an enthusiasm for life that needs to be encouraged in every way. But most primary school teachers come from a background in the humanities and are ill-prepared for the increasingly complex questions about science that primary school children might throw at them (Office of the New Zealand Prime Minister's Science Advisory Committee, 2011).

Teachers at school should be trained and given the acquaintance of fundamental Geology to be collaborated with teachings now and again.

Field trips should be done by school to introduce about the different rock types that form the earth and also about the resources we can vent into nature and how it can produce economic growth. As more knowledge are grasped by the children, it would also be wisely to teach about environment and also geohazards so they will always have in mind on how to sustain the place where they are living in.

Government and media

The Younger generations tend to follow a trend that involves the media, especially the internet. With the help of media, the government can perform campaigns or advertisements that curbs the knowledge of Geology such as awareness how the earth responds to developments that are taking place currently and how we as a society can help to sustain the earth.

Government could also enforce Geology knowledge to be learnt at school as an additional subject showing how the earth is in a Geology manner. Malaysia has lots of Geology excavation sites; for example, Batu Caves, an example of limestone feature rock or going to the seaside to look at the tides and the sandstones nearby if any. Fossil hunting could also be another activity that could attract younger children to appreciate Geology. All of these should be advertised by the Government but with input on learning Geology indirectly.

Sustaining the world for the future

When younger generations have a view of Geology at an early age, they will appreciate the world and surrounding more. They would have the knowledge of how the earth formed and how to look after it and they would learn about natural resources and how useful it is for the country and nation.

A sense of gratefulness towards the earth will be surfaced, thus maintaining the earth and caring for it will be an important task. Knowledge on Geology will be passed around, which will be beneficial for future generations in sustaining it for years and years to come.

Acknowledgements

I would like to acknowledge my family; my parents and siblings, especially my husband, Imil Shahrom Abdul Ghani whom has together tried to nurture and teach our son Maths & Science at an early age. A big thanks to my son, Izz whom has helped me see Science differently.

I would also like to thank my previous lecturers in UKM from the Geology Programme in enhancing my knowledge in Geology. Not to forget my peers whom has always given me hope when I needed it.

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3D KL

JONTIH ENGGIHON[1], TUAN RUSLI TUAN MOHAMED[1], QALAM A'ZAD ROSLE[1], MUHAMMAD EZWAN DAHLAN[1], MUHAMMAD RAMZANEE MOHD NOH[1] & ALVIN CLANCEY MICKEY[2]

[1]Department of Mineral and Geoscience Selangor and Wilayah Persekutuan
[2]Department of Mineral and Geoscience Malaysia

Abstract: The Mineral and Geoscience Department (JMG) in collaboration with the British Geological Survey (BGS) through the Official Development Assistance (ODA) program with the theme "Geoscience for Sustainable Futures-Resilience of Asian Cities" within 2 years (2018-2019) had paved a way forward in a project developing a comprehensive subsurface geological information database system. These invaluable existing and future drill holes data and information will be further used to construct 3-Dimensional geological models and the project is entitled as 3D KL. JMG will play the role as the lead agency which is in line with JMG's mandate under Act 129 - The Geological Survey Act 1974, Section 13 and Section 14 with the provision stated that person who bores, drills, digs or otherwise develops a hole, pit, shaft, tunnel, cutting or other excavation must notify JMG of such details. The source of data and information are from stakeholders involved directly or indirectly in site or subsurface investigation works such as Developers, Engineering Consultants, Geological Consultants, Soil Investigation Contractors, Government Agencies and any parties with sub surface data and information. The ultimate goal is a National Subsurface Database and acts as the Central Subsurface Database Repository for Malaysia. The database system will serve as an initial source of information and reference in any new developments planning to relevant parties such as the Project Proponent, Town Planner, Geologist, Engineer, Stake Holder regarding the physical underground condition of the existing site and furthermore for sub-surface investigation planning. As such this will avoid unforeseen ground conditions that could lead to delays and increases in costs for a project while at the same time these initial information can save on cost and time. However the existing information will not be used to exclude the needs for subsurface investigation work of any specific site. This database system will continue to be updated with available new data and information from time to time and maintained for the benefits of relevant parties and the country in general.

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S5-28

The sedimentology and stratigraphy of the Pedawan and Kayan Formations, Akses FAC Road (Matang Area) Kuching, Sarawak

NAJIATUN NAJLA MOHAMAD, ABDUL HADI ABD RAHMAN & MOHD SUHAILI IBRAHIM

Department of Geosciences, Faculty of Science & Information Technology,
Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak
E-mail: najiatunnajla@gmail.com; hadi_rahman@utp.edu.my; suhaili.ismail@utp.edu.my

Introduction

The geological record of the Kuching Zone extends back in time to more than 300 million years ago. This zone has been subdivided into five stratigraphic units, which are Pre-Carboniferous, Late-Carboniferous, Triassic, Jurassic-Cretaceous and Lower Tertiary age (Tan, 1986; Geological of Survey of Malaysia, 1995; Hutchison, 2005). We investigated the Pedawan and Kayan Sandstone Formations located along the Akses FAC Road in Matang area, Kuching, Sarawak.

The Pedawan Formation (Jurassic-Cretaceous) comprises of thick sequences of marine shale, mudstone and sandstone with subordinate beds of conglomerate, limestone, chert and andesitic to rhyolitic lava and tuffs (Tate, 1991). This formation represents calcareous shallow marine environment to a clastic-dominated deeper marine depositional environment (Breitfeld *et al.*, 2017). The Kayan Sandstone Formation consists of cross-bedded sandstone and subordinate conglomerate with thin beds of mudstone (Wilford, 1955). The sandstone is buffed to white and often contain fossil wood. The discovery of pollen indicates that the formation is a delta-typed deposit aged between Late Cretaceous to Early Eocene (Muller, 1968).

The Kayan Sandstone have been interpreted to be unconformably overlies the Pedawan Formation. However, no unconformity has been reported and their stratigraphic relationship remained unresolved. This paper reports new data collected from the facies analysis conducted on six (6) freshly exposed outcrops.

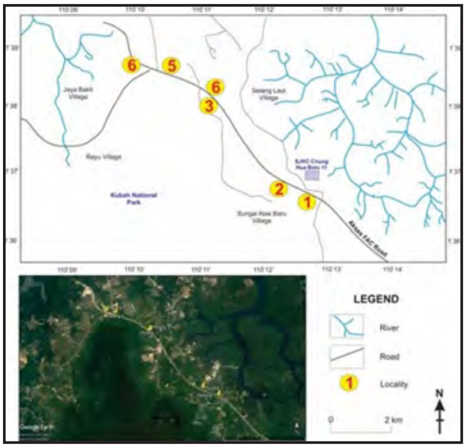

Figure 1: Maps displaying the research area located along Jalan Akses FAC, Kuching.

Result and discussion

Six (6) outcrops were evaluated (Figure 1). All outcrops are located along the Akses FAC road in Kuching area, Sarawak.

Locality 1

Locality 1 is identified to be a part of the Pedawan Formation. It consists of interbedded sandstone-mudstone, laminated mudstone, laminated sandstone, structureless sandstone and graded Bouma succession and with well-developed flame structures and load casts. This sequence is younging towards SSE.

Locality 2

Locality 2 is located near Locality 1, and also belongs to the Pedawan Formation. This outcrop comprises of interbedded sandstone-mudstone, laminated mudstone, laminated sandstone, structureless sandstone and graded Bouma succession. The similarity shown, however rock units in this outcrop is mud-dominated compared to Locality 1.

Locality 3

The outcrop here is part of the Kayan Sandstone Formation. The succession is sand-rich and is dominated with thick, bidirectional cross-bedded sandstone (herringbone?), trough cross-bedded and laminated sandstone.

Locality 4

Locality 4 is another outcrop of the Kayan Sandstone Formation. From the evaluation, this outcrop consists white structureless sandstone, laminated sandstone and trough cross-bedded sandstone. The younging direction is towards SSW. Most of the contacts are erosional-typed.

Locality 5

At locality 5, which is located next to outcrop 4, thick trough cross-bedded sandstone, with thin beds of bidirectional cross-bedded sandstone (herringbone?) are exposed at this locality. By the characteristics shown, it is presumed to be a part of Kayan Sandstone Formation.

Locality 6

Locality 6, which is opposite of the locality 3 is similar to the other outcrops of Kayan Sandstone Formation.

However, this outcrop is marked by numerous thin-bedded (1-5 cm) mudstone layers.

Conclusion

This paper reported new data collected from the facies analysis carried out on the exposed outcrops along the Akses FAC Road (Matang Area).

The rock successions belonging to the Pedawan Formation are characterized by interbedded sandstone-mudstone, laminated sandstone, laminated mudstone, structureless sandstone and thin-bedded, graded Bouma units.

The Kayan Sandstone Formation is generally sand-rich and characterized by bidirectional and trough cross-bedded sandstones. These units reflect tidal-fluvial environment of deposition.

Acknowledgement

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Sedimentological and diagenetic processes on Miocene carbonates, a comparison of proximal EX-buildup vs. distal JX mega-platform, Central Luconia Province, offshore Sarawak

Syed Haroon Ali*, Michael C. Poppelreiter, Markus Schlaich, Saw Bing Bing, Mukhriz Mubin & Redwan Rosli

South East Asia Carbonate Research Laboratory (SEACARL), Department of Geosciences, Faculty of Geosciences and Petroleum Engineering, Universiti Teknologi PETRONAS, 31750 Tronoh, Perak, Malaysia

*Corresponding author email address: ali_g03677@utp.edu.my

Introduction

It is well-known that there are significant differences in isolated carbonate buildups under meteoric/mixed marine and early marine/mixed marine diagenesis(Timms *et al*., 2015; Wilson & Evans, 2002). Isolated carbonate buildups (Figure 1) are a major gas contributor to Malaysia's hydrocarbon production but remained unstudied. Quantitative studies of these buildups are vital for understanding the highly altered pore and fabric structures. These EX and JX buildups were deposited during the middle Miocene times and represent Cycle IV and V deposition (Epting, 1980; Vahrenkamp *et al*., 2004).

The objective of this paper is to describe the buildups quantitatively with preliminary diagenetic, petrophysical rock types. EX and JX buildups are made up of similar constituents, faunal assemblages and comparable dimensions. The post depositional histories of both buildups located some 100 kilometers away, have similarities and differences. The majority of the secondary porosity (99%) in southern buildup EX created by early and late leaching, aided with dolomitization. However, in the northern buildup JX the reservoir properties mainly controlled by meteoric leaching and neomorphism(chalkification). There is a marked contrast in rock types in both buildups, e.g. the EX is characterized by argillaceous limestones (10%), limestones (55%), dolomitic limestones (20%), sucrosic and tight dolomite (15%). While in JX apart from argillaceous (10%) and mouldic limestones (40%), 3 additional limestone rock types are present namely, vuggy (20%), chalky (20%) and brecciated (10%). Argillaceous limestones are tight zones in both (EX and JX) and are result of extensive blocky/equant cementation, during early marine diagenesis. Significant intercrystalline (20%) and vuggy porosity (15%) has been seen in sucrosic dolomites in EX, and may have been resulted from mixed marine diagenesis. Diagenetic overprint in JX resulted in mouldic (21%) and vuggy (17%) porosities as a combination of meteoric and mixed marine diagenesis.

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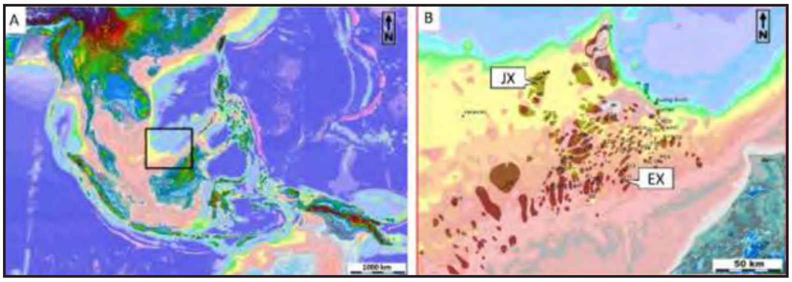

Figure 1: (A) Inset in the upper left shows regional position of the map on right side, (B) Shelf depths and distribution of carbonate buildups in Central Luconia, offshore Sarawak Basin and location of studied platforms, EX and JX.

S5-71

Evaluation of provenance and clay minerals of shales from the Belaga Formation in Central Sarawak, Malaysia

MAMEE ADWOA MAISIE & AHMED MOHAMED AHMED SALIM

Department of Geoscience,
Faculty of Science and Information Technology, Universiti Teknologi PETRONAS, Perak, Malaysia
Email address: maamemaisie1@gmail.com; mohamed.salim@utp.edu.my

Extended abstract: The advent of the generation of gas from shale over the past decades has reformed the traditional approach of geoscientists in the oil and gas industry. Previously, the trend of the petroleum (conventional resource) system required a source rock of which gas is spawned, thereafter, it migrates into a reservoir rock and further trapped where the focus of shale was considerably on their qualities as seals and potential generative source rocks. The increased global demand for energy supply due to modernization and industrialization has posed great insufficiency of conventional resources due to their depletion and current down-slope production. Therefore, sustainability and continuity of the International Energy sector has augmented its attention to harness cleaner fuels and prospects of unconventional resources such as shale gas, speculated as the forthcoming frontier of natural gas with technological advancement by year 2020 (Law & Curtis, 2002; Zahid *et al.*, 2007). Globally, submarine fans by way of their geometry, facies relationship and reservoir quality have gained huge acceptance and popularity as good hydrocarbon reservoirs (Shanmugam & Moiola, 1988). Again, the syntectonic sedimentary character of turbidites, usually of great lateral continuity and thickness makes it highly sought after by petroleum geologists as they are feasible accumulates of organic matter. The Belaga Formation is a deep marine turbidite interpreted in relation to a submarine fan (Bakar *et al*., 2007) and therefore a prospect worth evaluating. The scope of this paper will focus on the shales from the thick sedimentary sequence of the Belaga Formation (Upper Cretaceous to Eocene) consisting of five (5) members in Central Sarawak, Malaysia, of which attention is given to the provenance and clay minerals as factors to consider as predictive tools for organic matter richness and gas storage capacity using the spectral gamma ray method using Thorium (Th), Potassium (K) and Uranium (U) as indices for inferences (Table 1). A mineralogical chart of Th/K (ppm/%) indicates that the dominating clay minerals of the shales are mixed-layer types (Figure 1). Th/U(ppm/ppm) of Klaja & Dudek (2016) infers the provenance using Th/U as a redox indicator to assert that the shales are of anoxic conditions of deep-marine environments. Despite the relatively high insoluble Th values (9.93-20.13) ppm, the presence of U in substantial amounts, which only occurs in reducing conditions where it is preserved as a lower insoluble valence (U^{4+}) explains for the low Th/U values ranging between (1.86-4.57) ppm/ppm of the fifty-eight analyzed shale samples. The overall Th/U value of the evaluated shales remain less than 7, where Th/U < 7 is suggestive of marine sediments, grey and green shales, whereas Th/U < 2 is indicative of marine black shales of reducing conditions. The 30Ma interval of sediment deposition of the Belaga Formation Eocene recorded varied climatic fluctuations influential to clay minerals contained in the shales and ascribe the paleoweathering state of the shales, which from the standard imitative ternary plot of normalized K-U-Th of shales from Northern America address the shales of the Belaga Formation as of deep weathering residuum (Figure 2).

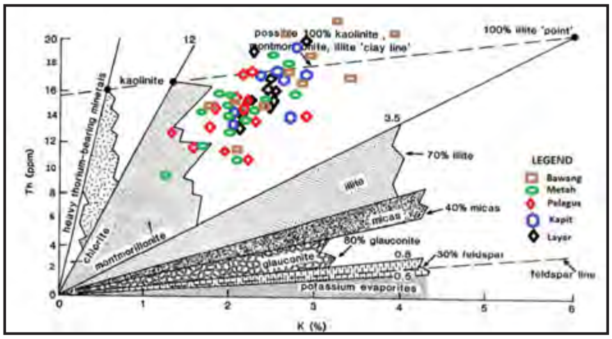

Figure 1: A mineralogical chart of Th/K (ppm/%) ratio chart for dominant minerals (Quirein *et al.*, 1982, modified).

Table 1: Spectral Gamma Ray values of K-U-Th from the shales of the Belaga Formation.

Member	*K min (%)*	*K max (%)*	*U min(ppm)*	*U max(ppm)*	*Th min(ppm)*	*Th max(ppm)*
Layar	2.19	2.84	3.5	8.02	13.36	20.13
Kapit	2.16	2.9	4.53	5.98	13.6	18.67
Pelagus	1.48	2.91	3.04	7.29	11.26	17.11
Metah	1.36	2.81	3.65	6.56	9.93	18.25
Bawang	1.9	3.95	3.06	8.37	11.79	24.23

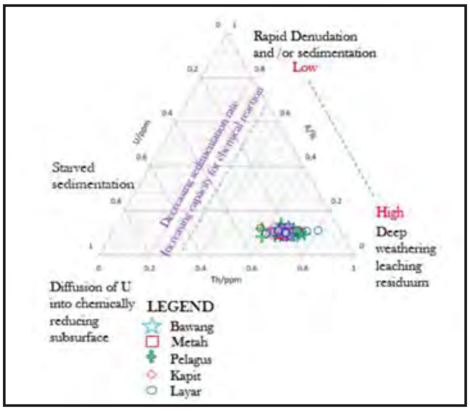

Figure 2: A normalized ternary plot of the SGR showing results of K, U, Th gamma ray emission of the shales from the Belaga Formation adopted from the evaluation of Oklahoma shales (Paxton *et al*., not published).

Keywords: shale gas, Belaga Formation, clay mineerals, provenance.

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ORAL PRESENTATIONS

GEOHAZARDS AND DISASTER RISK REDUCTION

Communication of geohazard information: An overview of examples from S.E. Asia

ALAN THOMPSON

Cuesta Consulting Ltd.

ORAL PRESENTATIONS

GEO-HAZARD/ GEO-MECHANIC

Lithologic map units and anticipated method of open excavation (<20m high) in Peninsular Malaysia

JOHN KUNA RAJ

c/o Department of Geology, University of Malaya
Email address: jkr.ttdi.tmc@gmail.com

Extended abstrat: Geology maps show the surface distribution of the earth materials in any area as well as the major geological structures present. Colors and symbols are used to represent the different earth materials and structures; the details shown dependent upon the scale of mapping (resolution). On large scale maps (scales >1:10,000) for instance, much detail can be shown as the distribution of individual, thick sedimentary beds and their bedding orientations, though on small scale maps (scales <1:50,000), only groups of sedimentary beds and regional structures as fold axes can be depicted.

Definition and classification of the earth materials shown on geology maps is based on standard geological nomenclature which differentiates between 'rock' and 'unconsolidated sediments' (without consideration of the scale of discussion). 'Rock' refers to "an aggregate of one or more minerals, e.g. marble, granite, or a body of undifferentiated mineral matter, e.g. obsidian, or of solid organic materials, e.g. coal" *(*Bates & Johnson, 1987*)* and is a term used for both small (hand specimens) and large bodies (outcrops). The term 'bedrock', however, is often used for large bodies of rock as this is "a general term for the rock, usually solid, that underlies soil, or other unconsolidated, surficial material" *(*Bates & Johnson, 1987). In Geology, the term "unconsolidated materials" or "unconsolidated sediments" refers to accumulations of particles that are not cemented. It is to be noted that the term 'unconsolidated' has a very different meaning in Civil Engineering where consolidation refers to the process involving the dissipation of excess pore water pressures.

In Geology, rocks are differentiated according to origin into igneous, sedimentary and metamorphic rocks; these groups being further subdivided on the basis of differences in texture, mineral and chemical compositions as well as geological age. 'Unconsolidated sediments' are also separated according to origin in terms of the mechanism and environment of deposition and further subdivided according to their textures and geological age. In view of the standard nomenclature, geology maps show the surface distribution of earth materials in any area based on their classification as being igneous, sedimentary or metamorphic rocks, or as 'unconsolidated sediments'.

In Civil Engineering, earth materials are separated into two broad groups, i.e. 'soil' and 'rock'; the definitions being dependent on the scale of discussion. Where small samples or hand specimens are considered, 'soil' is differentiated from 'rock' material by being 'a natural aggregate of mineral grains that can be separated by such gentle means as agitation in water' (Terzaghi & Peck, 1948, p.4). Where large bodies of earth materials are considered, however, differentiation between 'rock' and 'soil' masses is based on excavation criteria. For instance, a 'soil mass' is considered to be one that "can be removed by commonly accepted excavation methods, i.e. methods not requiring the use of explosives (blasting) for economic removal" (USBR, 1974). In Malaysia, the Public Works Department similarly distinguishes between 'common excavation' and 'hard material/rock excavation'; hard material/rock excavation being "excavation in any material that cannot be loosened by an excavator with a minimum operating weight of 44 tons (US or short tons) and minimum engine rating of 321 BHP" (JKR, 2005).

In view of these differences in definitions, problems arise when geology maps are used to predict the method of open excavation required for earthworks in an area. For instance, in hilly areas shown as granite on geology maps in Peninsular Malaysia, there is often no 'granitic rock' at, or close to, the ground surface, but rather several meters of weathered rock (commonly referred to as 'residual soil'). Similarly in areas mapped as "unconsolidated sediments" on geology maps, there has sometimes been involved 'hard material/rock excavation'.

This paper is prepared to address such problems arising from differences in definitions and classifications of earth materials in geology and civil engineering in Peninsula Malaysia. The paper aims to identify the expected method of open excavation required in areas of differing lithology as depicted in the 1:500,000 scale Geology Map of Peninsular Malaysia published in 1985 (JMG, 1985). The expected method of open excavation is identified based on differences in the "diggability" (Bell *et al.*, 1995) or "excavatability" (BGS, 2015) of the different litholgic units identified in the said Geology Map. The "diggability" or "excavatability" of the different lithological units will be based on consideration of the three main factors influencing open excavations (or process of removing earth materials to form a cavity at the earth's surface), i.e. the geotechnical properties of earth materials, the discontinuity planes present, and the

depth of weathering. The expected method of excavation will follow the guidelines set-up by the Public Works Department of Malaysia (JKR, 2005).

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Geomechanical characterisation and rock slope stability analysis, Bukit Kledang, Perak

ABDUL GHANI MD RAFEK* & IFFA HAZIRAH HUSAINI

Department of Geoscience, Universiti Teknologi PETRONAS
Bandar Sri Iskandar, Perak Darul Ridzuan
*Corresponding author email address: ghani.rafek@utp.edu.my

Bukit Kledang, a granite hill located approximately 30 km north of Universiti Teknologi PETRONAS along the Lumut to Ipoh road in Perak is a popular recreational area for outdoor activities such as hiking and cycling. It was during such a hiking trip that visual observations indicated potential instability of exposed granite rock slopes along the road leading up the hill. Based on these initial observations, a quantification of the rock slope stability was undertaken. For this purpose, the rock mass was classified using Bieniawski's (1993) Rock Mass Rating (RMR) system and these results were applied to determine the Slope Mass Rating, SMR (Romana *et al*., 2015 and Romana, 1985) of the investigated slopes in order to quantify the rock slope stability. A total of five rock slopes were investigated and have been labelled 1A, 1B, 2,3 and 4. For the RMR values, the slopes 2,3 and 4 are Class II, "Good Rock" and the remaining two slopes are Class III, "Fair Rock". However, the unfavorable discontinuity orientations with respect to slope orientation for slope 1B and 4 result in these two slopes having a low SMR rating falling into Class V, representing a high hazard. The remaining three slopes are Class III and can be considered as stable. This quantification clearly shows that slopes 1B and 4 need urgent mitigation.Table 1 summaries the failure modes and orientations with the respective slope stability analysis stereoplots shown in Figure 1.

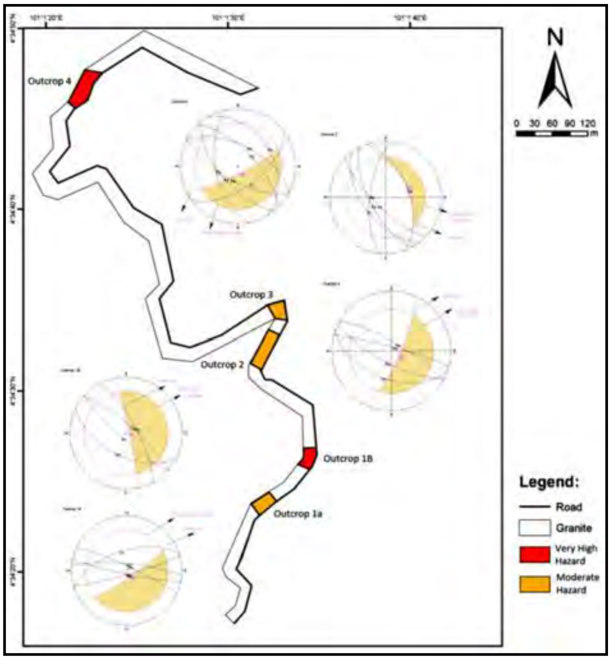

Figure 1: Slope hazard map, Bukit Kledang, Perak.

Table 1: Slope failure modes and orientations, Bukit Kledang, Perak.

Outcrop	Slope Face (Dip Direction/Dip)	Friction Angle (degree)	Failure Modes	Plane (Dip Direction/Dip)
1A	145/80	25	Wedge	F2 (005/82) & F4 (164/84) F3 (025/83) & F4 (164/84) F3 (025/83) & F5 (192/85)
1B	078/85	25	Wedge	F1 (222/81) & F2 (062/74) F2 (062/74) & F3 (041/78) F2 (062/74) & F4 (207/57) F1 (222/81) & F4 (207/57)
2	114/78	30	Wedge	F3 (015/84) & F4 (030/78)
3	060/54	30	Planar	F5 (070/55)
			Toppling	F1 (233/57) F3 (224/74) F4 (242/67)
4	153/80	25	Wedge	F1 (144/59) & F3 (059/39) F1 (144/59) & F7 (027/60) F1 (144/59) & F2 (046/67) F1 (144/59) & F6 (208/69) F1 (144/59) & F4 (230/64) F1 (144/59) & F5 (259/58) F3 (059/39) & F7 (027/60)
			Planar	F1 (144/59)

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S7-109

Tunnel support by Rock Quality Index (Q) system for ultrabasic rock: A case study in Telupid, Sabah, Malaysia

ISMAIL ABD RAHIM* & MOHAMAD SAIFUL NIZAM MOHAMAD

Natural Disasters Research Unit, School of Sciences & Technology,
Universiti Malaysia Sabah, Jalan UMS
88400 Kota Kinabalu, Sabah, Malaysia
*Corresponding author email address: arismail@ums.edu.my

Introduction

The Q-system was developed at NGI between 1971 and 1974 (Barton *et al*., 1974). Since the introduction of the Q-system in 1974 there has been a considerable development within support philosophy and technology in underground excavations. The types of rock bolts and fiber reinforced technology had been introduced and the continuous develops as support procedure. The most updated guideline for RRS in the support chart based on case histories in Norway can be found in NGI (2015). The Q-system can be used as a guideline in rock support design decisions and for documentation of rock mass quality.

The application of Q-system in tunneling in ultrabasic rock in Sabah, Malaysia is never been documented in literatures. Then this study was conducted to determine the Q-value, to estimate the support measures and to evaluate the suitability of Q-system for a propose 20m span, 10m high and eastern direction of a tunnel in ultrabasic rock in Telupid area, Sabah.

Geological background

The Telupid area consists of igneous and sedimentary rocks with minor occurrence of metamorphic rocks (Kirks, 1968; Sanudin & Baba, 2007). The oldest dated sedimentary rocks are radiolarian cherts of Early Cretaceous age (Basir Jasin, 1991). These thinly bedded cherts are closely associated with basic igneous of basaltic/spilitic type. Also closely associated with these two types of rocks are ultrabasic rocks (serpentinites/peridotites), intrusive rocks (dolerites) and metamorphic rocks (hornblendes schists and gneiss). This association of rock types, which resembles an ophiolite sequence is interpreted to represent an oceanic crust of Mesozoic age and it forms the basement rock here (Tongkul, 1997). The study area is only represented part of this ophiolite complex i.e. peridotite rock and quaternary alluvium along the river.

Methodology

The methodology of this study includes field study, laboratory study and testing and data analysis. In data analysis, the Q-system by Barton *et al*. (1974) and NGI (2015) were fully utilized in determining the Q-value and support procedure for the proposed tunnel in study area.

Results

The result of lithological and petrographical study shows that the ultrabasic rock is a massive rock mass and classified as peridotite. According to Le Bas & Streckeisen (1991) diagram, this peridotite can be classified as Lherzolite. The UCS test is showing that the peridotite can be classified as strong (92.88MPa) rock.

Summary of the Q-system's parameters and their ratings, Q value and related design parameters are shown in Figure 1 and Table 1. The support for the permanent and temporary roof and wall tunnel are shown in Figure 1 and Table 2.

Conclusions

The conclusions of this study are:

The Q-values are 1.4 (Class D or poor and type 5) and 3.5 (Class D or poor and type 3), for permanent roof and wall, respectively.

The support measures are systematic bolting and 9-12 cm thick and 700J energy absorption in fiber reinforce

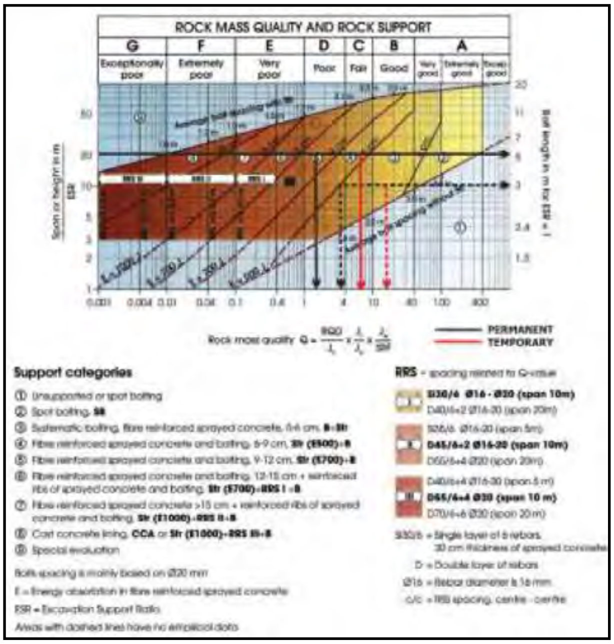

Figure 1: Lines of the result of Q-value and permanent and temporary support design requirement of tunnel roof (solid lines) and wall (dot lines).

Table 1: Summary of the Q-system's parameters and ratings, Q-value and related design parameters.

Parameters	Remarks	Notes / Rating			
RQD	Excellent quality	88.1			
J_n	Four or more joint sets	15			
J_r	Smooth planar	1			
J_a	Softening or low friction clay mineral coatings i.e. kaolinite, mica, chlorite, talc, gypsum, graphite and small quantities of swelling clay	4			
J_w	Dry excavation, or minor inflow dry	1			
SRF	Low stress, near surface and open joints	1			
Q	Type	Permanent		Temporary	
	Position	Roof	Wall	Roof	Wall
	(RQD/Jn) x (Jr / Ja) x (Jw / SRF)	1.4	3.5	7	17.5
Span	20m				
Height	10m				
ESR	Storage rooms, water treatment plants, minor road and railway tunnels, surge chambers, access tunnels	1.3			
Ed	Span or height in m / ESR	Permanent		Temporary	
		Roof		Wall	
		15.4		7.69	
P_{roof}	3.05MN				

Table 2: Summary of the result of permanent and temporary support design requirement of tunnel roof and wall.

Permanent support				
Position in Tunnel	Rock Mass Quality	Symbols	Rock support	Remarks
Crown	5 / Poor	Sfr (E700) + B	Systematic bolting , fibre reinforce sprayed concrete, 9-12 cm	20mm diameter, 2.5m space & 4 length bolts 9-12cm thick fibre reinforce shotcrete, 700J energy absorption in fibre reinforce shotcrete
Wall	3 / Poor	B + Sfr	Systematic bolting , fibre reinforce sprayed concrete, 5-6 cm	20mm diameter, 4m space & 2.75m length bolts 6-9cm thick fibre reinforce shotcrete
Temporary support				
Crown	3 / Fair	B + Sfr	Systematic bolting , fibre reinforce sprayed concrete, 6 cm	20mm diameter, 4m space & 4m length bolts 6cm thick fibre reinforce shotcrete
Wall	3 / Good	B + Sfr	Systematic bolting , fibre reinforce sprayed concrete, 5-6 cm	20mm diameter, 4.5m space & 2.75m length bolts 5-6cm thick fibre reinforce shotcrete

sprayed concrete as permanent support for roof are but systematic bolting and 6-9 cm thick fiber reinforce shotcrete for the wall.

Q–system is suitabe for the proposed tunnel in ultrabasic rock.

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S7-94

Strength and stiffness parameter study of Kenny Hill Formation with consideration of constitutive soil model for a Finite Element Analysis

CHEAH, FRANKIE & MOHD ASHRAF MOHD ISMAIL

School of Civil Engineering, Universiti Sains Malaysia, Pulau Pinang, Malaysia
Email address: cheahfrankie@hotmail.com; ceashraf@usm.my

Abstract: Constitutive soil model and its parameters are fundamental parameters in finite element analysis. Mohr-Coulomb, Hardening Soil and Hardening Soil Small Strain shall be adopted to model the geotechnical parameters of Kenny Hill Formation for the finite element analysis evaluated in this study. For practical purposes, a case study of the completed metro station in Klang Valley was selected to model in 3D with the consideration of three types of constitutive soil models. The instrumentation data during the construction was used to compare with the prediction from the finite element analysis. Plaxis 3D software was adopted as prediction tool in this study. Lateral wall deformation and ground surface settlement prediction were used to compare with the prediction. The outcome were concluded that the hardening soil and hardening soil small strain will be more suitable constitutive soil model to be adopted for deep excavation works.

Keywords: Deep excavation, 3D finite element analysis, advanced constitutive model, small strain characteristic

Landslide susceptibility assessment of the Cameron Highlands, Pahang, Malaysia area based on Combined Spatial Analysis Model – Frequency Ratio and Logistic Regression

MOHD FARID ABDUL KADIR*, FREDERICK FRANCIS TATING, ZAMRI RAMLI & FERDAUS AHMAD

Technical Service Division, Department of Mineral and Geoscience Malaysia, Jalan Sultan Azlan Shah, 31200 Ipoh, Perak
*Corresponding author email address: mhd.farid@jmg.gov.my

Abstract: Landslides are the natural phenomena related to the mass wasting process and frequently observed in hilly and mountainous area. It can result in enormous casualties and huge economic losses. New methodology in assessing this kind of geohazard is required to effectively identify the potential of landslide occurrence in particular area. Thus, local authority will benefit a better understanding of landslide hazard within their vicinity and to make a rational decision in land-use planning and slope management. The identification of areas where landslides are likely to occur is important for the reduction of potential damage.

This research was carried out at selected 275 km^2 of Cameron Highlands, in Pahang area. Cameron Highlands is one of the tourist hotspots in Malaysia. It is located at elevation ranging from 1,100 m to 1,600 m above sea level. Agricultural activity is among the largest contributor to the local economy. Poorly planned agricultural activity and development had contributed to the instability of the slope. Due to the complexity of many interrelated processes, the stability of a particular slope is difficult to determine and failure is generally impossible to predict with any degree of accuracy. A comprehensive field mapping and GIS-based spatial analysis can be applied to propagate understanding of landslide prone area.

The main objective of the research is to develop a landslide susceptibility map for Cameron Highlands area based on a combined spatial analysis method; the Frequency Ratio (FR) and Logistic Regression (LR) method. The reason of proposing various models was to tackle the disadvantage of the expert opinion and to reduce uncertainty in the final landslide susceptibility map. The use of advanced and modern geospatial technologies, known as light detection and ranging (LiDAR) for landslide inventory mapping, generating LiDAR-derived landslide causal factor maps and analyzing landslide susceptibility would enhance the quality of the susceptibility map. The LiDAR data was captured during the data collection campaign in 2014-2015 by Department of Mineral and Geoscience Malaysia through Slope Hazard and Risk Mapping (PBRC) Project.

Keywords: Landslide, susceptibility map, frequency ratio, logistic regression, Cameron Highlands

Assessment of geological condition for tunnels analysis using Inverse Distance Weighting method (IDW)

Mohd Faiz Mohammad Zaki[1,2], Mohd Ashraf Mohamad Ismail[1] & Darvintharen Govindasamy[1]

[1]School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang

[2] School of Environmental Engineering, Universiti Malaysia Perlis, Perlis, Malaysia

Email address: faizzaki@student.usm.my; ceashraf@usm.my; darvintharen@student.usm.my

Abstract: The geological condition of tunnel construction site varies from project to project. It significantly influenced the tunnel construction in terms of planning and design stage. As maintaining the stability of tunnels and surrounding structures was the main concern during planning and design stage, the geotechnical and geological properties of ground required careful yet detail characterization. The features of ground must be well considered in the tunnel design. The ground condition surrounding urban tunnels is broadly divided into tunnelling in soil and tunnelling in rock. At tunnel excavation face, soft ground has trouble in remaining stable in the short, medium or long term (e.g. soil and weak rocks). While hard ground expected the presence of rock and able to remain stable for an extended period upon excavation. However, the ground condition used to be more complicated as transition between soft ground and hard ground often occurred or existence of mixed ground condition. These two types of distinct ground condition have different tunnelling induced deformation mechanism. Detail consideration required in determination of ground condition as it determines the design approach of the construction. It also influenced the selection of construction methods. In the aspects of ground condition, tunnelling in soft ground is roughly divided into tunnelling in cohesive ground and cohesionless ground. The determination of this ground condition should be modelled using Inverse Distance Weighting (IDW) method. This study focused on the Klang Valley Mass Rapid Transit (KVMRT) project and determination of soil lithology is well established using IDW method.

Point load strength anisotropy index of schist at selected sites in Peninsular Malaysia

GOH THIAN LAI[1], ABDUL GHANI MD RAFEK[2] & AILIE SOFYIANA SERASA[2,3,*]

[1]Geology Program, School of Environment and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[2]Department of Geosciences, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia
[3]School of Engineering, Faculty of Computing, Engineering & Technology (FCET), Asia Pacific University of Technology & Innovation, Technology Park Malaysia, Bukit Jalil, 57000 Kuala Lumpur, Malaysia
*Corresponding author email address: ailie.serasa@gmail.com

Abstract: The concept of anisotropy can be regarded as the directional dependency of a determined parameter of rock material. Anisotropy occurs at all scales, and it can be observed from the material's mechanical strength, permeability and seismic properties, and it plays a significant role in rock mass classification. In the study of rock mechanics, the anisotropy of schist has become perhaps one of the widely studied area, focusing mostly on the behavior of schist under compression pressures. This type of foliated rock is a significant contributors to the complex behavior of geomaterials, due to its influence in the response of geotechnical structures such as tunnel structures, excavations and slope stability. This paper presents the point load strength anisotropy index study of schist which was investigated through the point load index strength (PLS) test. Schist samples were collected from seven localities; km 18 – 19, km 21 – 22, km 22 – 23, km 23 – 24, km 25 – 26 along the Pos Selim Road – Kampung Raja, Cameron Highlands; Kuala Kubu Bharu Road – Bukit Fraser (km 15); and Ukay Perdana, Ulu Klang. The result shows that the point load strength anisotropy index of schist to be 3.7. From the classification of degree of anisotropy, it can be concluded that schist is a highly anisotropic rock, which has a PLS strength that varies depending upon the orientation of the foliation to the applied load.

Keywords: Point load index strength (PLS), anisotropy, schist

ORAL PRESENTATIONS

GEOPHYSICS/ PETROLEUM GEOLOGY

Geoscience capability development in the petroleum industry: Challenges and opportunities

MAZLAN MADON

Malaysian Continental Shelf Project, National Security Council,
c/o Jabatan Ukur Dan Pemetaan, Tingkat 11, Wisma JUPEM,
Jalan Semarak, 50578 Kuala Lumpur, Malaysia
Email address: mazlan.madon@gmail.com

Introduction

After decades of exploration of its continental shelf, the petroleum-producing basins of Malaysia are rapidly approaching maturity, with diminishing volume of resource addition. The imminent decline could be slowed down by the testing of new plays in old and new basins with the help of highly qualified and competent geoscientists. For a long time, the national oil industry has been faced with not just a shortage of geoscience graduates but also the "readiness" of those graduates who, upon entry to the industry, take longer than expected time to develop into competent geoscience professionals. In this paper, the author shares his personal perspective[1], based on his experience with the national oil company, PETRONAS, on some of the key challenges in developing geoscience capabilities in the petroleum industry, and identifies some of the causes as well as the opportunities for remedial actions.

Geoscience "skill" development

In the late 1990s, Malaysia's national oil company, PETRONAS, developed its internal capability development programme whereby technical personnel are assigned to a specific "technical skill group" based on their degree qualification (e.g. Geoscience, Petroleum Engineering). The programme is regarded as a "success story" which was shared with the world in official presentations (Juniwati, 2012; Raiha Azni, 2013).

The Geoscience skill group was the first to implement the programme, which requires all geoscientists to undergo a common training relevant to their designated functions. After some time, it was realised that many geoscience graduates lack the most basic geoscience knowledge which they should have learned at university. To rectify this, some basic courses were added to the programme to enhance their understanding. The courses were also modified throughout the years according to the changing business priorities and the competing needs of the "generalists" on the one hand, and the "specialists" on the other. Yet, the poor understanding of basic concepts in geoscience remains a major concern.

In 1999/2000, a dual career progression was introduced to enable technical employees to choose a career path along either a managerial or technical ladder, the difference being that on the technical ladder, the career progression is "competency-based" rather than "time-based". At increasing levels of competency, senior geoscientists (generally after 7-10 years of experience) are therefore potentially able to progress from "staff" to "principal" to "custodian" geoscientist over a period of 15-20 years, alongside their peers in the equivalent managerial ranks (manager, senior manager, general manager). To some extent, this scheme has helped to reduce the promotional bottleneck at the senior geoscientist level. But competency assessments, whereby geoscientists are "tested" with an inventory of 20-plus "skills" by an assessor in the presence of a supervisor, can be a daunting experience. It was also realized that it took more than 10 years for a fresh graduate geoscientist to be eligible for promotion to "staff". In 2009, another programme was introduced to accelerate the progress, i.e. reduce the so-called "time to autonomy" from 10 to 7 years. After several cycles of assessments, it was revealed that the average time to autonomy is 9 years (as was also reported by Juniwati, 2012).

The accelerated competency development programme, however, did not address the root cause of the problem, i.e. the "readiness" of geoscience graduates for entry into the industry. In my own experience as an assessor, many graduates lack the basic knowledge they were supposed to learn at university. Unfortunately, the training programmes put too much emphasis on workflows and software skills (e.g., computer-based seismic interpretation), creating the so-called "Nintendo geologists"). By adopting a "cook-book" approach to geological analysis, we neglected the importance of self-learning, reading, thinking and scientific analysis. Perhaps, the term "skill" is being confused as a substitute fo "knowledge". Over time, the annual competency assessments have become what some ex-colleagues have called a "box-ticking exercise".

1. Disclaimer: The views expressed in this paper are solely of the author's, in his personal capacity, and do not necessarily reflect the views of any organizations with which he is/was affiliated.

Basin "skills"

Overall, the skill development programme has produced a cadre of geoscience specialists in e.g., sedimentologist, geochemist, biostratigrapher, seismic interpreter, reservoir modeller, sequence stratigrapher, and basin modeller. By their titles alone, it could be argued that not all specialists are equal, in the sense that the "breadth" and "depth" to which the relevant skills are treated are not the same (e.g. sedimentologist vs reservoir modeller, or seismic interpreter vs sequence stratigrapher). Hence, geoscientists tended to opt for the "narrowest" and "shallowest" specialisation. As a result, one type of specialist failed to attract enough young aspirants, i.e. "basin" or "regional" geologist, whose role is to integrate the various sub-disciplines and provide the much needed 'geological' meaning to the interpretations.

One could draw an analogy from the "artist vs artisan" debate. While an "artisan" is essentially a manual worker who is highly skilled at his "craft" and creates a product that is functional (e.g. seismic interpretation, or a basin model), the "artist" creates a product that is wider in both context and purpose, beyond its physical state (e.g. what the basin model means to play risk, or the implication of a seismic interpretation result to the tectonic framework). These "intangibles" outcomes provide the geological story or "meaning" to an otherwise mechanical exercise of interpreting seismic or building basin models. Put in another way, there is a difference between an architect who build houses, and the highly skilled "craftsmen" hired to actually build the house (e.g., bricklayer, plumber, electrician). Certainly, a few more "architects" are needed among the many "craftsmen".

Although there are textbooks and courses on basin analysis, there is no workflow or "recipe" that can be taught in a classroom. A basin geologist must, to some degree, be familiar with all the other specialised subjects, which could pose a serious problem if graduates lack the basic understanding of geoscience to begin with. If for the same salary and career opportunity, the reading list of a basin geologist is probably 10 times longer than, say, a seismic interpreter's, it is no surprise many geoscientists would rather "specialize" in a narrow field. Perhaps it is worth considering giving a better career incentive for basin geologists.

When this problem finally caught the attention of the top management, it was decided that a special programme was needed to groom a team of "basin experts". Participants were hand-picked from among the high-performers to undergo this one-year intensive programme on basin analysis, which after two years (2015-16) managed to produced about thirty potential "experts" before it was discontinued.

The role of the universities

The supply of geoscience graduates is no longer a problem, as there are now many local universities (including UM, UKM, USM, UMS, UMK, UTP, Curtin Sarawak) offering undergraduate geoscience courses. There could even be an oversupply of geoscience graduates in job market. Hence, it is important to ensure the high standards in geoscience teaching and curriculum are maintained.

One of the root causes for the longer time to autonomy among geoscience graduates is the university geoscience curriculum, which was shortened in 1996/97 from 4 to 3 years duration, forcing geology departments to cram as many modules as possible into a 3-year programme, often at the expense of important basic subjects. As a result, students are less grounded in the basics when they graduate. To address this problem, in 2007 an "inaugural" geoscience colloquium was organized to "develop action plans towards ensuring the supply of competent, qualified and intellectually ready geoscience graduates to meet industry challenges and preparedness for the global market". Representatives from the Ministry of Education, the petroleum industry, and geoscience departments in local universities attended the event and agreed on key recommendations to improve geoscience education, most importantly, for the universities to revert to the 4-year geoscience degree programme. Unfortunately, there had been no follow-up on that important resolution. The "inaugural" colloquium also became its last. It noted, however, that most geoscience degrees on offer now have reverted to 4 years, without any policy change made at the national level.

Postgraduate qualification

When geoscience degree courses at universities were still for a 3 year period, I argued that an MSc degree should be made the minimum entry requirement for geoscientists in the petroleum industry. Besides providing some industry-related "skills" to increase "readiness" for employment, the MSc course would help reduce, if not eliminate, the time and financial burden on oil companies to fill the knowledge gaps left by the universities at the BSc level.

Realising the benefits of post-graduate training to geoscientists, in 2006 Universiti Teknologi PETRONAS (UTP) launched its MSc in Petroleum Geoscience programme, with the understanding that its mother company will feed (and fund) a steady stream of junior geoscientists to undertake an intensive 18-month on-campus programme. Unfortunately, after the successful completion of the first batch of 18 students, business needs took priority over capability development and forced UTP to source for students and funding elsewhere.

The UTP MSc was an opportunity to set the benchmark for post-graduate entry into the industry. Following UTP, the two oldest geology departments at Universiti Malaya and Universiti Kebangsaan Malaysia started their own MSc programmes, thus creating a competition for graduate students who were already in short supply. Now, many oil company employees are enrolled in the MSc courses as part-time implies the employees themselves realize that the BSc degree is inadequate and having a post-graduate training would be an advantage.

As the largest employer of geoscientists in the country, the national oil company could take the lead to influence the industry to require a minimum MSc degree for intake into industry. The potential benefits would be immense, as it will encourage students to stay and pursue a post-graduate course before seeking employment or go on to do a PhD, as is the normal practice in many developed countries. A strong funding system for research students needs to be in place in order for this to happen. With strong financial and data support from the petroleum industry, this would encourage more geoscience research activities that will ultimately benefit the petroleum industry and the nation as a whole.

The role of the geological society

Data and information are essential for research activities. Without openly accessible data, ordinary Malaysians outside the petroleum industry are deprived of the knowledge generated by oil exploration activities in their own country. Although petroleum industry conferences provide a platform for intellectual discourse and exchange of information, they are beyond the affordability of academicians and students, unless with financial support from the industry. Hence, geoscience research can be carried out only by the oil companies themselves or by a few academics and students that are fortunate enough to have access to oil company data.

Scientific societies, such as GSM, used to play an important role in bridging the knowledge gap between industry and the public (especially academia). For 36 years (1977-2013), the Geological Society of Malaysia (GSM) collaborated with PETRONAS to organize and host the industry-sponsored petroleum geoscience conference. Through this annual event, geoscientific knowledge related to oil exploration is disseminated freely to the general public via its official publications, the Warta Geologi (its Newsletter) and the Bulletin. Sadly, the collaboration ended, when starting in 2015 PETRONAS decided to host a new conference series in collaboration with the European Association of Geoscientists and Engineers (EAGE). This is unfortunate because EAGE, which handles the publication for this conference, provides access to the conference abstracts only to their subscribers. This means that geoscientific knowledge gained through exploration activities on the Malaysian continental shelf, under the control of the national oil company, has now been made proprietary to a foreign scientific society. Only upon GSM's request, EAGE has kindly granted GSM members complimentary access to the abstracts of the 2015 conference. This is not a desirable situation.

Need for open data and knowledge sharing

Oil exploration and production data (well, seismic, production, reserves, etc.) are considered industry secrets which are strictly controlled by the PETRONAS. Access to primary (raw) data is normally given to oil companies when reviewing exploration acreages. In addition, on a case-by-case basis, postgraduate students are able to obtain permission to use primary data in their research projects. For the most part, primary data remain confidential, but sometimes, with prior permission from PETRONAS, secondary data, which include the interpretations of primary data, are shared publicly in technical paper presentations at local and international conferences.

In recent years, the practice of disguising well and field names in conference presentations, e.g., well "X", "ABC" or "XYZ" oil field (Pendkar *et al*., 2017; Razak *et al*., 2017; Shen, 2017), appears to signal a stricter regime of data control by the national oil company. Such strict data sensitivity may have been necessary during the early days of exploration, but nowadays when basins are approaching maturity and the much-needed detailed scientific studies are critically lacking, such strict confidentiality rules prevent meaningful intellectual and scientific discourse. Data confidentiality issues aside, free dissemination of scientific knowledge for academic purposes are desirable and should be encouraged. An open data system that gives accessibility of information to researchers outside the industry should lead to better knowledge generation and ultimately improve exploration success.

Like petroleum-related conferences, geoscientific research depends on the support from the petroleum industry, not just financially, but also for access to data. Due to inaccessibility to oil company data, there is not much research activity related to petroleum geoscience in academia, except at UTP, which enviably receives strong financial as well as data support. Again, this unfortunate situation needs to be addressed collectively by all stakeholders. In order to enable academic research in petroleum geoscience to make significant contribution to knowledge generation, there should be less restrictive access to oil company data. I was aware that in 2016 steps have been taken by the national oil company to gradually make oil company data and information more easily accessible to the public/academia. It is hoped that this initiative is still progressing, as it would benefit not just the industry, but students, academics, and the nation as a whole in developing capabilities in petroleum geoscience.

Concluding remarks

As a developing nation, Malaysia faces major challenges in developing "local" geoscience capability. Its national oil company, PETRONAS, is entrusted with this responsibility by default, as the key player in the industry. Several factors contribute to those challenges, among them: (1) Inadequate university geoscience curriculum, which affected the "readiness" of graduates entering the job market. (2) Over-emphasis in the in-house training courses on transferring "explicit knowledge" and "manual" skills (including software skills) while neglecting the importance of tacit knowledge and self-learning in geoscience education. (3) Inadequate interaction and collaboration between industry and public/academia to enable open sharing of geoscience information and knowledge. (4) Lack of open data system that can encourage a vibrant academic cculture of geoscientific research and industry-academia collaborative efforts.

Developing geoscience capability in the petroleum industry should not be solely the responsibility of oil companies, but is a national objective. The challenges could not be overcome without mutual cooperation between all the stakeholders in the national geoscience community (oil companies, universities, scientific societies, professional institutions, and relevant government agencies) in addressing the root causes in a holistic manner. It is hoped that this paper will trigger further discussions among stakeholders on ways to enhance geoscience capabilities, particular for the petroleum industry.

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Conventional core to outcrop: A comparison study of deepwater depositional environment and implications on the reservoir potential

MOHD ASRAF KHAMIS[1] & FELIX TONGKUL[2]

[1]JX Nippon Oil & Gas Exploration (Deepwater Sabah) Limited,
Level 15, Menara Prestige, No.1 Jalan Pinang, 50450 Kuala Lumpur, Malaysia
[2]Faculty of Science and Natural Resources, University Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia
Email address: asraf.khamis@gmail.com; ftongkul@ums.edu.my

Introduction

Deepwater exploration in NW Borneo has made a significant impact on the regional hydrocarbon portfolio (Figure 1). Giant discoveries made on Kikeh and Gumusut-Kakap proved a prolific working petroleum system of the area; and the subsequent discoveries have upgraded the remaining potential in the deepwater Sabah outboard area. Turbidite reservoirs associated with basin floor fan systems are substantial producing sands in these discoveries. The objective of this study is to evaluate the reservoir potential of turbidite deposits of deepwater basin floor fan observed in conventional core taken from well B-2 (Core 1) and B-2ST1 (Core 2); and to compare with several representative outcrops of deepwater Crocker Formation around Kota Kinabalu, Sabah (Figure 2).

Recognizing and understanding the architecture and reservoir characteristics of sand bodies in this tectonically active region pose a great challenge. To improve interpretation and prediction of subsurface depositional systems, outcrop studies are usually applied as subsurface analogues. However, in some cases, analogues are from basins located far and in remote areas with limited accessibility. Fortunately, we are in a relatively, unique situation, because the turbidite depositional systems which are currently being explored offshore Sabah have an equivalent depositional system onshore represented by the Crocker Formation.

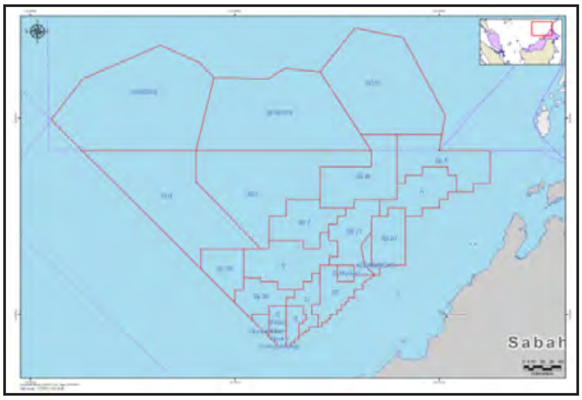

Figure 1: Deepwater/Ultra Deepwater acreages in NW Borneo.

Methodology and discussions

The evaluation of conventional cores and selected outcrops including analyses of their lithology, sedimentary structures, depositional facies and general properties such as grain sizes, sorting, clay ratio, lithological accessories, trace fossils, degree of bioturbation, visible porosity, diagenetic features and fractures. Conventional cores and outcrops can then be classed into different depositional packages based on their representative facies. Similar facies between conventional core and outcrop are correlated. The possible geometries and reservoir characteristics of the sand bodies within the Crocker Formation will also be discussed in this paper.

Both investigated conventional cores show bedding trends, as well as other sedimentary features that are

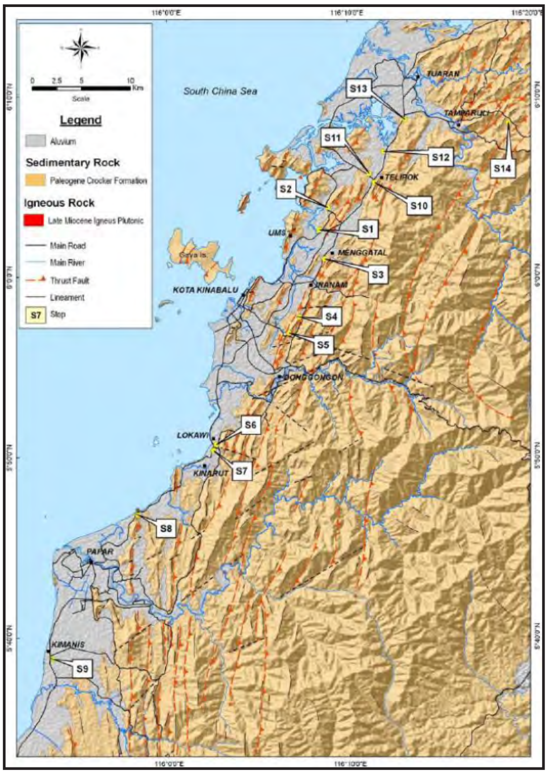

Figure 2: Localities of outcrops.

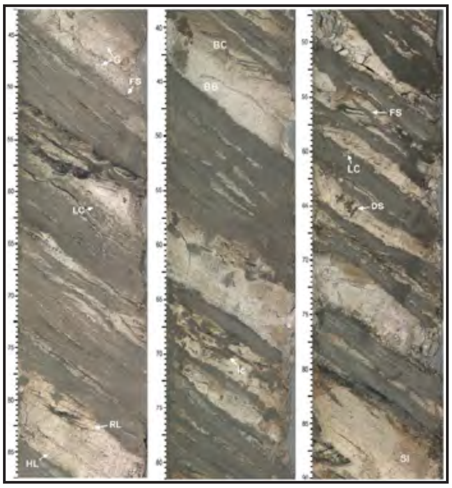

Figure 3: Part of Core 1 showing interbedded silty mudstone, with rippled sand laminae and cross-laminated sandstone.

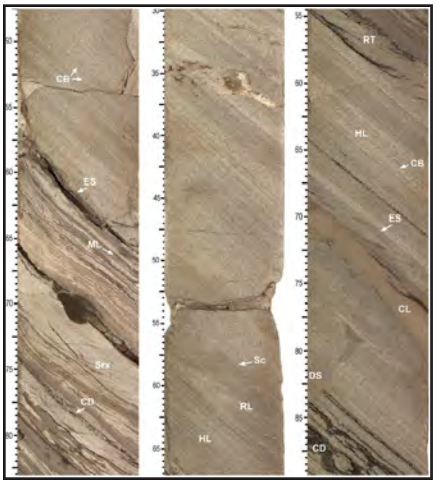

Figure 4: Part of Core 2 showing stacked turbidite fan channel sandstones interbedded with heterolithically interbedded rippled sandstones and silty mudstones.

similar to the outcrops. Core 1 is mainly comprised of heterolithic interbedded silty mudstone with common very fine rippled sand laminae, and very fine to fine ripple cross-laminated sandstone with common clay laminae (Figure 3). The lower part of the core containing common *Helminthopsis* and minor *Chondrite* burrows characteristic of a Nereites ichnofacies. These observations indicate that they were deposited in a broad levee adjacent to a submarine fan channel complex. Core 2 comprises a lower section of very fine to upper fine, moderately sorted, dominantly horizontally laminated and locally rippled, stacked turbidite fan channel sandstones interbedded with heterolithically interbedded rippled sandstones and silty mudstones interpreted as overbank/levee similar to Core 1 (Figure 4).

Conclusions

In assessing the reservoir quality, it is important to observe outcrop as a key analogue. The correlation between both conventional cores and outcrops will help in assessing the lateral continuity of targeted reservoir

Figure 5: Comparison of core features with outcrop, representing channel levee and slumps.

intervals and to analyse the effect of sedimentary pinch-out. Hence, this study will provide an insight on prospectivity of the potential oilfield and subsequently provide important inputs for resource assessment and ultimately for the field development planning.

Both cores pose a good reservoir potential with very good visible porosity in the thicker sandstone beds in Core 1 and also good visible porosity in the sandstone units in Core 2. Most of the sedimentary features found in both cores are indicative of deposition in a deepwater environment, mainly channel margins or levees (Figure 5), with mass transport complexes and slump deposits found in some parts of the studied cores.

Acknowledgements

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Application of VTI PSDM for imaging carbonate structures

SEYED YASER MOUSSAVI ALASHLOO*, DEVA GHOSH, YASIR BASHIR & AMIR BABASAFARI

Centre of Excellence in Subsurface Seismic Imaging & Hydrocarbon Prediction (CSI),
Department of Geosciences, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Malaysia
*Corresponding author email address: syaser.moussavi@utp.edu.my

Introduction

Prestack depth migration (PSDM) is recognized by the industry as a tool for areas with strong velocity variations, such as salt domes, thrust belts, faults, and stratigraphic structures (Jang & Kim, 2011). PSDM avoids numerous assumptions for stacking data, which restricts the effectiveness of imaging. However, one issue in PSDM is the use of isotropic approximation, which can still introduce errors in focusing of the seismic energy (Whiting *et al.*, 2003). Hydrocarbon reservoirs and overlying strata are commonly anisotropic.

In this study, we develop a prestack depth migration algorithm on the basis of an anelliptic vertical transverse isotropy (VTI) wave equation. A fast marching finite difference approach is used as our eikonal solver since it is fast and stable for traveltime computation (Moussavi Alashloo & Ghosh, 2017). The calculated isotropic and anisotropic traveltimes are compared and employed in a standard Kirchhoff migration to obtain the image of the subsurface. A real dataset, from Sarawak Basin is used to test the algorithm. Finally, we analyze the isotropic and VTI images quantitatively and qualitatively.

Methodology

By focusing on P-wave anisotropy, we develop an algorithm to incorporate VTI into prestack depth imaging. The general workflow for Kirchhoff PSDM is illustrated in Fig. 1 which in this study, a new algorithm for traveltime computing is developed. A powerful method for determining traveltime is the application of finite difference to solve the eikonal equation. In this study, we employ a fast marching eikonal solver in the isotropic and VTI concepts. We also test the results by using the Kirchhoff depth migration algorithm. Instead of using the elliptical eikonal equation, which is commonly used in the industry, we consider an anelliptic approximation because it is more realistic and accurate than the former.

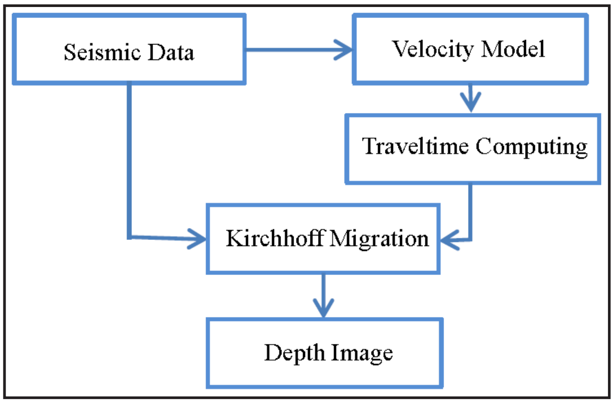

Figure 1: Workflow of prestack depth imaging applied in this study.

Results and discussion

The key results of the new VTI PSDM algorithm are demonstrated and discussed in this section. The Marmousi and real datasets are employed to evaluate the technique in different geological conditions. Figure 2 displays the real data common depth point (CDP) gathers, interval velocity and Eta models. The data, hereinafter called L1, is from Offshore Malaysia, and the streamer length is 8100 m with 648 receivers. The shot interval is 25 m, and the recording length is 10 s. The length of L1 is 37.5 km, and we aim to image the carbonate structure.

In the first step, isotropic and VTI traveltimes are computated for L1. The value ranges from 0 to 0.18. It is obvious that FMM can efficiently cover all the desired area in the model even with high complexity. Besides, the comparison of traveltime contours shows that the anisotropic wavefronts for area with strong anisotropy

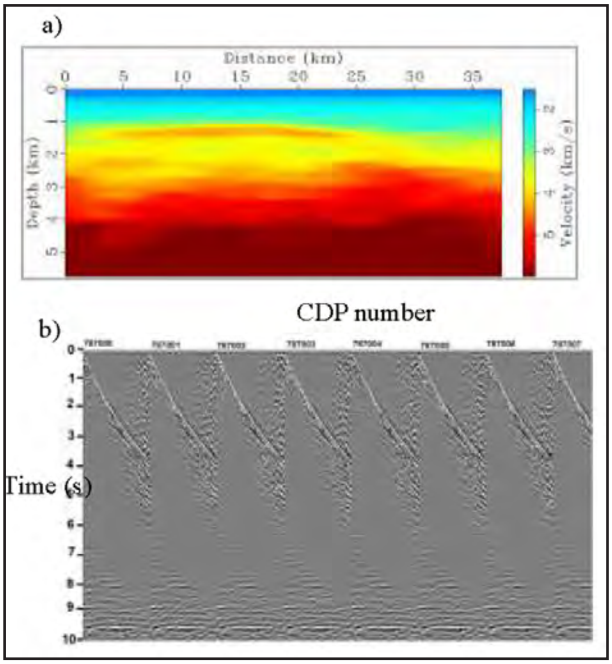

Figure 2: (a) L1 velocity model, and (b) A few CDPs of it which is ready for migration.

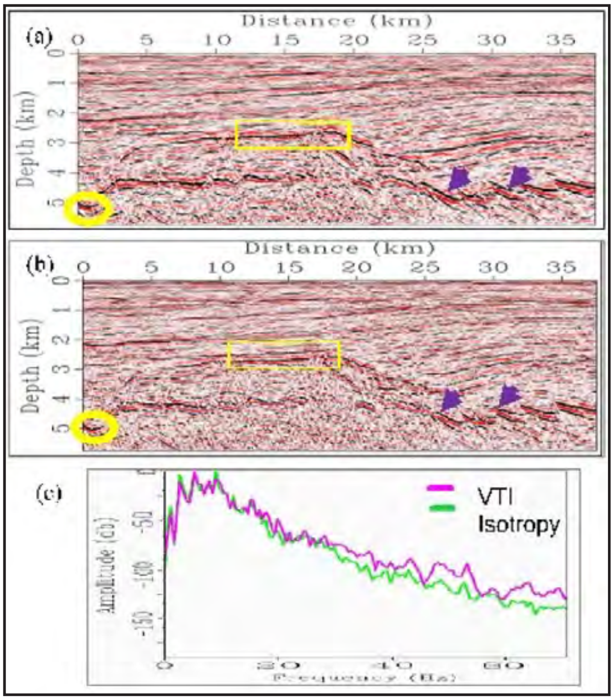

Figure 3: Comparison between (a) isotropic and (b) anisotropic images of L1. (c) Comparison on spectrum of the isotropic and VTI images of L1.

move laterally faster than isotropic ones, whereas their propagation speed in vertical direction is similar.

L1 dataset along with their traveltime are applied in PSDM algorithm to image the subsurface structures. The obtained isotropic and VTI images are then compared to find the differences. The L1 isotropic and VTI images are demonstrated in Figure 3. The yellow circles emphasis on the difference between positioning of events in both images. It is obvious that anisotropic imaging has shifted reflectors upward for depths below 1 km, in which in deeper parts, this difference is larger. Moreover, the VTI image provides more details since it has higher resolution. For instance, the rectangles represent that 3 layers are detected perfectly in the VTI image, while in isotropic one, they are not apparent. It should be mentioned that the best way for confirming the positioning of events is using the well log or check shots. Since there is no well in the area of interest, the positioning of reflectors cannot be verified conclusively.

Conclusions

Our results confirmed that the proposed anisotropic PSDM is efficient and accurate for imaging complex structures with less processing time and lower costs than other common depth imaging methods. The importance of considering anisotropy in seismic imaging was clearly presented. This method avoids mispositioning and misshaping in the image, which leads to accurate identification of the location of the well drilling site. Furthermore, the higher resolution, better interface differentiation, and continuous events of the images created by this method provide a reliable interpretation of the subsurface.

Acknowledgements

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Linking shelf to deep water: Understanding deep water sedimentation in above grade slope setting using near surface seismic data. A case study from Sabah deep water

SATYABRATA NAYAK*, PRABAL SHANKAR DAS, ANYI NGAU & AZWARI HUSLAN B MOHD

PETRONAS Carigali, Kuala Lumpur, Malaysia
*Corresponding author email address: satyabrata.nayak@petronas.com.my

Understanding sediment dispersal in Sabah deep water is quite challenging, thanks to the complex tectonic setting as well as multiple sediment sources. Presence of prominent thrust fault system in the slope region controls sedimentation to a greater extent. Undulated or rugged slope, where a number of mini basins are formed due to various reasons (thrust faults, salt diapir, shale bulge etc.) are termed as above grade slope (Prather, 2003). This study aims at understanding sediment dispersal in above grade slope system using near surface seismic (sea bed to 500 millisecond below) data. Densely spaced high quality 3D seismic data from multiple vintages, covering more than 12,000 square km are interpreted and analyzed for this study. Seismic time slices, time structure map and few attribute maps (i.e. variance, dip azimuth) are used to interpret geomorphic features.

On the shelf region, time slices equivalent to present day sea bed shows presence of well-defined incised valleys and fluvial channel system (Figure 1). Due to presence of acquisition foot prints, it is difficult to identify the features but still subtle impression of fluvial system could be interpreted throughout the shelf with higher degree of confidence. Presence of prominent incised valleys indicates shelf exposure during to sea level fall. With no age data for the above sequence, these could still be grossly correlated to later Quaternary sea level fall based on regional understanding. Exposure of shelf enables coastline moving basin-ward and emergence of prominent fluvial systems carrying higher volume of sediments from shelf to basin slope.

Slope region of the study area represents a typical above grade slope setting with intra-slope highs and mini basins. NE-SW trending highs are expression toe thrust running in the same direction (NE-SW). The slope morphology on the eastern part of the area is relatively steeper than at the western part. Eastern slope is characterized by prominent mass failures, deep cut canyons and extensive mass transport deposits. The central slope is characterized by presence of canyons but relatively less mass transport deposits. Western slope is relatively gentler with very small scale canyons and almost no mass transport deposits. These variation in slope architecture could be related to various factors such as local tectonics, gravity-driven and focus sedimentation fairway. As could be seen from the bathymetry map, the variation of slope architecture is affecting sedimentation in deep water varying from dominantly MTDS on the eastern part to turbidites on western part.

It is crucial to understand interaction between sedimentation on slope and structure (thrust folds) formation (Morley, 2009). Presence of intra-slope and highs (fold-thrust belt) and mini basins in the region contributed to the complex sediment infill in the area. Near surface sediment deposits in the study area are mostly post-kinematic. However, syn-kinematic deposition affecting some areas can be seen from small buckling

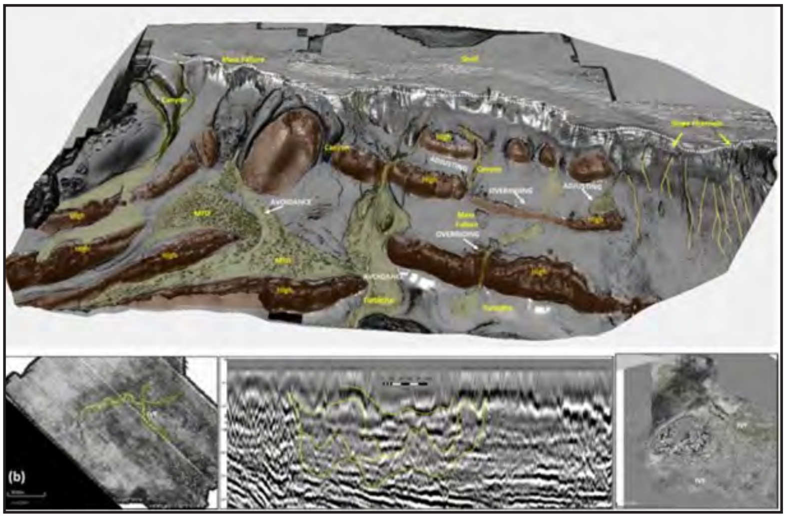

Figure 1: (a) Perspective view of modern day sea floor in the study area showing various geomorphic features on deep water slope regime. (b) Seismic Time slice and vertical section showing presence of incised valleys on shelf.

near seabed which indicate active tectonic movement till present-day. It could be summarized that the near seabed sediments are deposited post-structuration. Hence, it can be concluded that sedimentation pattern is structurally controlled to some extent. Irrespective of the nature of the deposits (MTDs or turbidities) authors would first like to discuss sediment fill in terms of Avoiding, Over-riding and Adjusting flows (Figure 1). Avoidance or avoiding flow represents sediment dispersal by-passing existing highs (structural or depositional) and filling up the next basin or mini basin (Jones *et al*., 2016). Sufficient sediment volume or strength of the flow may bypass few highs and then fill the mini basins or basins. In the present study, huge volume of mass transport deposits are found to be by-passing the highs and continuing into the next mini basins. These are one of the most effective way of deposition in post-kinematic stage. Over-riding flows are those flows which moves over an existing flow, instead of by-passing it. A good example of over-riding flow could be seen in the present study area where a slope canyon is seen cutting across central high and dispersing sediments down toward the next adjacent low/basin. The third type of sediment flows, Adjusting flow, is confined in nature and it fills the initial trough or mini basin and can generate stratigraphic play. The three different types of basin fill activities could be broadly correlated to major geomorphic features like incised valleys or channels, which act as conduit for sediment delivery to deep water.

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Delineation of fracture zone using 2D electrical resistivity and induced polarisation methods

DOUGLAS LAW SHEK HOUNG*, KHAIRUL ARIFIN MOHD. NOH & ABDUL GHANI MD RAFEK

Department of Geosciences, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Perak
*Corresponding author email address: douglas_g03711@utp.edu.my

Introduction

The geoelectrical survey is a geophysical method that utilized the principle of electrical current flow to investigate the subsurface structures and features of the earth. Flow of the electrical current in the soil and across subsurface materials is strongly influenced by the ability of groundwater or the matter itself to transmit the induced energy from one point to another (Slichter & Telkes, 1942). Response of the transferred energy is translated into the resistivity and chargeability values of the subsurface sections, hence imaging the structures and content of the earth based on the measured geoelectrical responses.

Exploration geoscientists applies the geoelectrical survey methods to study the subsurface of the planet for several reasons; environmental engineering, groundwater exploration, structural analysis, mineral prospecting and many more (Corwin & Hoover, 1979; Daily *et al*., 1992; Zhou & Adams, 2002). Mineralisation potentials are especially pronounced in regions with high concentration of sulphides, graphite and magnetite, all of which would cause anomalies in the geoelectrical readings obtained. The aim of the study is to determine possible mineralised fracture zones in the country rock formations, focusing on the electrical characteristics of the subsurface section in the high relief study area. This research was conducted using the Wenner-Schlumberger array for both the Electrical Resistivity (ER) and Induced Polarisation (IP) methods.

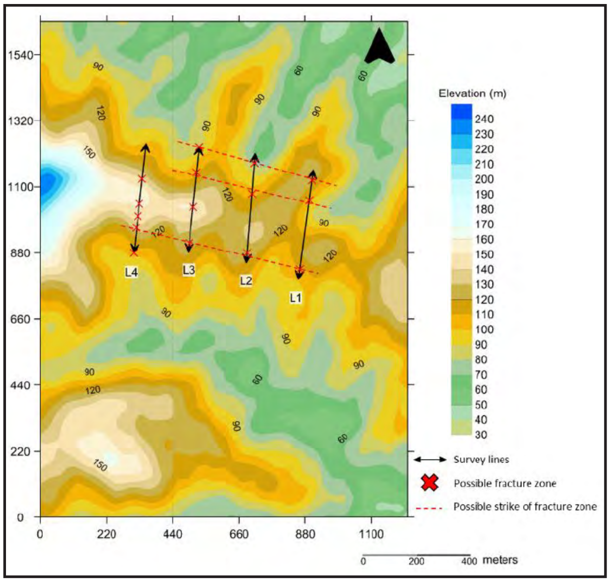

Figure 1: Topographic map of Field X with layout of survey lines.

Methodology

The survey area is situated in the hilly region of complex geology, with challenging terrains and declining slopes located both in the North and South section of the study area. 4 electrical survey lines (L1, L2, L3, L4) measuring 400 m each were laid out parallel to one another with a separation distance of 200 m between each line. The layout of the survey cables within the study area is illustrated as in Figure 1. Local coordinates with reference to the true RSO units are used to produce the map due to confidentiality issues. All the survey lines cross the region of high relief thus mapping the geoelectrical subsurface responses of the area.

GPS position of each electrode was recorded and the Digital Elevation Model (DEM) information was used as the input for the ER and IP pseudosections generated. Resistivity surveys are governed by the fundamental physical law of Ohm's Law and the data is recorded with the unit ohm-m (Ωm) while IP survey measures the electrode polarisation caused by conductive minerals in the subsurface, displaying the chargeability readings of the time-domain in milliseconds (msec).

Results

Both the apparent resistivity and chargeability data for all four survey lines were processed by using the RES2DINV software. These data are inverted numerically and then the software displays the true resistivity and

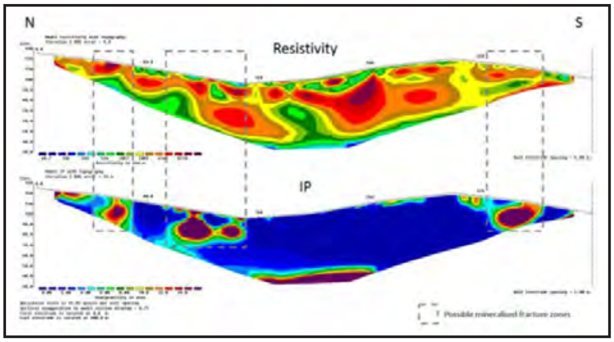

Figure 2: ER and IP pseudosection for L1. Mineralised fracture zone detected in the Northern and Southern region of the survey line.

chargeability models in the form of pseudosections, as a function of lateral distance and vertical depth.

High chargeability zones are discovered in the Northern and Southern regions of L1 and L2. These anomaly bodies have smaller dimensions as compared to the anomalies imaged in L3 and L4. The possible mineralised fracture zone is observed to enlarge towards the West of the study area and appears to be closer to the Central region of the survey lines L3 and L4.

The pseudosection for L1 is presented in Figure 2, where regions of low resistivity and high chargeability are highlighted as possible mineralised fracture zones. Located in the Northern and Southern section of the survey line, the connectivity of the fracture zones are labelled for each line and detailed in the topographic map in Figure 1.

Intersecting areas of low resistivity and high chargeability regions are defined as the prospective zones in which there is a high possibility of delineating the mineralised fractures. The possible fracture zones are highly concentrated along both the flanks of the high relief region with a strike of approximately E-W direction.

Conclusion

2D ER and IP surveys have been carried out to delineate the possible mineralised fracture zones in a region of complex geology. The prospective areas are characterised by identifying low resistivity and high chargeability anomalies.

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High resistivity reservoirs (causes and effects): Sahara Field, Murzuq Basin, Libya

ABUBAKER ALANSARI[1], AHMED SALEM[1], ABDUL HADI ABD RAHMAN[1] & NURI FELLO[2]

[1]Department of Geoscience, University Technology Petronas
[2]National Oil Corporation, Tripoli, Libya
Email address: alan.abu@outlook.com; mohamed.salim@utp.edu.my; hadi_rahman@utp.edu.my; nurim.fello@noc.ly

Introduction

Glacial upper Ordovician sandstone formation is an excellent oil reservoir. It is located on the South Western side of the Murzuq Basin (Figure 1). The overall reservoir thickness reaches about 400 meters. In Sahara field, extremely high resistivity intervals (more than 10,000 ohm-m) were encountered in four producing wells (W1, W2, Y3 & W4) (Figure 1), while the highest resistivity recorded in the adjacent ten producing oil wells is 50 ohm-m and below. In this paper, we will attempt to investigate the causes of this event and employ it to simply and quickly uncover more complicated reservoir history, such as wettability that often needs more expensive and intense data analysis. A reasonable core analysis program was designed by the operator to achieve a comprehensive reservoir rock characterisation. The program includes routine core analysis, special core analysis, and two wettability tests of the reservoir rocks. However, this analysis didn't accurately resolve the issue of high deep resistivity variation of producing oil wells and only stated that "high resistivity due to blocky clean sandstone that might be "oil-wet". As a result, a petrophysical analysis was carried on using an average saturation exponent (n) =1.96 for all the wells, which has not been a recommended practice when dealing with an oil-wet reservoir. Where "the (n) values are found to be higher significantly than in water-wet systems" [1-7].

Earlier last year [15], stated that identification of reservoir wettability is made routinely on core plugs. However, there are not many published petrophysical models that practically differentiate between oil-wet and water-wet fractions of a reservoir zones using commonly available log suites. Therefore, in this paper, we will be focusing on how to recognise and separate reservoir wettability fraction effects based on deep Resistivity log response and special core analysis results (SCAL).

Methodology

Detailed investigation is exclusively applied to deep resistivity data. Starting with data quality check and environmental correction using Schlumberger atlas to make sure that there was no technical error for deep resistivity readings. Then the correlation established between high resistivity wells and normal ones to develop a notion of how the resistivity values respond to vertical, lateral lithology, and facies changes within the oil field (Figure 1). A detailed careful mapping process for average deep resistivity has been performed in all available wells (oil-leg and water-leg) by using the top reservoir map (Figure 2) as trend map during the modelling process, then a simple grid was created for top and bottom reservoir. After that average resistivity were populated. Once all the resistivity maps were modelled in the reservoir, it is very crucial to

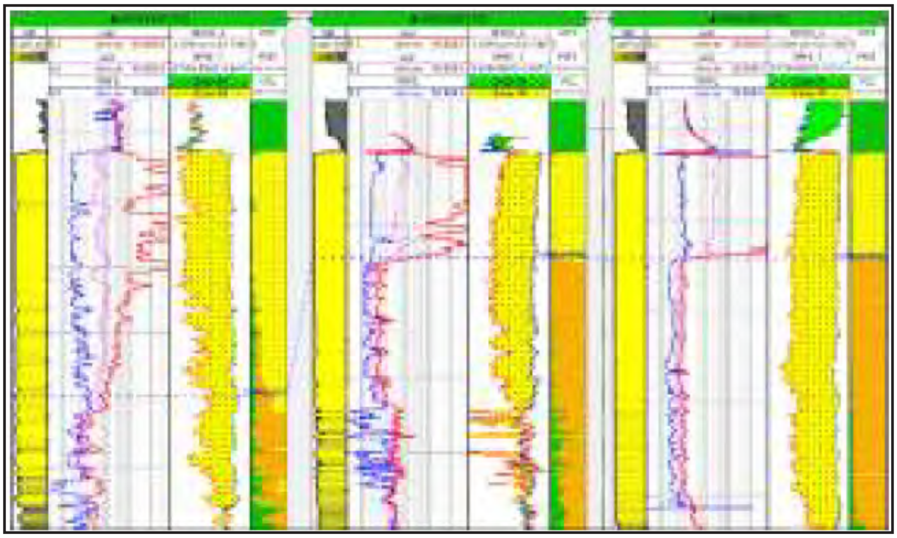

Figure1: Represents the main three wells with extremely high deep resistivity readings.

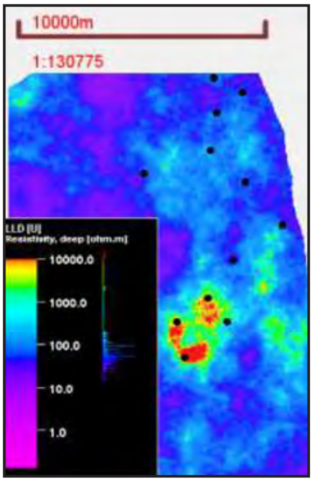

Figure 2: Illustrates the deep resistivity map for the oil leg within the field.

understand the reservoir pressure and fluid distribution and in doing so the height above free water level has been determined by using both core (SCAL) and logs data.

Results and discussion

Water-leg map exhibited a typical resistivity value for brine filled sandstone reservoirs, the highest deep resistivity value is 35 ohm-m, which scattered along the eastern boundary of the oil field, while the lowest resistivity readings can be seen in the south-west and the middle part of the oil field. However, oil-leg highest resistivity values recorded is more than 10,000 ohm-m and scattered near the south-west boundary of the oil field; also some lower connected and disconnected low resistivity zones (10-50 ohm-m) can be outlined, especially, in both Middle and southern parts. In a similar way to the above deep resistivity map, the estimated height above water level and capillary pressure have their highest values in the exact areas where extreme deep resistivity readings were recorded, around 120 ft. and 4000 psi respectively.

As a result, of significant capillary pressure in thicker reservoir area oil might have been able to displace water through geological time by benefitting of high connate pressure and buoyancy forces support, occupying all the minor pores and pushed the water into larger scattered pores leading to gradual alteration of reservoir wettability from water to oil-wet.

Hence, the brine fluids will no longer be connected to each other inside the pore system. Consequently, they will lose their contribution to resistivity readings. When the resistivity readings conducted in such clean and highly permeable oil-wet sandstone reservoirs, it is very likely that the resistivity current tends to follow the passes where the conductive mineral or fluid exist [5, 6-9]. But in the absence of the conductive connected brine fluid and the presence of mostly resistant clean quartz aranite (with a resistivity of more than 500k ohm-m) [9], and low clay mineral composition. Resistivity current will have to flow either through oil since it is the connected wetting phase or through the rock composition itself or both. Although the latter two observation yet to be accurately proved by conducting more analysis about the things that might cause an increase of origin rock resistivity that isn't applied to current cases, such as lack of pore fluid fill, lower salinity, compaction and lithification [5, 6].

Finally, it is believed that by applying this simple, quick and cheap methods in similar cases will help enrich exploration and production activities choices. By considering different scenarios for calculating sensitive reservoir properties such as fluid saturation, rather than just diving blindly into using Archie's equation that is meant to be valid for clean water-wet reservoirs.

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Integrated study of core, logs and seismic intepretation: Towards a relative sea level curve

REDWAN ROSLI[1], MICHAEL C. POPPELREITER[1], MARKUS SCHLAICH[1], MUKHRIS MUBIN[1], SYED HAROON ALI[1], SITI NUR FATHIYAH JAMALUDIN[2] & SAW BING BING[1]

[1] South East Asia Carbonate Research Laboratory,
Department of Geoscience, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak
[2] Department of Geoscience, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak
Email address: redwanrosli@outlook.com; m.poppelreiter@utp.edu.my; markusschlaich@gmail.com; mukhrizmubin@gmail.com; geologyuos@gmail.com; fathiyah.jamaluddin@utp.edu.my; bingbingsaw@gmail.com

Understanding the sequence stratigraphy of an isolated carbonate platform is important to understand the evolution of the platform. Subsequently, to have better prediction on facies distribution. The sequence development of an isolated carbonate platform is controlled by interplay between sea level, subsidence rate and carbonate productivity.Therefore, the objective of this paper will be focussed on the estimation of relative sea level change. Estimation of sea level curve of the Alpha platform in Central Luconia, Sarawak is done by core description, well logs analysis, and seismic interpretation. Integration of those study and interpretation is used to provide insightful understanding of sea level change, resulting in better understanding of the evolution of Alpha platform. The core data, well logs (high value of density log and peaks in gamma ray log) and seismic data were integrated to identify the argillaceous and tight interval. Those intervals are associated with the sea level rise phase (flooding surface). As for sea level high-stand (the late stage of sea level rise) is identified by presence of deep-water fossil assemblages; platy coral and red algae. Meanwhile for the low stand of sea level is identified by presence of benthic foraminifera, molluscs, and echniod. Those fossil assemblages are indicator of lagoon environment. Lastly, subaerial exposure is identified based on evidence of karst on seismic and core.

Alpha platfrom is a Middle to Late-Miocene age carbonate platform and located in Central Luconia, Sarawak (Arsat *et al*., 2010). It is a pinnacle stage of carbonate platform (micro-platform) that was initiated on top of mega platfrom.The platform has experienced build-up phase, followed by build-in phase during a series of third-order eustacy cyclicity (Vahrenkamp *et al*., 2016) The distribution of facies and architecture of Alpha platform is controlled by the direction of dominant wind and the interplay between eustatic sea-level and regional tectonic activity. The carbonate production rate of platform is controlled by two factors; the rate of relative sea level and the growth potential of the carbonate systems (Bosscher & Schlager, 1993). Therefore, it is crucial to have good understanding on sea level curve. Subsequently, improve our prediction on facies distribution and platform's morphology.

Three dataset were used; core, seismic data, and well logs data. The sedimentary log from core decription is tied with the observation from seismic interpretation and well logs signature.

Based on core description, the sequence boundaries are identified based on evidence of karst, rubble and chalkified limestone. Ten sequence boundaries are

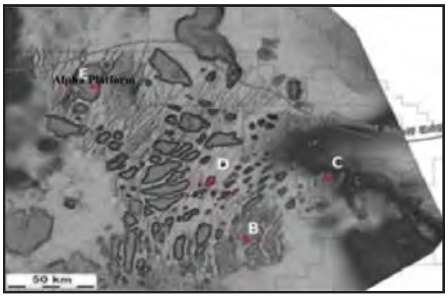

Figure 1: Alpha platform is located at North-West of Central Luconia, Sarawak Basin. Modified from Koša, 2015.

Figure 2: A) Argillaceous tight interval with planktonic foraminifera is indicator of flooding surface. B) Rhodolite with benthic foramnifera indicates lagoon to back reef environment. C) Massive coral is good indicator reefal environment. D) Karst features.

marked for Alpha-3 Well and four sequence boundaries are identified for Alpha-2 well. Those boundaries are tied with gamma ray log response and neuron density log. Figure 3 shows some example of result from core decription. Depositional envrionments are identifed based on fossil asemblages. Flooding surface is identifed based on presence of deep water faunal; planktonic foraminera, deep water large benthic foraminifera (Cycloclypeus) and argillaceous interval. Observation for flooding surface are then tied with well logs response (peak in gamma ray log and high density).

Discontinuity of seismic reflector as shown in figure 3 is identified as vertical karst. The karst on seismic is clear evidence of subaerial exposure. Subaerial exposure occurred due to decrease in sea level and exposed the top of platform. Then, the exposure surface is tied with the core observation.

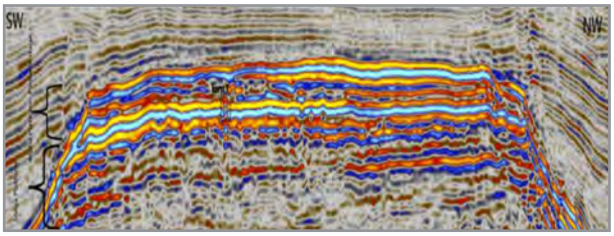

Figure 3: Seismic shows two stages of isolated carbonate platfrom, a mega platform and a micro-platform (Alpha field). Discontinuity of seismic reflector is possible evidence of karst.

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Seismic site effect of Bukit Tinggi from microtremor analysis

ABDUL HALIM ABDUL LATIFF[1] & AMIN ESMAIL KHALIL[2]

[1]Department of Geosicences, Universiti Teknologi PETRONAS
[2]School of Physics, Universiti Sains Malaysia
Email address: abdulhalim.alatiff@utp.edu.my; amin_khalil@usm.my

In between 2007 to 2009, Bukit Tinggi region has been shocked by minor earthquake activities, with the highest recorded tremor was recorded at 4.2 Mw which occurred on 7th October 2009. The sudden release of energy from the Bukit Tinggi fault line, has led to the question on the geological structure within the central Peninsular Malaysia region, and its seismic effect towards the local structure and building. While the tectonic of Peninsular Malaysia itself is deemed stable due to its location in the Sundaland block, the recent earthquake from Bukit Tinggi fault line is believed to be reactivated as a result of compressional stress release from the after effect of earthquake originated in Sumatran subduction zone. In view of this, several seismological studies are being conducted in the central Peninsular Malaysia region, especially on the trace of ground ruptures (Lat & Ibrahim, 2009; Mat Said, 2011), focal mechanism (Mat Said, 2011) and 1-D velocity determination for earthquake relocation (Abdul Latiff & Khalil, 2016). In this study, we complement these researches by investigating the seismic site effect of Bukit Tinggi area through the microtremor analysis. A seismic wave that originate from an earthquake can propagate and caused the soil and ground amplification, which its mechanism is controlled by the frequency content of ground motions. Thus, to identify the dominant earth period and the dynamical behaviour of the local soil and rock properties in the Bukit Tinggi region, we carried out 27 points of microtremor data acquisition using a weak-motion seismometer (Figure 1). Among many microtremor analysis, we incorporate Nakamura's horizontal-to-vertical spectral ratio (HVSR), which give important information in the soil amplification factor and its natural frequency (Nakamura, 2008). These properties have the capacity to influence ground motions and consequently give important information on the potential damage caused by future seismic activity. At the beginning of this research, 27 of 1-hour long duration of ambient noise data was recorded at Kampung Janda Baik, Bukit Tinggi between 24th to 28th January 2018 (Figure 2). The ambient data was then processed and transform into frequency spectrum for HVSR analysis. In frequency domain, the ratio between horizontal and vertical components was analysed in determining the resonance frequency of the area, as shown by the highest amplitude obtained (Figure 3). While the work conducted is only for 27 locations in Bukit Tinggi, we found that the resonance frequency in Bukit Tinggi region is between

Figure 1: The location map of study area in Bukit Tinggi, where the 1-hour duration of ambient noise recording were conducted (in yellow star).

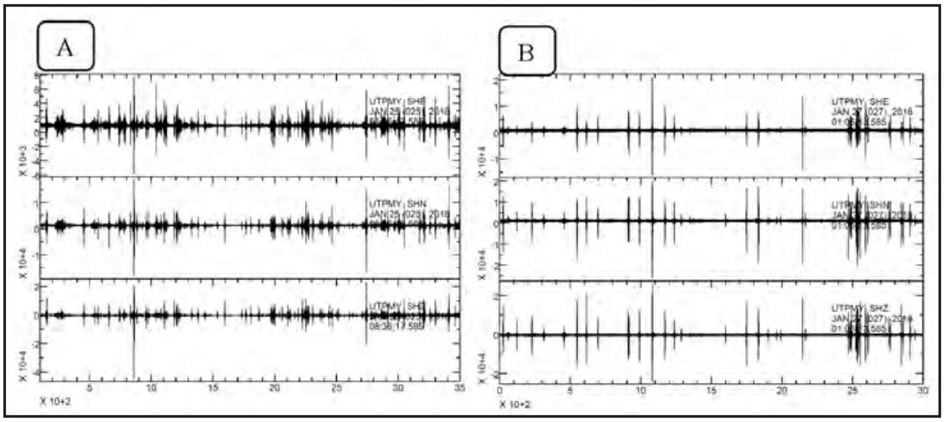

Figure 2: The recorded waveform at two locations as specified in Figure 1. Location A and B are part of 27 points with recorded ambient noise data in Bukit Tinggi.

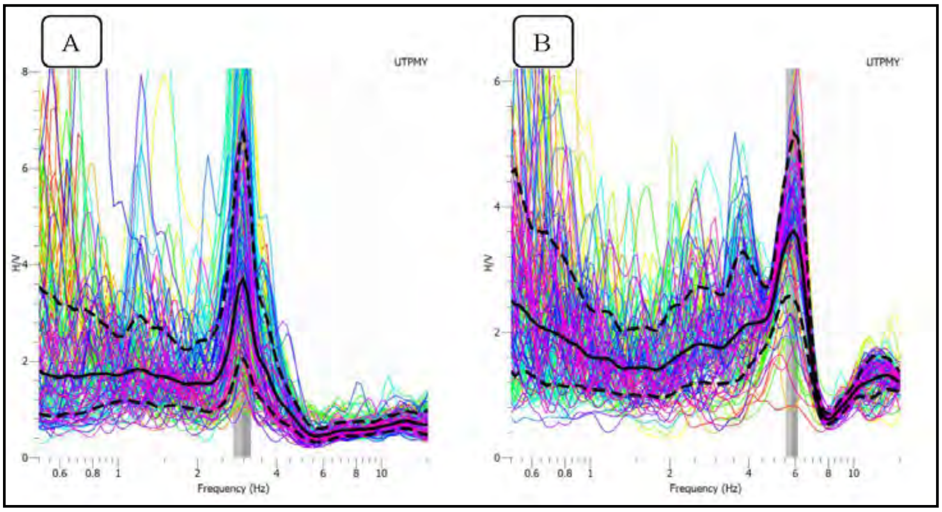

Figure 3: Horizontal-to-vertical spectral for two locations (A and B) indicate in Figure 1. In the spectral ratio, the resonance frequencies are found at 3 Hz (location A) and 6 Hz (location B).

3-6 Hz. This imply that the area is vulnerable if a local, high magnitude earthquake occurred as local earthquake exhibits similar frequency response. In addition, a regional but enormous earthquake (>9.5 Mw) that originate in Sumatra might also cause soil amplification in the area based on the HVSR analysis.

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Seismic anomaly identification in Pliocene stratigraphy, BG Field, Malay Basin

NUR HAZIRA HAMSAN[1], MD YAZID MANSOR[2] & LIAW KIM KIAT[3]

Petroleum Geoscience, Faculty of Geosciences & Petroleum Engineering,
Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia
Email address: nurhazira.hamsan@gmail.com, mdyazid.mansor@utp.edu.my, kimkiat.liaw@utp.edu.my

Introduction

The Malay Basin have been vigorously explored since 1968. Many oil and gas accumulations have been successfully discovered and mapped. Early exploration targets since 1970s – 1990s only targeting for easy structural traps within Groups D – K sandstone reservoirs (Ahmad Said, 1982). Several giant gas fields have been encountered within the north-central Malay Basin (Figure 1), such as Lawit and Jerneh fields which contribute to the Malaysian economic growth (Madon *et al.*, 1999). Most of the fields in Malay Basin are still producing. However, the existing resources is fast depleting due to its long production history. Therefore, it is an urgency to find new exploration prospect to replenish the existing resources.

BG field located in the north-central Malay Basin. The field was discovered by ExxonMobil with the first well drilled in 1970s, targeted for oil potential within reservoirs Group D to F. However, the field was abandoned in 2011 as the main objective is not achievable. The Pliocene, Group B sands were not targeted during the initial field development. This is due to the shallow, low pressure drilling hazard across the Malay Basin and poor reservoir development (Mohd Nasir *et al., 2008*). In this paper, we will examine on the shallow zone anomaly that presence in the Group B formation and looking for potential of new play type (stratigraphic trap).

Methodology

This study was based on a 2004 vintage 3D seismic data, covers ca. 335 sq km of study area in north-central Malay Basin. One prominent seismic anomaly within Group B were evaluated and mapped across the study area (Figure 1). This mapped horizon will act as a structural control when conducting horizon slicing. It will help to reveal any potential but subtle stratigraphic trap that is masked by using normal time slice method.

The presentation of this stratigraphic feature is enhanced by applying the sweetness attributes to the 3D seismic volume. With the contrast of colors that arise from the imageries, it will help to provide a clear geometric boundary of the stratigraphic play type with the presence of direct hydrocarbon indicator (DHI) of the gas bearing reservoir.

Conclusions

In conclusions, the shallow zone anomaly is analyzed and interpreted to have the shape and geometry of an offshore sandbar (Figure 2). The occurrence of this deposit within Pliocene stratigraphy has mapped with quite convincing Direct Hydrocarbon indicator (DHI), sweetness and bright amplitude. Its geometry is clearly visualized by using the horizon slicing method with dimension of 11.8 km x 4.8 km. Given the strong evidences from seismic, it indicates high possibility of gas filled reservoir due to strong amplitude contrast. This was previously overlooked as non-pay zone. The NE-SW major fault in this study area is believed to be a sealing fault that separates the reservoir sands into different compartments. A positive exploration outcome will result in opening a new play type. This will bring much benefit

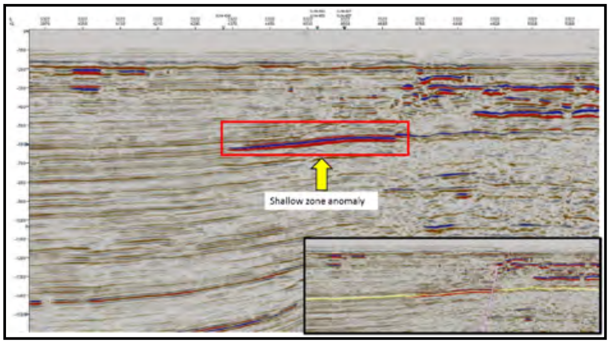

Figure 1: NW-SE vintage 3D seismic displaying a shallow zone of seismic anomaly (Red box) interpreted by yellow seismic horizon across the seismic dataset (black box).

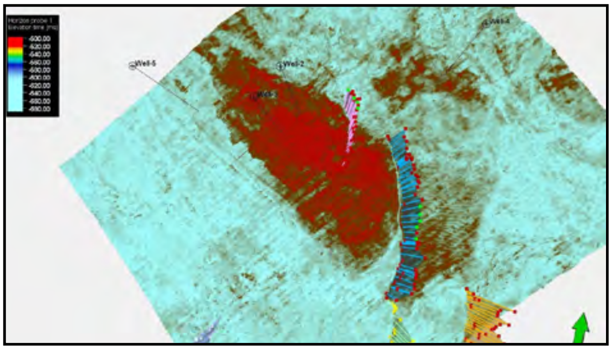

Figure 2: Horizon slice map generated from 3D sweetness attribute, displaying the potential of offshore sandbar development. It dimension is 11.8 km x 4.8 km, marked by the yellow arrow.

towards further development and monetization of oil and gas in X Field in particular, and Malay Basin, in general.

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S10-39

Geological interpretation of Spectral Gamma Ray (SGR) in Nyalau Formation of black shale and mudstone of Central Sarawak, Malaysia

WALAA ELNASIR IBRAHIM*, ABDUL GHANI MD RAFEK & AHMED MOHAMED AHMED SALIM

Universiti Teknologi PETRONAS, Department of Geoscience, Perak Darul Ridzuan, 32610 Seri Iskandar, Tronoh, Malaysia
*Corresponding author email address: umshamswalaa@gmail.com

Extended abstract: Shale is a fine-grained (grain size less than 4 microns in diameter) clastic sedimentary rock composed of mud and tiny fragments (silt-sized particles) of other minerals, particularly quartz and calcite (Q.R. Passey *et al.*, 2010).

To identify clay mineralogy, to determine depositional environment, to determine Gamma Ray in API by using Spectral Gamma Ray (SGR) and the relationship between TOC%/U concentration in Nyalau Formation onshore in Central Sarawak Basin, nine onshore samples were collected from Central Sarawak, Bintulu. The study focused on shale and mudstone samples obtained from the Nyalau Formation. Spectral gamma ray (SGR) readings of the outcrop was taken. Three outcrops of Nyalau Formation (Oligocene–Middle Miocene) are located at different sites in Bintulu area, Sarawak.

The mineralogical analysis were carried out by X-Ray diffraction (XRD) and FESEM at many magnifications. TOC content was measured using Analytikjena HT 1300 Solids Carbon Analyzer.

Cross-plots of thorium (ppm) versus potassium (%) were used to identify certain clay types (Figure 2), which are smectite, chlorite and kaolinite. These interpretations are very general. Hence, this study is improved by clay identification using high resolution scanning electron microscopy (SEM) (Figure 3), with EDX and X-ray diffraction (XRD). The Thorium to Uranium ratio varies with sedimentary processing and depositional environment. The Th/U ratios of the samples vary between 0.57 - 0.85, which indicates that Nyalau Formation is deposited in marine and reduced environment.

Using the formula taken from https://en.wikipedia.org/wiki/Gamma_ray_logging, the equation was used to calculate Gamma Ray in API,

GR API = 8 × Uranium concentration in ppm + 4 × thorium concentration in ppm + 16 × potassium concentration in percent.

There is a good match between the organic matter content determined in laboratory and U concentration from SGR cross plots in different facies type. Organic matter indicator has been confirmed by the presence of higher U concentration. The higher U (ppm) in Nyalau Formation is possibly due to their relatively higher clay content.

Detailed description in terms of clay mineralogy, depositional environment, Gamma Ray in API by

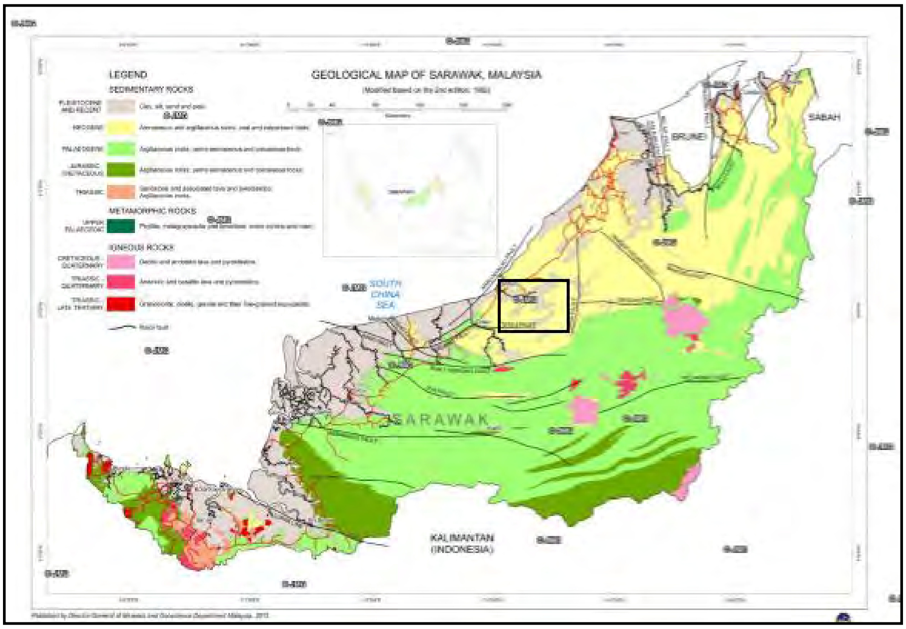

Figure 1: Location map of the study area (Madon, 1999).

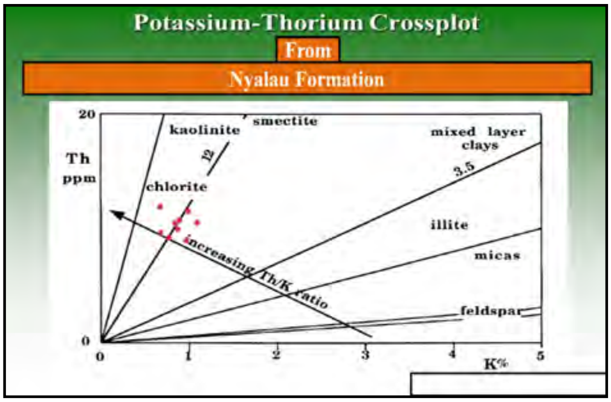

Figure 2: Results of the K % and Th (ppm) cross plot of Spectral Gamma Ray (SGR), using Schlumberger plots.

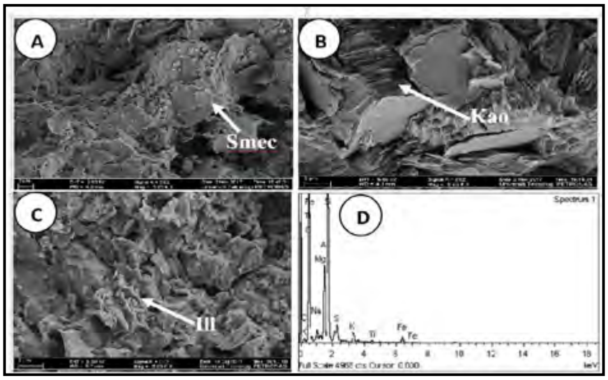

Figure 3: FESEM micrograph showing the clay mineral in the mudstone and shale samples. A) Smec = Smectite mineral with their Dispersive (EDX) Spectrumin D, B) Kaol= Kaolinite and C) ILL= Illite mineral.

using Spectral Gamma Ray (SGR) and the relationship between TOC%/U concentration. Radiometric analysis of Nyalau Formation showed that has smectite, clorite and kaolinite clay minerals are obtained from the cross plots of Th (vs) K and the presence of illite from FESEM Analysis. Moreover, Th/U ratio ratios evidenced to be useful when used as proxies for depositional environment reduction conditions, supposes that the depositional environment is reducing to marine with the data having Th/U ratio in the range of 0.57 to 0.85. High values of the Gamma Ray (GR) in Nyalau Formation range from 152.76 to 207.12 API which can be attributed to the ability of clays to absorb uranium and thorium through cation exchange capacity. A cross plot of TOC%/U shows a considerable positive correlation with the Organic matter evolution, its has been confirmed by the presence of higher U concentration. The higher U (ppm) in Nyalau formation is possibly due to their relatively higher clay content.

Keywords: Spectral gamma ray log (SGR), shale and mudstone, organic matter, Sarwak Basin

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S10-47

Malay Basin Upper Pliocene shallow, low pressure gas potential: Its implication towards onshore Peninsular Malaysia deltas hydrocarbon prospectivity

MD YAZID MANSOR & NUR HAZIRA HAMSAN

Department of Geosciences, Universiti Teknologi PETRONAS, Malaysia
Email address: mdyazid.mansor@utp.edu.my; nur_17000076@utp.edu.my

Abstract: The offshore Malay Basin is best known for its expensive Tapis crude blend production since late 1970s. The south Malay Basin Duyong gas field started production in 1984 for domestic use, followed by Jerneh-Lawit fields, landing gas in Kerteh, Terengganu. These early oil and gas fields development were based on market prices of around US$40-50 per bbl oil, and below US$1 per 1000 scf gas. In contrast, small and marginal subsurface gas volumes were considered uneconomical. Previously these simple structures were found using 2D seismic data. Since 1984 the advent of 3D seismic technology has allowed better subsurface resolution of these major fields. Some fields 3D data still suffered wipe-out effects from shallow gas diffraction across the structural crest. However, most other fields show pockets of bright anomalies which were interpreted as shallow hazards. The seismic anomalies have been variously penetrated above the Groups B/D Unconformity as low pressure gas in silty sandstones. Since early 2000 many of these shallow gas have been successfully mapped and drilled through safer site investigation and shallow section drilling technology. The current higher gas prices allow them as fuel alternative to support platform operations. Expanding this idea beyond Malay Basin, would there be a similar subsurface model of shallow gas trapped in the onshore Plio-Pleistocene deltas of east coast Peninsular Malaysia. The lower coastal plain of Kelantan River Delta has about 4,000 sq km area, while the Pahang River Delta has some 5,000 sq km area respectively. Effective future onshore seismic and non-seismic data acquisition may assist in uncovering prospective hydrocarbon resource. Any substantial gas pockets present in stratigraphically trapped sand bodies can be quickly developed to power small turbines for domestic electricity or industrial needs.

Keywords: Malay Basin, seismic anomaly, Pliocene, delta

S10-44

Seismic geomorphology analysis of coal-bearing reservoirs using Waveform Classification: A case study from the northern Malay Basin

ISMAILALWALI A.M. BABIKIR*, AHMED M.A. SALIM & DEVA P. GHOSH

Department of Geosciences, Universiti Teknologi PETRONAS
32610 Seri Iskandar, Perak, Malaysia
*Corresponding author email address: Ismailalwali_1600553@utp.edu.my

Introduction

The Malay Basin is a Tertiary rift basin, located offshore Peninsular Malaysia (Figure 1). It is one of the major sedimentary basins in the Southeast Asia region. Two working petroleum systems subdividing the Malay Basin into southern and northern regions. The Southern Malay Basin holds a mix of oil and gas whereas the Northern part is a gas-rich province (Ghosh *et al*., 2010).

The petroleum system components of the Northern Malay Basin comprise a mature source rock (coal and carbonaceous shale) of Group H and I that provide the hydrocarbon charge to reservoirs in E, D, and B groups. The hydrocarbon in the Northern Malay Basin is mainly gas, being trapped in the stratigraphically shallower units, E, D, and B. This is possibly due to the regional overpressure seal in the below Group F. These reservoir sequences are interpreted to be deposited in continental, coastal, and shallow marine environments (Madon *et al*., 2004).

Interpreting the geomorphological elements of Group E have proven to be challenging due to the thinly bedded nature of the reservoirs being below the seismic resolution in addition to the occurrence of numerous coal beds. Coal produces very strong negative impedance similar to the gas sand that introduces uncertainty to the seismic attributes for lithology and fluid prediction (Ghosh *et al.,* 2010). The aim of this work is to characterize the geomorphological elements of the coal-prone group E in an undeveloped field in the Northern Malay Basin.

Figure 1: Location map of the Malay Basin.

Methods

Waveform classification is an automatic pattern recognition technique that classifies areas of similar waveform along a horizon (Barnes, 2016). Change in the trace shape is strongly connected to the changes in lithology, porosity, and fluid content (Chopra & Marfurt, 2007). The presence of coal throughout group E interval largely affects the seismic amplitude and makes the analysis of the seismic amplitude attributes uncertain. Because seismic waveform caries information about phase, frequency and amplitude of the seismic trace, it has a better position to provide information about geomorphology and facies distribution in the studied interval. Pattern recognition technologies such as neural network provide good approaches to classify seismic waveforms (i.e. compare seismic trace shapes and group them into classes) (Coléou *et al*., 2003).

For this study, an unsupervised classification was carried out using a self-organizing map algorithm of Stratimagic® software to produce facies maps to help on the geomorphology interpretation and to get information about the geological variability and seismic facies distribution in the studied interval. The result is totally data-driven. These seismic facies were linked to the geological facies that has been interpreted using well data and other attributes. Generally, the unsupervised classification is accomplished in two steps. The first step is to analyze all the traces within the defined interval using the neural network algorithm and a number of modeled (synthetic) classes or traces are created based on a predefined number of classes to best represent all the waveforms in the interval. The second step is to compare each trace in the interval with the model traces and sort it to the class that gives the maximum correlation (Figure 2). Each resulting class is colour coded and presented (Chopra & Marfurt, 2007).

Results and discussion

Due to the coal masking effect, the produce conventional seismic attributes such as RMS amplitude were not able to image the geology of the studied interval (Figure 3).

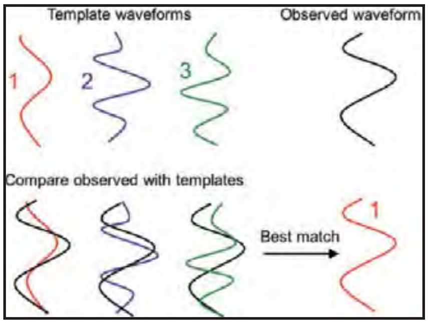

Figure 2: Waveform classification process matches observed trace shapes with a set of model traces and assigns each observed waveform to the most similar trace model. From Barnes, 2006.

The produced seismic facies maps were able to identify the depositional elements of the coal-prone Group E (Figure 4). The interval is dominated by a fluvio-deltaic system.

Many depositional elements such as distributary channels, floodplain, and distributary mouth bar were identified from the facies maps and confirmed by well data.

Conclusion

Coal has a significant importance as source rock in the area. It also provides good marker horizons for structural seismic interpretation. The introduced uncertainty in attributes analysis due to the presence of coal was removed by the application of sophisticated attribute techniques such as waveform classification. The interval of interest was interpreted as a subaqueous delta plain occupied by distributary channels and mouth bar deposits.

Acknowledgements

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

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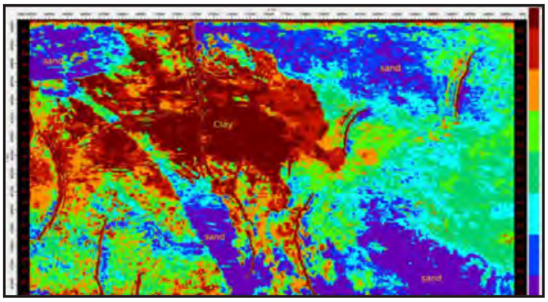

Figure 3: RMS amplitude map. A strong reflection of coal dominates the seismic response and conceals the geology.

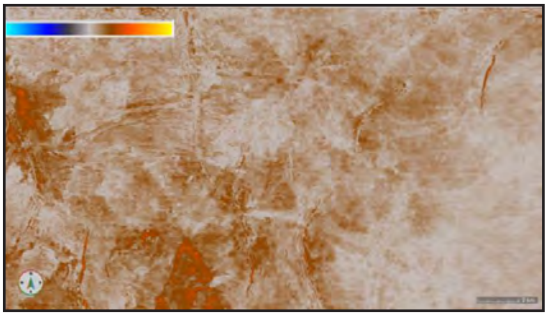

Figure 4: Trace-based Waveform classification map, showing a sand-filled distributary channel and mouth bar.

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Seismic geomorphology of channels in X-Block, Penyu Basin

NIK NUR ANIS AMALINA NIK MOHD HASSAN*, LIAW KIM KIAT & MD YAZID B. MANSOR

Petroleum Geoscience,
Department of Geoscience, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak, Malaysia
*Corresponding author email address: nik_17005940@utp.edu.my

Introduction

Penyu Basin is a complex, intracratonic basin located at offshore east of Peninsular Malaysia (Figure 1). Sediments in this basin were derived from the area of shallow pre-Tertiary basement, generally less than 1 km thick. This research focuses on the X-Block of Penyu Basin, ca. 890 km^2. It is located at north-east of Penyu Basin (Figure 1).

Three wells (i.e. R-1, R-2 and R-3) have been drilled in this area to test the basement drape structures. Oil has been discovered in R-1, but no hydrocarbon was found at R-2 and R-3 wells. Hence, this study aims to assess the stratigraphic traps, primarily traps formed by channel features and this can be done by studying the seismic geomorphology in the area of interest.

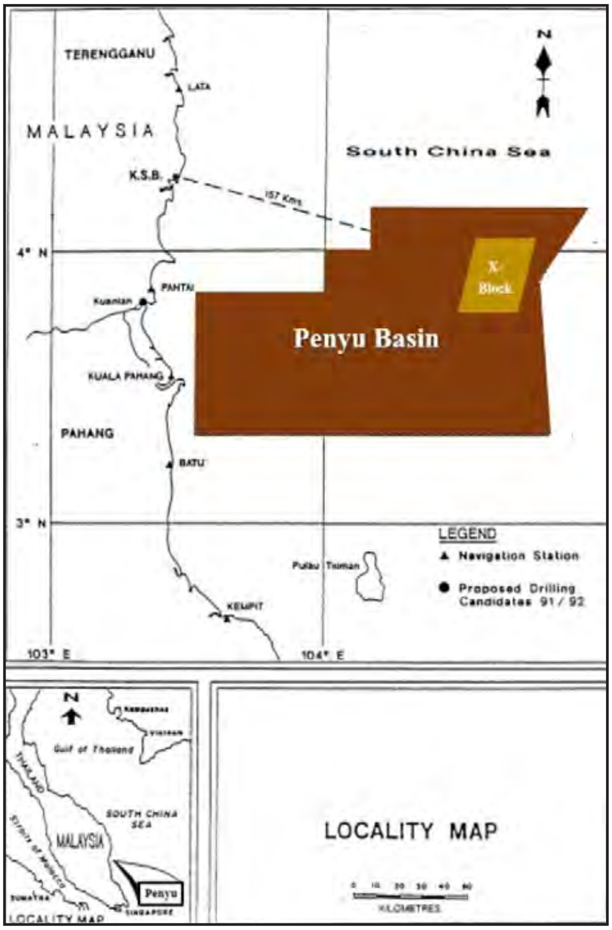

Figure 1: Location of Penyu Basin and the X-Block (modified from Jon Eckel, 1993).

Methodology

This study is primarily based on horizons interpreted in both inline and crossline directions, throughout the X-Block area. A total of three horizons are interpreted, named as H1, H2 and H3 (example in Figure 2). General method used for this study is shown in flowchart below.

Variance attribute, which is an edge method is used to image the discontinuities of seismic data, which can be related to the stratigraphy. This attribute measures similarity of waveforms or traces adjacent over the given lateral and/or vertical windows. By that, variance attribute is a very effective tool for delineation of channel edges in both horizon slices and vertical seismic profiles. Based on the interpreted horizons, horizon probes are generated respectively to better examine any geological features. Next, by using seismic geomorphology study, the seismic patterns are interpreted to determine geomorphology of a formation. This is similar as using satellite and aerial photos to portray the earth's surface (Koson *et al.*, 2014). Besides, this method can also be used primarily in viewing, mapping subsurface geological features, as well as interpreting structures and stratigraphy away from well controls.

Results and discussions

Seismic geomorphology study in X-Block reveals several types of channel features, ranging from straight

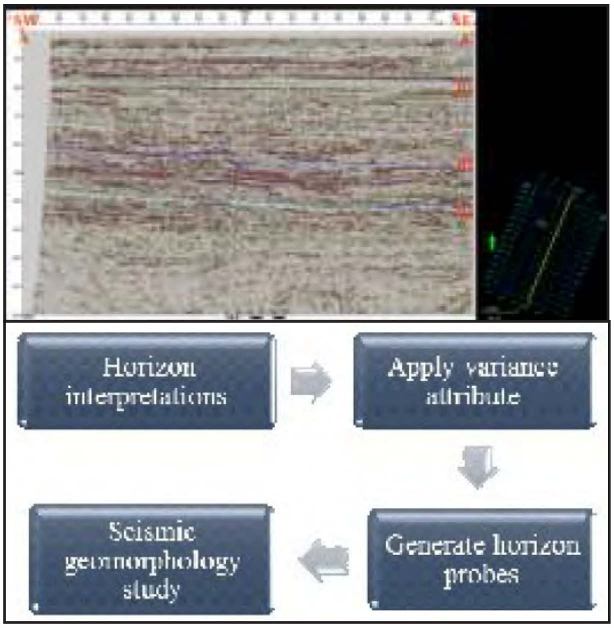

Figure 2: Horizon interpretations at inline 3073.

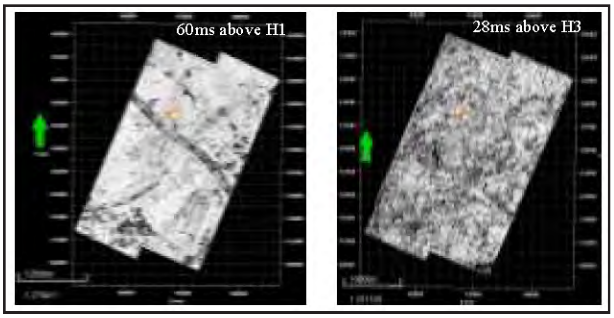

Figure 3: Examples of channel features obtained from seismic geomorphology study.

to meandering channels with different level of sinuosity (examples in Figure 3). Numerous channel profiles can also be seen throughout the seismic data in the study area. Most of the channels can be found in upper and middle part of the seismic section. As going deeper to the bottom section, only lineaments of faults and fractures are visible. In upper part of the seismic section, straight and long channel features can be observed and as moving downwards, the channel sinuosity increases resulting in meandering channel. The existence of lineaments at the bottom of seismic section indicates different depositional environment, prior to channel systems.

Acknowledgement

I would like to express my special thanks to my supervisor, Dr. Liaw Kim Kiat who always gives me guidance in completing my research. I also want to express my gratitude to my lecturers in Petroleum Geoscience department for helping me whenever I need assistance. Not to forget, I like to thank my parents and friends who are always supporting me and giving words of encouragement.

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ORAL PRESENTATIONS

MINERAL EXPLORATION/ GEOCHEMISTRY

NGC 2018 NATIONAL GEOSCIENCE CONFERENCE
S9-70

Review on exploration of rock aquifers

Vynotdni[1,*], Edy Tonnizam Mohamad[2], Ibrahim Komoo[3], Mariatul Kiftiah[4] & Al Mujida[5]

[1] Department of Civil Engineering, School of Engineering, Universiti Teknologi Malaysia, 81300 Skudai, Johor
[2,4,5] Geotropik, Department of Civil Engineering, School of Engineering, Universiti Teknologi Malaysia, 81300 Skudai, Johor
[3] Institute for Environment and Development (LESTARI), 43600 UKM Bangi, Selangor
*Corresponding author email address: vynotdni2@graduate.com.my

Introduction

The earth continent consists of 40% of metamorphic and plutonic rocks which means the tendency to meet rock terrain is high in any place (Jenifer & Jha, 2017). Hence, the exploitation of groundwater in rock could not be avoided in many part of the world. However, the problem in exploring rock aquifers is the low yield which is usually around 100 – 1000 litres per hour (Alle *et al.*, 2018). According to Mogaji & Lim (2018), the hydrogeologists have to develop efficient methods to successfully locate potential aquifer zones. Yet, there is no single efficient method to locate potential aquifer zone (Jenifer & Jha, 2017). Supportively, Yin *et al.* (2018) stated that the traditional method of drilling, hydrogeological mapping and geophysical surveys for potential zonation are expensive and time consuming.

Potential zonation

It can be seen clearly that many hydrogeologists around the world are trying to assess the potential zone prior to drilling to prevent low yield and save cost. The integrated approach and Geographical Information System (GIS) based models are widely used by hydrogeologists for this purpose. Other methods like geophysics, lineament mapping and hydrogeological mapping are also being used.

Lineament Analysis

Teikeu Assatse *et al.* (2016) developed lineament map by using remote sensing and GIS. The lineaments were found to be surface representation of discontinuities and act as groundwater flow paths. In addition, Kim *et al.* (2004) carried out extensive lineament mapping in which lineament distribution map, lineament length density map, lineament count density map and lineament cross-point density map were developed. The result shows a close relation between lineaments and well production.

Geophysics

Alle *et al.* (2018) used both 1D electrical resistivity technique and 2D electrical resistivity tomography (ERT) to identify the most efficient technique for potential aquifer zonation. The result shows ERT was more efficient in showing hydrogeological targets such as weathering thickness compared to 1D technique. Meanwhile, Chandra *et al.* (2010) used ERT and found out that the location of deepening of weathering process between quartz reef and granite to be prone for groundwater occurrence.

GIS

GIS models were developed by many researches to map potential aquifer zone. Most of the time, techniques such as remote sensing and multi criteria decision analysis were used to create these models. In addition, Jenifer & Jha (2017) further studied most suitable technique in multi-criteria decision analysis such as Analytical Hierarchy Process (AHP), Entropy and Catastrophe. The result shows that AHP is more efficient compared to other techniques. Also, in almost all researches the maps developed were more than 80% accurate (Adiat *et al.* (2012); Rajaveni *et al.* (2015); Yin *et al.* (2018)).

Hydrogeological Mapping

Rahiman *et al.* (2015) investigated hydrogeological characteristics in the study area through fault, fold, fracture and joint analysis. The faults and folds acted as barriers while the joints as passages.

Integrated approach

Integrated approach is where more than one method is used in identifying potential aquifer zone. Adabanija *et al.* (2014) carried out geophysical investigation, remote sensing, hydrogeological and hydrogeochemical investigation for this purpose. It was found out that the local geological structure controlled the availability of groundwater and managed to find high yield zone. On the other hand, Acharya & Prasad (2017) studied weathering profile, topography, fracture analysis and existing nearby well data to locate potential aquifer successfully. The lithostratigraphic contact showed higher potential to yield more in this study.

Conclusion

Therefore, method for exploration for rock aquifer must be selected carefully according to availability of fund, technology and on-field expert to save cost and time.

Acknowledgements

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Mineralogical analyses of Belata black shale, Peninsular Malaysia

ESTHER OWUSU BOATENG[1], HAYLAY TSEGAB [1,2], CHOW WENG SUM[1] & JOEL BEN AWUAH[3]

[1] Department of Geoscience, Universiti Teknologi PETRONAS, 32610 Bander Seri Iskander, Tronoh, Perak, Malaysia
[2] Southeast Asia Carbonate Research Laboratory, Department of Geoscience, Universiti Teknologi PETRONAS, Perak Darul Ridzuan 32610 Bander Seri Iskander, Tronoh, Perak, Malaysia
[3] Department of Applied Geology, Curtin University, Sarawak, Malaysia
Email address: besther2012@yahoo.com; haylay.tsegab@utp.edu.my; chow_wengsum@utp.edu.my; jbenawuah@curtin.edu.my

Introduction

Shales, by far are the most abundant type of sedimentary rocks mostly formed in marine environments close to continents at places where the seafloor falls beneath the storm wave base. They could also be formed at quiet parts of rivers, lagoons, lakes, tidal flats and deltas (Tourtelot, 1979).

Organic shales could be classified as argillaceous, siliceous or calcareous depending on their mineralogical content (Chermak & Schreiber, 2014). Black shales primarily have a composition of mixtures of non-clay minerals such as fine-grained quartz, feldspars, pyrite, carbonates and clay minerals such as smectites, kaolinite, chlorites, illites and mixed layers of the mentioned clay types. Studies into the type of mineral together with other geochemical parameters are necessary for the study of source rock, depositional environment and burial diagenesis (Niu *et al.*, 2018). In this work, the mineralogical composition of the Carboniferous black shales of Belata Formation which lies to the southern part of Tanjung Malim on the borders of Perak State and Selangor State of Peninsular Malaysia is studied (Figure 1).

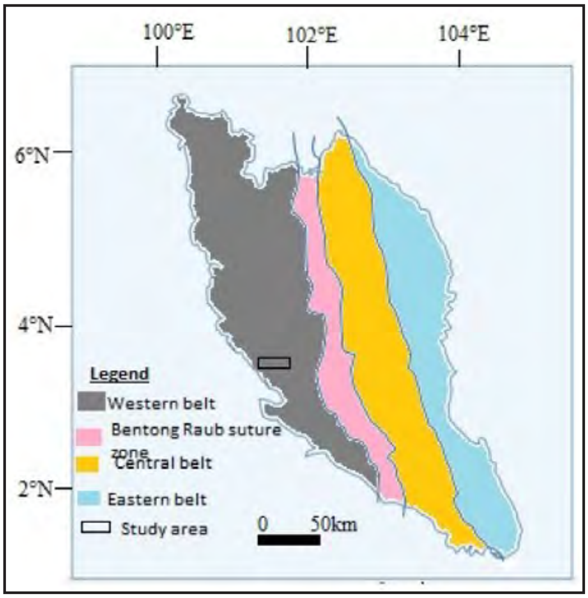

Figure 1: Geologic map of the Peninsular showing the study area (Lee *et al.*, 2004).

Material and method

Representative samples from different ages and localities of the black shales were subjected to detail mineralogical analysis at the Centralized Analytical Laboratory (CAL) in Universiti Teknologi PETRONAS. Twenty two black shale samples picked from the field were analyzed for their clay and non-clay fraction using X-ray Diffraction (XRD) analyses.

Result and discussion

Minerals present in the Belata black shale include non-clay minerals (quartz, feldspars and muscovite with traces of calcite and pyrite) and clay minerals (kaolinite and chlorites) as shown in Figure 1. Whiles minerals such as quartz, feldspars and chlorite minerals are products of detrital components of shales, minerals such as carbonates and sulfides may be formed in shale during burial or most probably as cementing or replacing materials.

The minerals present within the shales are dominated by felsic or silicic minerals such as quartz and feldspars (Figure 2) and hence could be interpreted as coming from

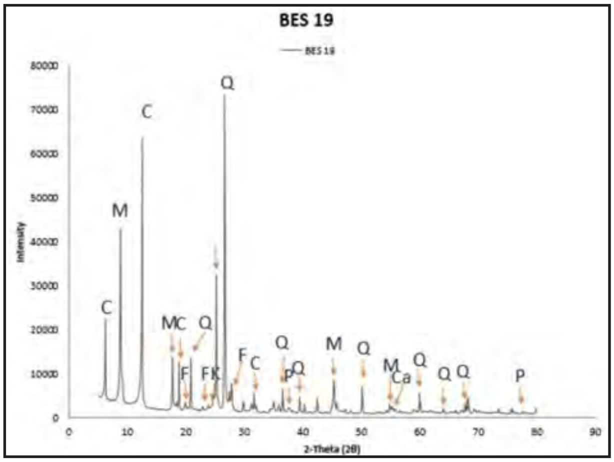

Figure 2: XRD pattern of the various mineral phases C-ChloriteM- muscovite mica,K- Kaolinite, Ca- Calcite, Q- Quartz, F- Feldspar (Albite) and P- Pyrite.

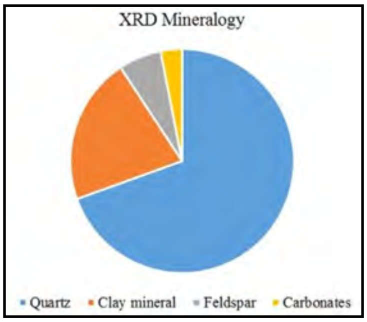

Figure 3: Mineralogical quantification using the rietveld analysis.

a felsic provenance which is not too distant away from the place of deposition. This assumption is also supported by the presence of K-feldspar in the mineralogical analysis. However, the use of higher magnification (SEM) and other geochemical parameters such as major and minor element proxies could aid in the depositional environment description of the shales. The black shales of the Belata Formation probably originated from a hidden felsic basement rock.

Conclusison

The Belata black shales are rich in felsic minerals such as quartz and feldspars. Minerals such as muscovite, calcite, pyrite, kaolinite and chlorite are also present and this may indicate a felsic source rock. Thus, the black shales of the Belata Formation probably originated from a hidden felsic basement rock.

Acknowledgements

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Zero mercury implementation management of artisanal gold mining at Geumpang Mountain, Pidie - Aceh, Indonesia

TEUKU ANDIKA RAMA PUTRA

Mineral Resources Engineering,
School of Material and Mineral Resources Engineering, Universiti Sains Malaysia,
14300 Nibong Tebal, Pulau Pinang, Malaysia
Email address: teukuandika@usm.my

Abstract: Most of artisanal gold mining operations in the world are using mercury to extract gold including the traditional miners in Aceh. Gold extraction using mercury is simple, unfortunately mercury is a powerful neurotoxin that is harmful to people. The study reviewed and investigated the mine management and economics to support implementing zero mercury processes in order to comply with modern environmental standards, reducing mercury use while realizing the dream of traditional miners by developing the wealth opportunities. There are a wide variety of zero mercury approaches to gravity concentration from basic such as panning and sluicing, to more complex such as centrifuges and shaker tables. Policy makers, miners and civil societies are three main stakeholders that have the important roles in the implementing. Planning, guide, decision and educational tool including system of graphics and explanation of barriers are all significant tools and methods in supporting zero mercury implementation.

S9-3

Preliminary assessment and optimization of blasting cost and cycle time of load-haul unit of Obajana Cement Quarry

SHAIB ABDULAZEEZ SHEHU[1,2,*], M.H.M. HASHIM[1] & MUYIDEEN ALADE SALIU[3]

[1] Strategic Mineral Niche, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, Engineering Campus,14300 Nibong Tebal, Penang, Malaysia
[2] Department of Mineral and Petroleum Resources Engineering, School of Engineering, Kogi State Polytechnic, Lokoja, Nigeria
[3] Dept. of Mining Engineering, School of Engineering, Federal University of Technology, Akure, Nigeria
*Corresponding author email address: shehu@student.usm.my; shehuthefirst@yahoo.com

Abstract: Blast design of Dangote Quarry was evaluated based on recommended standards for optimal fragmentation using empirical analysis. The resulting fragmentations were further analyzed using Kuz-Ram model. The current loading and haulage operations were also evaluated based on the unit cycle time to assess the possibility of minimizing operational cost and the idle time. The cost of blasting an area of Marble deposit measuring 402.5m by 9m (70,639 tons) using the initial blast design is USD12,584.85 while that of the modified blast design is USD10,782.67. This shows that a total sum of USD1,802.18 can be saved by adopting the modified design and this represents 14.32% of the initial design cost. Fragmentation analysis shows that the initial design has 95.6% of the blasted fragments within the range of 100cm with mean fragment size of 56cm. The modified design has 95.1% of the blasted material within 100cm with a mean fragment size of 64cm. The increase in the mean size has no significant effect on the primary crusher because the opening of the jaw is set at 150cm. The load – haul unit of the quarry is characterized with a waiting time of 4.35mins. The Suboleski's cycle time model adopted shows that the optimum number of dump trucks required by the excavator is three as compared to the initial four dump trucks. With this number of trucks, waiting time of dump trucks was eliminated while the idle time of excavator is at the minimum of 0.25min per cycle which is a drastic reduction to the initial waiting time of 4.35mins for the dump trucks. This empirical approach is simple and highly recommended for mine and quarry operators for optimum fragmentation. The haulage roads should be properly graded and maintained for better performance while ensuring regular scheduled maintenance of the loading and hauling equipment.

Keywords: Quarry, optimization, idle time, fragmentation, blasting

S9-70

Geochemical assessment of REE associated with weathered crust of Malaysian granite profile

Ali Yaraghi[1], Kamar Shah Ariffin[2], Kotaro Yonezu[3] & Norlia Baharun[4]

[1,2,4] School of Materials & Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia
[3]Department of Earth ources ering, yushu ersity, kuoka, Japan
Email address: a.yaraghi@yahoo.com; kamarsha@usm.my

Introduction

Rare earth elements (REEs: La-Lu) are defined as a group of elements composed of Scandium (Z=21), Yttrium (Z=39) and Lanthanides (Z=57-71) and divided into light REEs (LREEs: La-Eu) and heavy REEs (HREEs: Gd-Lu) [1].

Koppen-Geiger climate classification suggests that temperate and tropical sites are potential zones for weathered granite or ion-adsorption clay type REE resources, thus promoting of intensive chemical weathering and breakdown of REE-bearing minerals by such climate conditions [2,3]. In order to study REE behavior in granite weathering profiles, examining REE fluctuation in depth can be one of the best approaches. Major responsible mechanisms of fractionation and mobilization of REE can be resulted from weathering profile analysis. Mobility and fractionation of REEs during weathering of granites are strongly dependent on which REE- bearing minerals are present and the degree of weathering [3].

In this study, mineralogical and bulk chemical composition studies were conducted on two sets of samples from soil granitic profile of western tin belt of Peninsular Malaysia. Six (6) samples were taken from the outcrops of weathered crusts and fresh rocks in Dinding granite (Lumut site). Major element compositions were determined on fused disc and pressed powder using an X-ray fluorescence spectrometer Rigaku RIX3000 at the School of Mineral Resource Engineering, USM. Rare earth elements (REEs) were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) at Activation Laboratories Ltd. (ActLabs), Canada using total digestion technique. XRD analysis was conducted in order to determine the mineral composition and clay mineral in the weathered sample. Orientated samples were prepared for XRD analyses by disaggregated in distilled water and the <2 µm fraction was mounted on glass slide and then analyzed using a RIGAKU FKOD 10-015 X-ray diffractometer (XRD) in Dept. of Earth Resources Engineering, Kyushu University.

Conclusion

Weathered crust of granitic rocks from Lumut region is composed mainly of quartz, Halloysite (from Kaolinite group of clay minerals), Montmorillonite, Nontronite, and Dickite (from smectite group of clay minerals) and small portions of Sepiolite and chlorite. Parent rock mainly consists of quartz, feldspar minerals (Albite, Anorthite and Orthoclase) and Phlogopite from mica group.

The major elements and REE composition of the weathered crust and the parent rocks for Lumut region is

Table 1: Concentration of major elements and REEs of parent rocks and weathered crust from granitic rocks at Lumut region.

Sample Code	*Parent bedrock*	*LU-238*	*LU-239*	*LU-240*	*LU-241*	*LU-242*
Major element (wt. %)						
SiO_2	73.08	62.25	65.81	60.92	58.45	65.53
TiO_2	1.14	0.15	0.14	0.16	0.13	0.17
Al_2O_3	13.18	25.13	23.95	27.43	28.50	22.45
FeO_{total}	2.97	2.04	1.96	2.52	1.92	2.09
MnO	0.29	0.01	0.015	0.033	0.031	0.032
MgO	0.067	0.058	0.054	0.04	0.023	0.072
CaO	1.37	0.024	0.013	0.025	0.031	0.052
Na_2O	1.01	0.017	0.011	0	0.015	0.03
K_2O	4.57	0.929	0.92	0.64	0.39	3.18
P_2O_5	0.032	0.01	0.014	0.014	0.013	0.017
$S(SO_3)$	0.03	0.05	0.044	0.045	0.048	0.03
LOI	2.06	9.19	6.939	8	10.3	6.2
SUM	99.82	99.88	99.89	99.85	99.86	99.86
ASI	1.90	25.88	25.18	40.92	65.15	6.89
CIA	0.65	0.96	0.96	0.98	0.98	0.87
Rare Earth Elements (ppm)						
La	49.5	31.5	38.8	48.9	19	97.9
Ce	124.3	177.3	221.2	323.3	708.8	236.9
Pr	14.0	9.2	11.2	14.1	5.3	26.6
Nd	49.1	32.2	39.3	49.4	18	93.7
Sm	13.5	7.8	9.9	12.5	6.3	22.1
Eu	0.5	0.3	0.4	0.4	0.4	0.9
Gd	14.6	8.2	10.4	13.3	10.2	20.5
Tb	2.7	1.4	1.7	2.1	1.4	3.2
Dy	19.1	10	12.4	14.3	9.9	19.9
Ho	4.0	2.1	2.6	2.9	1.8	3.9
Er	12.7	7.1	8.6	9.4	6.1	12.4
Tm	1.9	1.1	1.3	1.5	1.1	1.9
Yb	12.7	7.4	8.8	9.7	7.6	12.2
Lu	1.8	1.1	1.3	1.4	1.3	1.7
Y	128.9	56.9	70.2	77	52.5	124.5
Sc	32.9	27.6	30.9	32.7	26.5	35.6
LREE	250.9	258.3	320.8	448.6	757.8	478.1
HREE	69.5	38.4	47.1	54.6	39.4	75.7
Total REE	320.4	296.7	367.9	503.2	797.2	556.8
REE+Y	449.3	353.6	438.1	580.2	849.7	678.3
Ce/REE	0.39	0.59	0.6	0.64	0.88	0.43
Ce/La	2.5	5.6	5.7	6.6	37.3	2.4
Eu/Sm	0.04	0.04	0.04	0.03	0.06	0.04

Note: CIA = Chemical Index of Alteration; ASI = Aluminum Saturation Index the weathering profile.

tabulated in Table 1 and shown in Figure 1. The content of Al_2O_3 and LOI in the weathering profile increased up to twice and five times, respectively compared with the parent rock, whilst other oxide content decreased in amount when weathering occurred. Mineralogical and petrological studies have shown many isolated granitic bodies in the western coast of Peninsula Malaysia comprise porphyritic to medium- grained mica (phlogopite)-rich granite. The weathered granite crust of the sites can be classified into four vertical profile from top to bottom (A-D). A) Thin, strongly weathered granite horizon (organic rich); B) Highly weathered massive granite (clay rich); C) Slightly weathered granite; and D) Massive parent granite bedrock. XRD analysis shows presence of kaolin and smectite rich clay groups (i.e. Kaolinite, Halloysite)) in horizons A and B, whilst phlogopite is the common mica in fresh granite bedrock. ICP-MS results indicated LREE, HREE and Y concentration is higher in the weathered S-type, ilmenite series granite bedrock of the Dinding Granite. At both sites, depletion of REE+Y content in horizon A is considerably apparent, whilst enriched in horizon B and/or C. The maximum content of REE+Y could be as high as 3000 ppm in horizon C especially at the Segari site. The total REE content of this weathered crust are relatively elevated compared to the parent rocks (3 to 7 times), especially in horizon B and C of both sites, respectively. The normalized isocon diagram shows that the mass balance of major and REE mineral components between each horizon in Lumut and Segari sites are different. The positive Ce anomaly in the horizon A of Lumut profile indicated that Ce is rapidly precipitated during weathering and retain at upper soil horizon.

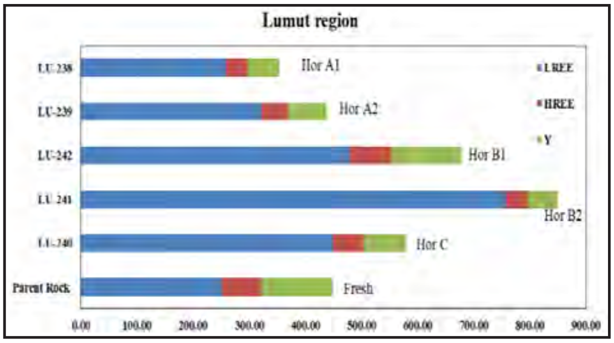

Figure 1: Total LREE, HREE and Y of weathered crusts.

Figure 1 showed that in Lumut region, the LREE and HREE increased from the parent rock to the horizon B but decreased slightly to the horizon A1 and A2 suggests that there were enrichment of REE in the horizon B.

Acknowledgement

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S9-70

Application of UAV photogrammetry for quarry monitoring and assessment

Sharan Kumar Nagendran & Mohd Ashraf Mohamad Ismail*

School of Civil Engineering, Universiti Sains Malaysia,
14300 Nibong Tebal, Pulau Pinang
*Corresponding author email address: sharanf1034@yahoo.com, ceashraf@usm.my

Abstract: In quarry production, survey work is necessary to monitor the height of stockpile and the quarry's walls to comply with the rules and regulation stated by the authority. Conventional method of surveying uses ground-based surveying at these sites to measure the X, Y and Z data. Nevertheless, these approaches are very time consuming and dangerous for the staff. Advancement in remote sensing specifically unmanned aerial vehicle (UAV) have become an alternative for surveying work. The use of drone for survey that is remotely piloted enables replacement of traditional method of surveying in quarries. This paper describes the application of drone mapping for quarry monitoring and management mainly stockpile and slope assessment. Quadcopter was used to acquire the aerial images for stockpile and both aerial and side images for slope assessment. Image captured were processed using a photogrammetry software, Agisoft Photoscan to produce the final output that consists of orthophoto, digital surface model, 3D dense pint cloud and 3D model. Based on the output, volume, height and area of stockpile computational were made in the photogrammetry software. The slope stability assessment computation was made using facet extraction to identify the major discontinuity sets for rock slope stability analysis. UAV photogrammetry grants precise approach, provides fast data recovery and is time saving for mapping a large area of quarry.

Keywords: UAV, photogrammetry, quarry, rock slope

POSTERS

PGE-22

Middle Ordovician (Llanvirnian) relative sea-level fluctuations

Teoh Ying Jia* & Nordiana Mohd Muztaza

Geophysics Research Group
School of Physics, Universiti Sains Malaysia, 11800 Batu Uban, Penang.
*Corresponding author email address: tyj@usm.my

Abstract: The Canning Basin is located between the Kimberley and Pilbara Precambrian cratonic blocks. It is a large but relatively poorly explored Paleozoic basin in remote Western Australia. During the early Ordovician period, the Australian continent was located near the equator. Middle Ordovician age Nita and Goldwyer Formations in Canning Basin are therefore warm water carbonates. Fischer plots are a popular tool to graphically illustrating deviations from average cycle thickness in cycle stratigraphy; this graphical method can used to define accommodation changes and depositional sequences on "cyclic" carbonate platforms (Fischer, 1964; Sadler *et al.*, 1993; Husinec *et al.*, 2008). Goldhammer (1987) used Fischer plots of Middle Triassic carbonates in Italy to define third-order sea-level fluctuations. The sea-level curves therefore remain valid working models for the long-term trends of the base level, representing marine transgressions and regressions along the world's continental margins and flooding or desiccation of inland seas and wide interior epi-platform basins (Haq & Al-Qahtani, 2005). Llanvirnian relative sea-level fluctuations were reconstructed by using Fischer plots methodology for three key wells (wells McLarty 1, Looma 1 and Robert 1) in Broome Platform and compared with Integrated Prediction Filter Error Analysis (INPEFA) data. The Goldwyer lower shale (interval Or1000P) shows increasing relative sea-level and this matches with a transgressive systems tract. Goldwyer middle carbonate (interval Or2000) shows relative sea-level drop and this matches with a regressive systems tract. Goldwyer upper shale (interval Or2000P) shows relative sea-level drop and this matches with a transgressive systems tract. Nita Formation Leo Member (interval Or3000) shows a relative sea level drop and this matches with a regressive systems tract. The Nita Formation Cudalgarra Member (intervals Or3000P and Or4000) with transgressive systems tract then this is followed by a regressive systems tract. This pattern matches with the relative sea-level curves in wells McLarty 1 and Robert 1. The correlation is weak for parts of well Looma 1. This is probably influenced by the fact that the thickness of this section is quite small. As a conclusion, Fischer plots for the Llanvirnian Goldwyer and Nita Formations show good agreement with the third order global sea level cycles of Haq and others. Fischer plots are generally correlated well with trend and cyclicity determined by INPEFA curves and as a method of cross-checking INPEFA data and sea-level change.

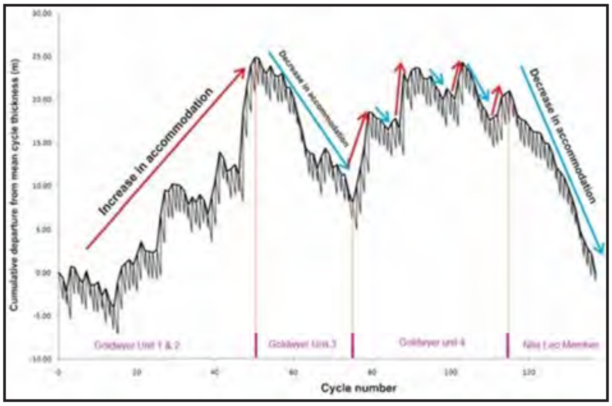

Figure 2: Fischer plots illustrated relative sea level curve of well McLarty 1.

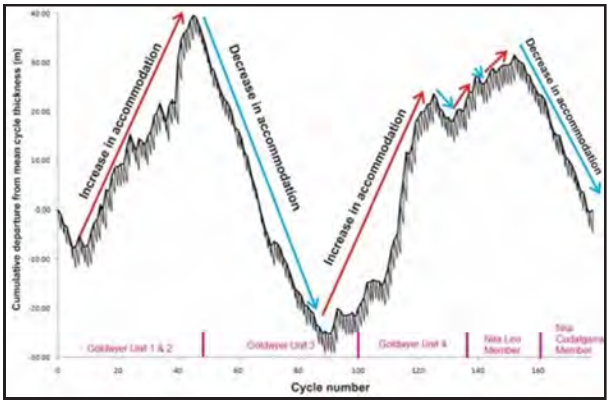

Figure 1: Fischer plots illustrated relative sea-level curve of well Looma 1.

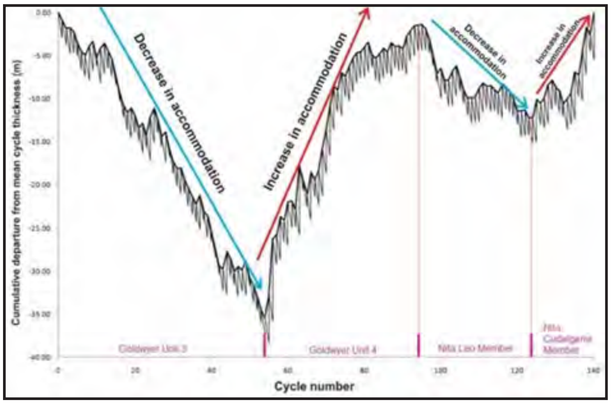

Figure 3: Fischer plots illustrated relative sea level curve of well Robert 1.

Keywords: Canning Basin, Nita Formation, Goldwyer Formation, middle Ordovician, llanvirnian, sea-level fluctuation

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Desulfurization of groundwater using marble filter

FITRI AKHIR, AIDA SAAD & AZAZI ZAKARIA

River Engineering and Urban Drainage Research Centre,
Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia
Email address: fitriakhir93@gmail.com; aidasaad@usm.my; redac01@usm.my

Introduction

Elementary analysis of groundwater taken in USM, Nibong Tebal, Malaysia found that the concentration of sulfur exceeded 200 ppm. Sulfur itself is non-toxic. However, the derivation of sulfur causes the formation of ferrous sulfide (FeS) and hydrogen sulfide (H_2F). FeS was reported by Science Laboratory Chemicals and Laboratory Equipment (2013), in material safety data sheet, to appear black or brown to the color of sludge. It is very dangerous and can cause adverse effect if it is ingested, inhaled or cames in contact with the eye.

FeS is also known for its corrosion problem to the industry and is named as rust sulfuration. Unstable FeS makes sulfur tends to degrade and attach on hydrogen gas to form H_2S. H_2S can also be produced by degradation of enzyme mechanisms from reducing sulfate bacteria. Colorless gas with rotten egg smell of H_2S can cause shortness of breath, low blood pressure and loss of consciousness at higher exposure levels. Thus, to avoid these consequences, marble filter is built to remove sulfur.

Previously, most researchers explored the potential of calcium carbonate in water filtration (Mohd Sanusi *et al.*, 2016). However, most of them are not aware of the particle size of calcium carbonate as sand size is important to produce high removal of sulfur. This research had compared the marble in sand size with the marble in pebble size to produce high removal.

Figure 1: Marble filtration process in comparing the size of pebble and sand size.

Result and discussion

Marble filter uses two sizes i.e. pebble and sand size (refer to Wentworth, 1922 scale). Both sides have capability in removing sulfur. However, they show different efficiency according to flowrate. Two tests provides results that are nearly similar (Table 1, Table 2, Table 3 and Table 4). Therefore, the data is accepted to be used as data interpretation. Flowrate 0.011 in Table 2 and Table 4 for marble in sand size show the highest removal efficiency and can trap sulfur even at low concentration.

Table 1: Test 1 for marble in pebble size.

Flowrate	*Before filtration (ppm)*	*After Filtration (ppm)*	*Total Removal*	*Removal efficiency*
0.033	507	210.7	296.3	58.44
0.017	323.1	154.5	168.6	52.18
0.011	415	93.95	321.05	77.36
0.008	437.7	134.4	303.3	69.29
0.007	537.1	102.6	434.5	80.90

Table 2: Test 1 for marble in sand size.

Flowrate	*Before filtration (ppm)*	*After Filtration (ppm)*	*Total Removal*	*Removal efficiency*
0.033	509.1	11.38	497.72	97.76
0.017	265.6	10.09	255.51	96.20
0.011	393.6	6.601	386.999	98.32
0.008	417.3	18.9	398.4	95.47
0.007	535	13.56	521.44	97.47

Table 3: Test 1 for marble in pebble size.

Flowrate	*Before filtration (ppm)*	*After Filtration (ppm)*	*Total Removal*	*Removal efficiency*
0.033	444.1	178.4	265.7	59.83
0.017	483.5	157.2	326.3	67.49
0.011	276	133.3	142.7	51.70
0.008	328.8	138.4	190.4	57.91
0.007	457.6	101.4	356.2	77.84

Table 4: Test 2 for marble in sand size.

Flowrate	*Before filtration (ppm)*	*After Filtration (ppm)*	*Total Removal*	*Removal efficiency*
0.033	348.9	11.38	337.52	96.74
0.017	471.2	14.55	456.65	96.91
0.011	286.1	7.611	278.489	97.34
0.008	315.2	11.2	304	96.45
0.007	453.8	18.98	434.82	95.82

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PGE-51

Physico-chemical characteristic of black shale from Sungai Perlis Bed around Kijal, Terengganu

SITI AISYAH RAMLI & ASKURY ABD KADIR

Department of Geosciences, Faculty of Science & Information Technology,
Universiti Teknologi PETRONAS, 32610 Sri Iskandar, Perak
Email address: siti_16004006@utp.edu.my; askury_akadir@utp.edu.my

Carboniferous marine shale, known as Sungai Perlis Beds are widely distributed in the southern part of Terengganu. Representative coring samples from different localities of black shale were analyzed based on their organic carbon content and mineralogy properties to study the shale characteristics, which influence the geomechanical properties of shale. Total organic carbon (TOC) of samples collected are quite high, 2.35 to 2.88 wt.% and fall into good to very good potential as source rock according to Peter & Cassa, 1994 (Table 1). The distribution of TOC value are increasing toward the southern area of Terengganu except for Teluk Kalong, TK sample. XRD analyses of samples from Sungai Perlis Beds formation show least variation in their mineralogical composition (Table 1). The shale samples are mainly composed of illite and quartz with minor composition of kaolinite. Presence of mineral Fe-rich phengite can be observed from Teluk Kalong, TK sample (16 %). While magnesian muscovite or called phengite as well detected from Bukit Kuang, BK sample (17 %). According to Fleet & Howie (2006), phengite is similar to muscovite with addition of magnesium, Mg, found in metamorphose low grade schist. Phengite found in TK shale samples rich in ferum, Fe affect from muscovite that being heated. Most illite minerals come from heated muscovite. Mixed layer of illite-smectite cannot be observed from any of the samples. XRD mineralogy analysis for the Sungai Perlis Beds black shale indicates high content of quartz and non-expanding clay, with low content of clay with high expanding capacity. These result showing that the investigated shale samples have brittle properties with low swelling capacity.

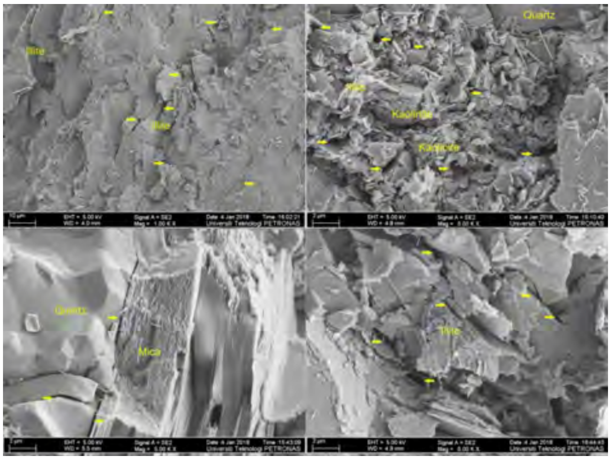

Figure 1: Resulted FESEM images with arrow showing microfractures.

Minerals detected from XRD analysis being correlated to the elements identified from XRF analysis. Major elements constitute are Si, Al, K, Ti and Fe. Illite is the weathered product of muscovite and feldspar and is known as a diagenetic mineral in marine sediment (Farrokhrouz & Asef, 2013). Compared to muscovite, illite has slightly more Si, Fe, Mg and water, and slightly less Al and interlayer K (Bailey, 1980). Weathered biotites from weathered granite may produce kaolinite with Fe and Ti oxyhydroxide (Velde & Meunier, 2008). Kaolinite is the product of partial weathering of hydro-thermally altered felsic rocks. Presence of Na may indicate the feldspar mineral.

The compounds and elements resulted through field emission scanning electron microscope, FESEM and energy dispersive x-ray, EDX analyses are shown in Figure 1. Crystal form of authigenic quartz overgrowth with clear intrapore can be observed with conchoidal fracture from the former grain attachment that being broke up during sample preparation with only silicon, Si and oxygen, O element detected from EDX. Morphology of plate-like or lath-like mineral showing the presence of non-expanding clay, illite with major elements silicon, Si, aluminium, Al and potassium, K while minor elements usually magnesium, Mg, calcium, Ca and ferum, Fe. For illite, potassium, K peak usually lower than aluminium, Al in the EDX spectrum graph. Stacks of clay mineral, kaolinite appear in between the quartz grain filling the interpore. Ragged edge of kaolinite in booklet form of stacking pseudohexagonal

Table 1: Resulted mineral composition from XRD bulk analysis and TOC values.

Sample	Non-clay mineral (%)		Clay mineral (%)		TOC (wt.%)
	Quartz	Phengite	Illite	Kaolinite	
BK	34	17	43	6	2.88
TK	22	16	47	15	2.35
PK	46.2	-	48.1	5.7	2.52
BP	34	-	58	8	2.38

shape allow the existence of micropores between the detrital grains. The nearly same height of aluminium, Al and silicon, Si peaks indicate the kaolinite.

Clear microcracks intra and inter mineral can be seen on FESEM image of Sungai Perlis Beds black shale samples. All samples have high content of C elements indicating high carbon content, representing Carboniferous marine shales.

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Slope investigation using integrated geophysical methods

NORDIANA MOHD MUZTAZA*, MUHAMMAD TAQIUDDIN ZAKARIA & TAJUDEEN OLUGBENGA ADEEKO

Geophysics Section, School of Physics, 11800 Universiti Sains Malaysia (USM), Penang, Malaysia
*Corresponding author email address: mmnordiana@usm.my

Abstract: Slope can be related with various factors before it can be determined its stability. From the engineering aspects which includes geotechnical parameter, the slope stability can be determined based on the slope angle and its steepness. The slope steepness can be grouped into three classes to determine the risk of landslide on hill-site development (Gue & Tan, 2004). However, the slope stability might not be affected only based on the steepness and the slope angle. It might also depend on the subsurface structure. Hence, the results obtained from geophysical methods were also important and need to ensure the slope stability. Seven 2-D resistivity and Self Potential survey lines were conducted with 1.5 m minimum electrode spacing and 3.0 m interval spacing respectively at Archaeology Gallery, Penang. The 2-D resistivity data obtained were transferred into the computer for further processing and was presented in 2-D resistivity inversion model via Res2Dinv and Surfer v8.0 software. While for SP method the data will be process using excel and presented 2-D and 3-D surface map using Surfer v8.0 software. The inversion models convey the subsurface structure on each line in which was represented by the resistivity values. The range of resistivity values were determined and classified into three classes for interpretation. The saturated zones, weathered granite and fresh granite were classified with range values of 1-400 Ωm, 1500-5000 Ωm and greater than 5000 Ωm respectively. The saturated zones were characterized by low resistivity and it also may indicate that the zones associated with the high water and clay contents and possible unstable fracture within the landslide mass (Göktürkler *et al*., 2008; Ronning *et al*., 2003) which were observed at topsoil at the study area. Low resistivity value (100-800 Ωm) might be alluvium which consist of sandy, silt and sand. The material that may cause landslide was unconsolidated characteristics may correspond to the resistivity lows with increasing moisture and fines contents (Drahor *et al*., 2006; Abidin *et al*., 2013). Subsequently, the results from SP method were used to verify the results of 2-D resistivity method. The directions and intensities of the water/high conductive were evaluated with self-potential (SP) method. Interpretation of SP support the results of 2-D resistivity method relating a saturated zone in the survey area. A zone that is fully saturated with sandy silt could be an influence factor the increasing water level because sandy silt is highly permeable in nature. There is a good correlation between the 2-D resistivity investigations and the results of SP. Other features such as presence of boulders was indicated by isolated high resistivity values, boulders overlie saturated zone and presence of fracture were also determined as indicated by the resistivity variations of the inversion models. These features can be the influence to trigger the landslide event in the early stages. Apart from precipitation as a major factor of the phenomenon, slope angle can also be one of the important factors to be aware to determine slope stability. Precipitation can affect the soil strength and texture while the slope angle can determine slope's class of landslide risk. This study area has been classified of having medium risk of landslide event.

Table 1: Summary of slope at Archaeology Gallery, Penang.

Criteria	Details
Type of soil	Presence of clay, silt and granite
Zones	consist saturated zones, weathered granite and fresh granite.
Factor cause to slope failure	Presence of saturated zone (1-400 **Ωm**), fracture, highly weathered granite, boulders and floaters (>3000 **Ωm**).
Slope steepness	Slope angle : 21°
Sum of precipitation (Month)	105.11 mm (May-Oct 2016)
Class of risk for land-slide event	Class 2 – Medium risk

Keywords: Slope, 2-D resistivity, self-potential (SP), saturated, landslide

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PG-9

The study of Chepor Member facies at Bumita Quarry, Perlis using seismic refraction and electrical resistivity method

HAZRUL HISHAM, NORDIANA MOHD MUZTAZA* & MUHAMMAD TAQIUDDIN ZAKARIA

Geophysics Section, School of Physics, Universiti Sains Malaysia, 11800, Minden, Penang, Malaysia
*Corresponding author email address: mmnordiana@usm.my

Abstract: The existance of outcrops allows observation and sampling of bedrock for geological analysis, they give highly detailed and spatially continuous information on petrology, facies, sedimentary structure, texture, grain types, morphometric properties, fractures and their orientations, joint patterns, compaction, diagenetic changes, and petrophysical and physicochemical properties (Van Dam *et al.*, 2015). The parameters of seismic refraction and electrical resistivity is very important in geological studies as the values indicate the type of rock or soil beneath the earth subsurface. In Perlis, the stratigraphic succession basically youngs eastward starting from the Setul Boundary Range (Jones, 1981; Meor, 2013). The bottom unit of the Kubang Pasu Formation (KPF) is known as Chepor Member. The Chepor Member consists of thick grey to red mudstone with interbedded tabular beds of quartzitic and feldspathic sandstone and sometimes bedded diamictite (Meor, 2004). The study is carried out to fulfill the following objectives : to study geological outcrop of Chepor Member at Bumita Quarry, Utan Aji and to integrate both seismic refraction and electrical resistivity parameter with the porosity and permeability of mudstone in Chepor Member. The data acquisition was carried out at Bumita Quarry, Utan Aji. The survey line at Bumita Quarry, Utan Aji was conducted perpendicular to the exposed bedrock. The geophone spacing applied is 2 m while electrode spacing for electrical resistivity method is 1 m. Both methods were conducted simultaneously on the same survey line. The rock samples are taken from the exposed outcrop using rock hammer for laboratory test. The rock specimen was cut into cylindrical shape using a diamond drill bit core driller. The method used for permeability test is nitrogen permeability test whereas for porosity, water immersion under vacuum is used. The rock samples were also brought to Mineralogical and Geosciences Department (JMG) in Ipoh to produce the thin section. Generally, the seismic velocity and resistivity value of mudstone produced by Reynolds, 1997 and Loke, 1999 respectively is in a wide range (Table 1), this research characterize the resistivity value of red mudstone and grey mudstone of Chepor Member at Utan Aji. Previous researchers have established the range values of seismic velocity and resistivity with respect to type of rocks presented in a table for references (Table 1). The broad range of this values might cause difficulties in interpretation since the range values overlapped with each other. In Perlis, Malaysia, seismic refraction and electrical resistivity methods were conducted at Chepor Member of Kubang Pasu Formation at Bumita Quarry, Utan Aji and the results were integrated with the values of porosity and permeability. The Chepor Member consist of red mudstone and grey mudstone. The seismic velocity of both mudstone is nearly the same with slight difference within 200 m/s. Pole-dipole array was used for the resistivity method. For resistivity values, red mudstone gives lower values (15 – 100 Ωm) than grey mudstone (120 – 500 Ωm). The porosity value for red mudstone is 0.95% while its permeability, 5.58×10^{-5} µd. Porosity value for grey mudstone is 1.9% with permeability 2.06×10^{-5} µd. Thus, the seismic velocity and resistivity values of mudstones of Chepor Member were established (Table 2).

Table 1: Geophysical parameter of mudstone with seismic velocity and resistivity values.

Geophysical parameter of mudstone	*Values*
Seismic velocity (Reynolds, 1997)	1000 – 4100 m/s
Electrical resistivity (Loke, 1999)	20 – 2000 Ωm

Table 2: Table of red mudstone and grey mudstone with respect to its parameters.

Parameters	*Red mudstone*	*Grey mudstone*
Seismic velocity (m/s)	1500 – 2100	1500 – 2300
Resistivity (Ωm)	15 – 100	120 – 500
Porosity (%)	0.95	1.9
Permeability (µd)	5.58×10^{-5}	2.06×10^{-5}

Keywords: seismic refraction, electrical resistivity, sedimentary rocks, Chepor Member, porosity, permeability

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PG-29

2-D resistivity and Time Domain Induced Polarization (TDIP) for shallow subsurface characterization

NUR AZWIN ISMAIL*, IFFAH ZALIKHA ROSLAN & KALAI VANI THIRMALINGAM

Geophysics Research Group
School of Physics, Universiti Sains Malaysia, 11800 USM, Pulau Pinang
*Corresponding author email address: nurazwin@usm.my

Abstract: Resistivity method concerns with resistivity (in ohm.m) of soils/rocks in term of the ability to resist the flow of the electrical current. While the Time Domain Induced Polarization (TDIP) deals with chargeability (in ms) that indicates the strength of polarization effects experienced by ions in the vicinity of metallic grains in soil/rock. Both properties are affected by water content, lithology, pore fluid chemistry, geometrical configuration and have significant potential for hydrogeophysical exploration (Binley & Kemna, 2005). 2-D resistivity and Time Domain Induced Polarization was conducted with objective to assess and differentiate the subsurface features by electrical properties. Different subsurface features might have same ability to resist the current flow and therefore it may lead to wrong interpretation in distinguishing these features. Integration of 2D resistivity and TDIP successfully classified the shallow subsurface features based on their electrical properties; resist the current flow (resistivity) and strength of polarization effects in term of ability to hold charge (chargeability). Results show that highly conductive area (clay and water saturated zones) have low resistivity (<10 Ohm.m) which allow the current to flow through it. However, TDIP can differentiate these materials through their chargeability properties. Clay saturated area has higher chargeability (>10 ms) compared to water saturated area (<10 ms). Clay particles have higher conductance surface and minerals which help in the charging process of particle and thus the chargeability value will be high (Amaya *et al.,* 2016). Clay mineral has good porosity and can hold a lot of water but the pores between these fine grains are so small that water flows very slowly through them which indicates low permeability (Morris & Shepperd, 1982). As for course materials and boulder, both will give high resistivity (>3500 Ohm.m) due to their ability to resist the current flow. In this case, lower chargeability (<10 ms) is correspond to the presence of coarse material and high chargeability (>100 ms) is caused by the presence of boulder. Chargeability is affected by grain size of soils (Keller & Frishchknecht, 1966). Chargeability value is low when uniform particles size of sand and gravel (coarse material) present while for fine grains, the value is greater. The coarse grains materials have high porosity and high permeability. The water will stay in tiny spaces between grains of sand and gravel. Besides, fracture is also detected with low to intermediate resistivity (300-3500 Ohm.m) and low chargeability (1-10 ms) while alluvium gives both intermediate resistivity and chargeability (10-800 Ohm.m and 10-80 ms) respectively. Fracture has high porosity and high groundwater conductivity and thus reduce the chargeability value (Juanah *et al*., 2012). Volcanic tuff

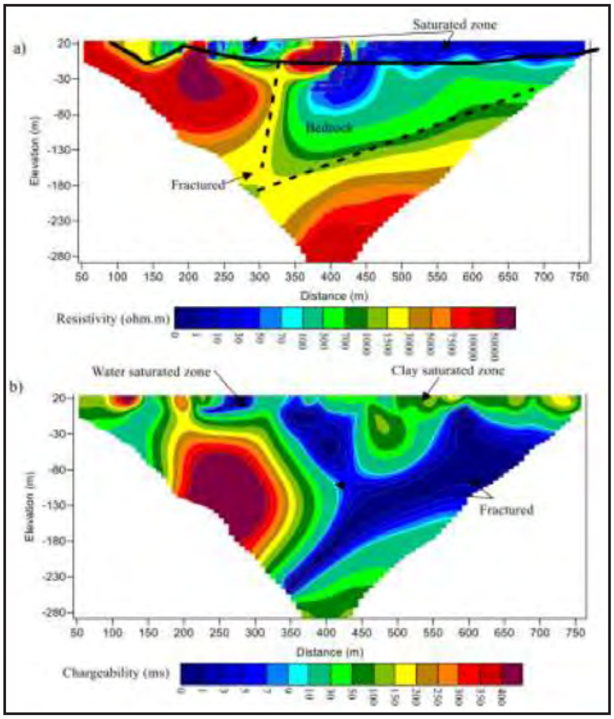

Figure 1: 2-D model inversion of a) resistivity and b) chargeability.

Table 1: Subsurface feature, resistivity, chargeability range and hydrological significance.

Subsurface features	Resistivity range (Ohm.m)	Chargeability range (ms)
Saturated clay	1-100	10-100
Saturated water	1-10	1-10
Alluvium	10-800	10-80
Volcanic tuff bedrock	>3500	30-200
Gravel	>3500	<10
Fracture	300-3500	1-10
Boulder	>3500	>100

bedrock is also identified with high resistivity (>3500 Ohm.m) and intermediate chargeability (30-200 ms). Figure 1 shows the 2-D model inversion for resistivity and chargeability and Table 1 shows the resistivity and chargeability values for subsurface features found.

Keywords: Resistivity, induced polarization, chargeability, clay, fracture

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Observations on comparative geological interpretation of two different resistivity surveys for the same landslide prone area

Afiq Farhan Abdul Rahim, Mohd Farid Mohd Dali, Mustapha Atta & Abd Rasid Jaapar

Geomapping Technology Sdn. Bhd., 907C, Diamond Complex, Bangi Business Park, Jalan Medan Bangi 43650 Bandar Baru Bangi, Selangor Darul Ehsan
Email address: info@geomappingtechnology.com

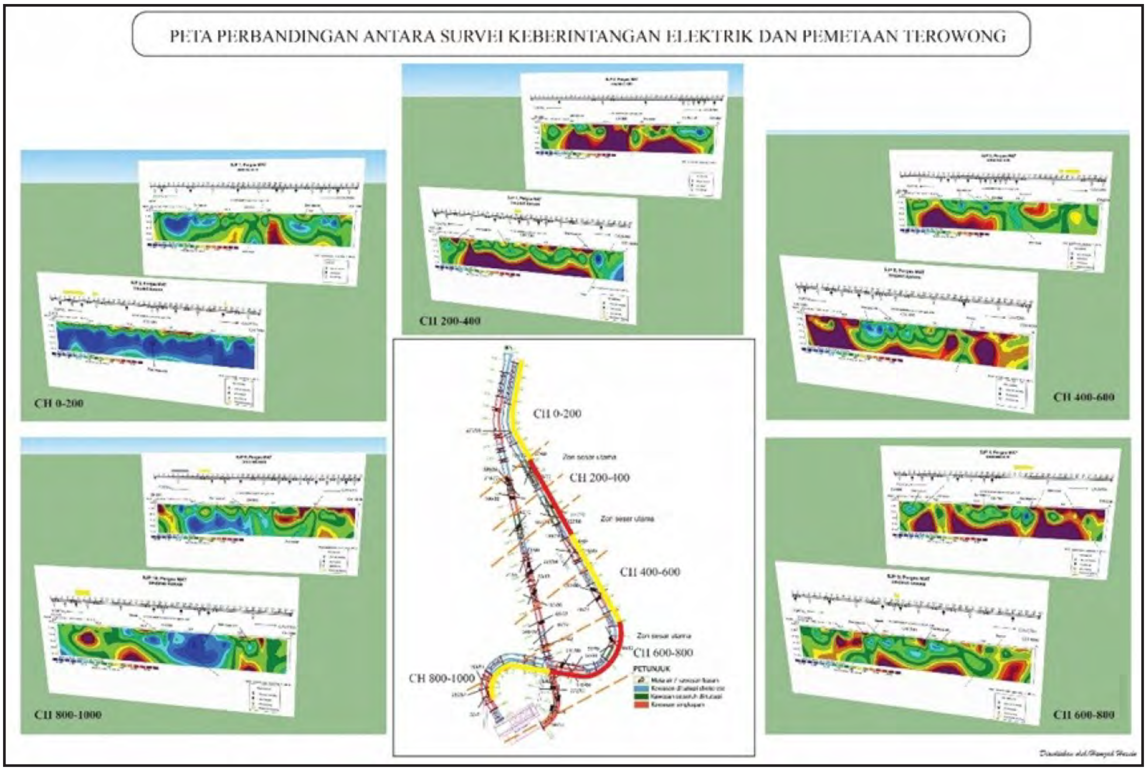
Abstract: All resistivity survey interpretation must be used with caution. When well done and supported by ground truth exercises they can be a valuable aid to site investigation, depending on quality of resistivity survey and the skill and the background of the interpreter. A situation has arisen where two interpretations on resistivity surveys of a landslide prone area were made by two different interpreters. This is used as an opportunity to illustrate the potential difficulty in obtaining a reliable interpretation. A case study of these two geophysical resistivity surveys done by different operators on a same location was examined. The area was a known potential geohazard zone, situated on a steep hillslope with a proposed excavation to make way for development. First resistivity survey (9 lines) was done in 2014 to complement the initial site investigation and utilized for infrastructure and excavation design purposes. No comment on geohazards and geological constraints were made in this report. However, upon excavation, multiple issues were stumbled upon on site including boulders, groundwater, and slope instabilities. This situation prompted the consultant to conduct comprehensive geological study in late 2017 including another resistivity survey (6 lines). The resulting pseudosections from second resistivity survey show multiple interpreted boulders and groundwater infiltrations akin to a colluvium deposit beneath the surface. Subsequent mapping and geological study confirms the findings, with paleo debris flow suspected responsible for the deposit based on topography. These new findings prompted new drawings and mitigation structures to be designed, further delaying the project. This study highlights the need for a proper geological approach in geophysical survey, as potential geohazards were overlooked in the first survey due to poor data analysis and presentation. Overlooked geohazards, in turn posed problems to the project itself, catching consultants and contractors off-guard, causing costly delays and structures re-design in later stages. Improved data presentation and interpretations were employed in the second survey, with proper geological approach, to assist the designers and engineers to better understand and mitigate potential geohazards.

Pencirian jasad batuan terlindung shotcrete menggunakan survei tomografi keberintangan geoelektrik

Hamzah Hussin[1, 2,*], Mohd Hariri Arifin[1], Tajul Anuar Jamaluddin[1] & Nadzari Ismail[3]

[1]Pusat Pengajian Sains Sekitaran , Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor
[2] Jabatan Geologi, Fakulti Sains Bumi, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan
[3]TNB Research Sdn. Bhd., No 1, Kawasan Institusi Penyelidikan, Jln Ayer Hitam, 43000 Kajang, Selangor
*Corresponding author email address: hamzah.h@umk.edu.my

Satu survei geofizik dilakukan di dalam sebuah terowong yang dilitupi oleh lapisan shotcrete untuk mencirikan jasad batuan yang berada disebaliknya. Sebanyak 10 garis survei telah dilakukan yang merangkumi lima garis untuk sebelah dinding. Setiap garis survei bersambung dari hujung ke hujung yang membolehkan satu profil keberintangan geoelektrik di dalam jasad batuan yang lengkap dapat dihasilkan. Panjang setiap garis survei ialah 200m. Secara umum, terowong yang dikaji merupakan sebuah terowong yang telah disokong dengan sistem penstabilan terowong seperti semburan shotcrete dan *rock bolt*. Semburan shotcrete menutup hampir 50% daripada keseluruhan terowong. Jasad batuan yang terdedah pula terdiri daripada jasad batuan granit yang segar atau sedikit terluluwa. Survei keberintagan elektrik dilakukan menggunakan beberapa peralatan mudah alih yang boleh di bawa ke lapangan. Set survei keberintangan menggunakan sistem ABEM SAS 4000 digunakan dalam kajian ini dan susunatur dwikutub-dwikutub telah digunakan dalam proses pengukuran data keberintagan bahan bumi. Dalam konfigurasi dwikutub-dwikutub, elektrod keupayaan disusun di luar elektrod arus dengan jarak antara elektrod CI dan C2 adalah sama dengan jarak antara PI dan P2. Data lapangan diproses menggunakan perisian Res2Dinv yang menggunakan kaedah pengiraan *2D finite element.* Tafsiran pada keratan rentas pseudo menunjukkan kehadiran tiga nilai keberintangan bahan yang berbeza iaitu berkeberintangan tinggi (> 1500 Ω.m), sederhana (100-500 Ω.m) dan rendah (< 25 Ω.m). Ketiga-tiga nilai ini ditafsirkan sebagai zon tepu air (berkerintangan rendah), jasad batuan terluluhawa (berkerintangan sedehana) dan batuan granit segar (berkerintangan tinggi). Perbandingan dengan pemetaan terowong menunjukkan zon tepu air merupakan kawasan resapan air berlaku ke dalam terowong, manakala nilai keberintangan serderhana selalunya berasosiasi dengan zon sesar.



Rajah 1: Perbandingan antara survei keberintangan geoelektrik dan pemetaan terowong.

PG-86

The effect of land reclamation on water clarity in Tanjung Tokong using remote sensing

NURULAMANI ROSMAN, AISAH ABDULLAH & ISMAIL AHMAD ABIR

School of Physics, Universiti Sains Malaysia

Field data (Secchi Disk Depth) of coastal water surrounding the reclaimed land located off the coast of Tanjung Tokong, Penang was taken on the same date as the overpass of Landsat 8 image on the 20th December 2017. Results from Secchi Disk readings show that, in general, the water clarity is worse near the reclaimed land when compared to protected areas, such as the National Park coastal area in northwest Penang. Furthermore, it was observed that Secchi depths become shallower to the northwest of the reclaimed land in comparison to the southern part. In order to estimate the Secchi Disk Depth using Landsat data, correlation between field data and satellite data was studied using linear regression approach. Correlation between ground data and atmospherically corrected satellite image for Band 5 (Near Infrared) was found to be the most robust with correlation coefficient close to one (R^2=0.7051). The selected linear regression model was then applied to estimate the Secchi Depth for the entire image and for archive Landsat 8 images of the study area. In addition, ocean bottom soil samples taken around the reclaimed land are of very fine and muddy nature, which was previously of a sandy nature; a healthy environment for crabs, molluscs and other organisms. Very fine sediments are in suspension in high energy environment resulting in lower water clarity and a decrease in light penetration. Although the degraded coastal water clarity of Tanjung Tokong suggests that the reclaimed land has an adverse effect on its water quality, important environmental factors, such as tides, waves and currents must be taken into account to fully understand their effects on coastal water clarity.

PG-87

Identifying geothermal potential sites in Jaboi Field, Sabang using satellite data

DWIKY POBRI CESARIAN[1], ISMAIL AHMAD ABIR[1] & MUHAMMAD ISA[2]

[1]School of Physics, Universiti Sains Malaysia, Penang, Malaysia
[2]Faculty of Mathematics and Science, Universitas Syiah Kuala, Banda Aceh, Indonesia

This study integrates various datasets to identify and map geothermal potential in Jaboi field, Sabang. Three datasets were used in this study: satellite imageries, geophysical resistivity data and ground temperature measurement. Landsat 8 and PALSAR DEM were used in this study. Land Surface Temperature (LST) and land cover were obtained from Landsat 8, while lineament and surface drainage were obtained from PALSAR DEM. Various information were overlaid on a single map and analyzed to observe features of interest i.e. LST, hot spring location, fault lines, lineaments and surface drainage. In addition, geophysical resistivity survey, VES 1-D method with Wenner array, was carried out with a total of 51 points scattered across the study area. The technique images resistivity values of different depth at one point, in this case at 250 m, 500 m, 750 m and 1000 m. Lastly, ground temperature measurement was acquired using needle probe temperature device with a total of 114 points distributed evenly around the survey area. The device is equipped with Arduino Uno as its microcontroller board and 5 pieces of temperature sensors mounted on a 2 meters iron rod. Additional information was used from geological map that was acquired from the Geological Research and Development Centre. All datasets were integrated mapping 4 areas which were considered to have geothermal potential. However, these areas vary in term of the clustering of the features of interest, such as high surface temperature, lineament and drainage density, fault existence, hot spring existence and the low resistivity subsurface. With all these criteria taken into consideration, ranking for potential area were made to decide which area has higher potential.

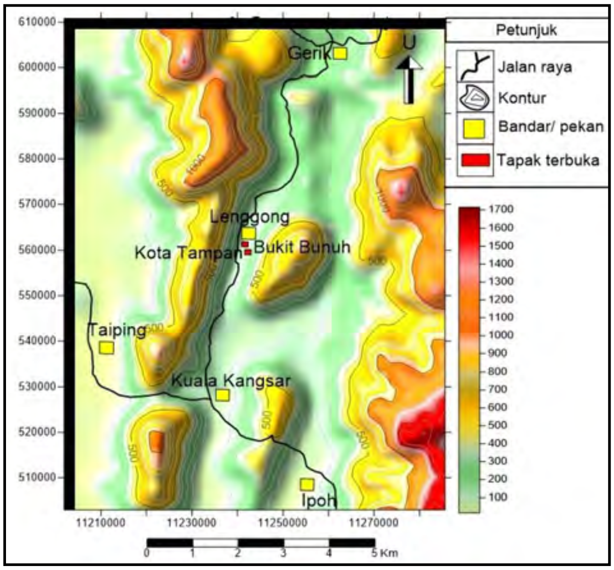
PGA-73

Eksperimen kesan guna: Fungsi alat repeh batuan impak Bukit Bunuh, Perak

SITI KHAIRANI ABD JALIL, JEFFREY ABDULLAH & MOKHTAR SAIDIN

Pusat Penyelidikan Arkeologi Global, Universiti Sains Malaysia, 11800 Minden, Pulau Pinang
Emel: sitikhairanijalil@gmail.com; jeff@usm.my; mmokh@usm.my

Abstrak: Pada Zaman Batu Lama atau dikenali juga sebagai Zaman Paleolitik, telah menjadikan repehan batuan sebagai alat yang digunakan untuk kerja-kerja ringan (Key & Lycett, 2015). Alat ini dikenali sebagai alat repeh. Sungguhpun demikian, fungsi sebenar alat tersebut tidak diketahui. Bentuk seumpama ini bukan hanya terdapat di Bukit Bunuh (Peta 1) tetapi di kesemua tapak Paleolitik di Asia Tenggara. Oleh kerana alat repehnya yang bersifat amorfus (Moore & Brumm, 2007; Marwick, 2008), maka kajian ini telah mengelaskan alat repeh kepada empat kumpulan utama berdasarkan bentuk morfologi mata tepinya iaitu alat repeh dengan morfologi cekung, cembung, lurus, dan tirus. Analisis ini cuba untuk mengaitkan morfologi atau bentuk mata tepi dengan fungsinya melalui kaedah eksperimen. Beberapa atribut kesan guna seperti jenis gilapan, jenis pecahan, jenis linear dan kebundaran adalah petunjuk penting untuk mengidentifikasikan fungsi sebenar alat repeh (Pedergnana & Olle, 2017; Lerner *et al*., 2007). Maka, hasil perbandingan antara atribut kesan guna yang terhasil pada eksperimen repehan (Jadual 1) dengan artifak alat repeh menunjukkan terdapat hubungan fungsi dengan morfologi mata tepi alat repehnya. Alat repeh ini telah dikenal pasti digunakan oleh masyarakat Paleolitik untuk aktiviti meraut, mengikis, menggergaji, menghiris dan menggerudi. Ini membuktikan alat repeh di Bukit Bunuh digunakan untuk pelbagai fungsi sesuai dengan cara hidup mereka yang bersifat nomadik. Maka hasil kajian ini secara umumnya telah berjaya mengetahui tentang klasifikasi dan fungsi alat repeh di Malaysia. Oleh itu, ia memberikan kefahaman tentang eksploitasi material batuan impak dan adaptasi persekitaran di Bukit Bunuh. Secara tidak langsung kajian alat repeh Bukit Bunuh ini telah memberikan data baru kepada data Paleolitik di Asia Tenggara.



Peta 1: Lokasi tapak terbuka Paleolitik Bukit Bunuh, Lenggong, Perak (*Sumber: Koleksi penulis*).

Penghargaan

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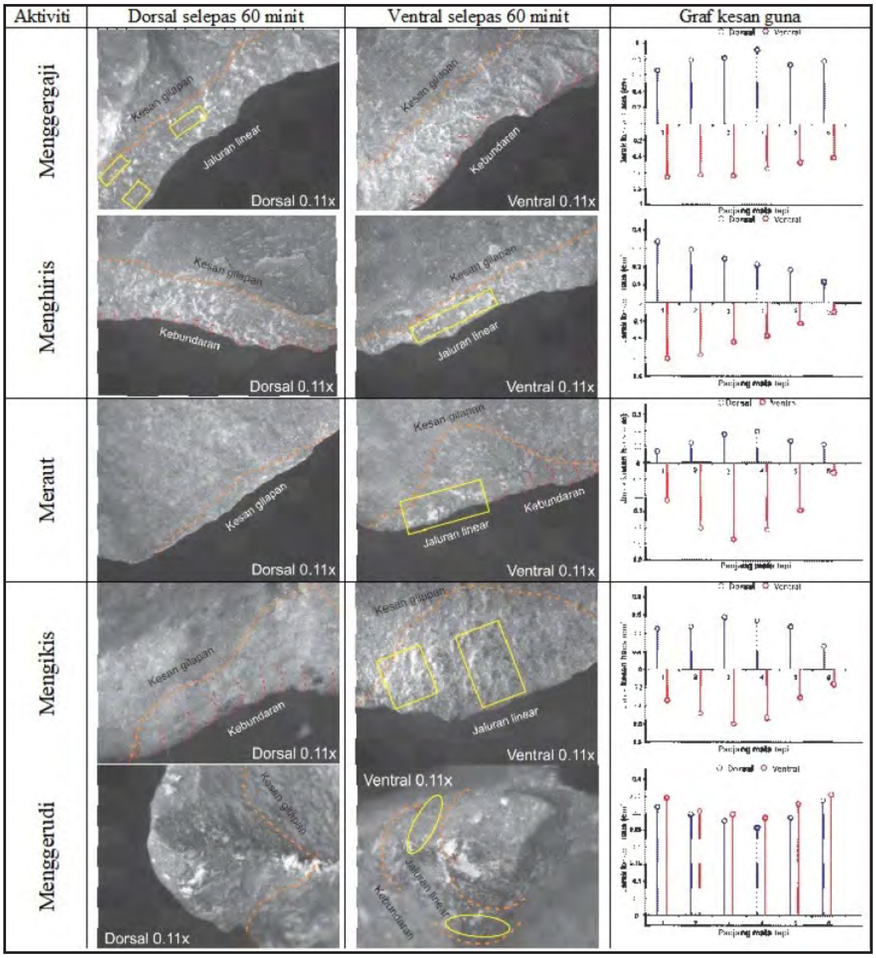

Jadual 1: Mata tepi repehan pada bahagian dorsal dan ventral selepas eksperimen serta graf kesan guna pada mata tepi repehan batuan impak (kuarzit) *(Sumber: Koleksi penulis)*.

PGA-75

Mineralogical analysis to identify ancient furnace structure in Jeniang, Kedah

NORHIDAYAHTI MOHD. MUZTAZA, MOKHTAR SAIDIN & HAMZAH MOHAMAD

Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800, Minden, Pulau Pinang
Email address: mhidayahti@driveattic.com; mmokh@usm.my; hbm@usm.my

Abstract: Jeniang is situated at the northen of Kedah, about 45 kilometres from the Sungai Batu Complex. The first site was discovered in 1990 but without a proper archeological research procedure. Until present, there are 10 ancient iron working sites that had been discovered in Jeniang, approximately 3.2 km^2, all located within the vicinity of Muda River. Excavations conducted by the Centre for Global Archeological Research, Universiti Sains Malaysia since 2010 have unearthed three sites which are in Kampung Gading (KG'10), Kampung Chemara (KC'10) and Kampung Sungai Perahu (KSP'12) (Figures 1, 2 and 3). Radiocarbon dating shows that the iron smelting activities were carried around the 1st BC until 13th CE.

Since the excavation at the furnace sites in Jeniang did not find any significant findings that relate with the function of iron smelting furnace (iron slags, iron ores etc.), mineralogical analysis using X-ray fluorescence (XRF) and X-ray diffraction (XRD) has been conducted in order to acquire the information of mineralogical changes as a result from the burning temperature on the furnace's wall.

Based from the mineralogical analysis on the chosen samples of the furnace's wall, information about the raw source of furnace construction is acquired (Figure 4). The presence of certain minerals also gives important information about the firing temperature that was operate during the firing activity using the furnace.

The presence of quartz (SiO_2) as the dominant mineral in almost every samples shows that sand is the main element of the furnace construction. The presence of Al_2O_3 shows the usage of clay mineral (montmorillonite, kaolinite and alophane).

The combination of these elements are widely used in many refractory products (such as ceramic) that are made of oxide which can withstand with high temperature - Silica Oxide (SiO_2), Aluminium Oxide (Al_2O_3) and Magnesium Oxide (MgO).

Based from the mineralogical changes from the outer furnace wall to the inner furnace wall, it clearly shows the influence of a higher temperature to the furnace that formed high phase minerals. This can be use as a reference to determine the furnace function. The presence of high phase minerals (mullite and cristobalite) in the sample analysed using XRD method show that the temperature during the firing operation of the furnace reached more than 1470°C (Figure 5 and 6).

Acknowledgement

The authors wish to express gratitude to USM Centre for Global Archaeological Research (CGAR) for the support in this research.

Figure 1: Site KG'10 in Kampung Gading.

Figure 2: Site KC'10 in Kampung Chemara.

Figure 3: Site KSP'12 in Kampung Sungai Perahu.

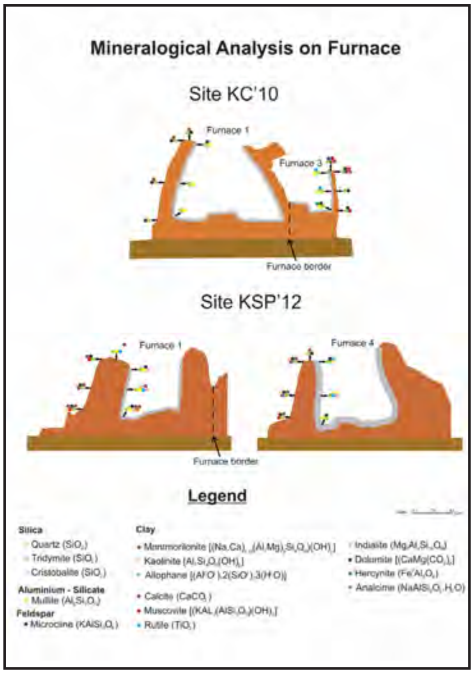

Figure 4: Furnace cross section and the presence of minerals from XRD analysis.

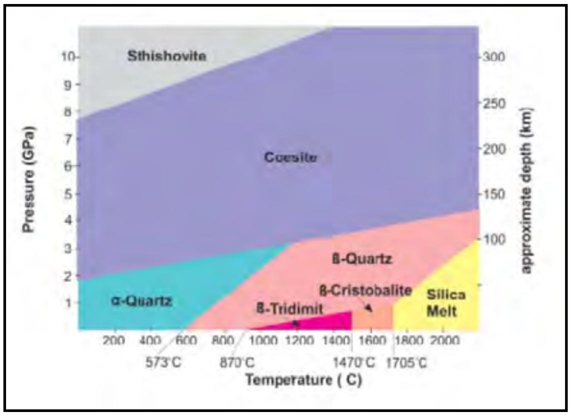

Figure 5: Phase diagram of SiO_2. Cristobalit formed at 1470°C until it reached its melting point temperature at 1713°C (after Wenk & Bulakh, 2003).

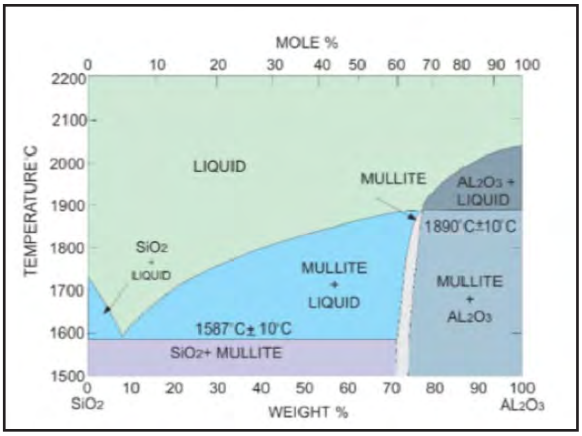

Figure 6: Phase diagram for the alumina-silica system. Mullite presence at the temperature between 1500°C followed by SiO_2 (formed as cristobalite in a solid state) (after Shackelford & Doremus, 2008).

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PGA-76

Perbandingan terhadap batu nisan khas Barus dan batu nisan Plak-Pling: Berdasarkan analisis motif ragam hias

WANI MALER[1], SUPRAYITNO[2] & MOKHTAR SAIDIN[3]

[1] Centre for Global Archaeological Research, Universiti Sains Malaysia
[2] Department of History, Faculty of Cultural Science, University of Sumatera Utara
[3] Centre For Global Archeological Research, Universiti Sains Malaysia
Email address: [1]wanimaler@yahoo.com; [2]nisanaceh@gmail.com; [3]mmokh@usm.my

Pengenalan

Adapun yang menjadi persoalan dalam penelitian ini ialah terdapatnya kesamaan bentuk ragam hias ornament yang terdapat pada nisan khas Barus dengan nisan Plak Pling dari Aceh. Penelitian ini bertujuan untuk mendiskripsikan ragam hias yang terdapat di kedua nisan tersebut dan mencari apakah terdapat koneksi di antara dua tipe nisan yang berbeda daerah ini. Lokasi penelitian di Barus, Kabupaten Tapanuli Tengah, Sumatera Utara. Sumber data penelitian diperoleh dari hasil survey dan mapping lapangan. Hasil dari penelitian ini ialah dijumpainya banyak batu nisan yang tersebar di kawasan Bukit Hasang, Barus. Dari banyaknya dijumpai taburan batu nisan, terdapat satu buah batu yang merupakan batu nisan khas Barus. Hiasan ornament yang terukir di batu ini memiliki kesamaan motif dengan nisan Plak-Pling yang terdapat di Aceh. Dari penyelidikan ini terdapat sebuah indikasi jika kesamaan ornament di ambil dari motif-motif tradisional yang terdapat dalam kesenian Nusantara. Motif yang terukir dalam batu nisan plak-pling merupakan motif *bugong awan si tangke* dan *Bungong Glimo.* Sedangkan ukiran yang terdapat pada nisan khas Barus hanyalah motif *bugong awan si tangke* yang menjadi ukiran utama dan terletak pada bagian atas. Kemungkinan terdapat hubungan di antara kedua nisan ini, karena menggunakan motif yang sama. Di mana penemuan nisan khas Barus yang satu ini sangat jarang dijumpai hampir di Nusantara.

Penghargaan

Ribuan terima kasih diucapkan kepada Naib Canselor Prof. Datuk Dr. Asma Ismail kerana memberikan kepercayaan yang tinggi untuk menjayakan kajian ini. Penyelidikan ini juga tidak akan dapat dilakukan tanpa adanya dana daripada geran Projek Arkeologi Malaysia dan Global (1001/PARKEO/870015). Ucapan terima kasih juga diucapkan kepada tim survey dan mapping (USU-USM), serta warga staf Pusat Penyelidikan Arkeologi Global USM atas segala jasa, tunjuk ajar dan tenaga yang dicurahkan sepanjang kajian dilakukan.

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Mineralogical evidence from Bukit Bunuh impact crater and its contribution to prehistoric lithic raw materials

NURAZLIN ABDULLAH, NOR KHAIRUNNISA TALIB & MOKHTAR SAIDIN

Centre for Global Archaeological Research, Universiti Sains Malaysia, 11800 Pulau Pinang
Email address: nurazlin.abdullah@gmail.com; norkhairunnisa27@gmail.com; mmokh@usm.my

Abstract: Centre for Global Archaeological Research (CGAR), USM had conducted geoarchaeology research at Bukit Bunuh Lenggong since 2008, proven the site is *in-situ* Paleolithic and meteorite impact crater site. Recent studies and research in geology and geophysics also has proven that Bukit Bunuh is a meteorite impact crater. The evolution of archaeological studies in Lenggong Valley had made it being listed as one of the UNESCO world heritages sites on 30 July 2012 through its chronology and importance to the country and world. The evidence of hand axe embedded in the suevite with the dating 1.83 million years shows a clear connection between evidence of archaeology and geology at Bukit Bunuh. The Paleolithic humans at Bukit Bunuh have chosen different raw materials to be used as stone tools and their equipment (Table 1). Most of the stone stools were selected from cherty metasediment and quartzite as their raw materials. Some of the stone tools were made from suevite and quartz. The Planetary and Space Science Center (PASSC), based in University New Brunswick, Canada, has listed six criteria for proving an area to be recognized as a meteorite impact area. One of the criteria is the presence of high pressure mineral polymorphs within *in situ* lithologies. This mineralogical research was focused to identify high pressure minerals. Samples taken in this research was heavy minerals. The samples were collected by using panning method and covering the Bukit Bunuh, Lenggong and its vicinity. Sampling was done in three phases and 61 samples were analyzed using XRD. As a result, the analysis indicates the presence of high pressure mineral polymorphs in the samples from Bukit Bunuh and surrounding such as stishovite, coesite, akimotoite, ringwoodite, reidite and wadsleyite. Due to these privileges, this may be the main reason for the edge of the stone tools, especially the flake tools and chunk tool mostly have edge that not been retouch. In addition, with the identified of these minerals has proven that rocks at Bukit Bunuh were good raw materials with strength and durability compared to the other types of rocks. Interpretation of lithic industry technology in Bukit Bunuh revealed persistent manufacturing technology that expeditiously and productively in accordance with its raw.

Acknowledgements

A special thank you to Professor Datuk Dr. Asma Ismail. This research was supported by Universiti Sains Malaysia through Grant Arkeologi Bukit Bunuh (1002/PARKEO/910328) and Grant Arkeologi Malaysia & Global (1001/PARKEO/870015). We also would like to thank Malaysia National Heritage for giving us permission to do the research at Lenggong Valley and Centre for Global Archaeological Research for the helping hands.

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Table 1: Statistic of Bukit Bunuh raw materials.

Raw Materials	Anvil	Core	Hammerstone	Flake tools	Pebble tools	Chunk tools
Quartz	2	229	37	21	9	133
Suevite	28	105	37	76	6	64
Quarzite	1	72	27	298	12	134
Cherty Metasediment	0	139	9	447	10	215

PGA-91

Kapak genggam Bukit Bunuh, Lenggong, Perak: Isu dan perdebatan teori Movius Line di Asia Tenggara

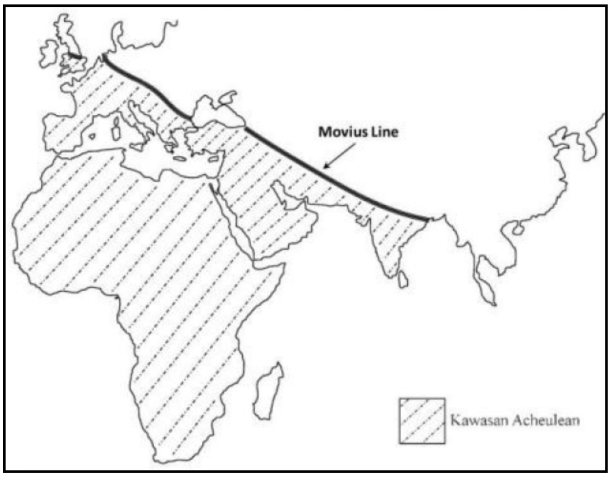
NORIDAYU BAKRY, JEFFREY ABDULLAH, MOKHTAR SAIDIN & SHYEH SAHIBUL KARAMAH BIN MASNAN

Pusat Penyelidikan Arkeologi Global
Universiti Sains Malaysia, 11800 USM, Pulau Pinang
Alamat emel: noridayubakry@gmail.com; jeff@usm.my; mmokh@usm.my; shyehsahibul@usm.my

Abstrak: Pada tahun 2001, Tapak Arkeologi Bukit Bunuh, Lenggong, Perak telah mencatatkan penemuan alat kapak genggam yang memberikan impak besar bukan sahaja kepada data paleolitik di Lembah Lenggong, malah kepada data paleolitik Asia Tenggara. Hal ini kerana penemuan ini nyata bercanggah dengan teori "*Movius Line*" 1948 (Rajah 1) yang mencadangkan pembahagian kawasan yang mempunyai teknologi alat batu yang maju yakni menghasilkan alat kapak gengam dan kawasan yang sebaliknya. Movius merumuskan bahawa Kawasan Asia Timur dan Asia Tenggara tidak menghasilkan alat kapak genggam tetapi hanya dicirikan oleh alat penetak dan repehan sahaja (sebelum ini dikenali sebagai alat tetak-menetak). Malah Alat litik yang dihasilkan di kedua-dua kawasan ini dicirikan sebagai "membosankan dan tidak imiginatif".

Kedudukan garis movius yang dicadangkan adalah bermula dari tenggara ke barat laut dari Teluk Bengal Barat Delta Ganges-Brahmaputra ke hujung Utara Himalaya. Oleh hal tersebut, Kawasan yang menghasilkan alat kapak genggam adalah terdiri daripada sebahagian besar kawasan di benua Eropah dan Afrika. Di Benua Asia pula hanya melibatkan kawasan yang kecil iaitu meliputi kawasan Asia Barat dan Asia Selatan.

Walau bagaimanapun, seiring dengan perkembangan kajian litik serta penemuan-penemuan baru di Asia Tenggara dan Asia Timur, terdapat pengkaji bersetuju bahawa kedua-dua kawasan ini turut menghasilkan alat kapak genggam. Namun terdapat juga pengkaji yang menyangkal dakwaan ini dengan mengemukan pelbagai faktor termasuk morfologi kapak genggam yang ditemui di Kawasan ini. Oleh hal sedemikian penemuan kapak genggam di Asia Tenggara telah menjadi isu dan perdebatan penting samada alat kapak genggam yang ditemui di rantau ini adalah sama atau tidak dengan kapak genggam di kawasan-kawasan lain dunia.



Rajah 1: Garis Movius Line (Selepas Lycett & Bae, 2010).

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Ribuan terima kasih diucapkan kepada Naib Canselor Datuk Prof. Dr. Asma Ismail. Penyelidikan ini juga tidak akan dapat dilakukan tanpa adanya dana daripada geran Projek Teknologi Litik di Zaman Paleolitik di Malaysia (1001/PARKEO/870013), geran Penyelidikan Arkeologi Malaysia Dan Global (1001/PARKEO/270015) geran Kajian Arkeologi Utara Sabah: Eksplorasi Bukti Manusia Awal (203/PARKEO/6730139) serta geran Kajian Bukti Laluan Moigrasi Zaman Paleolitik di Timur Sabah, Sabah (1001/PARKEO/8016020). Ucapan terima kasih juga diucapkan rakan-rakan seperjuangan dan warga staf Pusat Penyelidikan Arkeologi Global USM atas segala jasa, tunjuk ajar dan tenaga yang dicurahkan sepanjang kajian dilakukan.

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PGA-100

Sungai Batu as a geosite in Jerai Geopark and its contribution to the geoarchaeo-tourism industry in Malaysia

Siti Nurul Siha Mohamad, Mokhtar Saidin & Goh Hsio Mei

Pusat Penyelidikan Arkeologi Global, Universiti Sains Malaysia 11800 USM Pulau Pinang
Email address: nurulsihamohamad@gmail.com; mmokh@usm.my; hmgoh@usm.my

Abstract: Archaeological excavation at the Sungai Batu Site by the Centre for Global Archaeological Research (CGAR), USM, since 2009, revealed evidence of the oldest civilization site in Southeast Asia, began at 6th Century BC. The evidences are classified into three type of monuments and iron smelting workshop. The monuments are ritual site, river jetty and port administrative building. All the monuments are made from bricks. All these shows that since 6^{th} Century BC, there are "geologists" among the Sungai Batu population who knows where is the source for quality clays to make bricks and to mine the iron raw material. Besides that, the population also shows their right choice of the area for civilization. Sungai Batu is located 30 km southeast of Gunung Jerai. The geological evolution of Gunung Jerai allowed the suitable landscape for the civilization. The formations, rocks, minerals, and also the mangrove trees are great resources for the people to have clays and iron oxide for their building and industry. Therefore, Sungai Batu civilization evidence was chosen as one of geosite in Jerai Geopark. It presents the geoarchaeological concept where culture evidence was interpreted as part of a geological process.

Keywords: Sungai Batu, Jerai Geopark, geoarchaeo-tourism

PGA-101

XRD, XRF and SEM analysis of pottery from jetty and administrative sites, Sungai Batu Complex, Bujang Valley, Kedah

Mohd Hasfarisham Abd Halim & Mokhtar Saidin

Pusat Penyelidikan Arkeologi Global, Universiti Sains Malaysia 11800 USM Pulau Pinang
Email address: dustur_almuslimin1986@yahoo.com; mmokh@usm.my

Abstract: Archaeological excavation at Sungai Batu Complex exposed iron smelting workshop and monument sites. Both of the older monuments and iron smelting workshop dated at 6^{th} Century BC. The monument sites functioned as a ritual, river jetty or dock and the administrative buildings for the dock. One of the important artifacts found during the river jetty and administrative buildings excavation is the potsherds. This paper will discuss the analysis on the 15 potsherds and 17 clay samples to answer the origins of the raw material used. The composition of potsherds and the clays was studied by using XRD, XRF and SEM at the Center for Global Archaeological Research, USM. The results of the analysis showed all the potsherds were made from local clay. Therefore, this shows that the population at Sungai Batu Complex during this early civilization period knew the location and the quality of raw materials for pottery making.

Keywords: Sungai Batu Complex, early civilization, pottery, clay

PPG-14

Tertiary palynomorph from the Lambir Formation (Middle – Late Miocene), north Sarawak, Malaysia

MAZSHURRAIEZAL NASIR[1], ABDUL HADI ABD RAHMAN[1], ZAINEY KONJING[2] & M AZFAR MOHAMED[3]

[1]Department of Petroleum Geosciences, Universiti Technologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak Darul Ridzuan
[2] Orogenic Resources Sdn Bhd, Kawasan Perindustrian Tekali, Sungai Tekali, 43100 Ulu Langat, Selangor
[3]Department of Petroleum Engineering, Universiti Technologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak Darul Ridzuan
Email address: rizal_geo@ymail.com; hadi_rahman@utp.edu.my; zainey@orogenicgroup.com, azfar.mohamed@utp.edu.my

Introduction

The Middle - Late Miocene Lambir Formation is extensively exposed along the road from Bekenu to Miri near the Bukit Lambir National Park. This formation is characterized by a succession of interbedded sandstone and mudstone, passing into heterolithic interval in several exposures. Palynological analysis was carried out on the exposed Lambir Formation outcrops around Bukit Lambir National Park. There are eighteen (18) samples were subjected for palynological analysis. These samples were collected from two different outcrop locations mostly from the mudstone facies with few samples from sandstone facies. Most of the samples yielded moderately to well-preserved palynomorphs with at least 100 palynomorphs taxa were identified. In general, mangrove species are dominant in all samples dominated by *Zonocostites ramonae*. This followed by *Florschuetzia* group pollen represented by *Florschuetzia meridionalis*, *Florschuetzia levipoli* and *Florschuetzia trilobata*. The *Zonocostites ramonae* tends to present in great number especially in mudstone samples and overwhelming the pollen count. Other mangrove species present in the samples include *Acrostichum aureum*, *Excoecaria aggulocha*, *Spinizinicolpites echinatus*, *Avicennia* type and *Oncosperma* type. In addition, other palynomorphs sources are derived from peat swamp and riparian vegetation including montane, coastal and seasonal pollen component.

However, their occurrences are scarce. Some of dominant species which is originated from peat swamp vegetation includes *Palaquium* sp., *Dactylocladus* sp., *Blumeodendron* sp., *Stemonurus* sp., *Calophyllum* sp., *Cyrthostachys* sp., *Pandanus* sp., *Eugenia* sp., *Ilex* sp., and *Elaeocarpus* sp. Some taxa of open marine dinoflagellate cysts were also recorded represented by *Operculodinium* sp., *Lingulodinium* sp., and *Spiniferites* sp. The acme of mangrove palynomorphs which is dominated by *Zonocostites ramonae* including high proportion back mangrove pollen suggests a former mangrove belt was developed and associated with back mangrove swamps within coastal areas. This event probably associated with transgression phase or relative sea level rise. The presence of F. *trilobata, F. levipoli* and *F. meridionalis* are very significant at least in providing relative age for the Lambir Formation in particular. The occurrence of

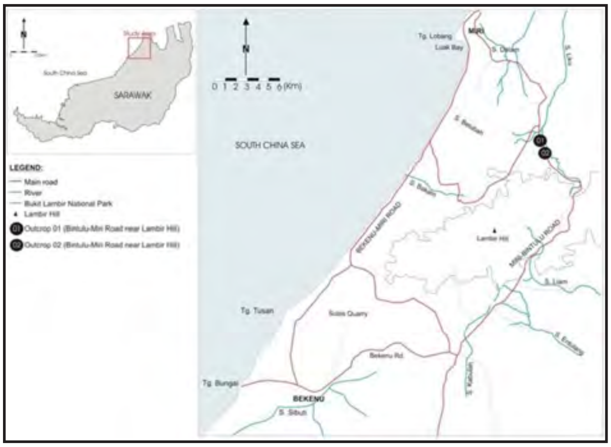

Figure 1: Outcrops location within the study area, northern Sarawak. Modified from Nagarajan *et al.* (2017).

Figure 2: Selected palynomorph from the study area. A. *Proxapertites* sp., B. *Florschuetzia levipoli,* C. *Dicolpopolis* sp., D. *Palaquium* type, E. *Cephalomappa* type, F-G. *Zonocostitres ramonae,* H. *Eugenia* type, I. *Campnosperma* type, J. *Casuarina* type.

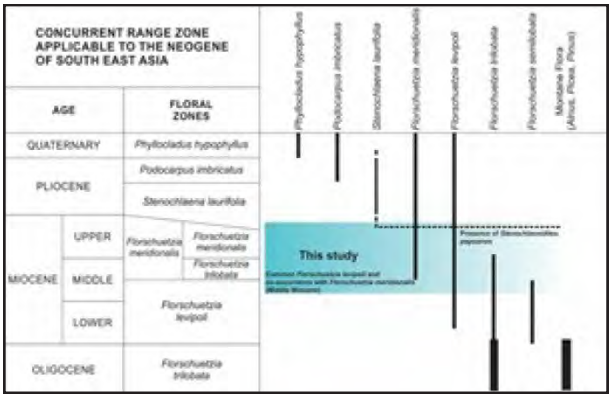

Figure 3: Palynostratigraphy of the study area based the concurrent zone of palynomorph. Modified from Morley (1978).

palynomorphs from the study area is compared to the palynological zonation published by Germeraad *et al*. (1968) and Morley (1978) which was developed for South East Asia region. The comparison results show the samples can be assigned into Middle Miocene-Late Miocene palynostratigraphic zones.

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Seismic reservoir characterization in a VTI anisotropic media: Case study in Malay Basin

AMIR ABBAS BABASAFARI, DEVA PRASAD GHOSH, SEYED YASER MOUSSAVI ALASHLOO, YASIR BASHIR, CHICA SAMBO & AHMED M.A. SALIM

Centre of Excellence in Subsurface Seismic Imaging & Hydrocarbon Prediction (CSI)
Faculty of Geoscience Department, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Malaysia
Email address: a.babasafari@yahoo.com; drdeva@utp.edu.my; syaser.moussavi@utp.edu.my; yasir.bashir@utp.edu.my; chico.sambo@utp.edu.my; mohamed.salim@utp.edu.my

Introduction

In spite of more than fifty years of observations in laboratory experiments, it is only in the past two decades that the Geophysicists and Geoscientists tried to use anisotropic correction on seismic data from academic and industry. Previously anisotropy was considered as noise which needs to be removed from the reservoir. Recent research has changed.

The Earth is not isotropic. It is assumed due to the complexity of the anisotropy in equations. Sedimentary rocks are anisotropic. Velocity anisotropy is the variation of this property on measurement directional. There are two type of anisotropy: intrinsic and induced. The intrinsic anisotropy is the result of dominant orientation of the sediment grains and pores that can be created by sediment composition, grain size, shape, orientation and compaction. Intrinsic anisotropy in sedimentary rocks is normally in the form of transverse isotropy. Most shale is intrinsically transversely isotropic. The induced anisotropy is created by the strain along with applied stress, fractures and mainly diagenesis. Moreover a non-uniform stress also has effect on changing an isotropic reservoir to anisotropic reservoir. In clastic sediments, anisotropy can arise during and after deposition. In carbonates, anisotropy is controlled mostly by fractures and diagenetic processes, and so tends to arise after deposition.

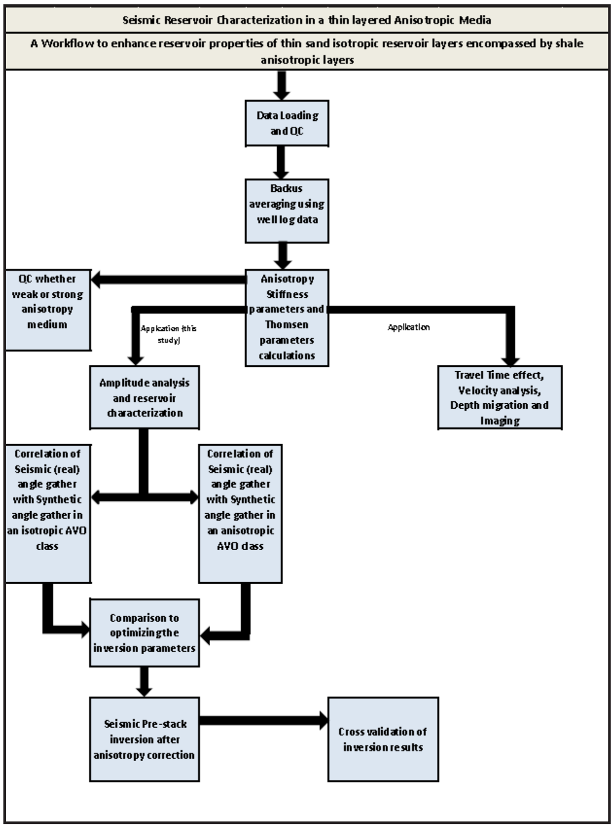

Figure 1: Work flow for anisotropy analysis.

Anisotropy is then one of the few indicators of variations in rock that can be studied with wavelengths longer than the scale of the variations.

Transverse isotropy is isotropy in the horizontal or vertical plane. There are different types of classification for anisotropy mediums in the real world just based on axis of the symmetry. Transverse isotropy with vertical axis of symmetry, with tilted axis of symmetry, with horizontal axis of symmetry and Orthorhombic are among the most predominant ones. There are also Monoclinic and Triclinic mediums which are more complicated to find the anisotropy parameters.

AVO (Amplitude Variation with Offset) analysis, as conventionally utilized nowadays, first time was applied by Ostrander (1982). Since then, AVO analysis has been accepted as an important exploration tool, and a large number of publications have been written on the many theoretical and practical aspects of the methods. Conventional AVO analysis requires to be corrected if anisotropy is present on either side of the reflection boundary. The inherent anisotropy of shales should be considered, both for structural imaging of subsurface features and for more advanced techniques such as amplitude variation with offset (AVO) analysis of hydrocarbon reservoirs. If a desired AVO signature is encountered, it needs to be known how much is due to hydrocarbon and how much is due to anisotropy.

Discussions and conclusions

Following work flow in Figure 1 displays the methodology used in this study. First using Backus averaging and Berryman equations, stiffness parameters together with Thomsen parameters at well locations are

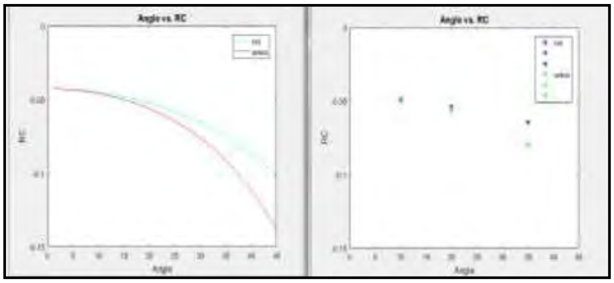

Figure 2: Amplitude variation with angle at reservoir interval for synthetic seismic gather (left) and real seismic gather (right).

calculated. Using Ruger relationship allows generating anisotropic reflection coefficients. Once amplitude changes computed, first isotropic and anisotropic synthetic gather are compared. Subsequently isotropic real seismic gather is generated.

Finally, seismic pre-stack inversion is performed to evaluate results after anisotropic term reduction.

The result demonstrates amplitude variation with angle has been changed if anisotropic term is deducted at reservoir interval (Figure 2).

Acknowledgements

We would like to express our gratitude to CSI/UTP for valuable resources and also Petroliam Nasional Berhad (PETRONAS) for providing the necessary information and data for this study.

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PPG-46

The effect of shale content to reservoir properties using Synthetic Core Plug Analysis

Nur Khalisa Binti Abdul Hamid[1], Numair Ahmed Siddiqui[1,2] & Asif Zameer[1]

[1] Institute of Hydrocarbon Recovery, Universiti Teknologi PETRONAS, Perak Malaysia
[2] Department of Petroleum Geosciencs, Universiti Teknologi PETROANS, Perak, Malaysia
Email address: khalisahamid@gmail.com; numair.siddiqui@utp.edu.my

Abstract: The quality of a reservoir is determined by its hydrocarbon storage capacity and deliverability. Hydrocarbon storage capacity depends on the effective porosity, whereas the deliverability is a function of permeability. Thus, this research project will analyze how different degree of shale content in sandstone will affect the porosity and permeability in order to understand reservoir behavior. The selected area to represent the shale and sandstone core plug samples is in Batu Gajah formation which is part of the Kinta Valley and is rich in sandstone, mudstone and shale. In this research, different approaches like, X-Ray Diffraction (XRD) analysis, Surface Area Analyzer and Porosimetry System (SAP), Poroperm Test and TinyPerm II Test are adopted to describe how shale contamination effect the reservoir properties. Results obtained from different approaches are used to predict the reservoir behavior. These experiments indicate that higher degree of shale present in a sandstone reservoir will reduce the interconnected porosity between the grains thus, decreasing the permeability as well. This is because the fine shale particles will occlude most of the available pore space.

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PPG-49

Facies and stratigraphic architecture of fluvial to tidal transition in a mixed tide- wave-influenced estuarine deposits; an example from Nyalau Formation, Central Sarawak, Malaysia

Zainey Konjing[1,2] & Abdul Hadi Abd Rahman[1]

[1]Department of Geoscience & Petroleum Engineering, Universiti Teknologi PETRONAS
[2]Orogenic Resources Sdn Bhd, Shah Alam, Selangor
Email addresses: zainey_g03671@utp.edu.my; zainey_geo@yahoo.com

Abstract: Facies models for transgressive mixed-energy estuarine deposits are under-reported in the Sarawak Neogene basin. Hence, facies and stratigraphic architecture of fluvial to tidal in a mixed tide- wave - influenced estuarine complex of the Nyalau Formation is presented here which was developed in the Sarawak basin during the Late Oligocene-Early Miocene. This study provides detailed facies and stratigraphic analysis based on outcrop sections which focuses on the southern to middle part of outcrop belt of the Nyalau Formation specifically Bintulu and surrounding areas (Figure 1). In general, the rock successions in these areas were mapped as Neogene rocks, predominantly arenaceous, argillaceous, coal and calcareous beds (Figure 2). Five facies association are recognized (Table 1). Tidal flat facies association (FA1) deposited in tide-influenced environment which is gradationally overlain by mangrove facies association (FA2). Mangrove facies association (FA2) deposited within muddy coastline that overwhelmed by mangrove complex and pass laterally landward into coastal peat swamp environment. Facies association mangrove (FA 2) commonly overlain by tide-influenced fluvial channel (FA3). Tide-influenced fluvial channel facies association (FA3) deposited within coastal lowland plain under mixed fluvial-tide influenced which may form a complex of bayhead delta, avulsion channel and tidal creeks. Interdistributary/estuarine bay facies association (FA4) commonly overlies tide-influenced fluvial channel. Middle-lower shoreface facies association (FA5) deposited in a wave-dominated shallow marine setting. Paleocurrent directions obtained from cross-bedded sandstones show bidirectional currents direction with dominantly north-southwest trending indicates ebb-directed channel forms with subordinate flood-directed. When the areas of lower coastal plain are punctuated by marine inundation including abandonment of distributaries and river channel, they relatively become estuaries and receive sediments from both marine and fluvial sources (e.g., Dalrymple *et al*., 1992; Dalrymple & Choi, 2007). However, areas of coastal may not entirely experience regional marine inundation due to topographic elevation that exceeds the rate of relative sea level rise and also active sediment progradation from landward. The areas that have not filled by deltaic progradation may form localize and narrow coastal embayment and/or estuary that favor development of fine-grained clastic strata. Though, various sandstone

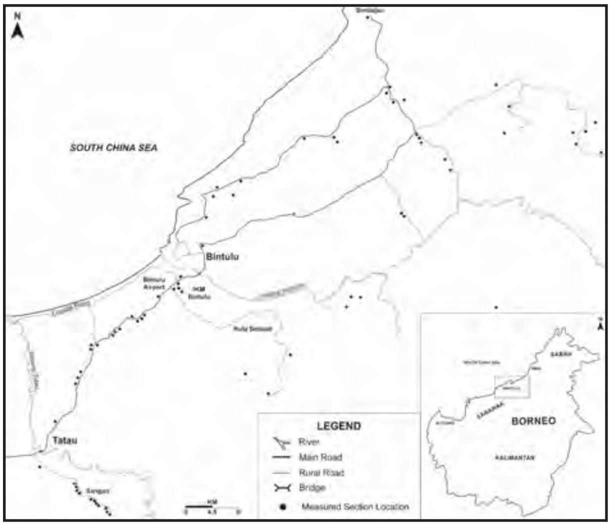

Figure 1: Map of the study area showing the location of stratigraphic logs.

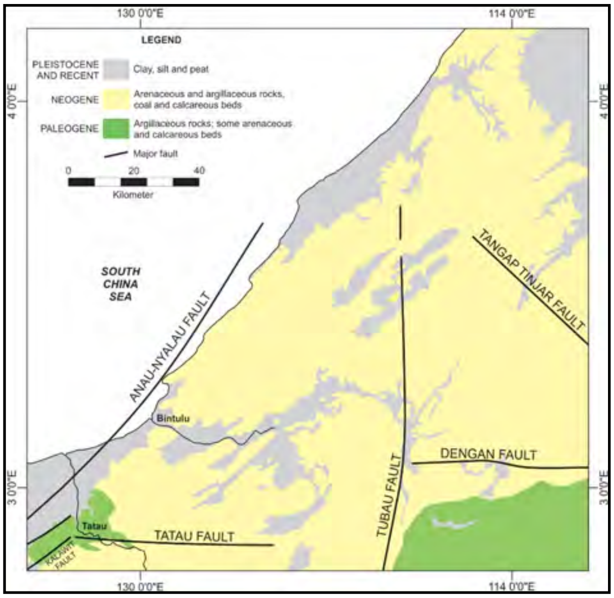

Figure 2: Figure showing distribution of Neogene rocks within Bintulu and adjacent areas.

Table 1: Summary of facies association.

Code	FA Name	Lithology	Primary sedimentary structure	structures	Geometry	Dimension	Interpretation
FA1	Tidal flat facies association	Moderate to fine grained sandstone, silty mudstone, mudstone and heterolithic beds	Lenticular, wavy, flaser bedding, ripple cross lamination (wave and current ripples). Bidirectional paleocurrent directions, small scale cross bedding	BI = 0 to 3 *Planolites, Paleophycus, Ophiomorpha, Rosselia, Chondrites, Terebellina, Skolithos*	Tabular	5 to 10 m thick	Tidal flat ranging from sand flat, mixed flat and mud flat.
FA2	Mangrove facies association	Mudstone, Silty mudstone, abundance of organic material, crushed plant fragments	Mottled, blocky and look massive with sparse lamination	BI = 0 to 2 Traces of *Skolithos and Thalassinoides*	Lenticular	2 to 5 m thick	Coastal mud flat overwhelmed by mangrove and shallow coastal peat swamp. Abundance of organic debris suggests a proximity to landward and terrestrial sources.
FA3	Tide-influenced fluvial channel facies association	Medium-coarse grained sandstone	Medium to large-scale trough cross bedding, parallel lamination, herring bone cross stratification, erosive scour-based sandstone, flaser, wavy ripple cross lamination	BI = 0 to 1 *Paleophycus*	Tabular to lenticular	1 to 5 m thick	Tide-influenced fluvial channel complex, deposited in landward direction probably near to the tidal limited zone (e.g., Dalrymple et al., 1992). This may correspond to tidal-fluvial channel within the inner zone based on the estuary model of Dalrymple et al., (1992).
FA4	Interdistributary/estuarine bay facies association	Dark fissile mudstone, carbonaceous rooted mudstone, paleosol, well- bioturbated mudstone and heterolithic mudstone	Parallel lamination, starved ripple, lenticular bedding, mottle	BI = 1 to 6 *Planolites, Thalassinoides, Terebellina Teichicnus* with rare *Skolithos, Ophiomorpha, Paleophycus Diplocraterion*	Lenticular	5 to 20 m thick	Interpreted as part of estuarine and/or bay fill formed under low to mixed energy condition and slow sedimentation rate. The mudstone which overwhelmed by organic debris, common rootlet traces, lack of fully marine fauna, variation in trace fossils including evidence of sub-areal exposure, suggests a restricted marine setting with a proximity to the riverine source, for instance at the bayhead within the inner part of an estuarine/embayment
FA5	Middle to lower shoreface facies association	Bioturbated mudstone, heterolithic beds, interbedded fine grained sandstone and mudstone, silty mudstone	Hummocky cross stratification, parallel lamination, lenticular, starved ripple, ripple cross lamination (wave and current ripples), soft sediment deformation	BI = 2 to 3 *Thalassinoides, Diplocraterion, Skolithos* and *Planolites*.	Tabular	1 to 2 m thick	Mud-dominated lithology and bioturbated heterolithic mudstone represents distal tempestites resulted from fall out suspension during ambient condition. Distinct and amalgamated hummocky beds are the product of strong combined oscillatory flow during storm event and fair-weather conditions.

facies i.e., narrow and elongate tidal sand bars and tidal channel sandstones are formed within these estuaries as a result of along coast variation in tidal prism as well as active sediment transport from landward areas.

Stratigraphically, three distinct genetically related intervals were mapped and defined as stratigraphic marker. Interval 1 represented by various thickness of erosional based, trough cross bedded and tide-influenced fluvial sandstones complex with associated paleosol and coal bearing successions. These multi-storey, channelized fluvial deposits are characterized by gradual increase in tidal sedimentary structures. The successions may represent the seaward margin of coastal plain facies that locally subjected to subaerial exposure characterized by poorly drained coastal wetland and flood plain including peat forming environment. The seaward portion of the channel belt is controlled by gradual seaward increase of tidal current that flow perpendicular to the shoreline with less- pronounced coastal and fluvial processes. Interval 2 composed of more basinal facies represented by thin bedded hummocky beds and thick successions of herring bone sandstone and associated tidal facies which commonly encased by thick mudstone with sparse cemented horizons and isolated coal bearing. These thinly bedded hummocky beds are commonly associated with bioturbated heterolithic intervals. Thick mudstone succession may represent the outer zone of estuary that pass laterally basinward into open marine setting. Interval 3 is marked by dominantly thin bedded hummocky beds interbedded with well-bioturbated heterolithic lithology and thick bioturbated mudstone intervals. This succession is interpreted to have been developed within a wave-dominated shallow marine shoreface setting. The high percentage of mudstone and high degree of bioturbation is indicative of transgressive regime, with minimal sand input. The occurrence of churned and highly bioturbated intervals reflect normal salinity basin, with very slow rate of sedimentation. Overall, northeastern ward facies changes form a distinct basinward projection of relatively coarse to fine-grained clastic strata generated through allocyclic control in sediment supply and surface processes including intermittent marine inundation in response to relative rising in sea level. In addition, the regional facies changes from south to northward through time can be explained by tectonic variation and structurally controlled basin. The complex distribution of sand-rich and mud-rich deposits that portray the estuarine sedimentation during the Nyalau Formation time is correspond to the initial development of fluvial distributaries in response to autocyclic control in sediment transport through time. Subsequently, the coastal plain is attributed to the abandonment phase of active fluvial distributaries accompanied by coastal inundation that marked the initial transgression of the basin.

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Geological modelling using gravity anomaly data: Lumut – Gua Musang transect, Malaysia

CHOONG CHEE MENG*, A PREVINA, SEAN LEE CHEONG HENG, OOI WEI CHIAN, NIK AZFAR AZWANIS NIK AZIZ, MUHAMMAD NOOR AMIN BIN ZAKARIAH & KHAIRUL ARIFIN BIN MOHD NOH[1]

[1] Department of Geosciences, Faculty of Sciences and Information Technology, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak, Malaysia
*Corresponding author email address: choong.meng@utp.edu.my

Introduction

The research is using gravity derived study to improve the understanding on the regional and crustal-scale geology of Lumut –Gua Musang transect. Similar studies across Peninsular Malaysia have been conducted few decades ago (Ryall, 1982; Loke *et al*., 1983). The profile crossed the Main Range granite which resulted from the crustal thickening process. Few regional-scale geological issues remained unclear such as thickness of the granite and crust, sediment thickness next to the Main Range.

Data acquisition and reduction

A total of 55 gravity stations established along the transect (Lumut - Simpang Pulai - Gua Musang road) (Figure 1). The gravity readings measured using Scintrex CG-5 Autograv gravimeter with 3-5km spacing. Gravity data reduced to Bouguer anomaly by applying drift correction, latitude correction, free–air correction, Bouguer correction and terrain correction. The model is constructed up to 50km depth by best fit the observed gravity to calculated gravity using Oasis Montaj software.

Results and discussion

The lithologies of the model are Kinta Paleozoic limestone (density: 2.60g/cm^3), Main Range granite (density: 2.60g/cm^3), interbedded sandstone and mudstone (Kati Formation, density: 2.58g/cm^3), carbonaceous schist (Batu Gajah schist, density: 2.58g/cm^3), schist (Bentong-Raub Suture Zone, density: 2.75g/cm^3), igneous dyke (density: 2.65g/cm^3), chert unit (Bentong-Raub Suture Zone, density: 2.50g/cm^3) and mudstone (volcaniclastic rocks of Gua Musang Formation, density: 2.40g/cm^3).

In general, the model (Figure 2) showed the granitic area such as Main Range has gravity minimum. The metamorphic rocks and sedimentary rocks of other region appeared to have a relatively positive anomaly. From the crustal modelling, the crust of granitic region is relatively thicker, where the Main Range area is ~40km. The thickness of granite batholith is generally 15km, and can up to 21km . General range of crustal thickness of the model is 32-40km. The thickness of Kati Formation, Batu Gajah schist and Kinta limestone in the western part of model has thickness less than 3km. Meanwhile, the thicknesses of rocks of Central Belt and accretionary complex are at most 5km.

Acknowledgement

Thanks to Department of Geosciences, Universiti Teknologi PETRONAS for giving permission to use gravimeter to conduct the research. Thanks to South

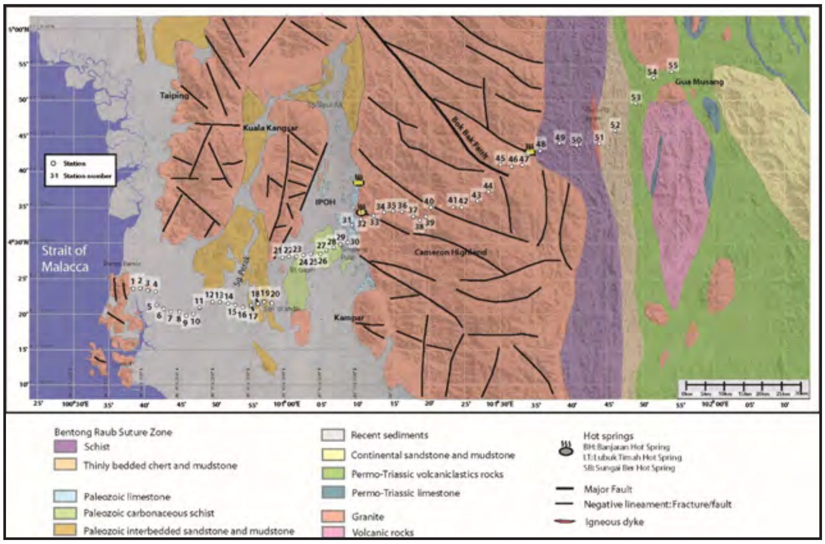

Figure 1: The maps show the stations which gravity data were acquired. Geological map modified from Dato' Yunus (2014).

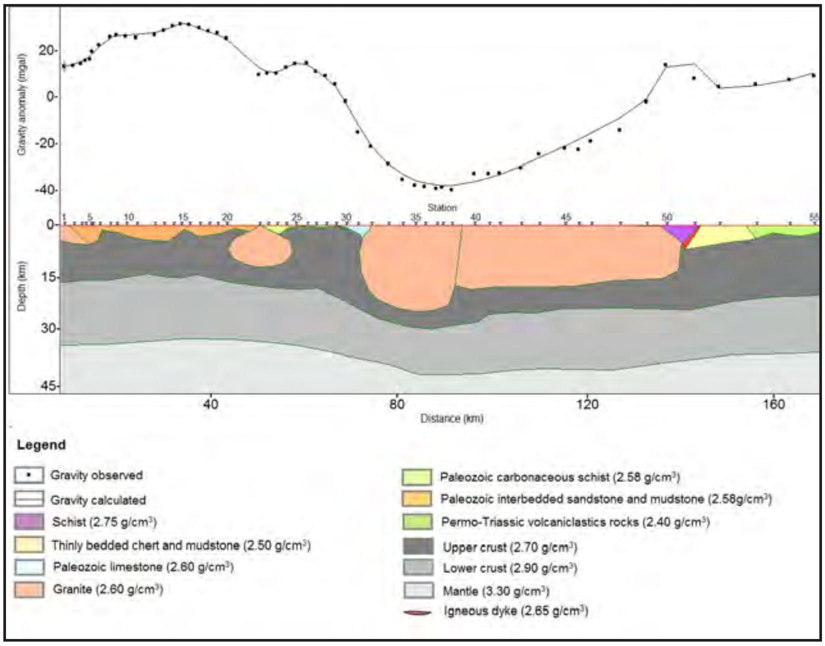

Figure 2: Crustal model of Lumut-Gua Musang transect.

East Asia Carbonate Research Laboratory (SEACaRL) for technical support.

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PME-17

Refractory gold ore characteristics from Central Gold Belt Malaysia

IN SOPHEAK, HASHIM HUSSIN, SUHAINA ISMAIL & *MAYOMI ITO

Mineral Resources Engineering
School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia
*University of Hokkaido, Japan
Email address: in.sopheak02@gmail.com; srhashim@usm.my

Abstract: More than 90 % of gold in Malaysia was mined from Central Gold Belt, and it was the main role to lead the country's economy. The Selinsing Gold Mine Manager, Pejom Gold Mine, Ulu Sokor Gold Mine, Kanan Kerbau Gold Mine and Raub Gold Mine are some of the important gold mines at the Central Gold Belt. Gold mineralization in Central Gold Belt is dominated by gold, and it exists in quartz lode and stockwork deposits. In this study, the gold ore samples were taken from three different locations in Selinsing Gold Mine Manager. Thorough mineral characterization studies were done by using ore microscope, Scanning Electron Microscope equipped with Energy-dispersive X-ray spectroscopy (SEM/EDX), X-ray diffraction (XRD) and X-ray fluorescence (XRF). Through this analysis, it was found that gold mineralization in Selinsing gold mine were found in both "visible" and "invisible" gold which is associated with quartz veins and sulfide minerals. The presence of gold was formed as free milling gold in size of 130 µm diameter, while stibnite, chalcopyrite and pyrite appeared as major components. However, gold is also found as solid solution component and bearing with sulfide minerals, such as stibnite, arsenopyrite, chalcopyrite, sphalerite, galena and pyrite.

Keywords: Refractory gold ore, Central Gold Belt, gold mineralization, visible gold, invisible gold

Major element geochemistry of soil produce from felsic volcanic rock in Teluk Ramunia

SITI NADZIRAH NAZRI & AZMAN ABD GHANI

Department of Geology, University of Malaya, Malaysia
Email address: sitinadzirahn@gmail.com; azmangeo@um.edu.my

Introduction

This research area is in Teluk Ramunia at the south-eastern part of Johore. Teluk Ramunia used to be known as the main bauxite producer of Malaysia in the early nineteenth century. This study will look at the variation of major element content in the soil profile. Weathering of the volcanic rock produced a bauxite bearing soil. A soil profile (~ 6.0 m height) was selected and 13 rock soils have been analysed from this profile at the interval of ~0.5m (Figure 1). Geochemical analysis of the fresh rock is taken from Roselee, 2014 which is the representative parent rock of the soil profile in the same area.

Geology of Teluk Ramunia

The geology of Teluk Ramunia is dominated by a variety of volcanic rocks ranging from lava to pyroclastic tuff. The volcanic rocks consist of andesite, rhyolite and rhyodacite. The lava type rocks are profound to be black to green brown. Whereas, the pyroclastic rocks are of a wide-ranging variation in colour and texture (Ghani *et al*., 2005).

Geochemistry

The analysed major oxide elements are as shown in Table 1. The SiO_2 content from the fresh rock is 71.1%, Al_2O_3 is 12.69%, Fe_2O_3 is 3.16%, CaO is 0.97% , MgO is 0.12% , Na_2O is 4.21% , K_2O is 4.49% , MnO is 0.04% , TiO_2 is 0.35% and P_2O_3 is 0.03%. The SiO_2 content from this soil profile ranged from 30.6-63.0%, Al_2O_3 from 21.38-38.37%, Fe_2O_3 from 3.35-13.8%, CaO and MgO from 0.01-0.02%, Na_2O from 0.01-0.06%, K_2O from 0.07-0.11%, MnO from 0.01-0.10%, TiO_2 from 0.41- 0.70%, P_2O_3 from 0.01-0.02%. A prominent change between the fresh rock (A0) and soil is shown in Figure 2. The SiO_2 content decreases from 71.1% (A0) to 30.6% (L), whereas Al_2O_3 increases from 12.69% (A0) to 38.37% (L). The fresh rock has high K_2O and Na_2O content from 4.49% and 4.21% respectively, which is > 4%. However, K_2O and Na_2O content in the soil profile decreases drastically from 0.07-0.11% and 0.01-0.06% respectively. Fe_2O_3 is less enriched in the fresh rock (3.16%) as compared to the soil (3.35-13.8%). The low LOI content in the fresh rock (0.58%) compared to the soil profile (10.23-18.92%) clearly indicates that it has not undergone much weathering process. In general, Al_2O_3 and TiO_2 shows an increasing significant correlation with decreasing SiO_2 as the LOI content increase from 0.58-18.92%. The increasing speed of SiO_2 removal with the increasing enrichment of Al_2O_3 marks the early stages of diagenesis (Grubb, 1968). The Fe_2O_3 and K_2O content both has no significant trend with decreasing SiO_2. The elements that consist of CaO, MgO and P_2O_5 in the soil profile of Teluk Ramunia are

Table 1: Major element concentrations in % of samples from Teluk Ramunia soil profile.

Sample	A0	A	B	C	D	E	F	G	H	I	J	K	L
Depth/cm	0	42	84	126	168	210	252	294	336	378	420	462	504
SiO_2	71.1	58.8	63	61.7	58.2	58.4	55.7	51.5	55	46.4	52.2	36.1	30.6
$Al_{2O}3$	12.69	21.38	23.02	22.6	22.34	25.3	24.37	23.98	26.16	25.44	28.04	36.36	38.37
Fe_2O_3	3.16	7.96	3.35	4.62	7.57	4.08	7.75	12.43	6.28	13.81	5.13	9.22	11.18
CaO	0.97	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	-	-	-	-
MgO	0.12	-	0.02	0.01	0.01	0.01	-	-	-	-	0.01	0.01	-
Na_2O	4.21	0.06	0.05	0.06	0.07	0.05	0.05	0.04	0.04	0.04	0.04	0.01	0.01
K_2O	4.49	0.08	0.09	0.08	0.11	0.1	0.09	0.08	0.07	0.07	0.09	0.1	0.07
MnO	0.04	0.08	0.1	-	0.07	0.01	0.01	0.01	-	0.03	0.01	-	-
TiO_2	0.35	0.43	0.5	0.46	0.41	0.45	0.41	0.44	0.47	0.43	0.58	0.59	0.7
P_2O_5	0.03	0.02	0.01	0.01	0.01	-	-	0.01	0.01	0.01	-	0.02	0.02
LOI	0.58	10.43	10.23	10.35	10.84	11.26	11.63	11.97	11.85	13	12.98	17.7	18.92
Total	99.13	99.43	100.59	99.97	99.78	99.69	100.07	100.45	99.94	99.3	99.07	100.09	99.94

Notes: The "-" defines that the value is not determined as it is below the detection limit which is < 0.01%. A0 is a fresh rock that is assumed to be the parent rock at depth 0 cm.

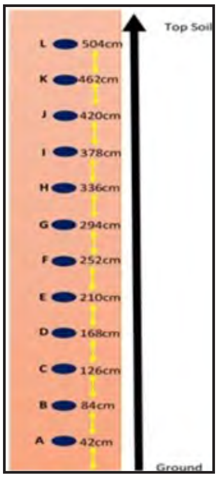

Figure 1: Shows the schematic sketch of the profile showing the interval (in cm) between sample.

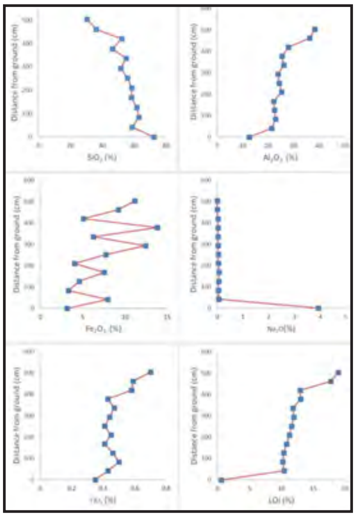

Figure 2: Variation plots of major elements in % versus the distance interval between samples.

all within the range of 0.01-0.02% which were close to their detection limit.

Conclusion

The SiO_2 content in the fresh rock and soil is quite high which is 72.4% and 58.8%-30.6% respectively. Thus, this felsic rock is known to be highly evolved due to SiO_2 content is >70%. Significant increment of Al_2O_3 suggest that this soil profile is a bauxite bearing soil. The increasing LOI content in the soil shows an increasing in weathering intensity with depth from ground to the top of the soil profile.

Acknowledgement

The work is partly sponsored by University Malaya Research Grant Nos. RG041/09AFR and UM/MOHE High Impact Research Grant (UMC/HIR/MOHE/SC/27).

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PME-36

Mineralogy and geochemistry of iron-copper in Mengapur Project, Sri Jaya, Pahang, Peninsular Malaysia

AHMAD FAUZAN YUSOFF & JASMI HAFIZ ABDUL AZIZ

Department of Geology, University of Malaya, Malaysia
Email address: jasmihafiz@um.edu.my

Introduction

The Mengapur Project is located at central of Pahang state in Peninsular Malaysia and has been reported as a skarn deposit, Lee & Chand (1981a). It takes about 17 km to the northwestern side of Sri Jaya town. Mengapur project lies between longitude of 102°49' and latitude of 03°44', Lee (1990) based on geological map dated year 1976 with the scale of 1: 63,360. The aim for this study is to focus on the mineralization concept and geochemistry on iron-copper deposit.

Regional and local geology

The Mengapur deposit is located regionally within the Central Belt of the Malay Peninsula that is characterized by a predominance of gold and base metal mineralization (Scrivenor, 1928). In general, the study area specifically located around the Middle-Triassic Lepar Granodiorite intrusive. However, this area is formally known as Bukit Botak intrusive complex. The sedimentary rocks mainly carbonaceous limestone interbedded with calcareous shale were metamorphosed to form skarn with a mineralogy comprised predominantly of diopside and garnet with little or minor idocrase. The skarns have formed the preferred host rocks for sulphide mineralization Lee (1990) (Figure 1). The skarn alteration is dominated by pyroxene-rich skarn and lesser garnet-rich skarn. Both skarn varieties can contain small to high amounts of sulphide and iron-oxide minerals.

This area has been divided into three (3) mineralization zones. Zone A located at the southeastern part of Bukit Botak is relatively enriched in copper and gold sulphide ores of the skarn and vein type. Zone B is located southwest of the rhyolitic tuff, consists mainly of sulphide ores of skarn with enrichment in copper and silver. While Zone C located northern part of Bukit Botak and mainly comprises of thick layer of gossanous oxide ores zone with enrichment of copper as well as silver, Lee *et al*. (1980).

Fieldwork and laboratory work

Fieldwork has been done by collecting 39 surface samples of ore rock around the mine as total but only 16 samples and 12 samples in powder form was take for the ICP-MS and XRD analysis respectively. The selected samples is choose because of the less weathered conditions. Laboratory work has been done by using several methods such as microscopy study, elemental map of micro X-ray Fluorescence (XRF), Induce Coupled Plasma Mass Spectrometry (ICP-MS) and X-ray Diffraction (XRD). All these method were used for the mineralogy and geochemsitry analysis.

Result

From microscopy observation (Figure 2), the most abundant minerals in that area are hematite (Fe_2O_3) dominantly associated with magnetite (Fe_3O_4) and also some with sphalerite (ZnS) and chalcopyrite ($CuFeS_2$). Also includes minor calcite and quartz as gangue minerals. This microscopy observation however shows that the sulphide minerals become more enrich when toward the Zone C. According to the paragenetic sequence result, the first minerals present is magnetite because it shows embayed structure in microscopy observation. Then after brittle deformation, others minerals such as hematite, sphalerite and chalcopyrite are formed.

Elemental map of micro X-ray Fluorescence (XRF) was performed samples from zone C to determine some of the composition oxide minerals and sulphide mineral content in the microscopy studies. From this study, sulphide minerals are much abundant compared to the oxide minerals where comprises much pyrrhotite and chalcopyrite.

The host rock for these deposits is limestone (calcite) and according to X-ray Diffraction (XRD) analyses the most abundant group of mineral contain in this skarn deposit are sulphide mineral (pyrrhotite) and pyroxene mineral (hedenbergite and diopside) groups. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis (Figure 3) shows that the copper increases with increasing Ag, Sb, Se, W, Bi, Mo, Sn, Fe and Te as a result reflect in terms of mineral exploration and copper prospect. These elements become most important pathfinder elements for skarn deposit in Mengapur Project.

Conclusion

These results can give one an idea which is skarn deposit in Mengapur Project characterized as a copper skarn because it is primarily contains abundant element Cu and lesser abundant Au and Ag. It is surprising because the result shows that the abundance of sulphide minerals is typically of copper skarn mostly in the form of pyrrhotite. This is fairly unique to copper skarns. From literature reviews, the pyrrhotite has been documented to be more common in gold skarns with a reduced mineralogy and/ or intrusive rock character such as at Fortitude, Nevada

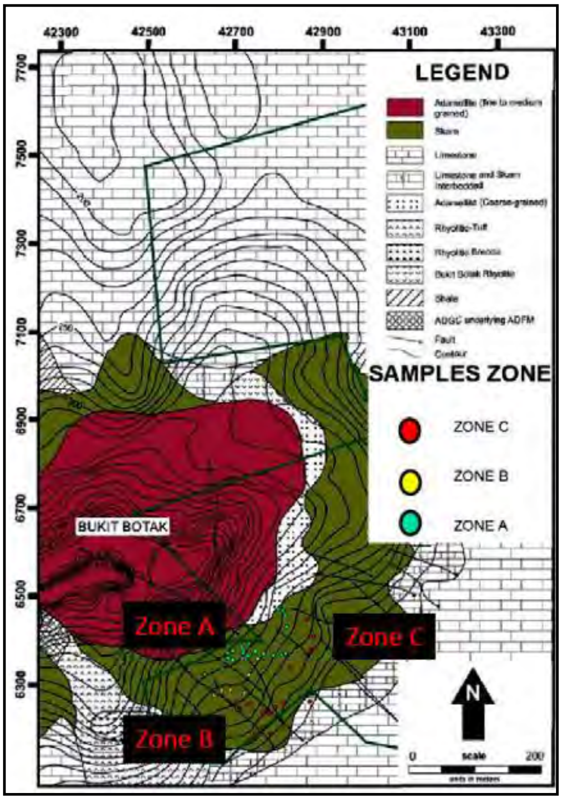

Figure 1: Sampling geological map of Mengapur Deposit. (digitize from Cermat Aman Sdn. Bhd Company).

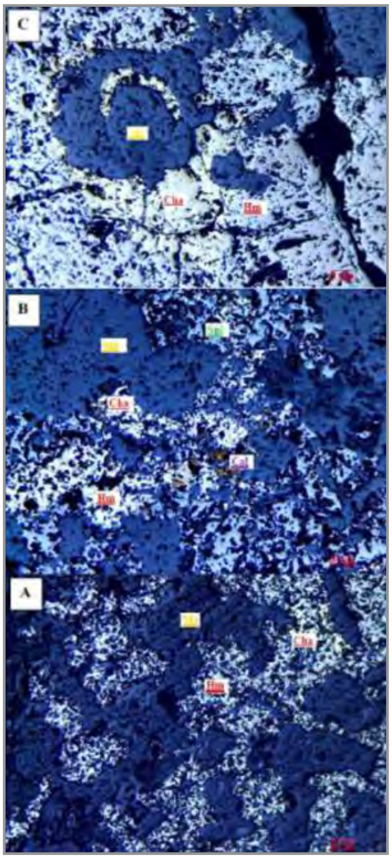

Figure 2: A: Zone A, B: Zone B and C: Zone C. Microscopy observation shows that the sulphide mineralization increase towards Zone C. Mg: Magnetite, Hm: Hematite, Spl: Sphalerite, Cha: Chalcopyrite, Cal: Calcite Scale: 1:0.1.

	Au	Ag	Pb	Sb	Cu	Fe	As	Zn	Se	Te	W	Bi	Ni	Cd	Co	Be	Mo	Sn
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	0.005	0.01	0.5	0.05	0.2	0.01	0.2	2	1	0.05	0.1	0.01	0.2	0.02	0.1	0.05	0.05	0.2
Sample																		
BB1	NSS	0.76	179.5	2.62	130.0	31800.00	6.2	33	2	0.05	7.8	4.92	3.5	0.05	1.6	3.93	56.90	12.1
BB3	NSS	0.07	16.3	1.86	115.5	176500.00	2.9	236	1	<0.05	11.5	2.63	10.4	0.02	3.3	2.83	13.45	20.3
BB5	NSS	5.15	20.4	2.06	5850.0	150000.00	7.8	30	56	0.39	183.0	106.50	21.4	0.10	31.1	0.14	150.00	35.0
BB7	NSS	0.32	13.3	1.50	304.0	190500.00	2.4	242	3	0.10	14.4	8.27	11.2	0.04	5.3	2.70	49.30	14.1
BB8a	NSS	1.30	19.9	0.76	3590.0	220000.00	4.0	55	15	0.94	40.1	135.00	15.3	0.09	13.2	1.28	118.00	6.5
BB11	NSS	0.14	13.7	1.75	65.3	335000.00	1.8	144	1	0.07	85.1	7.63	9.2	0.09	2.9	0.58	17.50	95.7
BB14	NSS	0.92	6.4	0.48	3970.0	333000.00	2.1	42	23	0.68	41.1	105.50	19.8	0.03	19.0	0.88	3.49	9.9
BB16	NSS	1.00	14.5	36.10	71.8	276000.00	150.0	6	24	0.17	3.9	10.30	31.0	<0.02	14.9	<0.05	3.46	2.5
BB17	NSS	1.47	20.5	2.73	4380.0	250000.00	5.7	124	13	0.54	73.8	96.10	12.9	0.29	10.9	1.09	114.00	15.5
BB19	NSS	0.12	21.0	2.40	75.1	67400.00	2.3	772	1	0.15	40.8	7.13	13.4	0.96	4.4	2.41	82.60	50.7
BB22	0.047	0.98	102.5	15.00	2530.0	248000.00	26.7	143	13	0.51	36.5	49.50	15.8	0.33	6.5	0.24	21.40	101.0
BB25	NSS	12.30	147.5	4.29	3600.0	370000.00	597	207	3	0.48	49.8	147.50	10.4	2.59	11.0	1.39	1270.00	25.6
BB29	NSS	0.80	15.8	3.12	2480.0	364000.00	3.3	132	17	0.13	74.7	72.20	17.3	0.15	23.8	0.21	3.50	134.0
BB30	NSS	0.73	15.3	1.52	1690.0	404000.00	3.4	238	17	0.42	41.7	411.00	12.1	<0.02	26.4	0.24	4.50	184.0
BB32	NSS	1.36	8.2	1.47	1720.0	468000.00	4.9	40	4	17.90	131.5	1980.00	17.3	<0.02	43.1	0.22	8.05	1.5
BB36	NSS	1.16	7.6	0.97	2450.0	402000.00	4.0	61	22	1.25	71.8	170.00	22.0	0.16	16.3	0.36	12.65	14.3
Primitive Mantle	0.001	0.02	0.1	0.01	28.0	62200.00	0.1	50	0.04	0.02	0.02	0.01	2000.0	0.04	100.0	0.06	0.10	0.1
Bulk Cont. Crust	0.001	0.06	11.0	0.20	27.0	52100.00	2.5	72	0.13	0.00	1.0	0.18	59.0	0.08	27.0	1.90	0.80	1.7
Upper Cont. Crust	0.002	0.05	17.0	0.40	28.0	39300.00	4.8	67	0.09	-	1.9	0.16	47.0	0.09	17.0	2.10	1.10	2.1

Figure 3: Trace elements composition in skarn deposit from Mengapur Project. Au: Gold, Ag: Silver, Pb: Lead, Sb: Antimony, Cu: Copper, Fe: Iron, Zn: Zinc, Se: Selenium, Te: Tellurium, W: Tungsten, Bi: Bismuth, Ni: Nickel, Cd: Cadmium, Co: Cobalt, Be: Beryllium, Mo: Molybdenum, Sn: Tin and NSS: Not Sufficient Sample.

and Hedley. More studies need to be done to know how this was formed.

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Trace elements composition of iron at Pulai, Kelantan

NUR NADWA SYAHIRAH AI ZAMRUDDIN & JASMI HAFIZ ABDUL AZIZ

Department of Geology, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia
Email address: nurnadwashahirah2@gmail.com; jasmihafiz@um.edu.my

Introduction

The recently discovered iron deposit at Pulai in the volcanic meta-sedimentary rock mineralised with hematite and magnetite remains a big question to solve, as Pulai is known as the potential area for gold mineralization. Numerous high-grade (> 55% Fe) iron-ore deposits in small scale and economical to mine is identified in eastern part of Pulai mining area, Southern part of Kelantan, Peninsular Malaysia. The aims of this research are to understand the mineralogy, trace element distribution and geochemistry of iron in Pulai.

Methods

Samples of iron ores were collected and analyzed for mineralogy of ore by microscopy study while trace elemental compositions of ore were obtain by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). 21 selected samples are used to study the mineralisation and geochemistry of iron in Pulai ML1/2013.

Geological background

Pulai is located 15 km to the east of Bentong-Raub Suture, which separates Peninsular Malaysia into two tectono-stratigraphic blocks, known as Sibumasu Block and the East Malaya Block (Metcalfe, 2000, 2013). Pulai comprised of Permo-Triassic carbonate-argillite-volcanic of Gua Musang Formation sequences with widespread distribution across northern Central Belt (Yin, 1965; Mohamed *et al*., 2016).

The stratum in Pulai is mainly Permian lower metamorphic rock with pyroclastic and volcanic rocks, striking North-North East direction. Iron ore in Pulai mostly found as big boulders of chloritised and sericitised volcanic tuff (from 0.1 meter, up to 2 meters width), blackish-brownish in colour of ferromanganese with some vugs due to weathering effects. Pulai iron mineralisation also associated with magnetite and hematite, together with sulphide minerals of pyrite, chalcopyrite and pyrrhotite.

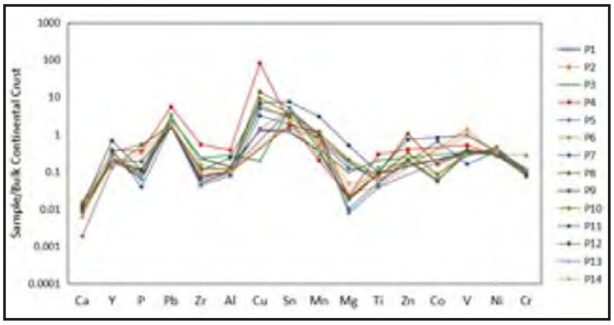

Figure 1: Multielement variation diagrams for iron samples, normalized to bulk continental crust values from Morgen & Anders (1980), Anders & Grevesse (1989), and Rudnick & Gao (2003).

Result

Elemental compositions of ore and host rock of Pulai were obtained by ICP-MS. Host rock of Pulai, mostly tuff and andesite are rich in Al, Mg, Mn, Pb, Ti, Ni, Zr and V. For mineral exploration and iron prospecting, Al, Mg, Mn and Ti are considered to be the most important pathfinder elements for Pulai iron ore (Table 1).

Fe content of ore are varies widely from 279000 ppm to 546000 ppm for Pulai Iron Ore. The concentration of trace elements in iron samples of iron in Pulai are varies as shown in Table 1. Al, Mn and S are the most abundant trace element. The Al values vary from 6510 to 32100 ppm averaging 12406 ppm while Mg concentration has an average value of 2945.86 with wide range of values (215 to 14200 ppm). S values range from 24.1 to 29500 ppm with average of 4156.2 ppm. Be, Y and Sn have the lowest concentrations with the average values of 1.64 ppm, 5.21 ppm and 5.85 ppm respectively (Table 2).

Multi-element variation diagram of iron ore in Pulai is plotted in order of increasing compatibility into magnetite and normalized to Bulk Continental Crust (BCC) to approximate the composition of the fluid or liquid from which the iron formed (Figure 1). The high compatible elements (Cr, Ni, V, Co Ti and Mg) are depleted and have the low overall abundance of trace elements compared to the low compatible element.

Meanwhile, iron in Pulai ML1/2013 has low Co/Ni (0.08-1.04, average: 0.53), low Ti (165-6750 ppm, average:1107.6), medium Cr (10.1-36.5 ppm, average: 15.19), medium V (15.8-667 ppm, average: 94.9 ppm) and Ni (15.54-26.7 ppm, average: 19.55 ppm) while high Ni/Cr (0.48-2.3 pp, average: 1.44 ppm).

Discussion

The high Ni/Cr (>1) of Pulai iron value indicate hydrothermal systems of iron formation (Dare *et al*., 2014a). This indicate that the magnetite ore fluids in Pulai with higher solubility of Ni than Cr (Dare *et al*., 2014a; Zhao *et al*., 2016).The depletion and low concentration of Ti, Al and Zr indicate that iron evolved from hydrothermal fluids, as these elements are immobile during hydrothermal alteration (van Baalen, 1993: Ray & Webster, 2007; Dupuis

Table 1: Geometric mean values of iron samples at Pulai, Kelantan.

Met-al	Geometric Mean
Al	10000 ppm (8000 to 55000 ppm, 1σ variation range; n=21)
Fe	4000 ppm (90000 to 530000 ppm, 1σ variation range; n=21)
Mg	1800 ppm (500 to 6000 ppm, 1σ variation range; n=21)
Mn	525 ppm (200 to 1800 ppm, 1σ variation range; n=20)
Ti	400 ppm (240 to 1800 ppm, 1σ variation range; n=21)
Cu	180 ppm (38 to 400 ppm, 1σ variation range; n=13)
V	47 ppm (28 to 160 ppm, 1σ variation range; n=21)
Zn	30 ppm (14 to 70 ppm, 1σ variation range; n=14)
Ag	24 ppm (1.4 to 50 ppm, 1σ variation range; n=10)
Pb	22 ppm (18 to 53 ppm, 1σ variation range; n=21)
Ni	20 ppm (17 to 23 ppm, 1σ variation range; n=21)
Zr	17 ppm (6.8 to 60 ppm, 1σ variation range; n=20)
Cr	14.5 ppm (12 to 20 ppm, 1σ variation range; n=12)
Sn	6.5 ppm (3.2 to 14 ppm, 1σ variation range; n=18)
Y	4.5 ppm (3.4 to 14 ppm, 1σ variation range; n=21)
Be	1.4 ppm (0.85 to 3.2 ppm, 1σ variation range; n=14)

& Beaudoin, 2011; Nadoll *et al*., 2012; 2014). Cr and Ti that are compatible in magnetite, this support that the fluid from which magnetite precipitated was poor in these immobile element. The enrichment of compatible element Cu and Pb are due to acidic condition as those elements are highly mobilised during oxidation and weathering process represent the weathering process of magnetite into hematite in Pulai.

The low concentration of Ti (<2 wt.%) reveals the pattern of low temperature hydrothermal magnetite, about 300 to 500°C, as those elements are present at low concentration and immobile during hydrothermal alteration.

Conclusion

The trace elements distribution indicates that Pulai iron ore are associate with low hydrothermal fluid source, associated with volcanic rhyolitic tuff as the host rock. The iron orebodies conformable with the host rock. The ores composed Fe-oxides (magnetite and hematite) and Fe-sulfides (pyrite, chalcopyrite, pyrrhotite) together with quartz and variable contents of minerals.

Acknowledgement

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Table 2: Element concentrations of iron samples analyzed by ICPMS.

Element	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	La	Mg
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
P1	0.578	11400	<3	<5	<0.5	<5	377	<1	<1	13.1	34.4	383000	176	<0.5	492
P2	<0.5	8390	<3	<5	<0.5	5.92	278	<1	<1	12.3	39.3	546000	849	<0.5	713
P3	<0.5	23000	<3	<5	<0.5	<5	<50	<1	<1	13.7	5.26	382000	2960	0.518	2710
P4	<0.5	32100	<3	43.2	0.513	17.1	<50	<1	<1	<10	2210	279000	2040	1.583	633
P5	2.15	7870	<3	<5	0.607	5.46	85	<1	<1	13.8	37.1	498000	<100	<0.5	215
P6	1	9320	7.36	<5	<0.5	5.07	484	<1	2.17	36.5	167	280000	<100	1.847	668
P7	<0.5	6510	<3	<5	1.2	<5	<50	<1	17.8	10.1	86.4	377000	<100	2.111	277
P8	2.36	8200	<3	<5	3.03	8.28	418	<1	4.21	14.1	<5	484000	222	<0.5	574
P9	2.64	9120	<3	<5	<0.5	<5	604	<1	1.63	14.5	134	298000	513	<0.5	3510
P10	<0.5	10300	<3	<5	3.15	6.3	687	<1	2.33	11.6	251	438000	<100	0.6	5870
P11	1.57	20100	<3	<5	2.68	6.58	531	<1	22.2	<10	187	485000	<100	15.18	14200
P12	1.59	9930	<3	<5	1.13	8.32	<50	<1	1.46	11.1	373	549000	<100	2.563	5260
P13	<0.5	8910	<3	<5	0.863	<5	<50	<1	<1	15.9	<5	425000	<100	<0.5	4780
P14	4.1	8540	<3	<5	<0.5	<5	<50	<1	<1	<10	<5	534000	221	<0.5	1340
P15	3.28	43400	<3	748	1.29	<5	613	<1	<1	<10	221	111000	19400	<0.5	2170
P16	<0.5	54600	<3	236	0.906	<5	811	<1	<1	<10	367	59900	6840	50.17	16200
P17	<0.5	121000	<3	131	0.811	<5	354	<1	<1	15.6	<5	165000	7710	<0.5	1210
P18	<0.5	4250	<3	<5	<0.5	<5	350	<1	<1	<10	<5	25200	187	<0.5	260
P19	5.61	8850	<3	6540	3.71	<5	760	<1	20.1	<10	<5	40600	186	8.255	516
P20	<0.5	65900	<3	762	1.2	<5	1430	<1	30.1	<10	<5	90100	720	3.001	3660
P21	<0.5	51200	<3	1150	1.3	<5	<50	<1	<1	<10	<5	128000	30900	<0.5	2720
Bulk Continental Crust	0.056	84300	2.5	456	1.9	0.18	45800	0.08	27	135	27	52100	15000	20	28000
Primitive Mantle	0.019	19300	0.1	5.1	0.06	0.001	20700	0.04	100	3000	28	62200	180	0.551	212000

The effectiveness study of calcium and magnesium oxides in acid mine drainage treatment

ANUAR OTHMAN[1,*], AZLI SULAIMAN[2], ISMAIL IBRAHIM[3] & MOHD SYAHRIR MOHD ROZI[4]

[1,3,4] Mineral Research Centre, Department of Mineral and Geoscience Malaysia, 31400 Ipoh, Perak
[1,2] Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor
*Corresponding author email address: anuarpjj@gmail.com

Introduction

Calcium and magnesium are both elements in Group 2 of the periodic table which also known as alkaline earth metals. Other elements in group 2 are beryllium, barium, strontium and radium. In this study, calcium oxide (CaO) and magnesium oxide (MgO) were used to treat acid mine drainage (AMD). CaO and MgO used were HmbG reagent grade, Germany. AMD sample was collected from a tin tailing pond located at Pengkalan Hulu, Perak. Active treatment by using a jar test was used in this study.

AMD can be considered as one of the main water pollutants in many countries caused by the mining activities whether from abandoned or active mines (Geoffrey & Sehliselo, 2014). AMD can be treated by two methods; passive and active treatments. The active treatments commonly use alkaline chemicals to precipitate heavy metals, adsorption, ion exchange and membrane technology (Kebede *et al.*, 2017).

Six experiments were carried out for both materials in studying their effectiveness in treating AMD based on weight parameter. The parameter weights used for CaO were 0.2, 0.4, 0.5, 0.6, 0.8 and 1.0 g. The parameter weights used for MgO were 0.2, 0.4, 0.6, 0.8, 0.9 and 1.0 g. The retention times used in the experiments of CaO and MgO were 0, 5, 10, 15, 20, 25 and 30 minutes, respectively. Figure 1 shows a jar test of AMD sample before and after treatment with 8.0 g of MgO.

Results and conclusions

Tables 1 and 2 show the pH values of AMD after reaction with CaO and MgO, respectively. The results show that pH values of AMD sample had increased after reaction with both materials. The Parameter weight suitable to be used to treat AMD using CaO was 0.5 g at retention 10 min to 30 min. The parameter indicated that pH values obtained comply with Standards A and B for Environmental Quality Act 1974. The act stated that for Standards A and B the optimum limit are 6.0 to 9.0 and 5.5 to 9.0, respectively. The parameter weight of MgO suitable to be used to treat AMD was 0.7 g at retention time 15 min to 30 min.

Based on the results it can be concluded that MgO is more suitable to treat AMD because the increasing of pH obtained is still under the maximum value of Standard A and B, 9. Also based on pH values obtained,the results indicate that the reaction between AMD and CaO is more reactive compared to the reaction between AMD and MgO.

Figure 1: AMD sample a) before and b) after reaction with 8.0 g of MgO.

Table 1: PH values obtained after reaction between CaO and AMD.

Retention time (min)	CaO (g)					
	0.2	0.4	0.5	0.6	0.8	1.0
	pH					
0	2.58	2.58	2.58	2.58	2.58	2.58
5	3.07	4.56	5.82	9.39	11.42	11.84
10	3.05	4.58	6.03	9.45	11.26	11.82
15	3.02	4.58	6.15	9.43	11.16	11.80
20	3.01	4.58	6.22	9.42	11.10	11.79
25	3.00	4.58	6.28	9.39	11.05	11.78
30	2.99	4.58	6.32	9.37	11.01	11.77

Table 2: PH values of AMD sample after reaction with MgO.

Retention time (min)	MgO (g)					
	0.2	0.4	0.6	0.7	0.8	1.0
	pH					
0	2.58	2.58	2.58	2.58	2.58	2.58
5	3.04	4.18	4.93	5.38	5.68	6.79
10	3.10	4.26	5.41	5.97	6.40	8.48
15	3.16	4.31	5.68	6.36	7.07	8.70
20	3.21	4.33	5.89	6.72	7.74	8.76
25	3.25	4.38	6.06	7.08	8.18	8.78
30	3.29	4.41	6.21	7.46	8.41	8.79

Acknowledgements

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PME-103

Prediction of blast induced vibration at Lafarge Quarry in Kanthan, Ipoh, Perak

MOHD HAZIZAN MOHD HASHIM[1,*], KHAIRUL SHAZWAN PELAWANG[1] & SHAIB ABDULAZEEZ SHEHU[1,2]

[1] Strategic Mineral Niche, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, Engineering Campus,14300 Nibong Tebal, Penang, Malaysia
[2] Department of Mineral and Petroleum Resources Engineering, School of Engineering, Kogi State Polytechnic, Lokoja, Nigeria
*Corresponding author email address: mohd_hazizan@usm.my

Introduction

Blasting is the most common method of excavating rocks for various purposes. The energy from blasting cannot be completely utilized for rock breakage. The waste energy produced undesirable environmental effects that can cause human discomforts and structural damage. Such blast effects may lead to ground vibration air blast and fly rock. A good blast must be designed to minimize such harmful effects by predicting the likely level of the blast discomfort. The level of such effects varies with the site geological condition, explosive usage and blast geometry amongst other factors.

Results and discussion

In current practice, to predict blast induced ground vibrations quarry operators use square root scaled distance equation by taking site constants, K and β values as 1140 and -1.6 respectively. However, these values are adaptation from Australian Standards (AS 2187.2 -1993), where Standard Association of Australia has developed a Scaled Distance chart to predict blast-induced ground vibrations when blasting is to be carried out to a free face in average field conditions. This is due to currently no suitable standard to be uses in ground vibrations prediction as reported by Ghani (2013).

This study evaluates the site constants (k, β) for Lafarge Quarry located in Kanthan, Perak Malaysia. The constants were further used to predict the level of vibration for a given distance and maximum instantaneous charge (Q). Ten blast events were studied and the maximum instantaneous charge per delay was recorded for each blast.

The Peak Particle Velocity (PPV) for each blast was measured using an Instatel MiniMate Plus fixed at 600m from the blasting site. The scaled distance (SD) was also evaluated for each blast. A regression analysis was carried out to evaluate the specific site constants (k and β) for the studied quarry as -1.66 and 2,262 respectively.

These values further proved that no numerical fixed constants can be universally accepted to evaluate blast damages because of varying geological factors across the globe. A model was generated to predict ground vibration for the studied quarry using these site constants and was found to provide closer PPV values to the actual reading compared to the Australian Standards (AS 2187.2 -1993).

Conclusion

Blasting can be seen to give rise to many unwanted and sometimes disturbing effects, but with modern technology and techniques, these impacts can be minimised. Hence, the approach to predict blast-induced ground vibrations is essential to ensure that the quarry operation run smoothly and safely (Roy *et al.*, 2016). Furthermore, by running the blasting efficiently, it also promotes good fragmentation (in term of desirable size reduction) hence promotes low energy consumption, higher productivity and overall sustainable operations.

Acknowledgements

The authors wish to acknowledge Universiti Sains Malaysia for the financial support through the grant no. 8014043.

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PME-104

A preliminary characterization study of copper dross (CD) and roasted copper dross (RCD) as a by-product in tin smelting

Syed Mohd Syafiq Idid, Suhaina Ismail & Nurul 'Ain Jabit

Strategic Mineral Niche Area Group,
School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
Email address: ainjabit@usm.my

Introduction

The Malaysian Smelting Corporation or MSC is the second largest supplier of tin metal in the world, behind China's Yunnan Tin Company (https://www.msmelt.com/abt_cp.htm). About more than 27, 000 tonnes of tin metal was produced in 2017 and its operation is one of the most low cost smelting plants in the world. This plants operates on converting primary, secondary even complex tin bearing ores to high purity tin metal for industrial applications. At the same time intensive production of tin metal have generates a huge amount of waste in the forms of fines, slimes, slag, and dross. Therefore it is important to utilize this waste or by product that still comprise some valuable metal that can be extract using various process (Dimitrijevic, Urosevic and Jankovic, 2016). Transformation of such solid wastes from one form to another in view of its valorization either by the same production unit or by a different industrial installation has thus become very essential not only for conserving metal and mineral resources but also for protecting the environment (Panda *et al.*, 2015).

Copper dross (CD) and roasted copper dross (RCD) is a by-product in roasting of tin ore which contain significant amount of tin and copper that still have economical values. Therefore it is essential to study the mineralogy and chemical reaction involved in this by product to come out with feasible extraction process. Hence, the aim of this work is to investigate the mineral compositions of CD and RCD materials for evaluation of potential extraction process. This work involved characterization studies using X-ray Fluorescence (XRF), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) & Energy Dispersive X-ray (EDX) for chemical composition, mineral phases, mineral morphological and identification analysis respectively.

Results and discussion

Elemental and Mineral Phases Analysis

Two types of dross samples (CD and RCD) wwas provided by Malaysian Smelting Corporation (MSC) in the form of accumulated powder that form a stone shape. The samples were crushed using the cone crusher and grind to achieve homogeneous samples size (80 % passing 75μm). The first step of characterization study is investigating the compositions of dross samples by using XRF. From the analysis, it was found that there are major constituents identified such as Sn, Cu, Fe and S followed by other minor element. The elements with a percentage below than 0.1% are recorded as trace elements. For the RCD sample, highest amount of SnO_2 is identified with 67.25% followed by SO_3 with 8.12%, Fe_2O_3 with 7.65%, and CuO with 2.38%. For CD sample amount of SnO_2 present was about 62.75% followed by SO_3 with 14.35 %, Fe_2O_3 is 9.41% and CuO with 2.50%. The significant difference in CD and RCD is the amount of sulphur. The lower amount of sulphur was found in

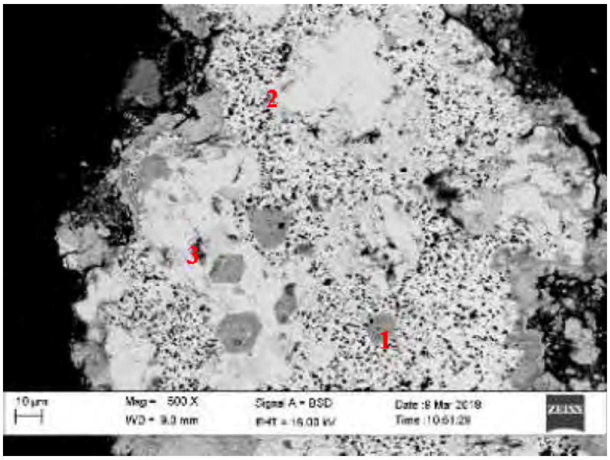

Figure 1: Backscattered image of CD sample.

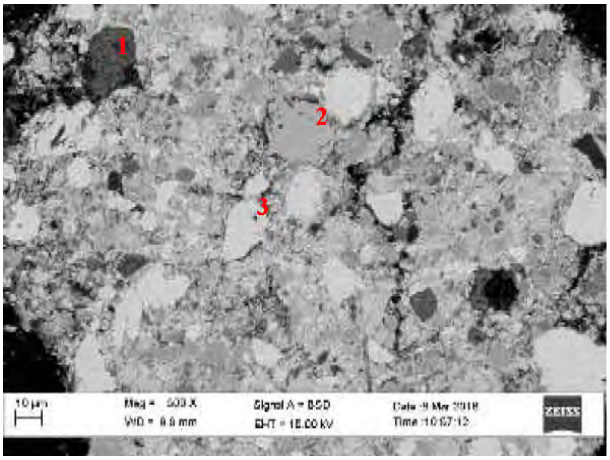

Figure 2: Backscattered image of RCD sample.

RCD samples due to the effect of roasting process to remove the content of sulphur in CD samples. Mineral phases identification was analysed by XRD using Bruker D8 Advanced X-Ray Diffractometer with Cu-Anode and Kα radiation. The identification of mineral phases was done with PANalytical X'Pert HighScore plus Software (v2.2e) and PANAlytical ICSD database. The main mineral phases identified by XRD is cassiterite (SnO_2), ilmenite ($FeTiO_3$) and magnetite (Fe_3O_4).

Morphological studies

Morphological studies of dross samples; CD and RCD was performed using SEM/EDX. Different morphologies were observed at CD and RCD samples revealed that the samples contain different types of minerals due to different shapes and variation of brightness. Figure 1 displays a porous grain (label as 1) encapsulated the compact grains with white (2) and greyish (3) colour. The main components identified in this figure (via EDX) is Sn and Fe and Cu and O which may be in the form of oxide. It is revealed that white porous and solid grains consist higher content of Sn. Other minor elements which is trace elements may not be detected in this SEM/EDX.

Morphology of RCD samples shown in Figure 2, indicate that the surface of the grain are found to have medium angularity and consist a non-porous grains. The different grey shade levels in RCD reflecting compositional variations of C, Sn, Cu and Fe content. The lighter grey or white colour grains indicate higher content of Sn (determine by EDX) compared to darker grain which is contains more carbon.

Conclusion

The by-product of tin smelting such as dross has a potential to be reutilize and recover. In order to assess the feasibility of dross for tin extraction, characterization study is essential. This research work reveals that CD and RCD contain significant amount of tin and other elements that can be recover. Further work should be done for details characterization on dross samples.

Acknowledgement

The authors greatly appreciate to Malaysia Smelting Corporation (MSC) for providing materials and to Geological Society of Malaysia (GSM) for giving this opportunity to publish this work.

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https://www.msmelt.com/abt_cp.htm

PME-105

Textural and morphological properties of aplitic kaolin from Kinta Valley

KHONG LING HAN, HAREYANI ZABIDI* & KAMAR SHAH ARIFFIN

School of Material and Mineral Resources Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia
* Corresponding author email address: srhareyani.zabidi@usm.my

Introduction

Kaolin are industrial minerals with a wide range of industrial applications (Yuan *et al.*, 2015; Murray, 2007; Murray, 2000). Properties of kaolin however can vary significantly depending on their parent material and forming condition (Masoud *et al.*, 2013; Wilson & Jiranek, 1995; Varajao *et al.*, 2001; Yuan *et al.*, 2014; Sayin, 2007). Systematic and proper characterization of the properties of kaolin is necessary to enable better understanding on the behavior of the clay. This paper is aimed to report and discuss the morphological variation of aplite derived kaolin from East Kinta Valley.

Methodology

Two processed kaolin originated from East Kinta Valley labelled as SA and SC with different morphological composition are selected for this study. Particle size analysis by laser diffraction method is first adapted to determine the quantity of fine fraction in each material. The next step involve extraction of <2 μm fraction by decantation technique. The variation in morphological properties between the raw material, fine fraction and coarse fraction are then examined using SEM technique.

Result and discussion

Particle size distribution

The result of PSD analysis is tabulated into figure 1. Clay SA and SC has an average particle diameter of 20 and 11 μm respectively. The <2 μm fraction of both clay is low, which constitutes to only 9 and 12 %vol composition in SA and SC respectively.

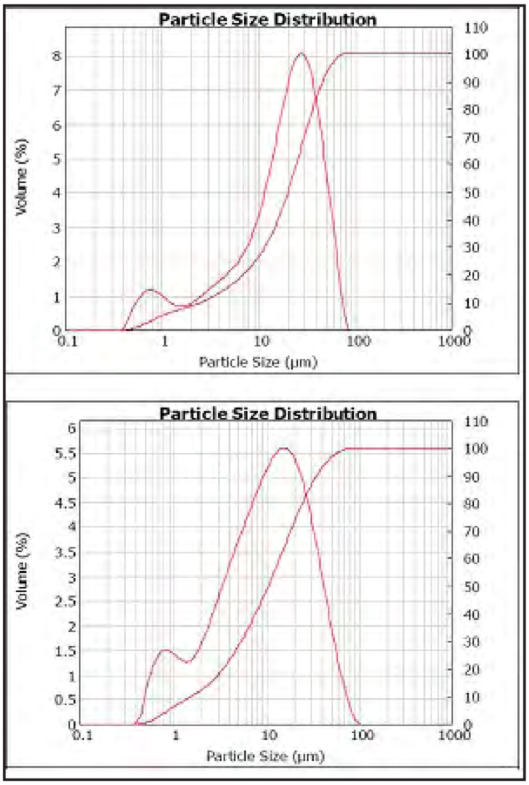

Figure 1: Particle size distribution of processed clay from SA and SC.

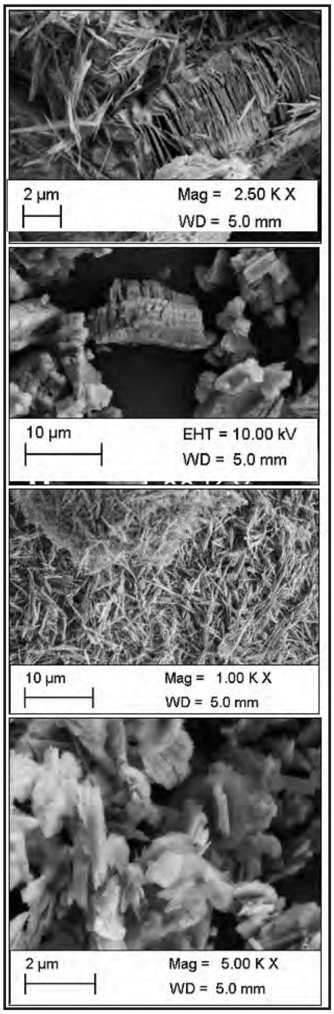

Figure 2: SEM images of processed aplitic kaolin clay. (A), Halloysite-kaolinite mixture from SA. (B), Platy and stacked kaolins from SC. (C), Tubular halloysite separated from SA by decantation. (D), platy fine size kaolin separated from SC by decantation.

Scanning electron microscope

SEM images supported by the particle size analysis reveal that for both materials are principally the soft kaolin type dominated by coarse book like kaolinite stacks (Pruett, 2016). Decantation had efficiently classified the clay into two fractions based on their size. Clay SA had it finer tubular halloysite particles separated from the book like stacks of kaolinite. Sample SC on the other hand had the finer delaminated platy kaolinites and kaolinite stacks classified into two fractions.

Conclusion

The textural and morphological properties of aplitic kaolin had been successfully investigated and characterized using PSD and SEM techniques. The kaolins are principally the soft type where coarse kaolinite stacks contribute to the major composition. The kaolin however can be classified into two types based on the morphology of finer particles which may be consists of; i) delaminated platy kaolin, or ii) tubular shaped halloysite. Sorting of the clay into different size and morphological fraction creates a product with less variation in properties between individual particles, and with more potential for tailoring or engineering of their properties

Acknowledgement

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PME-108

Mineralogical characterisation of complex sulphide gold ore from Pahang, Malaysia

MOHD HAIKAL ROSLI, MOHAMMAD HAFIZUDDIN MOHD SAFRI, HAREYANI ZABIDI, NURUL AIN JABIT & SUHAINA ISMAIL*

Strategic Minerals Niche Area
School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
*Corresponding author email address: suhaina@usm.my

Introduction

The Malaysian sulphide gold ore mostly occur at the state of Pahang as example at all the region of Selinsing. At Buffalo Reef, the gold mineralization is hosted by widespread occurrence of low regional grade metamorphism and subdivide into three section which is Buffalo Reef Centre, Buffalo Reef North and Buffalo Reef South. The various lithological and geological occurrence cause the alteration of diversity of mineral composition in rock or soil sample. The sulphide gold ore is a complexity ore which intend a specific observation and study to extract the ore from hard rock mining or alluvial mining (Zhou *et al.*, 2004).

Sulphide complex gold ore encapsulated by the sulphide particle or partially liberated. The gold is associates with the sulphide mineral mostly iron sulphides which include pyrite, arsenopyrite, and pyrrhotite. Owing to the complexities in the associated minerals of suplhide gold ore led to poor results on recovery of the mineral and also influence the process flow of froth flotation.

Processing has not shown actual results economically (Bargawa & Hardiyanto, 2017). Some problems become obstacles in developing the people's mining business. For this reason, a comprehensive characterization method including physico-chemical characterization, morphological observation and mineral liberation determination were implemented for optimal gold recovery.

Materials and methods

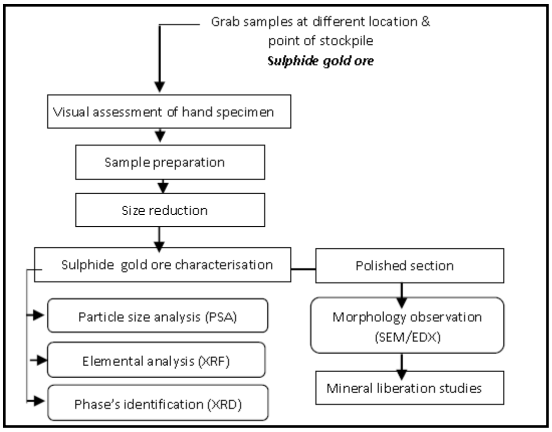

Figure1: Flowchart depicting the stages involved.

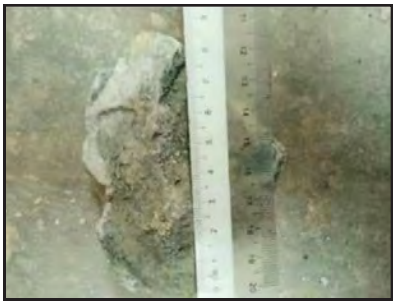

Figure 2: Collected ore sample from stockpile.

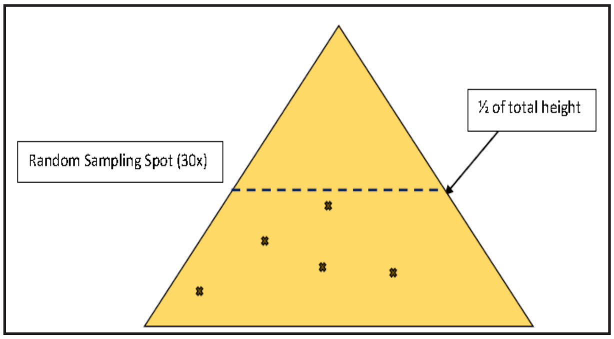

Figure 3: Grab-random sampling methods.

Results and discussion

Morphological study - Optical microscope

Figure 4: Optical microscope image (A) -0.075mm non-polarized (B) (-0.09+0.075) mm non-polarized.

Polarizing optical microscope is used on polish section on every 12 size fractions to study the morphology of the sample HG2-1 which is collected from the Buffalo Reef Stockpile. There are a few other mineral that have been found under the optical microscope, such as quartz, arsenopyrite, chalcopyrite and pyrite. Chalcopyrite is brassy yellow color mineral.

Morphological study - SEM and EDX

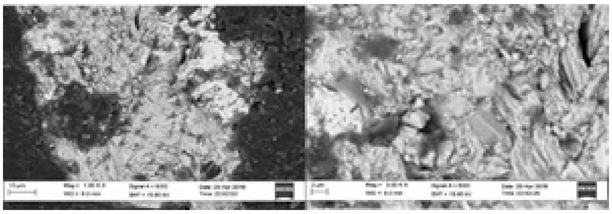

Figure 5: Morphological observation under Secondary Electron using FESEM at -75μ size fraction.

The grain structure is cubic, irregular and flaky with different white shades.

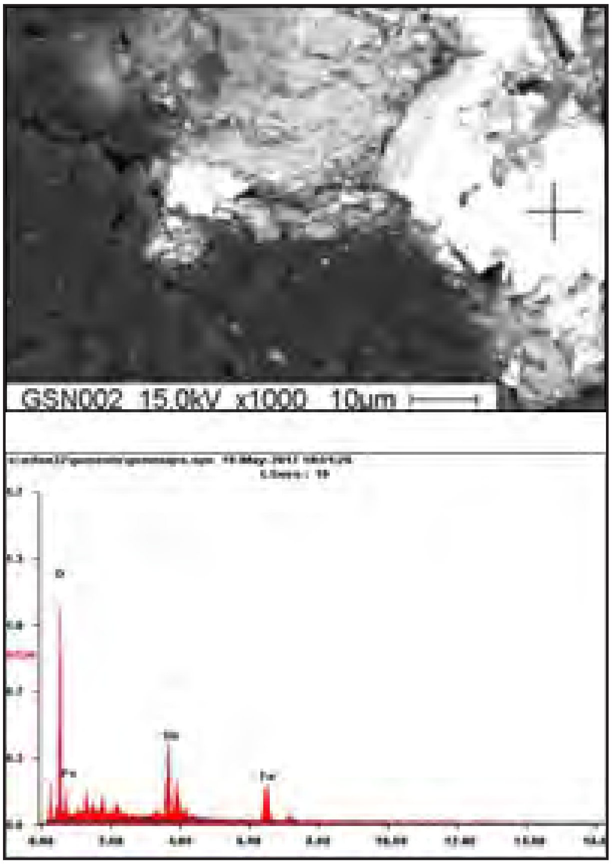

Figure 6: SEM and EDX analysis of the ore at -75μ size fraction.

The major mineral formed at the size fraction -0.075mm of GSN2 sample is stibnite and possible pyrite. From the image EDX, the color of white dull region indicated the formation of prismatic and orthombic shape of stibnite.

Elemental composition

The mass percent (%) of the elements consist in the X-ray Fluorescence (XRF) result determined that the highest amount of element in the sulphide gold ore sample is Silicon, Si, with an average value of 32.7294% of mass percent while there the lowest amount of element in the sulphide gold ore sample Gold, Au with average value of 0.0032% of mass percent. Other elements with low amount of mass percent such as Cr, Mn, Ni, Cu, Zn Rb, Sr and Zr are the trace elements found inside the sulphide gold ore samples.

Mineral phase identification

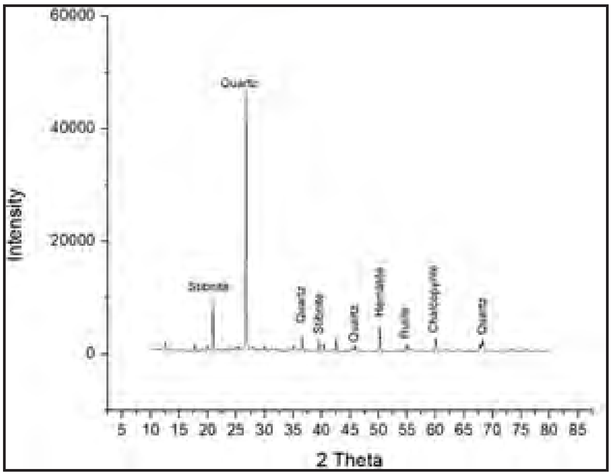

Figure 7: XRD Pattern of sulphide gold ore.

Based from Figure 5, the most abundant phase in the sample is quartz (98-002-8390), SiO_2. The value of the quartz is 96.9%. The other phase detected by the XRD are Stibnite (98-001-2229), Chalcopyrite (98-001-1734), Hematite (98-006-9769), Rutile (98-001-7824) and Gold 98-006-2629with the value of <4%. ***Goodness of Fit = 7.61427, RWP value = 15.79608.***

Conclusions

A comprehensive characterization on sulphide gold ore play an important part in enhancing the up-scaling processing of gold ores. The most abundant mineral in this sulphide gold ore is quartz, followed by stibnite and hematite.

Acknowledgments

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PME-110

Physical and chemical characterisation of Malaysian sulphide gold ore from East Peninsular Malaysia

HUD MOHAMAD MUZAFFAR, SUHAINA ISMAIL, NURUL 'AIN JABIT & HASLIZA MAT SAAD

Mineral Niche Area, School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia, Penang,Malaysia
Email address: srhasliza@usm.my

Malaysia has a long history of widespread small-scale gold mining throughout the country, especially in the Central Belt of Peninsular Malaysia and highly potential region for the gold mining industry. The Central 'Gold Belt' is a 20km wide, a major N-S trend of gold mining districts that shows the important role of hydrothermal fluids in the development of gold in Peninsular Malaysia, especially in the North Pahang and Kelantan area (Khamar Shah, 2012). The Selinsing gold deposit is located in northwest Pahang, approximately 50km north of Raub Town in central Malaysia. The Selinsing deposit and other major gold deposit in the region such as Ulu Sokor, Pulai, Buffalo Reef, Penjom and Raub deposits are located to the east of the Bentong-Raub Suture Zone. Ore minerals at the Selinsing gold deposit include pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, pyrrhotite and gold. Gangue minerals include ankerite, rutile, sericite, hematite, calcite, illite and chlorite. (Makoundi *et al*., 2014). Gold is present in refractory sulfide gold ores are mainly in arsenian pyrite and arseno pyrite, where it occurs in both the chemically bonded state and as nano-size grains of metallic gold (Chen *et al*., 2002). The sulfide gold ore is a complex ore which required a specific observation and study to extract the gold from its ore due to its high economic value.

Materials and methods

In this research, the sulfide gold ore is obtained from the Selinsing Mine, located in East Peninsular Malaysia. Different type of ore will have different mineral composition. Sulphide gold ore is considered as refractory gold ore where those gold ores do not yield high recoveries in conventional cyanide leaching circuits. When gold is associated with sulfides, it can be either fully encapsulated by the sulfide particle or partially liberated, i.e. exposed on the edge of the sulfide mineral.(Chen *et al.,* 2002) The purpose of subjecting refractory sulfide gold ores to mineralogical examination is to identify the mineral composition of sulfide gold ore from East Peninsular Malaysia and to determine the associated mineral of the sulfide gold ore.

When properly characterized, sulfide complex gold ores can be efficiently processed and increase the gold recovery. The samples are raw sample which are directly collected from the High Grade Sulphide Ore stockpile at Selinsing Gold Mine, Pahang. The samples comprises of bulk rocks and soils.

The method used on the site is grab sampling by taking about 25-30 randomly chosen spots, below ½ of the stockpile height. Total weight of the sample taken is about 68.6 kg which then undergoes crushing using jaw and cone crusher to reduce the size. To obtain the representative samples, the sample were split using cone and quartering method and John's Riffle Splitter which reduce the sample down to 1.73 kg. Ring mill is used to grind the samples before it becomes suitable for characterization process. The samples are divided into bulk sample and 5 sieve size fractions: 90µm, 75µm, 50µm, 38µm and -38µm. Both bulk sample and the 5 size fractions are subjected to characterization analysis using elemental composition analysis (XRF) and phase identification X-Ray Diffraction (XRD). This enables to determine if the gold preferentially concentrated in a particular size fraction and its mineral composition.

Bulk sample are subjected to fire assay analysis, bottle roll cyanidation leach test and morphological study using

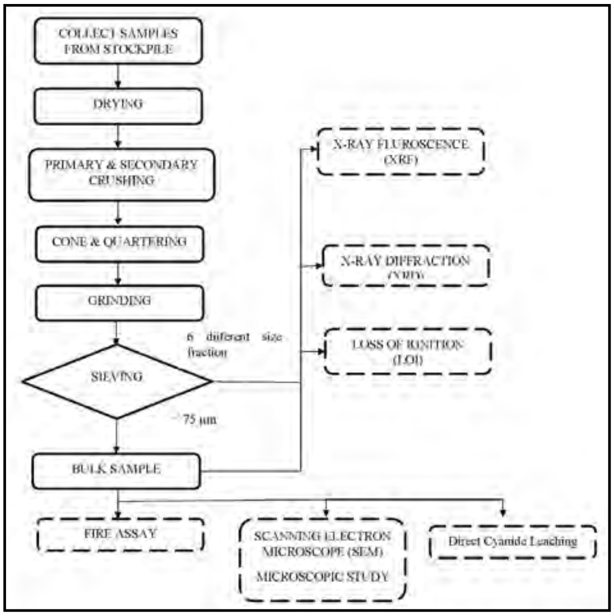

Figure 1: Overall process flow.

optical microscope and SEM/EDX of polish section. Fire assay analysis is carried out to determine the amount of bulk gold content inside the sulphide ore samples. The cyanidation leach test is used to quantify the gold that can be extracted via direct cyanidation i.e liberated gold, free and exposed after milling process. The ore samples primarily compose of quartz and K-feldspar (microcline). The main sulphide minerals are chalcopyrite, stibnite, pyrrhotite and arseno pyrites.

The gold was found associated with arsenopyrite, stibnite and quartz. The head grade was found to be in the range of 0.954 g/T based on fire assay result while direct cyanide leaching gives 83% recovery indicates that the sulphide ore sample can be classified as partly refractory.

The simplified overall process flow done during this project are as shown in Figure1.

Acknowledgements

The authors greatly appreciate to Selinsing Gold Mine, Pahang for providing materials and to Geological Society of Malaysia (GSM) for giving this opportunity to publish this work.

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PME-113

Effect of grinding additives in dry grinding of mica in planetary mill

Shafinaz Saad & Syed Fuad S. Hashim*

School of Materials and Mineral Resources Engineering
Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia
*Corresponding author email address:mrsyfuad@usm.my

Abstract: Grinding process of mica was carried on with a laboratory scale planetary mill by varying the operation variables such as grinding period, rotational speed and percentage of grinding media. The ground products were characterized by X-ray Fluorescence (XRF), Particle Size Analyzer (PSA), X-ray Diffraction (XRD), and Scanning Electron Microscope (SEM). The size reduction and structural change of mica take place simultaneously as the planetary mill produces extremely high grinding efficiency except for the extreme condition that contributes to the existence of agglomeration. SEM analysis shows that delamination and breakage mechanism took place according to the varying operation variables in the planetary mill. XRD patterns, the peak intensities tend to reduce after 40 min for both peaks chosen for analysis and this is due to the long duration of the grinding that influences the crystallinity of mica samples, micronization (size reduction) makes the structure disordered and generates crystal lattice defects. From result and analysis showed that the rotational speed give significant effect on the product produced.

Keyword: dry grinding, grinding additives

PRG-2

Structural control on karstification of three Silurian – Triassic carbonates overlying the metamorphic formations of west Peninsular Malaysia

HAREYANI ZABIDI*, NUR LYANA KHALIL, NUR EMILIA QISTINA MOHD ANUA & SYARAN SURI

[1]School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang

*Corresponding author email address: srhareyani.zabidi@usm.my

Introduction

Karst feature is a unique features that only can be found at carbonate formation and is different from one place to another. This is due to the various factors involved in karstification process that strongly effect the development of karst features. It is known that karstification is influenced by many factors such as lithology, groundwater and temperature, but it also been interpreted that geological structure is an important variables as the others. As in some cases, geological structures like faults, joints, and folds are the single most vital factor in karst features development (Waltham *et al.*, 2005). As in Waltham & Fookes (2003), historical geology (structural geology and sedimentation) and climate are the combination that greatly give impact to the karst classification system and karst complexity level increases as in heavily tectonized rock.

A number of researchers had studied about the great relationship between development of karst features and geologic structures – Andre & Rajaram, 2005; Ford & Williams, 2007; Palmer, 2007; Sauro *et al.*, 2013; Shanov & Kostov, 2015; Sissakian *et al.*, 2016. Despite progresses in understanding of structural control on karst development, there are still lack of studies about it here in Malaysia even though carbonate formations are in many scattered localities. The nearest study been documented was by Zabidi *et al.* (2016) that concluded the limestones are highly fractured and all karstic surfaces at the three different limestone formations were consistently developed along the joint set orientations.

Most of the limestones are mainly characterized by unfavorable structural conditions such as fracturing and jointing. Therefore, this study is aimed to identify geological structures that control the karstification process of three selected carbonate formations as well as their geological characteristics (age, lithology and sedimentology).

Methodology

Three main rock formations have been selected for this study which located in western belt of Peninsular

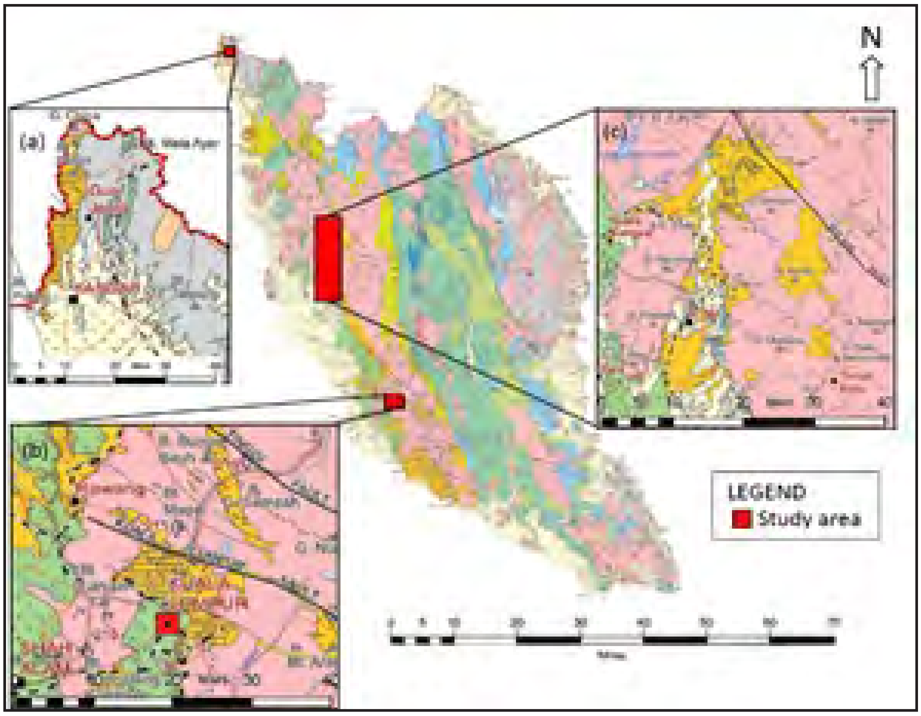

Figure 1: Location of studied areas, two sites of quarries and one tunnel site.

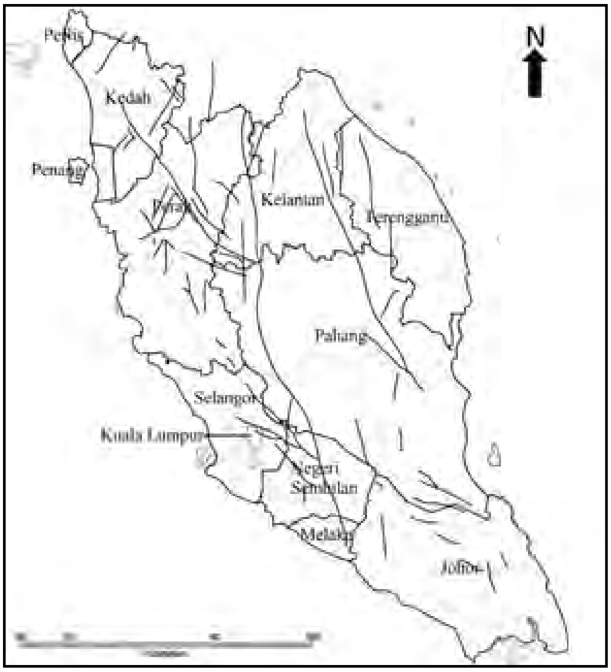

Figure 2: Modified structural pattern of Peninsular Malaysia.

Malaysia that are Chuping Limestone Formation, Kinta Limestone Formation and Kuala Lumpur Limestone Formation. Case study was specifically taken at limestone quarries in Perlis (Chuping Limestone) and Kinta Valley, Perak for Kinta Limestone while for Kuala Lumpur Limestone was taken at Stormwater Management and Road Tunnel (SMART) tunnel site. These three carbonate formations had undergone karstification and have many fracture systems and joints. For these reasons, the structures need to be identified to know whether it control the karstification process or not.

For sites data, detailed structural mapping were carried out at each selected localities of the three limestone formations. During the mapping, detailed orientation measurement (dip direction and dip angle) of discontinuities and karst surfaces were taken. The discontinuities are including joint, bedding, fault and vein. The accumulation of the discontinuity directions are displayed by using rose diagram, so that the dominant directions are easily been figured out.

Karstification

Chuping Limestone Formation, Kinta Limestone Formation and Kuala Lumpur Limestone Formation are aged from Silurian to Late Triassic, white in color, pure

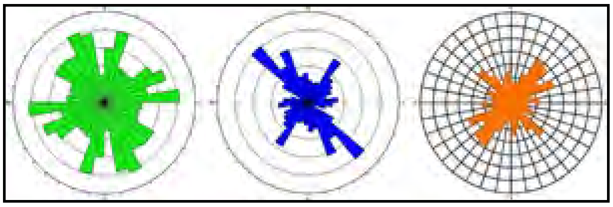

Figure 3: Rose diagram of discontinuity orientations for (a) Chuping Limestone Formation; (b) Kinta Limestone Formation; (c) Kuala Lumpur Limestone Formation

in composition, fined grain, and deposited in shallow marine shelf environment. Each formations had undergo several deformation phases and it is believed to happen at the same period. Deformation become the origin of the present existed structures. All of the limestone formations were trending accordance to the deformation and dominant regional structures of Peninsular Malaysia (Figure 2).

The discontinuities of these limestones preferential oriented dominantly at N030°-N070°, N080°-N090°, N100°-N120°, N130°-N140° to N150°-N170° (Figure 3). Karst orientations were developed along with discontinuity orientations, especially in N010°-N020°, N040°-N060°, N080°-N090° and N120°-N160° directions. This conclude that structures controlled the karstification process at the three western belt limestone formations.

Acknowledgements

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The geology of Kudat Peninsula, Sabah: New insights from field geology and subsurface interpretation

NABILAH MOHAMED ZAINUDDIN*, SITI NUR FATHIYAH JAMALUDIN, CHOONG CHEE MENG & MOHD SUHAILI ISMAIL

Geosciences Department, Universiti Teknologi PETRONAS, Malaysia
*Corresponding author email address: nabilahzainuddin21@gmail.com

Kudat Peninsula, part of northern Sabah is a structurally complex province believed to be influenced by the rifting and opening of the South China Sea, Sulu Sea and Celebes Sea. Several episodes of deformation had impacted northern Sabah forming faults, folds, and fold-thrust belt shaping the basin present today. It is also believed that these events had eventually formed the chaotic unit of Ophiolite, Crocker and Kudat Formation forming a Mélange zone (Tongkul, 1990) commonly found in this region.

Technical approach for this study includes field observation, sample collection, age dating, and subsurface interpretation based on the onshore seismic data. Detail outcrops descriptions involving 82 outcrops on the lithology and structural measurements of beddings, faults, and folds found in Kudat Peninsula were observed. Complimenting these data are the seismic line acquired in the onshore of Kudat Peninsula for the detail subsurface interpretation. Onshore acquisition had produced seismic data with higher noise to signal ratio, thus, an improvement was done to these seismic data by applying structural smoothing attribute to increase the continuity of the reflector (Abdul Latiff *et al.,* 2015).

Tajau, Sikuati and Gomantong members of Kudat Formation consist of interbedded sandstone and mudstone. The thick sandstone beds in the Northern Kudat terrane, known as Tajau member has early to middle Eocene calcareous nannofossils (Rahim *et al*., 2017). The mélange zone appeared as a strip, bounded by major faults situated in between Tajau and Sikuati Member (Figure 1). The mélange is made up of an intensely deformed mixture of Ophiolitic Basement rock (Clennell, 1991) and present in the form of knockers and lens-shaped phacoid structures. This knocker is referred as a boulder of chaotic unit comprising of red chert and red mudstone. Presence of *Cyclicargolithus floridanus* (NN6) and other associated nannofossils in the mudstone of the Mélange unit is dated Middle Miocene in age. Paleoecology of these nannofossils is shallow marine environment.

Structural analysis reveals Kudat Formation has intensively folded strata in all members, having similar bedding direction of NE-SW to NNE-SSW and NW-SE. Figure 2 shows the conceptual cross- section from South to North of the peninsula. The major rock formations or members are bounded by major strike-slip faults and thrust faults. Within the major faults, several thrust faults occur due to the abrupt changes in the beddings orientation and presence of small-scale folds.

Referring to the cross-section in Figure 3, Mélange zone is found in between Tajau and Sikuati Member and in the Crocker Formation. Hypothetically, these exposed Mélange rocks originated from the older basement rocks that had been imbricated and deformed forming a chaotic unit.Moreover, repeated occurrence of the Mélange unit in the younger formations indicates that the basement rock deposited closed to these formations, where possibly Kudat Formation is lying on top of the basement rock as shown in Figure 3.

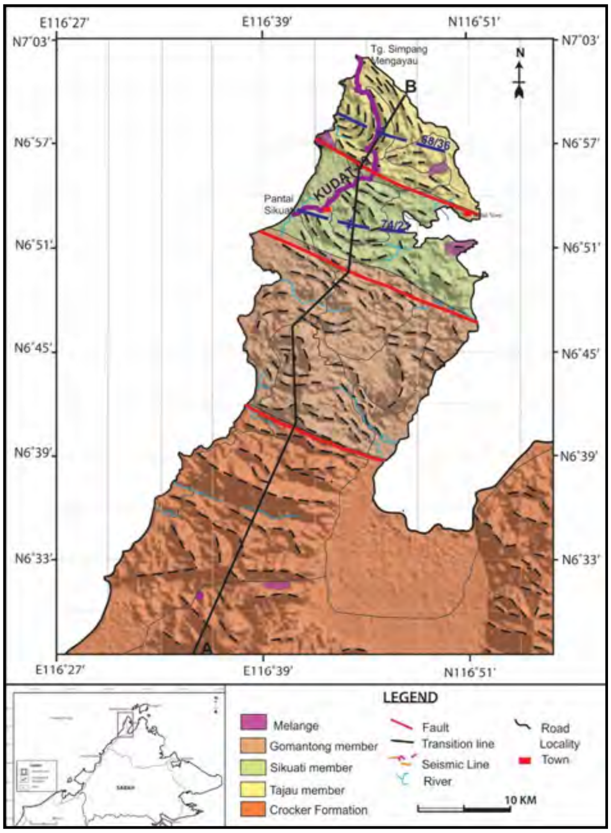

Figure 1: Geological map of Kudat Peninsula comprising Crocker Formation, and Tajau, Sikuati and Gomantong Member of Kudat Formation. The geological cross section is from A to B.

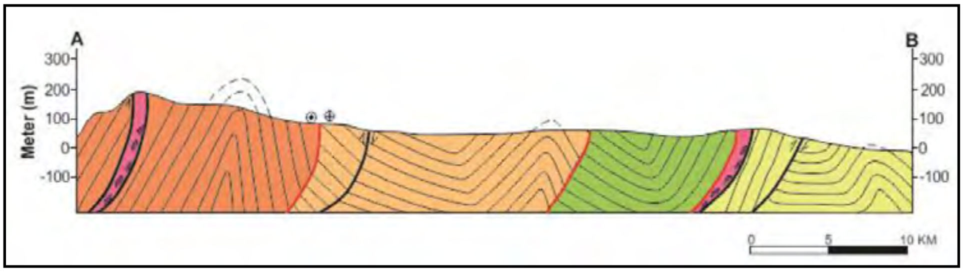

Figure 2: Cross-section from South (A) to North (B) of Kudat Peninsula.

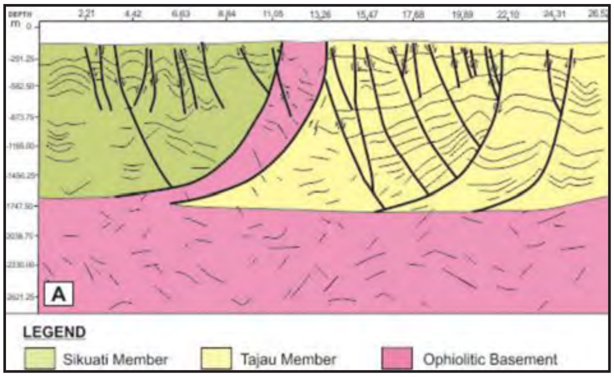

Figure 3: Seismic interpretation of onshore seismic line 9 located in the north of Kudat Peninsula.

Conclusion

Kudat Peninsula is underlain by the Ophiolitic Basement, Kudat Formation, and Mélange unit. All three members of Kudat Formation consist of interbedded sandstone and mudstone. Middle Miocene Mélange unit found in the northern and southern part of Kudat Peninsula is made up of a mixture of older rocks which had been moved by the reverse faults and uplifted to the surface, in the form of a chaotic deposit. The main bedding trend of the structures in Kudat is in the direction of NE-SW to NW-SE. Comparison between the geological cross- section of Kudat Peninsula with onshore seismic interpretation gave a new insight on the geology of Kudat Peninsula, which possibly showing that Kudat formation is sitting on top of the Ophiolitic basement and the Mélange unit found in Kudat Peninsula is originated from this basement rocks.

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Quaternary biostratigraphy of borehole sample (BH1) from Pontian, western Johor, Peninsular Malaysia

ABDUL HADI HASHIM[1,2,*], HABIBAH JAMIL[1], ZAINEY KONJING[2] & RAMLAN OMAR[1]

[1]Geology Programme, School of Environmental and Natural Resource Sciences, Faculty of Science and Technology,Universiti Kebangsaan Malaysia
[2]Orogenic Resources Sdn Bhd, Selangor, Malaysia
*Corresponding author email address: a.hadi.hashim@gmail.com

Johor is one of the state of Malaysia with the longest coastline-facing the South China Sea in the east, the Strait of Malacca in the west and the Strait of Johor in the south. Early geological study of Quaternary in this area was done by Bosch (1988) and Tjia & Sharifah Mastura (2013). Descriptions of Quaternary deposits in this area are as follows; the coastal plain of western Johor which is underlain largely with marine clay, silt, and peat deposits of Holocene age. On the seaward side, the coastal areas are almost entirely covered with marine clay and silt that extends as far as 30 km inland along several river valleys. Marine clay and silt sequence contain shells and fine sand laminae whilst upper part of the sequence contains abundant plant remains and wood fragments. These signifies deposition ranging from shallow to marginal marine, intertidal mudflat and mangrove to shallow coastal swamp environment. Extensive peat deposits are common (thickness up to 6 m) on the inland side on the coastal plain. In most areas, the peat is underlain with marine clay and silt. There is also a granite body located adjacent to Batu Pahat where marine sand ridges can be found in its southern and eastern margins (up to 8 km long and 300 m wide). Terrestrial deposits of sand, silt and clay are found in the valleys penetrating inland. Preserved biological indicators such as pollen, foraminifera, radiolaria and others has been applied to Quaternary deposit in South East Asia region in gaining deeper understanding of its paleo-environment (e.g. Wang *et. al*., 2000; Woodroffe, 2005). This paper presents the results of biostratigraphic analysis from 40 meters depth borehole sample labelled BH1 from Pontian District, western coast of Johor (Figure 1). The study focusses on foraminiferal analysis aided with palynology to provide new insight about paleoenvironment and sea level change especially during Holocene. This also was done by conducting direct correlation with corresponding lithology. Foraminiferal studies on the BH1 core yield a diverse assemblage of the foraminifera in the Quaternary comprises a total of 30 genera of benthic species. Foraminiferal assemblage shows significant variations in overall abundance pattern with increasing core depth. In general, benthic forms dominate all over the record. Amongst which the genus *Asterorotalia* dominates in most of the samples followed by *Pseudorotalia* and *Quinqueloculina* taxa. Echinoid spine and ostracod remnants are common in the

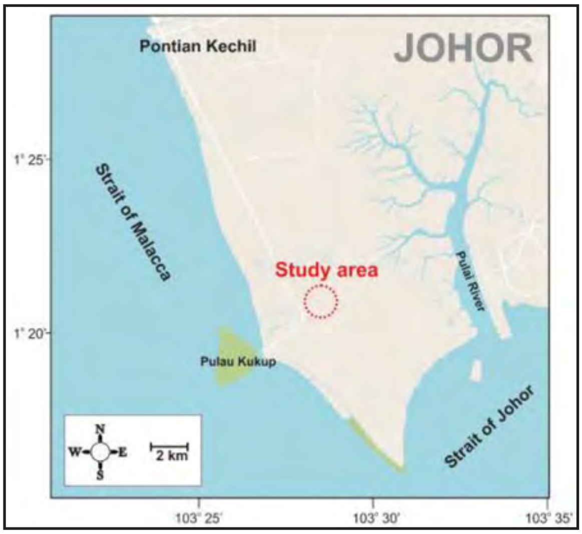

Figure 1: Study area in Pontian, Johor.

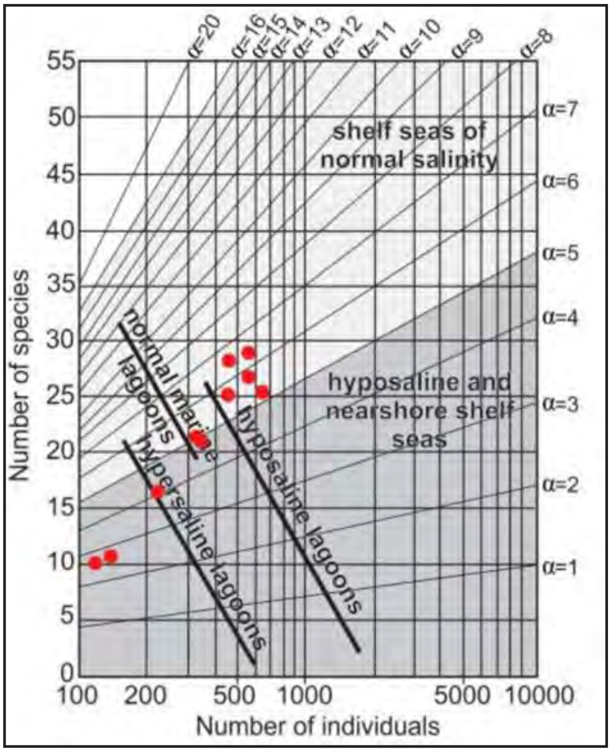

Figure 2: Plot illustrating BH1 environment based on number of species and number of individual (after Wright, 1972).

core samples. Based on the abundance patterns, BH1 core indicate a range of marine conditions namely hypersaline lagoons, normal marine and shelf seas of normal salinity (Figure 2). Palynological analysis from samples BH1 reveals significant abundance of mangrove pollen notably *Rhizophora* with common understorey species represented by *Polypodium* and *Acrostichum aureum.* Several species occur regularly which include *Excoecaria aggallocha*, *Asplenium* sp. *Stenochlaena palustris, Sonneratia* sp. and *Bruguiera* sp. Other species that originated from peat swamp were also recorded such as *Campnosperma, Zalacca*, *Cystostachys* and *Cephalomappa* with moderate occurrence of palm pollen. Direct indication of sea level change is given by overwhelming percentage of *Rhizophora* pollen corresponding with occurring of thick clay. There is also close correlation between mangrove pollen and foraminifera assemblages recorded from the borehole sample. This is shown by the increasing pattern of Miliolid group which includes *Quinqueloculina* and *Triloculina* coincides with increasing percentage of *Rhizophora.* Drastic increase in abundance of *Quinqueloculina* sp. along with *Pseudorotalia* sp. indicates brackish to marine conditions which suggest initial phase of transgression into the basin.

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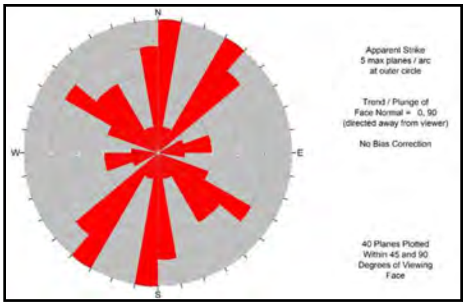
Tanah runtuh cetek di Bukit Fraser, Pahang

Abdul Qayyum Jalal, Mohd Hariri Arifin & Nor Shahidah Mohd Nazer

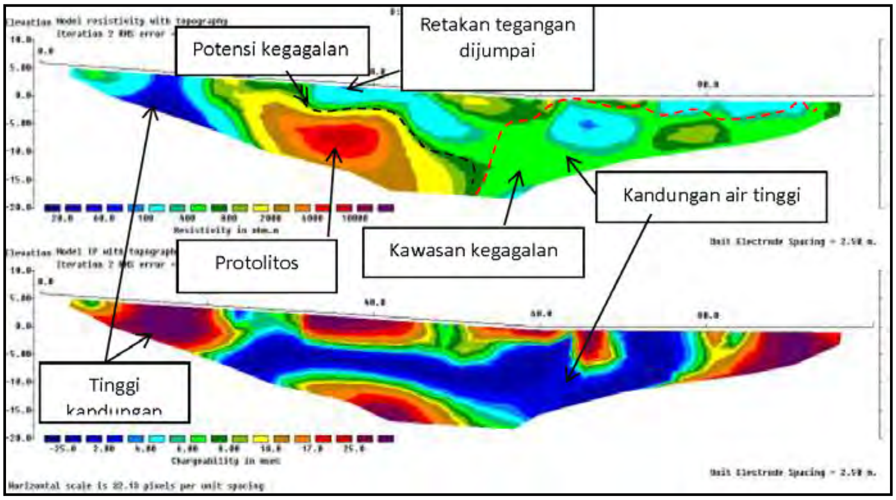
Pusat Sains Bumi dan Alam Sekitar, Fakulti Sains & Teknologi, Universiti Kebangsaan Malaysia, 43600, UKM Bangi, Selangor, Malaysia
*Corresponding author email address: shahidahnazer@ukm.edu.my

Masalah kestabilan cerun di sekitar Bukit Fraser semakin membimbangkan di mana 22 tanah runtuh cetek telah dikesan setakat 6 Ogos 2017. Pengaruh topografi memainkan peranan penting apabila kedudukannya yang terletak di kawasan tanah tinggi dengan morfologi lembah dan perbukitan mendorong kepada hakisan angin dan air secara langsung terhadap permukaan lereng bukit. Sebanyak enam cerun dipilih bagi mengkaji aspek geologi kejuruteraan tanah cerun cetek yang gagal. Kaedah keberintangan geoelektrik dan pengkutuban teraruh pula digunakan bagi mendapatkan gambaran sub-permukaan cerun yang gagal dari pandangan 2-Dimensi. Berdasarkan analisis geologi struktur, kawasan ini mempunyai tiga set lineamen utama berorientasikan Utara-Selatan, Timur Laut-Barat Daya, dan Barat Laut-Tenggara (Rajah 1). Satu set lineamen yang minor pula berkedudukan Timur-Barat. Sistem salirannya bercorak reranting ke sub-reranting dan kebanyakkan mengalir ke arah Barat Laut, Timur Laut dan Selatan. Berdasarkan penilaian terhadap aspek geologi kejuruteraan cerun, cerun 1 ditafsirkan mengalami kegagalan secara gelinciran tanah jenis putaran disebabkan oleh set ketakselanjaran dan muka cerunnya terlalu tegak (74º). Kegagalan cerun pada cerun 2 pula disebabkan oleh resapan air longkang yang terperangkap di dalam tanah. Jatuhan tanah telah berlaku pada cerun 3 disebabkan potongan cerun yang tegak (75º) dan kedudukannya pada zon ricih. Dua aliran debris telah berlaku pada lokasi berbeza iaitu masing-masing pada cerun 4 dan cerun 5. Cerun 4 telah gagal berpunca daripada larian air bawah permukaan manakala cerun 5 gagal kerana kewujudan laluan air bawah tanah berserenjang dengan alur cerun tersebut yang merupakan sebuah lembah tergantung (Rajah 2). Cerun 6 pula berkedudukan di atas potongan sesar dan dibina terlalu tegak (76º). Kegagalan cerun ini adalah gelinciran tanah jenis translasi. Berdasarkan analisis saiz butiran, cerun 1 dibentuk oleh pasir berlodak manakala Cerun 4 pula adalah pasir berlumpur. Bagi cerun 2, 3, 5 dan 6 pula dibentuk oleh pasir berlodak bergred buruk (Jadual 1). Berdasarkan penafsiran rajah *pseudo* 2-Dimensi



Rajah 1: Set-set lineamen utama di Bukit Fraser.

Rajah 2: Cerun 5 a) Bahagian atas cerun b) Aliran debris menuruni cerun sepanjang alur lembah tergantung.



Rajah 3: Gambar rajah *pseudo* 2-dimensi cerun 5.

Jadual 1: Pencirian tanah baki di cerun 1, 2 dan 3.

Cerun	*Cerun 1*	*Cerun 2*	*Cerun 3*	*Cerun 4*	*Cerun 5*	*Cerun 6*
Had cecair (%)	37.2	27.5	25.50	32.1	37.30	34.5
Had plastik (%)	33.45	23.25	24.11	21.75	28.14	30.3
Indeks keplastikan (%)	3.75	4.25	1.39	10.35	9.16	4.2
Pengelasan butiran halus	Lodak (Keplastikan sederhana)	Lodak (Keplastikan rendah)	Lodak (Keplastikan rendah)	Lempung (Keplastikan rendah)	Lodak (Keplastikan sederhana)	Lodak (Keplastikan rendah)

(Rajah 3), kewujudan bahan tinggi kandungan air terdiri daripada lodak dan pasir bernilai kurang 100 Ωm dapat dicerap pada hampir semua kawasan sub-permukaan cerun. Kehadiran bahan berlodak memperlihatkan nilai kebolehcasan yang tinggi iaitu melebihi 10 milisaat dan sebaliknya bagi bahan berpasir. Keseluruhannya, cerun-cerun di Bukit Fraser mengalami kegagalan jenis tanah runtuh cetek disebabkan oleh faktor sudut potongan cerun yang amat curam, jasad cerun yang telah sepenuhnya terluluhawa kepada tanah baki bergred VI, kehadiran air yang tinggi di dalam jasad cerun berlodak dan berpasir, serta morfologi cerun yang terdedah kepada agen hakisan sehingga mendorong kepada peningkatan resapan air hujan yang bertindak melemahkan struktur tanah.

Durability characterisation of weathered sedimentary rocks using slake durability index and jar slake test

WONG JIA MANG & ABDUL GHANI MD RAFEK

Department of Geoscience, Faculty of Science & Information Technology, Universiti Teknologi PETRONAS, 32610, Seri Iskandar, Perak
Email address: jia_16001961@utp.edu.my; ghani.rafek@utp.edu.my

Weathering causes the rocks to loose their original strength and can cause an increment in slaking. This causes a limitation to obtain rock samples for physical and mechanical rock tests. Furthermore, weathering of heterogeneous sedimentary rock mass produces a non-systematic weathering profile that is dependent on the characteristics of the unweathered, interbedded sedimentary sequence. In this case, slake durability test has been applied to quantitatively evaluate the rock's strength. Its advantage is in the simple test procedures which requires only small size of rock block samples. Slake durability index (Id2) of weathered soft rocks is influenced by the degree of weathering (Agustawijaya, 2004). In addition, Mohamad *et al*. (2011) stated that jar slake test can also be applied to measure durability of weak rocks. Thus, in this study both slake durability and jar slake tests have been applied to characterise a sedimentary rock mass weathering profile. The study was conducted in Kati Formation of Carboniferous to Permian age that consists of slightly to completely weathered sedimentary rocks. The outcrop is located along the road A164 from Parit to Kuala Kangsar (N04º32', E100º56'). Slake durability test was done according to the standard method proposed by ISRM (2007) and ASTM (2004) while jar slake test was conducted according to Santi (1998). Although many researchers such as Martinez-Bofill *et al*. (2004) recommended that the slake durability test of up to five cycles is more appropriate, two cycles is actually enough as there is constant changes in the slake durability graph and the completely weathered rocks with high slaking cannot be determined up to five cycles. The final laboratory results were classified using slake durability classification based on Franklin & Chandra (1972) and also weathering grades of the rocks as shown in Table 1 and 2. Results show that the durability decreases with increasing weathering. However, presence

Table 1: Laboratory test results for sandstone.

Weathering Grade	*Average Id2 (%)*	*Classification based on Franklin & Chandra (1972)*	*Jar Slake Test*
Completely weathered sandstone	0.3	Very low	Completely breakdown to mud
Completely weathered sandstone with iron staining	15.0	Very low	Breaks rapidly and form many chips/ develop new fractures
Highly weathered grey sandstone	22.0	Very low	Sample fractures create chunky material
Highly weathered iron banded fractured sandstone	46.0	Low	No change
Highly weathered iron recemented sandstone	67.0	Medium	No change
Slightly weathered sandstone	87.0	High	No change
Slightly weathered iron recemented sandstone	98.0	Extremely high	No change
Fresh grey sandstone	91.0	Very high	No change

Table 2: Laboratory test results for mudstone and chert.

Weathering and Rock Types	*Average Id2 (%)*	*Classification*	*Jar Slake Test*
Completely weathered mudstone	2.0	Very low	Completely breakdown to flakes
Highly weathered mudstone	12.0	Very low	Breaks slowly and develops few fractures
Moderately weathered mudstone	68.0	Medium	No change
Slightly weathered shale	83.0	High	No change
Slightly weathered chert	98.0	Extremely high	No change

of iron staining and iron recementation increase the rock durability. Completely weathered sandstone has the mean second cycle slake durability index, Id2 of 0.3 % to 15.0 %, highly weathered is from 22.0 % to 67.0 %, slightly weathered is 87.0 % to 98.0 % depending on the presence of iron recementation and fresh sandstone is 91.0 %. For mudstone, mean Id2 for completely weathered is 2.0 % while highly weathered mudstone is 12.0 %. Moderately weathered mudstone has an average value is 68.0 %, slightly weathered shale 83.0 % and slightly weathered chert has the average Id2 of 98.0%. Jar slake test has the advantage to classify the highly weathered to completely weathered sandstone and mudstone into higher slaking properties. Completely weathered rocks have higher slaking properties where the rock samples breakdown completely. For highly weathered rocks, the breakdown is into chips and fractures. Jar slake test is suitable only for weathered rocks with slake durability value, Id2 below 25 %. Jar slake test using tap water shows no changes to the rocks from fresh to moderately weathered.

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Fracture and faults in vicinity of dolomitization zones of Kinta Valley, Perak, Malaysia

Nurul Afiqah Mohammad Zahir, Askury Abd Kadir & Jasmi Abd Talib

Department of Geosciences, Faculty of Science and Information Technology,
Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak
Email address: afiqahzahir94@gmail.com; askury_akadir@utp.edu.my; jasmi_atalib@utp.edu.my

Since the 19th century, Kinta Valley had numerous companies operated on mineral resources such as tin, limestone and dolomite. Thus, a lot of studies have been made especially on the Kinta Limestone which acted as the main target of natural resources.

Dolomitization is one of the processes in carbonate rocks which may change their original petrophysical characteristics (Al-Awadi, 2009). From previous studies, to fulfil few conditions as an agent of dolomitization, a lot of models had been proposed (Morrow, 1982). Machel (2002) have stated that these parameters such as fluid chemistry, kinetics factors, hydraulic gradient, host rock permeability and the time of formation are the major parameters that control this process.

From previous studies of Kinta Valley, dolomite in Kinta Valley is massive and highly fractured, which is believed to be the factors that contributed to dolomite formation (dolomitization). Besides, these fractures also play a crucial role to control the flow of fluids and its distribution.

Dolomite bodies are commonly found in Kinta Limestone. However, no studies have been made about the origin of dolomite. Fluids originating from magmatic water or hydrothermal fluids seeped through deep-seated fault and altered the limestone to dolomite bodies (Pirajno, 2009).

Thus, to understand the mechanism of fluid conduits flow, structural analysis was carried out to determine the major trend of these structures and the fault-type that might correspond to the dolomite formation. This would render the research team to study the fault or fracture of the limestone that is associated with dolomitic bodies.

In this study, there are four study areas to investigate the formation of dolomite in Kinta Limestone, which is Sungai Siput Quarry, Kek Look Tong, Anting and Lafarge Kathan quarries (Figure 1). By using the scanline method, all structural reading was taken to ensure the systematic fractures data can be expressed.

From the results, fractures trend is dominant with medium to high dipping in NW-SE and NE-SW direction

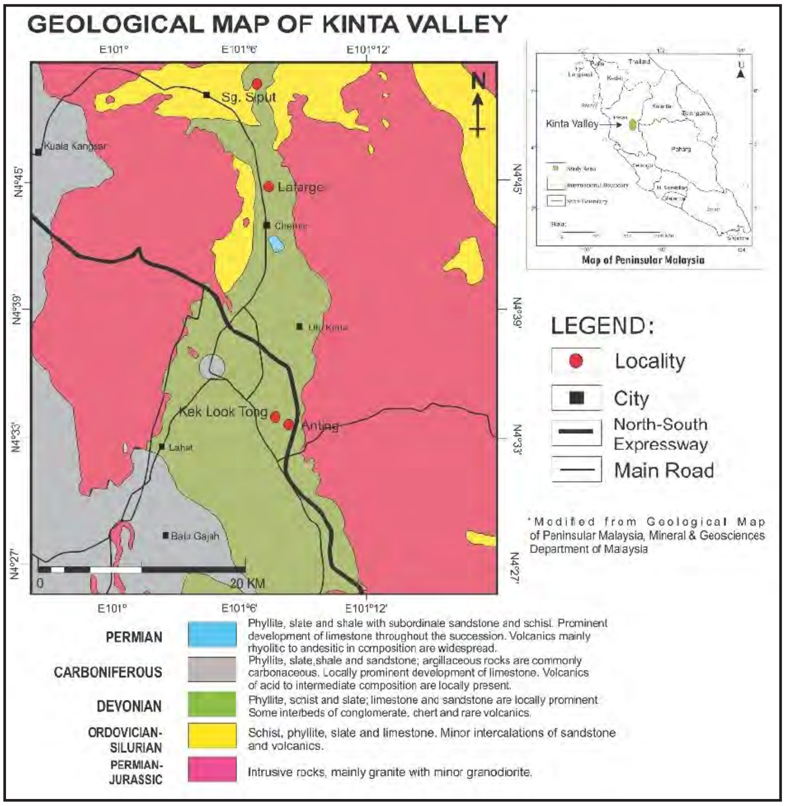

Figure 1: Geological map of the Kinta Valley and the localities of the study. (Modified from Geological Map of Peninsular Malaysia, Minerals & Geosciences Department of Malaysia).

Table 1: Dolomite orientation with the possible fault-type of the study area.

Locality	*Fracture Trend*	*Fault-Type (Possible)*	*Direction (Fault-Type)*	*Dolomite Orientation*
Anting		L-SSF	NW-SE	~294/84, NW-SE
Kek Look Tong	NW-SE	SSF	NW-SE	~320/90, NW-SE
Lafarge	NW-SE, NE-SW, N-S	R-SSF, L-SSF	NW-SE, N-S	163/64, NW-SE
Sungai Siput	NW-SE, NE-SW	NF	N-S	*unrecognizable

(Table 1). Most of the fault-type and dolomite orientation in the study area show a NW-SE direction (Table 1) which is probably a possible source of hydrothermal fluids conduits for dolomitization in the Kinta Valley.

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PGH-81

Evaluation of tunnel interaction in Kenny Hill Formation using finite element modelling

Darvintharen Govindasamy, Mohd Ashraf Mohamad Ismail & Mohd Faiz Mohammad Zaki

School of Civil Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
Email address: darvin.intharen@yahoo.com; ceashraf@usm.my; faizzaki@student.usm.my

Abstract: The number of town population growth is the reason for the expansion of transportation and infrastructures in metropolitan cities. Due to that urban tunnelling is turn out to be common in the most area. Considering the environmental impacts, going underground become a feasible choice for the development of transportation. But, when dealing with urban tunnelling always meet with complex mechanism due to soil interaction between ground and tunnels. Tunnelling problem must be considered as a three-dimensional problem. However, we can simulate the three-dimensional plane problem into a two-dimensional plane problem by considering certain assumption which governs the missing dimension. This paper is to show the simplified method for ground settlement prediction of tunnelling excavation using the PLAXIS 2D software. The two simplified methods are lining contraction and stress reduction method. The comparison between these two methods is described in this paper in terms of contraction ratio and unloading factor which can be used for tunnelling problems. This study was done in the Kuala Lumpur Kenny Hill Formation basically based on geotechnical data of Klang Valley Mass Rapid Transit (KVMRT) system. Hardening soil model chooses as the constitutive model for this analysis because of it able to represent the actual soil behaviour compared to Mohr Coulomb Model. The effectiveness of simulation using these two methods was verified with the monitored ground movement data. A relationship between these two methods was formed as the outcome of the study.

Keywords: Lining contraction, stress reduction, Kenny Hill Formation, hardening soil model, tunnelling

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PGH-93

Assessment of supporting system of Hulu Terengganu hydroelectric surge chamber cavern in Malaysia

Onimisi A jimoh, Shehu Shaib Abdulazeez, Mochamad Trisugiwo & Hareyani Zabidi*

School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia, Engineering Campus, 14300 Nibong Tebal, Pulau Pinang, Malaysia
*Corresponding author email address: srhareyani.zabidi@usm.my

Abstract: When rocks are excavated, the in-situ stress is disturbed and thereby causing a state of instability due to the deformation caused by the creation of space in the in-situ rocks. This research assessed the supporting system used in a surge chamber cavern excavated for Hulu Terengganu hydroelectricity project in the northwest of Peninsular Malaysia. The results obtained were compared with the installed supports. Geological mapping of the excavated region was carried out to outline the discontinuity parameters of the rock. The rock mass quality (Q), the rock mass rating (RMR), the geological strength index (GSI) and the uniaxial compressive strength were evaluated using standard methods and procedures. The strength and rock mass properties were further used to classify the rock and establish the required standard supports for the surge chamber cavern. The wall height is approximately 40m. It requires systematic bolting with 7 to 11m length of rock bolt at a maximum wall spacing of 1.5m. The required reinforce shotcrete falls within a thickness of 50-90 mm. The currently installed shotcrete is within the minimum of 50mm thickness and has a spacing of 3.0m along the wall which is too large for reliable safety. The cavity of the crown is critical and to consider unforeseen geological weaknesses in rock mass, maximum safety must be ensured by increasing the current thickness of the shotcrete and reducing the spacing to a maximum of 1.5m as evaluated using the rock mass properties.

Keyword: Rock mass rating, geological strength index, deformation, shotcrete, cavern

PGH-96

Rock slope discontinuity extraction from 3D point clouds: Application to an open pit limestone quarry

Syaran Suri, Hareyani Zabidi, Aisyah Shahirah Juhari, Solihin Yaacob & Nur Emilia Qistina Anua

Mineral Resources Engineering, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
Email address: syaransuri@gmail.com; srhareyani.zabidi@usm.my

Abstract: Discontinuities dominantly play a key role in the mechanical, hydraulic and deformational behavior of rock masses, frequently having a considerable influence on the stability of rock slopes. Thus, it is importance to have a profound knowledge about the discontinuity network in rock engineering. Meanwhile, quarry is a common place for instability of the rock slope happens due to the activities on site such as excavation and blasting. These activities eventually create fractures, faults, and joints. Traditional measuring techniques are prone to human bias and provide only a rough knowledge about the discontinuity network. To increase the reliability of discontinuity models, digital mapping techniques such as Structure from motion (SfM) using data from Unmanned Aerial Vehicle (UAV) and remote sensing, like Close-Range Terrestrial Digital Photogrammetry, were developed. This paper focuses on the plane identification within 3-D point clouds using Discontinuity Set Extractor (DSE) in MATLAB® (The Mathworks Inc.). The 3-D point cloud is generated with the program Agisoft PhotoScan Professional digital photogrammetry software (version 1.1.6) from photos using UAV method. To verify the plane identification with MATLAB® the results were compared with manual mapping. Rosette plot of both methods show the same direction but different in quantity of the discontinuities set. The most dominant direction is N330˚ - N340˚ on NNW-SSE. While, the least dominant discontinuities orientation happens to occur at E-W with the direction of N080˚-N090˚.

Keywords: Open pit quarry, discontinuity, point clouds, UAV

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PGH-97

Slope stability assessment in opencast quarry – An UAV approach

NUR EMILIA QISTINA MOHD ANUA, HAREYANI ZABIDI, AISYAH SHAHIRAH JUHARI, SOLIHIN YAACOB & SYARAN SURI

Mineral Resources Engineering, School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang
Email address: nuremilia56@gmail.com; srhareyani.zabidi@usm.my

Introduction

The unfavourably oriented discontinuities with respect to the slope cutting orientation may results in instabilities or rock slope failure. The major factor that controls the rock slope stability is the geological factors. The role of geology on slope problems and assessment is variable, depending to the subsoil constituent and structures itself. Rock slope stability is defined as a process whereby slopes are stabilized against the possibility of instability for both cut and natural slope (Kamaruszaman & Jamaluddin, 2016).

The exploitation activity can causes various type of instabilities in open pit quarries, especially when the development schemes do not depends on scientific process (Guadri *et al.*, 2015; Hadji *et al.*, 2016). In geo-mining literature, main used methods to assess the slope stability of rock mass in open cast mines are kinematic analysis, limit equilibrium calculation, and rock mass classification system. They controlled by mechanical parameter, geological conditions, geometrical design, and discontinuities characteristics (Brady & Brown, 1993).

The purpose of this study is to assess the stability of the limestone quarry slope at Hume Cement Quarry for safety purposes by using unmanned aerial vehicle (UAV) or drone. Hume Cement Quarry is an open pit quarry located in Gopeng, Perak (Figure 1) that excavate limestone to process it into cement for multi-purpose. This limestone is part of Kinta Valley Formation or known as Kinta Limestone. The length of the rock section investigated in this study is about 55m. The quarry face is almost vertical, with height of 15m. The quarry face was labelled as Window A.

Stereographic plot from the photogrammetric mapping shows 10 major discontinuity sets found at Window A. The properties of each discontinuity set is shown in Table 1. J1 (237/34) is the most dominant discontinuity set. Result of kinematic analysis with friction angle of 30° indicate that the quarry face have one most possible mode of failure which is wedge failure. The wedge failure may occur with 8 critical intersection between the discontinuity sets.

Acknowledgements

Authors would like to express their gratitude towards all of the people involved in this research. This study is supported by FRGS (203.PBAHAN.6071361).

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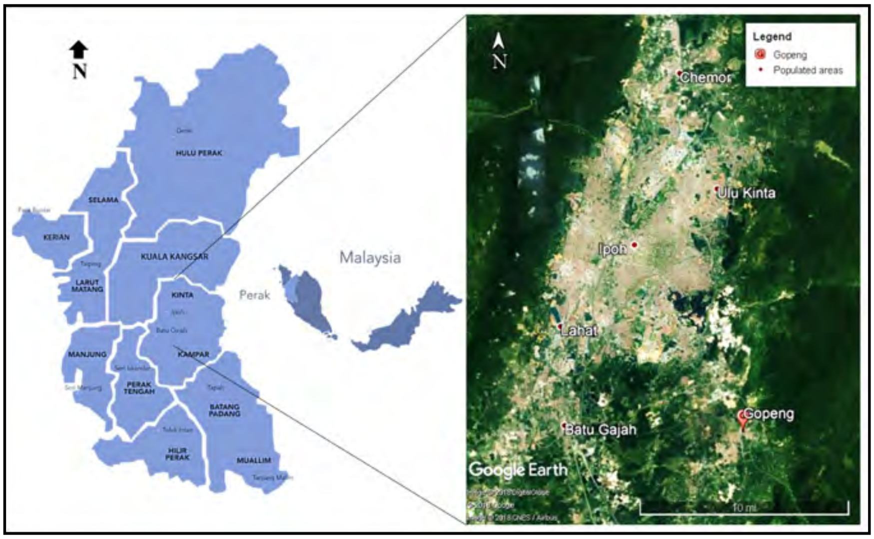

Figure 1: Location of Gopeng in Perak from Google Earth (15/8/2018).

Table 1: Properties of major discontinuity sets.

Discontinuities joint set	*Dip direction*	*Dip*	*Number of clusters*	*Number of points*	*Density*
J1	237.52	34.49	495	430294	4.0755
J2	241.26	80.17	876	252696	0.9131
J3	65.32	88.21	597	175798	0.6382
J4	170.31	89.44	145	47771	0.4902
J5	195.75	87.94	707	41223	0.3743
J6	28.49	86.95	829	94509	0.3528
J7	185.19	76.54	583	80926	0.2802
J8	4.18	88.77	295	27113	0.2497
J9	33.11	66.35	442	42415	0.2432
J10	321.01	65.5	217	49348	0.1893

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The geotechnical properties of soft rocks of Semantan Formation at Segamat, Johor

N.H JAMIN[1], N.R AHMAD[2] & U.M.N OSTADI[1]

[1]Department of Geosciences, Faculty of Science and Information Technology, Universiti Teknologi Petronas, 32610 Seri Iskandar, Perak
[2]Department of Civil and Environmental Engineering, Universiti Teknologi Petronas, 32610 Seri Iskandar, Perak
Email address: nurhuda.jamin@utp.edu.my; niraku.ahmad@utp.edu.my; ummi.qiyaadah@gmail.com

Introduction

Soft rocks are sedimentary rocks that are generally softer than igneous and metamorphic rock with classified medium to fine grain size and it is often mistreated as soil by the non-geologists. Although sedimentary rocks tend to show behavior of soil, however their mineral compositions and fabric still intact that they should not be treated as soil but rather as soft rocks. The behavior of these sedimentary rock masses usually very anisotropic especially with the presence of flysch (Marinos & Hoek, 2001) of rhythmic alterations of sandstone and fine grained (pelitic) layer which is the typical characteristic of Semantan formation in the central belt of Peninsular Malaysia.

The study area located at Segamat, Johor focusing on two outcrops and ten rocks samples collected. The geology of the study area was recognised as Tenang beds and further decided that the extension of the Tenang beds was part of Gemas formation (Foo, 1970). Jaafar, 1976 included the Gemas formation as part of Semantan formation. In general, the Semantan formation represent a deep-marine setting environment (Metcalfe *et al.*, 2013) of Permian-Triassic successions with typically consists of thin bedded sandstone-mudstone alternations of strongly flysch characteristic (Madon, 2010). The volcanic and tuffaceous sediments also recorded widespread along the central belt (Ong, 2001) indicates the influence of tectonics and volcanic arc activities.

The complex geological processes and heterogeneous masses present a major challenge to engineers and geologist as they cannot be easily be classified using the standard of widely used rock masses classification system.

Objectives

To investigate geotechnical properties of the soft rock formation at Segamat area and correlate with the geological process and regional history.

Methodology

The methodology used in this research was divided into two parts which were the field work comprises of outcrop study and hand sample observation. There are ten samples collected from the two outcrops studied which were used in the laboratory tests of the basic geotechnical including moisture content, specific gravity, plastic and liquid limit, particle size distribution. The strength tests comprise of compaction test and unconfined compression test (UCT).

Results

The two outcrops studied showed the formation consisting heterogeneous layers of sandstone, shale, clay and siltstone. From the particle size distribution tests, all the samples have more than 50 % of percentage finer of sand particles and were poorly graded (Figure 1). The

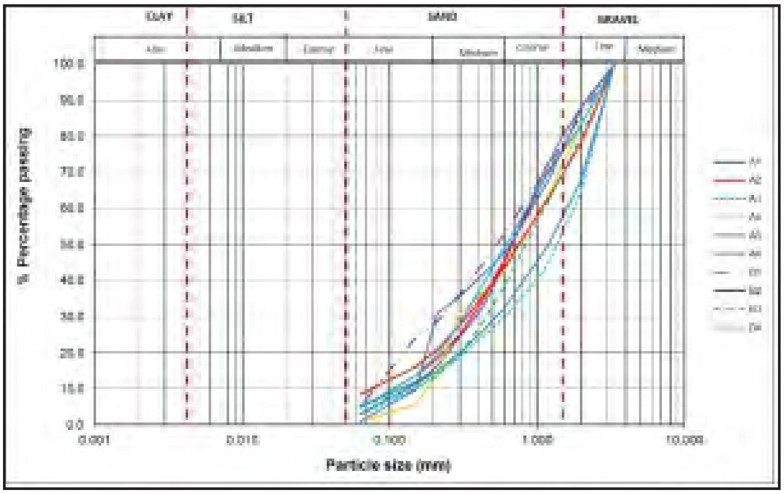

Figure 1: Particle size distributions of the ten rock samples in the study area.

Table 1: Geotechnical properties of the ten rocks samples.

Sample	Plastic & Liquid Limits			Dry density (Mg/mm3)	Optimum Moisture content (%)	UCS (kPa)
	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)			
A1	36.00	22.20	13.80	1.58	13.6	642.8
A2	46.40	33.27	13.13	1.37	16.6	868.7
A3	40.50	29.11	11.39	1.46	16	767.8
A4	54.45	36.73	17.72	1.24	26	1002.9
A5	53.10	37.81	15.29	1.23	26	956.2
A6	38.90	29.41	9.49	1.45	14.4	363.9
B1	53.80	37.65	16.15	1.28	22.5	1156.2
B2	38.90	28.73	10.17	1.42	15	1666.1
B3	48.80	33.71	15.09	1.34	22	815.4
B4	42.40	27.76	14.64	1.40	17	963.7

samples were having medium plasticity with plasticity index were in between of 10 to 20 %. The rock shows intermediate plasticity and high percentage of clay size particles which supports the hypothesis of different strength of rock with same lithology are due to different percentage of clay. The remoulded strength of Unconfined compression strength (UCS) tests was from 363.9 kPa to 1666 kPa. The inconsistency of the UCS values were to the different structure orientations from these samples (Table 1). From the SEM test, samples B1 and B4 have highly porous cellular structure and consists of irregular-shaped particles and the TOC were recorded about 5 to 7 %. Some observation of tuff in some of the samples gave a preliminary insight of possible geological process involved during the deposition were probably affected by tectonic events or volcanic activity at recent times because of the samples highly porous criteria, very low degree of compaction and loose cementation observed from the outcrop.

Conclusion

The heterogeneity and variability of strength in Semantan formation successions are the main concerns in determining their geotechnical and mechanical properties which in some cases they are too soft to be tested in rock mechanics equipment and too hard for soil mechanics equipment. Correlation on geological processes and depositional history leads to better classification and understanding of their characteristics.

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CERAMAH TEKNIK TECHNICAL TALK

Application of high-resolution telemetered sensor technology to develop conceptual models of catchment hydrogeological processes

Professor Kevin M. Hiscock (University of East Anglia)
Date: 9 August 2018 (Thursday)
Venue: Department of Geology, University Malaya, Kuala Lumpur

Professor Dr. Kevin M. Hiscock is the Head of School of Environmental Sciences, University of East Anglia (UAE), United Kingdom. He completed his PhD at the University of Birmingham on the hydrochemistry of the Chalk aquifer in north Norfolk and have extended his research interests at UEA to include the application of stable isotope methods and dissolved gases in hydrogeological investigations. He has employed stable isotopes of water and noble gases to understand groundwater recharge and flow processes and has developed nitrogen isotope methods to demonstrate the sources and fate of nitrate in several aquifer systems, both in the UK and internationally. One of his special interest has been the evaluation of the production and consumption of nitrous oxide in groundwater and the contribution by aquifers of this greenhouse gas to the atmosphere. Prof. Hiscock is the author of the popular book entitled “Hydrogeology: Principles and Practice” and he has published over 130 peer-reviewed papers. He was in Kuala Lumpur as the External Assessor for B.Sc. in Geology and B.Sc. in Applied Geology programmes of University Malaya.

In his talk, Prof. Hiscock presented the results of long-term monitoring (2012-2018) of the arable headwater sub-catchment of Blackwater in Norfolk, eastern England using telemetered in-situ sensors. He examined the relationships between rainfall–runoff, catchment connectivity, antecedent moisture conditions and fertiliser application with nitrate-N and total phosphorus (TP) fluxes. He demonstrated that although the precipitation totals did not vary substantially between years, the timing of rainfall strongly influenced runoff generation and subsequent nitrate-N and TP fluxes. The greatest fluxes only occurred when shallow ground water was within 0.6 m of the ground surface and runoff coefficients were greater than 0.1. Throughout the period, dry antecedent conditions had a temporary effect in elevating TP loads. Proportional reductions in annual riverine nitrate-N and TP loadings were not observed at the sub-catchment outlet as loadings were largely influenced by annual runoff. Nitrate loadings were slightly higher during fertiliser application, but there was little relationship between P fertiliser application and riverine TP load. These data indicate that this intensive arable catchment may be in a state of biogeochemical stationarity, whereby legacy stores of nutrients buffer against changes in contemporary nutrient inputs.

CERAMAH TEKNIK TECHNICAL TALK

Hydrocarbon retention in clastic reservoirs of NW Borneo - Examples of hydrocarbon trap, reservoir, seal and implications on hydrocarbon column length

Dr Franz L Kessler
Date: 24 August 2018 (Friday)
Venue: Department of Geology, University Malaya, K.L.

Franz is an industry geoscientist. He joined the oil industry with a PhD on mixed clastic and carbonate sequences. During his more than 30 years of industry exposure, he dealt with geophysical and regional geology challenges in Africa, Brazil, the Middle East, and SE Asia. He taught petroleum science as department head for 3.5 years in Curtin Sarawak. He believes that geological insight can only be attained through fieldwork exposure. Since 2015, Franz works as a consultant and trainer.

Abstract: Estimating the length of hydrocarbon is a tricky matter, given it requires a solid understanding of, in particular, reservoir and seal properties.

In our work (with Dr. Jong) we looked up empirical reservoir and seal data from Sarawak and Sabah, and devided these in three success patterns:

1. *Deepwater claystone seal + deepwater turbidite reservoir + gas + overpressure*

In this scenario there is little or no retention risk in relation to top seal, as long as seals are sufficiently lithified to withstand buoyancy pressure.

2. *Deepwater claystone seal + deepwater turbidite reservoir + oil + hydrostatic*

In this case oil is preferentially retained, whilst gas is removed via a regional aquifer possibly leading to small gas accumulations in updip direction.

3. *Shallow marine clay + topset reservoir + hydrostatic + oil (gas more rarely)*

In shelfal, but essentially subtidal settings, relatively thin and often bituminous clay sequences can potentially hold back significant oil and gas columns. This setting, however, is also characterized by frequent reservoir discontinuity, such that hydrocarbons are located in (at least on production scale) isolated lenses.

In conclusion, column length is a derivative of several factors affecting the integrity of a hydrocarbon trap. The presence of an effective and laterally continuous top seal is perhaps the most important enabler; relatively thin top seal can be surprisingly efficient. Contiguity of hydrocarbon reservoirs, with isotropic reservoir characteristics can be a positive factor for the development of longer hydrocarbon columns. Moreover, the overall sand-to-shale ratio is critical. Hydrocarbon columns tend to be longer in clay prone environments (sand to clay juxtaposition is here more likely; and a better fault seal due to good SGRs). On the other hand, hydrocarbon columns tend to be short in shallow marine to deltaic settings given discontinuity of reservoirs, abundance of sand and poor fault sealing. Therefore, both POS of volume and POS of long columns is far higher than in turbidite reservoir/seal associations compared to shallow marine shelfal settings.

CERAMAH TEKNIK TECHNICAL TALK

Carbon capture and storage: What are the big issues and opportunities facing the petroleum industry in Malaysia?

Professor John G. Kaldi
(Chief Scientist, Cooperative Research Centre for Greenhouse Gas Technologies; Australian School of Petroleum, University of Adelaide, Australia)

Date: 24 August 2018 (Friday)
Venue: Department of Geology, University Malaya, Kuala Lumpur

Fossil fuels such as coal, oil and natural gas, currently supply around 85 per cent of the world's energy needs, and will continue to do so for many years to come. However, the burning of fossil fuels is a major source of carbon dioxide (CO_2), the principle greenhouse gas (GHG) linked to rapid, human-induced climate change. Significant additional CO_2 is emitted from the production and separation of large CO_2–rich gas accumulations. These are common in Malaysia which has offshore gas fields having some of the highest concentrations of CO_2 in the world, ranging from 25 to 87%. These gas fields are a significant challenge to operators because the high CO_2 makes the development of most of them uneconomical. One potential solution to this challenge is the capture, transport, storage & utilization of CO_2. This talk addresses the various technologies for GHG reduction and focuses mainly on geosequestration. Also known as carbon capture and storage (CCS), geosequestration involves the long-term disposal of captured CO_2 emissions in subsurface geologic formations. Geosequestration comprises a number of steps: first, the CO_2 is captured at the source, the captured CO_2 is then transported, typically via pipeline, from the source to the geologic storage site; next, the CO_2 is injected via conventional wells into the geologic reservoir, where it is stored in the geologic reservoir, and where its movement is carefully monitored and the quantity stored is regularly verified.

The main geological conditions for the geosequestration of CO_2 include many of the same requirements as for a hydrocarbon prospect: a porous and permeable reservoir rock, a trap, and an impermeable caprock. Expertise in locating such formations is well established within the petroleum industry, and CCS geoscientists and engineers utilise existing technology to identify and assess specific sites for geosequestration. Each site is evaluated for its potential storage volume as well as to ensure that conditions for safe and effective long-term containment are present. Monitoring programs are then put in place that provide long-term assurance of the safe containment of the CO_2.

Malaysia is presently a net producer/exporter of gas but may become a net importer if an economic and environmentally sustainable method for production of its high CO_2 fields is not found. Such efforts require top quality science, appropriate regulation and acceptance by the community. Subsurface geologic storage sites need to be characterised with respect to the physical and chemical processes which will take place during and after injection. Similarly, appropriate technologies for monitoring the injected CO_2 need to be selected. In addition the risks associated with all phases of the process must be identified. These tasks will fall to geoscientists and engineers who are familiar with subsurface technologies and who have been able to become similarly well versed in geosequestration.

Report on "Regional Geoheritage Conference 2018" at Khon Kaen, Thailand

The Royal Thai Government through DMR, CCOP and the National Geopark of Thailand, in collaboration with KWGM, JMG, UKM, UPN Veteren, GST and GSM organised a Regional Geoheritage Conference 2018 from 2 to 4 April 2018 on the theme of "Geoheritage for People", held at the Pullman Raja Orchid Hotel, Khon Kaen, Thailand. Approximately 80 Geoscientist from Thailand, Malaysia, Indonesia and invited participants for the first time from Myanmar, Lao, Cambodia and Vietnam shared their knowledge and discussed technical issues on Geoheritage and Geopark setting. A total of 13 Malaysian delegates headed by Prof. Emeritus Ibrahim Komoo together with the President of the Geological Society of Malaysia, Mr. Abd Rasid Jaafar participated in the 2-day conference in Khon Kaen and a one-day fieldtrip around Phu Khum Khao and Phu Noi at Kalasin Province excavation sites. A wide spectrum of discussion was held during the conference, which were categorised into aspiring Geopark, Geoheritage, Geoeducation and Geotourism themes.

During the one-day fieldtrip, it was exciting to see the real excavation, restoration, analysis and naming procesess of vertebrate fossils of dinosaurs. Bones are scattered everywhere and the process of excavation moved at a slow pace to ensure the treasure can be preserved in a proper manner. Chisel, hammer and brush were used to reveal the fossils; followed by the moulding and wrapping of the findings. Most of the dinosaur fossils are found in the reddish brown sandstone of the Sao Khua Formation of Early Cretaceous Period, about 130 my. At one of the site, almost 70% of Sauropod bones had been discovered, and it is the most complete and well-preserved fossil in SEA. Sauropod is a herbivore and was a great-great-great grandfather of giraffes. Palaeontologist had identified one of new species of sauropod found as *Phuwiangosaurus sirindhonoe*. Two large new species of terapods were also discovered and named as *Siamosaurus suteethonni* and *Siamtyrannus isanensis*.

Prepared by,
ASKURY ABD KADIR

Dinosaur fossil in the process of excavation

An almost complete skeleton of a dinosaur.

Skeletons from excavation site for cleaning and preservation.

The first discovery of dinosaur in Thailand in 1976.

Skeleton under excavation

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Dear Members

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UPCOMING EVENTS

September 24 - 25, 2018: 2018 International Short Course on Earthquake Source and Hazard, Kuala Lumpur, Malaysia. Contact GEOTROPIK Secretariat, email: geotropik@utm.my or tel. no: 07-5531766 for details.

September 27-28, 2018: Back to the Future - the Past and Future of Oil and Gas Production in the Asia Pacific Region Conference, Bangkok, Thailand. Contact Programs Manager, AAPG Asia Pacific Region, Tel. No. +65 96536728 for information.

October 1-5, 2018: Short course on Application of Diffusion Studies to the Determination of Timescales in Geochemistry and Petrology, Ruhr-Universitaet Bochum, Germany. More details are provided at http://www.gmg.rub.de/petrologie/

October 10-11, 2018: Seismic Characterisation of Carbonate Platforms and Reservoirs Conference, London, UK. Contact email address: georgina.worrall@geolsoc.org.uk.

October 10-12, 2018: 9th International Conference on Asian Marine Geology (ICAMG-9), Shanghai. Visit https://icamg-9.tongji.edu.cn for further details.

October 13-21, 2018: 15th Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia (GEOSEA 2018), Hanoi, Vietnam. Visit website: http://geosea2018.dgmv.gov.vn for more information.

October 17-19, 2018: CYPGasTech 2018 Conference, Limassol, Cyprus. For details, visit: www.cypgastech.com.

October 28 -30, 2018: Deep and Ultra-deep Petroleum Systems: What we know and don't know (Workshop), Beijing, China. Details can be extracted from: https://www.aapg.org/global/asiapacific/events.

October 31-November 1, 2018: GSL Marine Minerals: A New Resource for the 21st Century Conference, London, UK. Contact email address: georgina.worrall@geolsoc.org.uk for information.

October 31-November 2, 2018: 5th Mozambique Gas Summit and Exhibition, Maputo, Mozambique. Visit https://www.mozambique-gas-summit.com to find out more about event.

November 4-7, 2018: International Conference and Exhibition (ICE 2018), Cape Town, Africa. More information at: http://capetown2018.iceevent.org/.

November 5-9, 2018: Africa Oil Week, Cape Town, Africa. To find out more, contact +44 (0) 207 596 5065/ +27 11 880 7052 or email to info.africa@ite-events.com.

November 12-15, 2018: 1st Conference of the Arabian Journal of Geosciences (1st CAJG), Hammamet, Tunisia. Contact: contact@cajg.org for queries.

November 12-15, 2018: Abu Dhabi International Petroleum Exhibition and Conference, Abu Dhabi, UAE. Visit website at https://www.adipec.com/

November 13-15, 2018: AAPG/EAGE/MGS 4th Myanmar Oil and Gas Conference, Yangon, Myanmar. Contact: Programs Manager, AAPG Asia Pacific Region, Tel. no.: 65 96536728.

November 14-15, 2018: Argentina Shale Production Exhibition and Conference, Buenos Aires, Argentina. Visit www.argentina.shale-production.com for further information.

November 14-16, 2018: 4th International Downstream-Tech Vietnam Conference, Hanoi, Vietnam. Visit http://www.connecforce.com/downstream-vietnam/ to find further details.

November 27 -30, 2018: The Nineteenth CWC World LNG Summit & Awards Evening, Portugal. Details at https://world.cwclng.com/

December 3-4 December, 2018: Bottom of the Barrel Technology Conference, Bahrain. Details at: https://europetro.com/week/bahrain2018.

December 3-5, 2018:Second JCTI Workshop, Hong Kong. Details can be obtained from www.hkges.org/JTC1-2nd/index.html.

December 5-6, 2018: ME-CAT 2018 – Middle East Catalyst Technology Conference, Bahrain. Details at: https://europetro.com/week/bahrain2018. Details at: https://europetro.com/week/bahrain2018.

December 11-13, 2018: AAPG/EAGE Shale Gas Evolution Symposium, Manama, Bahrain. More details can be found at: https://www.aapg.org/global/middleeast/events.

December 12-14, 2018: Future Energy Asia Exhibition and Conference, Bangkok, Thailand. Further information can be found at www.futureenergyasia.com.

January 23-24, 2019: Oil and Gas IoT Summit, Lisbon, Portugal. Visit https://www.oilandgas-iot.com to discover more about event.

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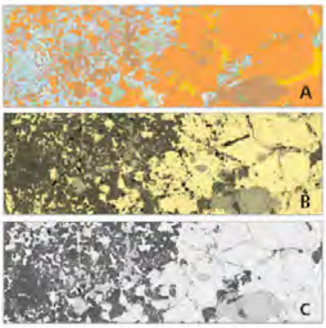

A–Mineralogy map; B–Metals map; C–BSE imaging.
Fraser Mine sample courtesy of University of Leicester, U.K.

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Title must be informative and reflects the content of the paper. Title in Malay should include an English translation. It should be concise (less than 20 words). Avoid using abbreviation in the title.

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Tel: 603-7957 7036 Fax: 603-7956 3900 E-mail: geologicalsociety@gmail.com

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