GEOSEA 2009

Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia

8 – 10 June 2009 • Istana Hotel, Kuala Lumpur, Malaysia

Programme and Abstracts

Organiser:

Geological Society of Malaysia

Co-organisers:

Minerals & Geoscience Department Malaysia (JMG)

Universiti Kebangsaan Malaysia (UKM)

University of Malaya (UM)

Petroliam Nasional Berhad (PETRONAS)

Editors
G.H. Teh, T.F. Ng & Mohd. Shafeea Leman

Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia (GEOSEA 2009)
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Published by

Institute for Environment & Development (LESTARI) &
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, MALAYSIA

Geological Society of Malaysia
c/o Department of Geology, University of Malaya
50603 Kuala Lumpur, MALAYSIA

ISBN 978-983-99102-7-8

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planetearth Earth Sciences for Society

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The Honourable Minister of Natural Resources and Environment Malaysia
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Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, MALAYSIA

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Institute for Environment & Development (LESTARI)
Universiti Kebangsaan Malaysia
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Printed by
Art Printing Works Sdn. Bhd.
29 Jalan Riong, 59100 Kuala Lumpur

Foreword

A very warm welcome to each and everyone of you to Kuala Lumpur and GEOSEA 2009. It is nice to have you all here and thank you for your support.

GEOSEA 2009 is the eleventh in the series of Congress of the Geology, Mineral and Energy Resources of Southeast Asia, with the aim of fostering an exchange of ideas, information and cooperation in geology, mineral and energy resources and related issues in the core countries, namely, Indonesia, Malaysia, the Philippines and Thailand. In addition to core countries, GEOSEA 2009 is expanded to include participation from neighbouring countries, to establish a new era of regional collaboration among geological institutions.

It is pertinent to note that GEOSEA 2009 is organised to mark the conclusion of the United Nations International Year of Planet Earth (IYPE), 2007-2009. This triennium event aims to ensure greater and more effective use by society of the knowledge accumulated by the world's 400,000 Earth scientists, with ultimate goal of helping to build safer, healthier and wealthier societies around the globe is expressed in the Year's subtitle 'Earth Science for Society'.

To cushion the effects of the global economic downturn, the Congress fees was drastically reduced and the length of the Technical Programme trimmed to 2 days instead of 2 ½ days. We are glad you have responded by taking the initiative to be present here today. The themes of the Technical Sessions have been streamlined to conform to selected themes of IYPE.

There will be a total of 92 oral presentations consisting of four Keynotes, four Regional & Country Papers and 84 technical papers. There are also 12 poster presentations and six Side Events. Unfortunately the Post Congress Fieldtrip was cancelled due to insufficient participants.

In order to foster the spirit of cooperation between geoscientists from the core countries and those interested in the geology, mineral and energy resources of Southeast Asia and neighbouring areas, the idea of a permanent GEOSEA Secretariat has been mooted and hopefully it can be crystallised so that GEOSEA and its main objectives can be a reality and activities of interest can be planned and organised for the benefit of all member countries.

It is hoped that with GEOSEA 2009, the aspirations of GEOSEA can be revived and reactivated and member countries come forward to host GEOSEA when their turn are due.

Once again, thank you for your worthy support, have a productive Congress, and I hope you also take the opportunity to roam through our beautiful country before you leave. We look forward to seeing you at the next GEOSEA Congress.

On behalf of the GEOSEA 2009 Organising Committee I would like to thank all sponsors and donors for their generous support.

G.H. Teh
Chairman
GEOSEA 2009 Scientific Subcommittee

Schedule of Events

Monday, 8 June 2009			
08:00 – 09:00	Registration		
09:00 – 09:30	Opening Ceremony		
09:30 – 10:00	Tea Break		
10:00 – 10:40	Keynote 1		
10:40 – 11:40	Regional & Country Papers	Technical Session 2a	Technical Session 3a
11:40 – 13:00	Technical Session 1a		
13:00 – 14:00	Lunch Break		
14:00 – 14:40	Keynote 2		
14:40 – 15:40	Technical Session 1b	Technical Session 2b	Technical Session 3b
15:40 – 16:00	Tea Break & Poster Presentations		
16:00 – 17:00	Technical Session 1c	Technical Session 2c	Technical Session 3c
17:30 – 19:30	Side Event 1: IYPE Regional Meeting		
17:30 – 21:00	Ice Breaker		
Tuesday, 9 June 2009			
08:40 – 09:20	Keynote 3		
09:20 – 10:40	Technical Session 1d	Technical Session 2d	Technical Session 3d
10:40 – 11:00	Tea Break		
11:00 – 13:00	Technical Session 1e	Technical Session 2e	Technical Session 3e
13:00 – 14:00	Lunch Break / GEOSEA Business Meeting		
14:00 – 14:40	Keynote 4		
14:40 – 15:40	Technical Session 1f	Technical Session 2f	Technical Session 3f
15:40 – 16:00	Tea Break		
16:00 – 17:00	Technical Session 1g	Technical Session 2g	Technical Session 3g
17:00 – 17:30	Closing Ceremony		
17:30 – 19:30	Side Event 2: Asian Dialogue on Geoheritage Conservation: Issues and Challenges		
Wednesday, 10 June 2009			
09:00 – 13:00	Side Event 3: Workshop on Geomodelling: Computer Applications in the Earth Sciences (Venue: Minerals & Geoscience Department. Maximum 15 persons)		
09:00 – 13:00	Side Event 4: Workshop on Ore Deposit Models in SE Asia (Venue: Minerals & Geoscience Department. Maximum 15 persons)		
09:00 – 17:00	Side Event 6: Workshop on Engineering Geology of Rock Slope (Venue: Minerals & Geoscience Department. Maximum 15 persons)		
09:00 – 13:00	Side Event 7: Workshop on Knowledge Management (Venue: Universiti Kebangsaan Malaysia, Bangi)		

Venues			
Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian	Other venues

Note: Side Event 5 and Post Congress Fieldtrip are cancelled

Programme

Monday, 8 June 2009

Room 1: Mahkota

OPENING CEREMONY

09:00	:	**Welcoming Address by Dato' Yunus Abdul Razak** President, Geological Society of Malaysia & Chairman, GEOSEA 2009 Organising Committee
09:10	:	**Opening Address by Y.B. Datuk Douglas Uggah Embas** Minister of Natural Resources and Environment Malaysia
9:30 - 10:00	:	Tea Break

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<tr><th>Time</th><th>Room 1:
Mahkota 3</th><th>Room 2:
Delima & Nilam</th><th>Room 3:
Baiduri & Berlian</th></tr>
<tr><td>10:00 - 10:40</td><td>Keynote 1
ED DE MULDER
Earth science for society – Beyond IYPE</td><td></td><td></td></tr>
<tr><td></td><td>Regional & Country Papers</td><td>Technical Session 2a
Deep Earth</td><td>Technical Session 3a
Hazards & Megacities</td></tr>
<tr><td>10:40 - 11:00</td><td rowspan="3">Paper 1
HEE-YOUNG CHUN & MARIVIC PULVERA UZARRAGA (CCOP)
Promoting Geosciences in East and Southeast Asia – Issues and Challenges
Paper 2
LAMBOK M. HUTASOIT (IAGI, ASSOCIATION OF INDONESIAN GEOLOGIST)
Promoting geology in Indonesia – Issues and challenges
Paper 3
F.G. DELFIN JR. (GEOLOGICAL SOCIETY OF THE PHILIPPINES)
Promoting geology in the Philippines – Issues and challenges
Paper 4
ARAYA NAKANART (GEOLOGICAL SOCIETY OF THAILAND)
Promoting geosciences in Thailand – Issues and challenges</td><td>Paper 2a1
H.D. TJIA, ZAINAL ABIDIN JAMALUDDIN, MOHD NIZAM BIN MD NOORDIN, MUHAMMAD EZWAN DAHLAN, ZAKARIA MOHAMAD
Superimposed displacements on record in the Bukit Tinggi Fault Zone, Pahang, Malaysia</td><td>Paper 3a1
F. TONGKUL, AHMAD KHAIRUT TERMIZI, EJRIA SALEH, NOOR FARASALIZA SAKHO
Tsunami inundation modeling for Eastern Sabah, Malaysia</td></tr>
<tr><td>11:00 - 11:20</td><td>Paper 2a2
SENDJAJA, P., SUPARKA, M.E & SUCIPTA, E.
Adakites rocks from Sintang, West Kalimantan and Una-Una Island Central Sulawesi, Indonesia: Evidence of slab melting subducted young oceanic crust</td><td>Paper 3a2
H. ZABIDI
Deterministic karst cavity distribution prediction through geospatial analysis: A case study of SMART tunnel project, Kuala Lumpur, Malaysia</td></tr>
<tr><td>11:20 - 11:40</td><td>Paper 2a3
MICHAEL COTTAM, ROBERT HALL & CHRISTIAN SPERBER
Age, origin and exhumation of the Mount Kinabalu Granite, Sabah</td><td>Paper 3a3
ABD RAHIM BIN HARUN & ABDUL RAHIM BIN SAMSUDIN
Gravity method and its contribution to geological mapping and cavity detection in Peninsular Malaysia</td></tr>
<tr><td></td><td>Technical Session 1a
Resource Issues</td><td></td><td></td></tr>
<tr><td>11:40 - 12:00</td><td>Paper 1a1
RASOUL SORKHABI & FELIX TONGKUL
Dry gas, tight reservoirs in the West Crocker turbidites: A new exploration play offshore Northwest Borneo</td><td>Paper 2a4
NURCAHYO I. BASUKI
A petrographic study on diagenesis of reef-associated Rajamandala carbonate rocks, Padalarang area, West Java, Indonesia: preliminary results</td><td>Paper 3a4
MUSTAFFA KAMAL SHUIB
Evidences for Quartenary to present seismicities in Malay Peninsular</td></tr>
</table>

Time	Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian
12:00 - 12:20	Paper 1a2 Haftay Hailay Abraha & Askury Abd Kadir Naturally fractured basement reservoir: An example from Ruby Field	Paper 2a5 Priadi B., Sucipta IGBE & Sopaheluwakan J. Post-collisional granitoids in Central Sulawesi, Indonesia	Paper 3a5 Rodeano Roslee, Ismail Abd. Rahim & S. Abd. Kadir S. Omang Geological factors contributing to the landslide hazard occurences in the Trusmadi Formation slopes, Sabah, Malaysia
12:20 - 12:40	Paper 1a3 Mohammed H. Hakimi, Mohamed R. Shalaby & Wan Hasiah Abdullah Reservoir Characterization and Hydrocarbon Potential of the Lower Cretaceous Biyad Formation, East Shabowah Oilfield, Yemen	Paper 2a6 Grace Cumming, Khin Zaw, Sandy Chitko, Zaw Naing Oo & Horst Zwingmann Recent Pliocene volcanism recorded at Mount Popa, Central Myanmar	Paper 3a6 Tan, B.K. Engineering geology of rock slopes – Some recent case studies in Malaysia
12:40 - 13:00	Paper 1a4 Visut Pisutha-Arnond, Wirot Teeratananon, Benjawan Vorakulamornrat, Supaporn Pisutha-Arnond & Poonsawat Prajukbunjong Diagenesis of Tertiary reservoir sandstones in the Northern Malay Basin, the Gulf of Thailand: A key of success for hydrocarbon exploration	Paper 2a7 Norlina Astana, Baba Musta & Junaidi Asis Chemical weathering of igneous rocks in Mount Kinabalu, Sabah	Paper 3a7 Richard Mani Banda, Zakaria Mohamad & Kamaludin Hassan Geological significance of landslide occurrences in Canada Hill, Miri, Sarawak
13:00 - 14:00	**LUNCH BREAK**		
14:00 - 14:40	**Keynote 2** Christopher J. Schenk Geologic assessment of undiscovered oil and gas resources in basins of Southeast Asia		
	Technical Session 1b Resource Issues	Technical Session 2b Deep Earth	Technical Session 3b Hazards & Megacities
14:40 - 15:00	Paper 1b1 Supaporn Pisutha-Arnond & Visut Pisutha-Arnond Can Permian limestone in Central Thailand be the source of hydrocarbon?	Paper 2b1 T. Ahmad, M. Alam, Md. Naushad & M.K. Mishra Geochemistry and petrogenesis of mafic magmatic rocks of the Betul Supracrustals, Central Indian Tectonic Zone: Tectonic implications	Paper 3b1 Chow, W.S., Pierson, B.J., Zuhar, Z.T.H. & Askury, A.K. Assessment of rockfall hazards at a construction site, Gunung Panjang, Ipoh, Perak
15:00 - 15:20	Paper 1b2 Patrick Gou Organic petrographic characteristics of the Crocker Formation, NW Sabah, Malaysia	Paper 2b2 Djadjang Sukarna Noble metal contents of high-Mg arc basalt from Galunggung Volcano, Indonesia	Paper 3b2 Ismail Abd Rahim, Sanudin Hj. Tahir, Baba Musta, Shariff A. K. Omang and Rodeano Roslee The value of Rock Mass Rating (RMR) system for heterogeneous flysch deposit of the Crocker Formation from Tamparuli, Sabah

Time	Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian
15:20 - 15:40	Paper 1b3 **Rolando Peña** Lexicon of Philippine Stratigraphy 2008	Paper 2b3 **Supartoyo, Emmy Suparka, Imam Achmad Sadisun & Chalid Idham Abdullah** Tectonic geomorphology of the Walat Fault at Sukabumi area of West Java, Indonesia	Paper 3b3 **Ghani Rafek, A., Goh, T.L., Baizura Yunus, N. & Hariri Ariffin, M. & Rahim Samsudin, A.** Quantification of discontinuity surface roughness: stepchild of rock mechanics in Malaysia?
15:40 - 16:00	**TEA BREAK & POSTER PRESENTATION**		
	Technical Session 1c Resource Issues	Technical Session 2c Deep Earth	Technical Session 3c Hazards & Megacities
16:00 - 16:20	Paper 1c1 **A.H. Eki, S. Akmal, Z.A. Sulaiman & H. Mohamad** Characterisation of fine mica (sericite) from Coldstream, Bidor Area, Perak State, Malaysia	Paper 2c1 **Win Swe** Sagaing Fault of Myanmar: A brief overview	Paper 3c1 **Abd Rasid Jaapar** Cracks mapping: A case study on applying geologic skills in dilapidation survey
16:20 - 16:40	Paper 1c2 **Lolita Marheni** Investigating the differences of characteristics of the tin deposits between Bangka and Belitung Islands	Paper 2c2 **Azman A. Ghani** Characteristic of S-type, continental collision magma from the Main Range Granite of Peninsular Malaysia	Paper 3c2 **Mohd For Mohd Amin, H.M. Abdul Aziz K.M. Hanifah, Amir Hamzah Mustapha & Chan Sook Huei** Engineering properties of limestone from Pandan Indah, Kuala Lumpur
16:40 - 17:00	Paper 1c3 **Citra Nurwani & Achmad Syaukani Anugrah** Sunda shelf as potential area of tin deposit	Paper 2c3 **Anwar Abdullah, Juhari Mat Akhir & Ibrahim Abdullah** Filters integrated for the extraction of lineaments from Landsat TM-5 in the Sungai Lembing – Maran area, Malaysia	Paper 3c3 **Tajul Anuar Jamaluddin, Michael Goay Kee Hong, Mahadzer Mahmud & Fadlee Baba** The significance of relict structures in slope failure geoforensic investigation – A case study from Serendah Selangor, Malayisa
17:30 - 19:30	Side Event 1: IYPE Regional Meeting		
19:30 - 21:00	**ICE BREAKER**		
Tuesday, 9 June 2009			
8:40 - 9:20	**Keynote 3** **Charles S. Hutchison** Tectonic evolution of Southeast Asia		
	Technical Session 1d Resource Issues	Technical Session 2d Earth & Life Through Time	Technical Session 3d Hazards & Megacities
9:20 - 9:40	Paper 1d1 **Azimah Ali** Trade liberalisation and sustainable energy resources	Paper 2d1 **Richard Mani Banda, Daulip Lakkui, Peter Chung & Nightingale Lian** Lithostratigraphic and biostratigraphic corelations of Miocene sediments in the Pinangah Coal Basin and surrounding areas, Sabah	Paper 3d1 **John Kuna Raj** Minimizing failures at slope cuts in the granitic bedrock areas of Peninsular Malaysia

Time	Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian
9:40 - 10:00	Paper 1d2 TAKAYUKI MANAKA, KHIN ZAW & SEBASTIEN MEFFRE Characteristics of Sub-Microscopic Gold and Trace Element Geochemistry of Pyrite in the Long Chieng Track and Ban Houayxai Epithermal Deposits, Lao PDR	Paper 2d2 MUSTAFFA KAMAL SHUIB, MOHD FOR MOHD AMIN, TAJUL ANUAR JAMALUDDIN & WAN ZULHAIRI WAN YAACOB Soft-sediment deformation structures within the Indian Ocean tsunami deposit along the northern coast of Peninsular Malaysia	Paper 3d2 CHE NOORLIZA LAT Trends in the Southeast Asia earthquake activity
10:00 - 10:20	Paper 1d3 ZAW NAING OO & KHIN ZAW Geology and mineralization characteristics of Meyon gold deposit, Mon State, Southern Myanmar	Paper 2d3 INGA SEVASTJANOVA & ROBERT HALL Detrital heavy minerals from the Malay Peninsula and their use as provenance indicators in the Cenozoic Basins of Sundaland	Paper 3d3 SOE THURA TUN & MAUNG THEIN Some observation on Earthquake Hazard in Myanmar
10:20 - 10:40	Paper 1d4 EDI SUHANTO, KASBANI & HARAPAN MARPAUNG Geophysical electrical resistivity signatures on non-volcanic hosted geothermal areas in Indonesia	Paper 2d4 YASAMIN KH IBRAHIM, LEE CHAI PENG, GATHONE CRANBROOK & LIM TZE TSHERN Preliminary report of vertebrate fossils in limestone caves at the foot of Batu Caves, Bukit Batu, near Kuala Lumpur	Paper 3d4 NG, T.F. , J.K. RAJ, AHMAD TAJUDDIN IBRAHIM & NORSAFAWATI SAAID Evidence of palaeoseismic slip near Bukit Tinggi, Peninsular Malaysia
10:40 - 11:00	TEA BREAK		
	Technical Session 1e Resource Issues	Technical Session 2e Earth & Life Through Time	Technical Session 3e Groundwater & Soil
11:00 - 11:20	Paper 1e1 RIDWAN ARIEF & R. HUTAMADI Review of alluvial gold potency relation to the local people mining in Indonesia	Paper 2e1 WAN HASIAH ABDULLAH, LEE CHAI PENG AND MUSTAFFA KAMAL SHUIB Coal-bearing strata of Labuan: mode of occurrence and organic petrographic characteristics	Paper 3e1 ZAW WIN, UMAR HAMZAH, MOHD AZMI ISMAIL & ABDUL RAHIM SAMSUDIN Geophysical mapping of hydrocarbon-contaminated soil and groundwater at Sungai Kandis, Klang Selangor
11:20 - 11:40	Paper 1e2 CHARLES MAKOUNDI & G.H.TEH Geology, structure and mineralization of the Tersang Hill Mine, Pahang, Malaysia	Paper 2e2 SIMON SUGGATE & ROBERT HALL Provenance of Neogene Sandstones in Sabah, NE Borneo	Paper 3e2 LAKAM MEJUS, NOR DALILA DESA, JEREMY DOMINIC, ROSLANZAIRI MOSTAPA, ASMINAH RAJULI, HISAM AHMAD & ISMAIL TAWNIE Fractured rock zones determination for groundwater exploration using electrical resistivity imaging
11:40 - 12:00	Paper 1e3 DEDDY AMARULLAH & DAVID P. SIMATUPANG Coal bed methane potential of Tanjung Formation in Tanah Bumbu South Kalimantan	Paper 2e3 BHAKTI H. HARAHAP Tectonostratigraphy of the Phanerozoic continental province succession in Southern Papua, Eastern Indonesia	Paper 3e3 KAMARUDIN SAMUDING, MOHD TADZA ABDUL RAHMAN & ISMAIL ABUSTAN Heavy metals profile in groundwater system at solid waste disposal site

Time	Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian
12:00 - 12:20	Paper 1e4 **Somboon Khositanont, Khin Zaw, Prayote Ounchanum & Theerapongs Thanasuttipithak** Cu-Fe-(Au) mineralization at PUT2 deposit, Loei Province northeastern Thailand	Paper 2e4 **Kyaw Linn Oo, Khin Zaw, Myitta & Day Wa Aung** Tectonic Setting of Pondaung Sandstones, Southern Chindwin Basin, Myanmar: Evidence from XRF-major and trace element geochemical analysis and LA ICP-MS U-Pb zircon geochronology	Paper 3e4 **Noraini Surip, Khairul Anam Musa & Abdul Razak Zainal Abidin** GIS-based weightage overlay for groundwater potential study in Perak, Malaysia
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12:40 - 13:00	Paper 1e6 **Lolita Marheni, Esti Anggraeni & Leyla Sari** The environmental effects of small scale tin mining in Bangka Island, Indonesia	Paper 2e6 **Che Aziz Ali** Microfacies and diagenesis of Setul limestone in Langkawi and Perlis	Paper 3e6 **Nur Islami, Samsudin Hj Taib & Ismail Yusoff** The Subsurface profiling comparison of Tawang and Pangkalan Chepa area, North Kelantan
13:00 - 14:00	**LUNCH BREAK & GEOSEA BUSINESS MEETING**		
14:00 - 14:40	**Keynote 4** **Khin Zaw** Metallogeny of mainland SE Asia		
	Technical Session 1f Resource Issues	Technical Session 2f Geoscience Tools	Technical Session 3f Groundwater & Soil
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15:00 - 15:20	Paper 1f2 **Nyunt Htay** Geology and mineral resources of the area between Nogmung and Kan Paiti, Northeastern Kachin State, Myanmar	Paper 2f2 **Umar Hamzah, Rofiqul Islam & Mark Jeeva** Electrical resistivity survey of oil-spilled sandy soil at an abandoned Seberang Prai TNB power supply station	Paper 3f2 **Zahir Yahya** Hard rock aquifers in Peninsular Malaysia
15:20 - 15:40	Paper 1f3 **Kusdarto** Rocks potential pesources used for K-fertilizer from Ringgit Beser Complex area, Situbondo Regency, East Java Province, Indonesia	Paper 2f3 **Khairol Nizam A. Aziz, Che Noorliza Lat & Ahmad Tajuddin Ibrahim** Investigation of saltwater intrusion in Marang, Terengganu using the resistivity method	Paper 3f3 **Muhammad Barzani Gasim, Joy J. Pereira, Fredolin T.Tangang, Ekhwan Toriman & Sahibin Abd, Rahim** Case study of an extreme rainfall event during 2006/2007 flashflood in the middle and southern part of Peninsular Malaysia: a climate change threat?
15:40 - 16:00	TEA BREAK		

Time	Room 1: Mahkota 3	Room 2: Delima & Nilam	Room 3: Baiduri & Berlian
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16:20 - 16:40	Paper 1g2 **Heryadi Rachmat, Budi Brahmantyo, Igan Sutawidjaja** Mount Rinjani as first geopark in Indonesia	Paper 2g2 **Samsudin Taib** The gravity and magnetic anomaly in North-West Malaka, Malaysia	Paper 3g2 **Srilert Chotpantarat & Chakkaphan Sutthirat** Influence of unsaturated soil hydraulic parameters on nonequilibrium transport of Mn^{2+} under single and multiple metals through lateritic aquifer: A case study of gold mine in Thailand
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President, Geological Society of Malaysia &
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Keynote 1

Earth science for society – Beyond IYPE

Ed de Mulder
International Year of Planet Earth Corporation

The International Year of Planet Earth (IYPE) was proclaimed by the General Assembly of the United Nations for 2008. IYPE aims to raise massive public and political awareness of the relevance of the Earth sciences for Society as expressed in the IYPE's subtitle: Earth science for Society and in particular to use such knowledge more effectively in decision making to contribute to safer, healthier and more prosperous societies throughout the world, in particular in developing countries. The IYPE was initiated by the International Union of Geological Sciences (IUGS) and UNESCO. The IYPE lasts for three years: 2007, 2008 and 2009. Following UN proclamation an organizational structure, the IYPE Corporation, was developed and 80 countries and regions joined the initiative by creating their own National IYPE Committees. Many nations in the GEOSEA region followed that example and currently National Committees exist in China, Indonesia, Japan, Korea, Malaysia, Philippines, Thailand and Vietnam, alongside a Regional Committee. The region is represented in the IYPE Board and is directly involved in IYPE decision making. Most of the income is generated from IYPE Founding and International Partners. In November 2009, the IYPE A major international event will review the results of the IYPE triennium and will pay attention to new initiatives building on the IYPE legacy. The IYPE Science programme focused on ten themes: groundwater, health, climate, hazards, natural resources, (meg)cities, soils, oceans, deep Earth and life. The International Year made a real difference through its outreach programme that has been taken up with great enthusiasm by almost all National IYPE Committees.

Keynote 2

Geologic assessment of undiscovered oil and gas resources in basins of Southeast Asia

Christopher J. Schenk
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The U.S. Geological Survey (USGS) is currently assessing the potential for undiscovered oil and gas resources in priority basins of Southeast Asia as part of an assessment of undiscovered global oil and gas resources. The USGS approach in each basin is to define all aspects of total petroleum systems (TPS), geologically define areas to be assessed (assessment units, or AU), and assess the potential for undiscovered oil and gas resources. In the Malay Basin Province an Oligocene-Miocene Composite TPS was defined to encompass two assessment units; the Main Malay-Tho Chu AU and the Khmer Trough AU. In the Main Malay-Tho Chu AU about 7 billion barrels of oil (BBO) is known, with the largest oil field discovered in the early 1970's. Moderate to high potential exists for smaller undiscovered oil fields. Known gas is about 80 trillion cubic feet of gas (TCFG), with significant gas discoveries made in the early 1970's and in the late 1990's, with largest gas field sizes of about 3 to 6 TCFG. Moderate to high potential exists for undiscovered gas fields. In the Khmer Trough AU known oil from limited exploration is about 0.24 BBO, and potential exists for undiscovered oil fields. In the Penyu-West Natuna Basins Province an Oligocene-Miocene Composite TPS was defined that includes the Gabus-Udang-Urang Sandstones AU. Known oil is about 0.75 BBO, with the largest oil field found in 1988, but no oil discoveries have been made since 1995. Low potential exists for undiscovered oil fields. Known gas is about 4.2 TCFG, with the largest gas field discovered in 1984. Moderate potential exists for smaller undiscovered gas fields. In the Cuu Long Basin Province an Eocene-Oligocene Composite TPS was defined that encompassed the Syn-Rift Reservoirs AU. In the oil-prone Cuu Long Basin, the total known oil is about 6.5 BBO, with the largest oil field of about 2 BBO discovered in 1975. The potential exists for numerous undiscovered oil fields of moderate to small size. After 30 years of exploration about 2 TCFG has been discovered in two gas fields, and the potential for undiscovered gas fields is low. In the gas-prone Nam Con Son Basin Province an Eocene-Miocene Composite TPS was defined that includes the Miocene Reservoirs AU. About 0.5 BBO of oil is known from this basin, and the largest oil field was discovered in 1988. Potential exists for undiscovered oil fields of small size. About 12 TCFG is known in this basin, with the largest gas field of about 4 TFCG discovered in 1995. Most gas fields in this basin were discovered in a short period of exploration in the mid-1990's, and potential is moderate to high for undiscovered gas fields. In the offshore Thai Basin Province an Eocene-Miocene Composite TPS was defined that includes the Pattani Trough AU. In this AU known oil is about 0.9 BBO, with the largest oil field discovered in the mid-1990's. Moderate potential exists for numerous smaller undiscovered oil fields. Known gas in this AU is about 17 TCFG, with the largest fields discovered prior to 1990. Moderate potential exists for numerous undiscovered gas fields.

Keynote 3

Tectonic evolution of Southeast Asia

Charles S. Hutchison
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The Palaeo-Tethys Suture is a prominent N–S tectonic feature of Peninsular Malaysia. It divides the country into a Sibumasu block on the west and an Indochina block on the east, known locally as East Malaya. It is known as the Bentong-Raub Suture. The suture zone is characterized by an assemblage of carbonaceous pelitic schist, serpentinite, amphibole schist , mélange and chert, as well as post-suture redbeds. Oceanic cherts within the suture zone record a history of the Palaeo-Tethys from Late Devonian to at least Late Permian. The redbeds remain undated. Extrapolation southwards has been confirmed towards the Indonesian islands of Bangka and Billiton, and northwards along the Gulf of Thailand to Sa Kaeo. The Sa Kaeo suture has been strongly offset left-laterally by the Chao Phraya and Mae Ping faults to the Nan Uttaradit Suture, associated with less prominent island arcs of the Sukhothai zone, that also correlate with the western part of East Malaya.

Sibumasu is characterized by Carboniferous–Permian glacial diamictites (pebbly mudstones), whereas the East Malaya and Indochina Block is characterized by fusulinid limestones and Cathaysian equatorial *Gigantopteris* flora. Sumatra has a Cathaysian affinity terrain west of the Sibumasu Block, formerly referred to as the "Jambi Nappe". Characteristic Lower Palaeozoic fossils allow the Sibumasu localities of Langkawi, Tarutau and Phuket to have been positioned near the Canning Basin of Australia before its Lower Permian rifting from Gondwanaland. The Indochina and South China terranes had rifted from Gondwanaland in the Early Devonian and were spared the Upper Palaeozoic glaciation and instead developed equatorial *Gigantopteris* flora.

Sibumasu collided with East Malaya and Indochina in the Late Triassic at the Indosinian Orogeny, resulting in important tin-bearing crustal S-type granites, characterised by the Main Range of the Peninsula, the 'tin islands' of Indonesia and parts of central Thailand. Late Cretaceous granites, commonly associated with high grade metamorphic core complexes, have not yet been successfully integrated into the regional tectonic analyses.

Eocene collision of India, with maximum impact at the Assam–Yunnan syntaxis, caused escape tectonics, resulting in clockwise rotation of Southeast Asian terranes brought about by a large number of right-lateral wrench faults and an oroclinal tectonic shape. Right-lateral movement on the faults has resulted in Tertiary rift basins and tanspressional transverse ranges of Jurassic–Cretaceous formations. However, palaeomagnetic data have not successfully supported the clockwise rotations because of commonly occurring rock remagnetisation. The right-lateral faulting of Sumatra is an integral part of the clockwise orocline, but is popularly also attributed to ongoing oblique subduction at its active trench.

GEOSEA 2009 Kuala Lumpur

Keynote 4

Metallogeny of mainland SE Asia

Khin Zaw

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The mainland SE Asia and the adjacent area of South China region is endowed with a diversity of mineral deposit types. The region has undergone multiple tectonic and magmatic events and related metallogenic processes and resulted in the formation of the diverse styles of base and precious metal deposits (VHMS, MVT, epithermal and skarn deposits; Khin Zaw *et al*., 2007a, 2007b; Khin Zaw, 2008a, 2008b). The region is characterized by an assembly of major crustal terranes of Gondwana affinities involving South China, Shan-Thai, Indochina and west Myanmar terranes. These crustal terranes host major mineralized Fold Belts (e.g., Paleozoic to Cenozoic Loei Fold Belt in Thailand and Laos, Paleozoic Troungson Fold Belt in Laos and Vietnam and Cenozoic Monywa-Wuntho belt in Myanmar). The region has a variety of deposit types and styles from VHMS deposits (e.g., Bawdwin deposit in Myanmar and Tasik Chini deposit in central Malaysia), MVT deposits (e.g., Song Tho deposit, Thailand, Theingon deposit, Myanmar and Pha Luang deposit, Laos), orogenic gold deposits (e.g., Penjom and Selinsing gold deposits, Malaysia, Moditaung deposit, Myanmar and Huai Kham On deposit, Thailand) to sedimentary-rock hosted gold deposit (Sepon, Lao PDR, Kyaukpahto, Myanmar and Langu deposit, southern Thailand). Porphyry related skarn copper-gold deposits are also abundant (e.g., Phu Kham, Laos, Puthep and Phu Thap Fah, Thailand, and Megapur, Malaysia). Low-sulfidation epithermal gold deposit (Chatree, Thailand and Ban Huayxai deposit, Laos), and high-sulfidation copper deposit (Monywa, Myanmar) are also found. Recent detailed geochronological studies of the Loei Fold Belt (LFB) in Thailand and Lao PDR using LA ICP-MS U-Pb zircon, Re-Os molybenite, Ar-Ar and K-Ar dating indicate that most productive Cu-Au skarn-mineralised intrusions are Early to Middle Triassic in age, whereas weakly mineralised systems are Late Triassic to Early Jurassic and tend to be younger in age. Magmatism and mineralization in the belt are linked to two subduction-related systems: the Earliest Permian and Late Permian to Middle Triassic continental-based island arcs followed by Late Triassic to Jurassic post-collisional magmatism (Khin Zaw *et al*., 2009a, 2009b). The Cu-Au skarn deposits have been also affected by a significant later thermal event associated with India-Asia collision and resulted in resetting of the K-Ar and Ar-Ar systems to record younger ages. Further research are required not only to constrain the age of magmatic-volcanic events and mineralization of the other Fold Belts in SE Asia but also to understand the genesis of the individual ore deposits or districts, to establish the time-space relations for mineralization in the entire region and to apply these results for better targeting the potentials and prospective grounds for mineral exploration.

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Regional & Country Paper 1

Promoting Geosciences in East and Southeast Asia – Issues and Challenges

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The Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) is an intergovernmental organization with twelve Member Countries – Cambodia, China, Indonesia, Japan, Korea, Malaysia, Papua New Guinea, Philippines, Singapore, Timor-Leste, Thailand and Vietnam. Since its founding in 1966, it has started promotion of geosciences in the region through implementing capacity-building projects and activities in georesources, geoenvironment as well as geoinformation sectors. Recognizing the current and emerging geoscience issues, CCOP has taken a look at its relevance to the region, by looking into its organization strategies. In February 2008, CCOP had a strategic planning workshop focusing on the issues at hand, and the challenges it brings to the organization, and brainstorming on alignment of its strategies in addressing the issues as well as facing the challenges including the promotion of geosciences. This paper will partly present the ideas and results of our strategic planning of CCOP.

Regional & Country Paper 2

Promoting geology in Indonesia-issues and challenges

Lambok M. Hutasoit
President, IAGI (Ikatan Ahli Geologi Indonesia, Association of Indonesian Geologist)

Based on its vastness and the numerous geological phenomena in the country, the number of geologists in Indonesia is still insufficient. This condition has caused the utilization of its geological natural resources to be less optimum, and unpreparedness in handling geological hazards. Some recent examples of the above problems are discussed in this presentation. All the problems descend from lack of geological knowledge in the society, which is the main issue. Education, formal as well as informal, is the key to find the solution to this main issue. IAGI has been involved in this aspect for many years. The formal education mainly includes establishment of new geology departments in universities in some parts of the country and addition of geology material into the curricula of elementary and high schools. The informal education mainly consists of socialization of geology to other elements of the society, such as government official, legislator, professional, and common people, through short course and mass media. What people see in geological industries, such as petroleum, mining, and public work, can also be included in this type of education. All the above activities have increased geological consciousness in the society, but it is still not sufficient in the country, which means that there is still a lot remaining to be done.

Promoting geosciences in the Philippines – Issues and challenges

F.G. Delfin Jr.

President, Geological Society of the Philippines

The promotion of geosciences in the Philippines takes place at three separate but related spheres – educational, professional, and political. In all three sectors, the Geological Society of the Philippines (GSP) is involved, working with other organizations and institutions of varying public and private mandates with results that have so far been mixed.

Geoscience education at the secondary level in the Philippines, except for dedicated science high schools, is best described as insufficient. Geology is incorporated in the general science subject in first year high school, taught by teachers who often have limited background in the subject. Five universities in the country now offer the bachelor's degree in geology but only the three in metropolitan Manila are widely regarded as possessing basic faculty and laboratory resources. One of the most critical drawbacks for geology majors is insufficient exposure to actual field work and mapping. To help address these constraints, the GSP has embarked on helping high schools establish geology clubs and hold annual geology quiz shows to promote geosciences; at the collegiate level, GSP actively exhorts the private sector to hire geology majors as on-the-job trainees and summer interns to further hone their competencies in basic geological skills.

GSP's recent efforts at continuing professionalism of geoscientists in the Philippines have focused on two major themes: 1) bridging the gap between researchers and practitioners, and 2) enhancing ethical and accountable practices. Creation of the GSP website and e-group, the holding of symposia and colloquia, the publication of the refereed *Journal of the Geological Society of the Philippines*, and the holding of the Society's annual geological convention GEOCON are all meant to enhance member interaction. As a result networking has increased but regular exchange of recent knowledge through journal publication has been stymied by the preference of some academics to publish their research in higher-ranked international journals and the restrictions on time and confidentiality often faced by private sector geologists. Following Australian and Canadian norms on ethical mineral reserves reporting, the GSP started "competent persons (CP) in mining" program which require mining companies to follow strict guidelines on reserve definitions and reporting. Only geologists accredited by the GSP as CP are allowed to sign off on mineral reserve estimates accepted by the Philippine Stock Exchange.

GSP's attempt at geosciences promotion at the level of public policy has been the most frustrating. While in some ways this is self-inflicted as many geoscientists still think the impossible – that the political process be rational and scientific – GSP faces many deep-rooted institutional obstacles to influencing national and local public policies. For instance, a bill to modernize the regulation of the Philippine geological profession filed alongside companion bills for the mining and metallurgical engineering professions have been languishing in Congress for nearly four years now. Similarly, attempts to implement a science-based geologic hazard mitigation strategies, while successful in some spots, often face tough opposition from local political and business interests. Finally, the general public and the media tend to have little interest in complex technical issues like the extended continental shelf or nuclear plant siting. Much more work and patience is required of the GSP and the scientific community in general if it wishes to be relevant and successful in policy advocacy.

Regional & Country Paper 4

Promoting geosciences in Thailand — Issues and challenges

Araya Nakanart

President, Geological Society of Thailand

Since 1967, the Geological Society of Thailand (GST) was founded by a number of some engineers and geologists who mostly worked with the Department of Mineral Resources (DMR). GST activities at that moment, were scheduled and supported under the opinions of high rank DMR people, some international cooperations were created, such as GEOSEA and also IGCP.

In 1989 a group of geologists re-founded the GST for new regulation and logo in convenient meeting and inter-cooperation. The numbers of members were increased including non-geologists. Some activities were still scheduled under DMR who controlled many geologists except the other in the universities.

In the year of 2002, the DMR was splitted into four departments under the coincidence of re-structural government organization. Some GST members migrated into the Department of Mineral Fuels (for petroleum and other fossil fuels), the Department of Primary Industry and Mining, the Department Groundwater, and the Department of Geology (still namely DMR).

In consequently, many GST members worked with the private sector, especially, PTTEP, Chevron, PDI, THL, Akara Mining, and also the universities.

As the enlargement of geoscience aspect in the country, the population of geologist is increased in both government and private sectors. Especially a huge of university students are interested in the study of geology, geoscience, and earth science which are carried on in Chulalongkorn, Chiang Mai, Khon Kaen, Suranaree Technology, Kasetsart, and Mahidol Universities.

GST as the center of the various geologists in the country has set up three targets of the society in the period of 2006-2010 served for the members as follows:

I Established the GST branches in the northern and north-eastern parts of the country in 2006

II Cooperated with international societies for academic and technical exchanges, i.e.

- a. The Geologists' Association, in England leaded by Dr. Michael F. Ridd in 2007, for technical knowledge.
- b. The Geological Society of Japan leaded by Dr. Gaku Kimura in 2007, for active fault exploration information.
- c. The Geological Society of Malaysia leaded by Dato Yanus Abdul Razak in 2008, for GEOSEA 2009.
- d. The American Association of Petroleum Geologists leaded by Dr. Scott W. Tinker in 2009, for affiliated society with AAPG to held the meeting in 2010.

III Purchased permanent office in Bangkok in 2009, for professional organization to create the activities for GST members and public.

Dry gas, tight reservoirs in the West Crocker turbidites: A new exploration play offshore Northwest Borneo

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With increasing demand for oil and gas in recent years, especially in the populous and rapidly growing economies of Southeast Asia, geological analysis of hydrocarbon resources in this region has become an urgent matter not only for world market but also for the regional economic development. In this paper, we evaluate the hydrocarbon prospectivity of West Crocker Formation of Oligocene age which dominates the geology of northwest Borneo including the city of Kota Kinabalu. These deepwater turbidites are sand-rich sediments interbedded with shale layers, and remain unexplored offshore Sabah. West Crocker Formation is at least 1,000 m thick and over 25,000 square kilometers in extent, making it a world-class turbidite basin (Tongkul, 1989, 1990; Crevello *et al*., 2008). The sedimentary package is dismembered and stratigraphically repeated by a number of reverse faults which are also outcropped in western Sabah. We studied the West Crocker turdities in several locations in and around Kota Kinabalu and collected rock samples for source rock and reservoir rock evaluation. Our results offer the following petroleum system model for this formation:

Source Rock

Samples from the Trusmadi Shale (dark grey argillite) underlying the West Crocker Formation as well as interbedded shale units within the West Crocker Formation indicate that these rock units are potential hydrocarbon source rocks. Their total organic carbon (TOC) values range from 0.1 to over 5%. Rock Eval (pyrolysis) Tmax values for organic rich samples are 470-500° C, and Vitrinite Reflectance values are 1.3-2.0% indicating that the rocks are over-mature for oil but within the wet gas/dry gas generation window.

Reservoir Rock

The West Crocker Formation in the study area is divided into the Lower Sandstone Unit and Upper Shale Unit. The Lower Sandstone Unit contains thick sandstone beds adjacent to the proposed source rocks. The sandstone is quartz rich (over 70%) and individual sandstone layers range from tens of centimeters to a couple of meters. If hydrocarbon were generated, the sandstone would easily act as reservoir. Nonetheless, the collected samples show low porosity (8-15%) and may be largely considered as tight gas reservoir. Apart from joints, fracture networks are found close to faults. The shale beds interbedded with the Lower Sandstone Unit are relatively thinner (several to tens of centimeters).

Seal Rock

The Upper Shale Unit of the West Crocker Formation may act as an efficient cap rock over the Lower Sandstone Unit. These shale rocks (dark grey argillite) have very low porosity and permeability values.

Structural Trap

Reverse faults (NNE-SSW trending and east-dipping) within the Lower Sandstone Unit of the West Crocker Formation have mainly moved along the thin shale layers and the faulting has created meter-scale fault zones containing clay-rich fault rocks with very low porosity (<5%) permeability (<0.001 md). Mercury-injection data obtained from some of these fault rocks indicate high capillary pressures capable of supporting hydrocarbon column heights of several hundreds of meters.

Overall, this study suggests the presence of dry gas in tight sandstone reservoirs in the West Crocker Formation offshore Sabah. This opens an entirely new play for exploration in addition to the recent oil discoveries in the Neogene clastic sediments of deepwater Sabah.

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Resource Issues Paper 1a2

Naturally fractured basement reservoir: An example from Ruby Field

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The occurrence of naturally fractured basement reservoirs has been known within the hydrocarbon industry for many years. Generally regarded as non-productive, they have failed to draw the attention of the explorationists. Often passed over as of 'no economic potential', their investigation by exploratory drilling has been left to chance. Interesting enough there are still many companies that stop drilling the operations the minute basement is found. Yet, they are commonly distributed in various petroliferous regions throughout the world. Some examples on the fractured basement reservoirs from various countries have been discussed in detail and showed there are commercial excellent basement reservoirs. Basement reservoirs are typically complex with multiple lithologies, possible two or more fracture systems and multiple oil-gas and oil-water contacts and hence are challenging reservoirs for the geologists, explorationists and reservoir engineers. An attempt has been made in this article to understand hydrocarbon production fractured basement formations, particularly in Ruby field (Vietnam), which is a granite fractured reservoir, along with review of naturally fractured basement reservoirs in different countries (Table 1), assembled primarily from published literatures. This project has clearly described the nature of the fractured basement reservoir including how the trap is formed, the source rock, the properm properties, fracture intensity and aperture, by taking an example of fracture basement reservoir from Ruby Field. Moreover, there are oil and gas fields "left behind" in areas where basement was not entered by the drill bit but where mature oil or gas source rocks are close to basement and where basement is fractured or weathered and occurs within structural closure. Therefore, there needs to be a paradigm shift in the mentality regarding basement. These reservoirs need to be studied closely. Coring is typically difficult due to the fractured nature of the reservoirs, and provides more challenges to geoscientists and reservoir engineers.

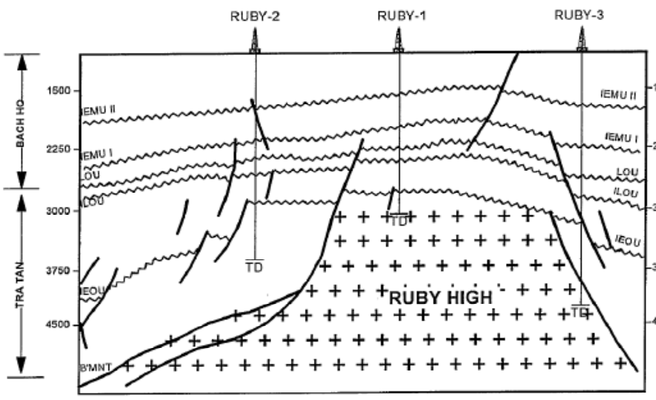

Figure 1: Stratigraphic cross section along SW-NE in Ruby Field (PETRONAS Carigali).

Table 1: Selected Oil Fields from different countries of fractured basement reservoirs for comparison.

Continent	Country	Oil/gas filed	Rock type	Age	Depth (ft)	Production (b/d)	Reference
Asia	China	Yaerxia Oil Field	metamorphic	Palaeozoic	8,530-10,500	1,050	P'An,1982
		Xinglongtai (oil & gas field)	metamorphosed granite	Mesozoic	2,300	756	P,An, 1982
	Indonesia	Sumatra Oil Field	metaquartzite	Pre-Tertiary	1,634	1,680	P,An, 1982
	Yemen	Kharil Oil Field	metamorphic basement	Mesozoic			P,An, 1982
	Vietnam	White Tiger Oil Field	Mainly granites	Cenozoic	16404	1,500 m^3/day	Areshev *et al*, 1992
		Dragon Oil Field	Mainly granites	Cenozoic	13154	8,000	George, 1995
		Dai Hung Field	Granitic basement	Late Cretaceous	n.a.	35,000	Puong Tung, 2001
North America	USA	Orth Oil Field	quartzite	Precambrian	n.a.	939 (each well)	Walters, 1953
		Ringwald Field	quartzite	Precambrian	3,270-3,284	190	P'An, 1982
		Kraft-Prusa Field	Mainly quartzite	Precambrian	3,180-3,337	108	Walters, 1953
South America	Chile	Lago Mercedes Field	grano-diorite	Permo-Triassic	Data not found	1,140	Dean *et al*., 1993
	Venezuela	La Paz Oil Field	granite	n.a.	8,889	3,600	Landes et al, 1960
		Mara Oil Field	metamorphic and igneous	Silurian-Devonian	1,190	2,700	Landes, 1959
Africa	Egypt	Hurghada	granite	Miocene	1,670-2,000	n.a.	P'An, 1982
	Libya	Nafoora-Augila	granite	Precambrian	8,530 - 8,563	1,500 (well D9)	Belgasem *et al*., 1990
Europe	New Zealand	Kora Oil Field	granitoids	Mesozoic	5886-6018		Russell, 1997
	UK	Clair Field	granites	Devonian-Carboniferous	n.a.	960(Well 206/7-1)	Coney *et al*., 1993
FSU	Russia	Shaim Field	metamorphic and igneous	Paleozoic	n.a.	25(Well 7 and 11)	P'An, 1982
	Kazakstan	Oimasha Field	granite	Early Palaeozoic	12,200-12,310	1,382	Reisser, 1996

Resource Issues Paper 1a3

Reservoir Characterization and Hydrocarbon Potential of the Lower Cretaceous Biyad Formation, East Shabowah Oilfield, Yemen

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The East Shabowah Oilfield in the Masila Basin is one of the most productive oilfields in the Republic of Yemen containing sediments ranging in age from Jurassic to Tertiary (Figures1 and 2). Studies of reservoir characterization and hydrocarbon potential of the Lower Cretaceous Biyad Formation have been carried out here using well log data collected from ten different wells in the study area (Figure 3). The Biyad Formation is mainly clastic and conformably overlies the Saar Formation. The reservoir rocks are assigned to Lower and Upper Biyad Members, the most important reservoir rocks in the East Shabowah Oilfield, (Beydon *et al*., 1998; Total Co., 1999).

Computer-assisted log analyses were used to evaluate petrophysical parameters such as the shale volume (Vsh), effective porosity (Φe), total porosity (Φt), water saturation (Sw), hydrocarbon saturation (Sh), flushed zone saturation (Sxo) and true resistivity (Rt). These parameters are plotted versus depth to illustrate the variations through the whole interval (Figure 4). Different Cross-plots such as RHOB / NPHI, RHOB / DT, GR-RHOB, and GR-NPHI, were constructed for to Lithology and porosity identification of the Biyad Formation in the studied wells (Figure 5). Isoparametric maps are used to illustrate the spatial variation of petrophysical parameters and to show their relationships with the geologic setting of the study area. Based on the results obtained, the sediments of Lower and Upper Biyad Members is interpreted as a good reservoir rocks which is supported by the effective porosity values of 15-20 % and high values of hydrocarbon saturation exceeding 50%. The Lower and Upper Biyad Members of the Biyad Formation reveal promising reservoir characteristics which should be taken into consideration during future development of the field area.

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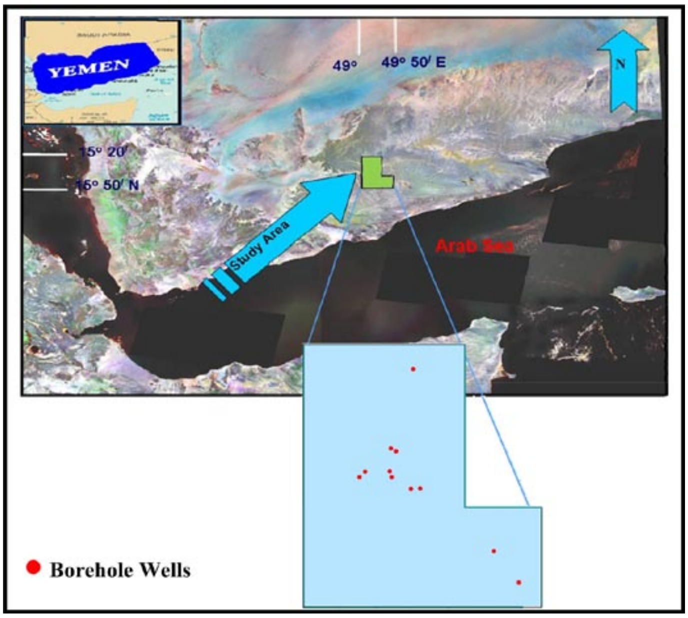

Figure 1: Mosaic of TM Landsat image of Yemen showing the location map of studied wells at the East Shabowah oilfield

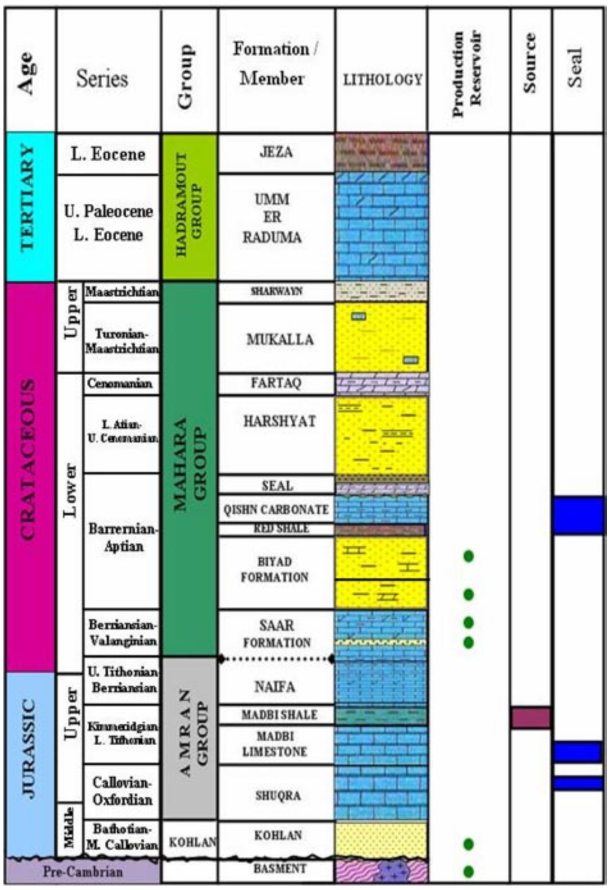

Figure 2: Lithostratigraphic column of East Shabowah area, Masila Basin (modified after Total Company, 1999).

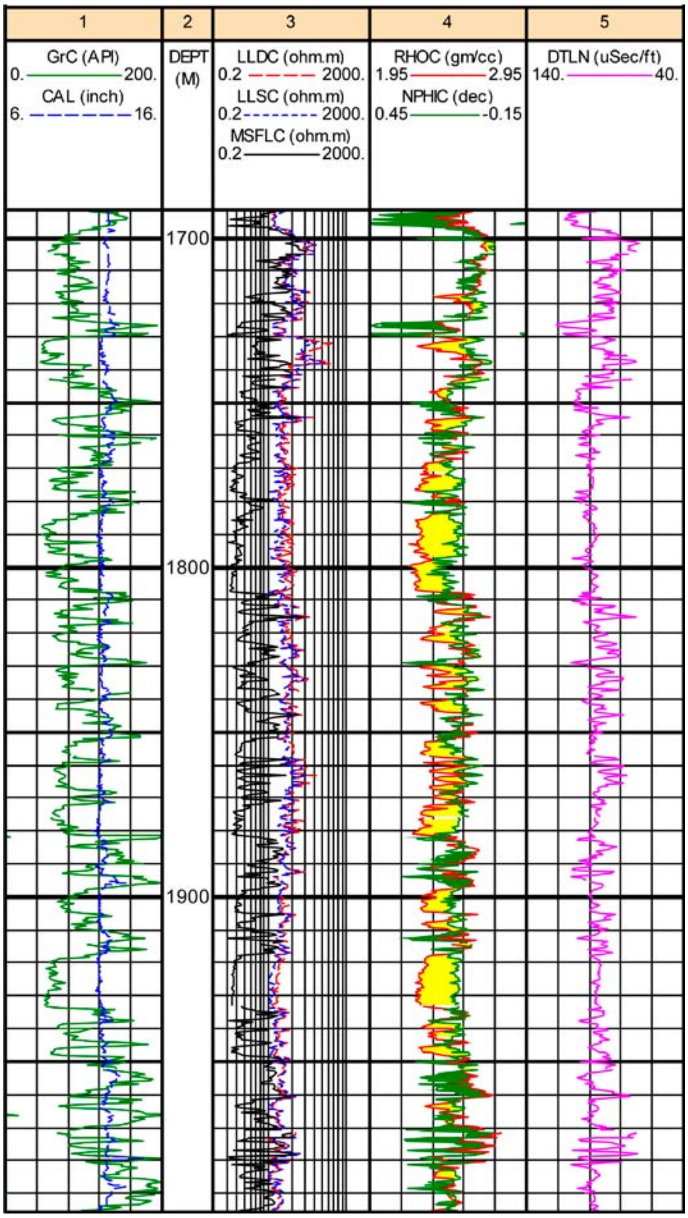

Figure 3: Input well log data for the studied well.

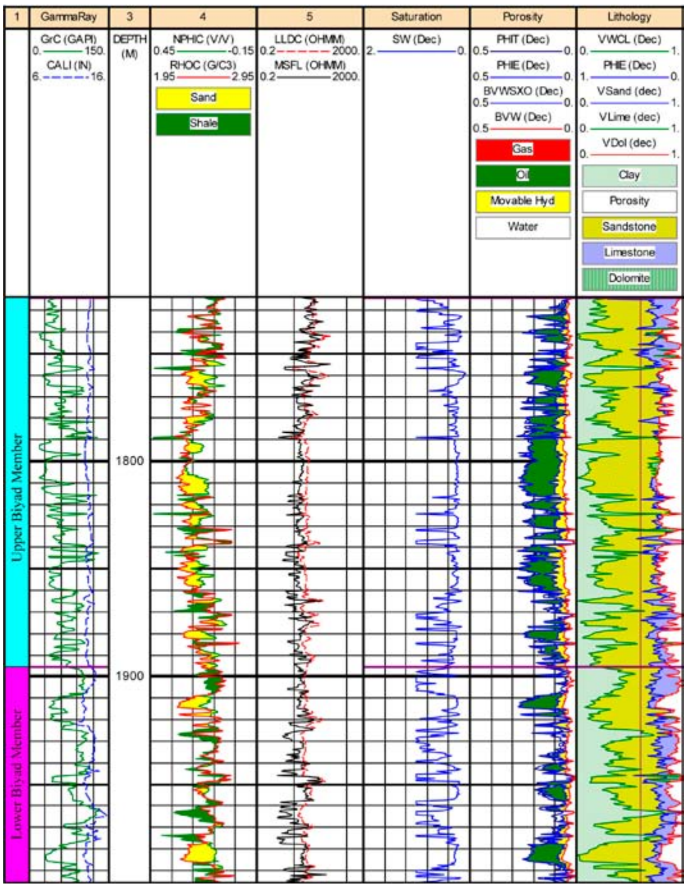

Figure 4: Litho-saturation cross-plot of the Biyad Formation for the studied well

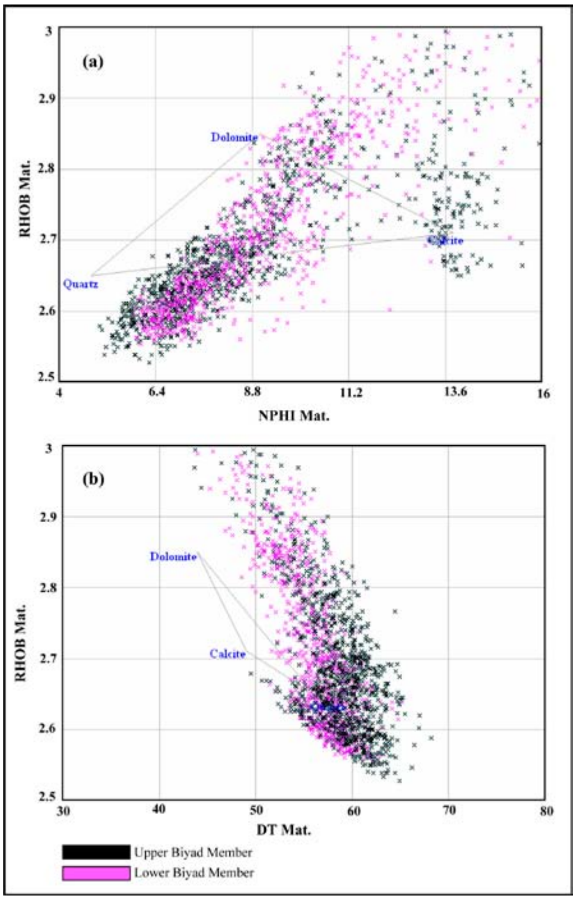

Figure 5: Lithological identification Cross-plots of Biyad Formation for the studied well, (a) RHOB mat-NPHI mat. Cross-plot and (b) RHOB mat- DT mat. Cross-plot

Resource Issues Paper 1a4

Diagenesis of Tertiary reservoir sandstones in the Northern Malay Basin, the Gulf of Thailand: A key of success for hydrocarbon exploration

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Understanding of reservoir rocks has been one of the key aspects in petroleum exploration and production, which is mainly obtained from indirect geophysics data. In this study, the cementation, porosity and diagenetic history will be investigated directly from some reservoir core samples through the petrographic study, X-ray diffractometry (XRD) and scanning electron microscope (SEM) analysis. The Tertiary sandstones in the Northern Malay Basin are known to be excellent reservoir rocks for hydrocarbon. The investigation of diagenetic events through the petrography, XRD and SEM of core samples can show the events that promoted the reservoir qualities explicitly.

The rock sequences consist of alternating clayey siltstone, sandy siltstone, silty sandstone, mudstone interbedded with pebble conglomerate sandstone and mudstone. The fine-medium-grained reservoir sandstones are composed mainly of quartz, minor feldspars, rock fragments and some carbonate grains and are classified as litharenite and sublitharenite with well developed secondary porosity. Significant cementations are major quartz overgrowth, carbonate overgrowth, pore-filling kaolinite/dickite, siderite/ankerite and minor illite. Porosity values estimated from point count analysis range from around 10% to 24% which agree fairly well with values estimated by other technique.

There are several major diagenetic events that affect the porosity of reservoir rocks. The first was compaction, the typical event found in almost every kind of sedimentary rocks. After compaction, the primary or initial intergranular porosity was reduced by two types of cementation. The first one was minor carbonate overgrowths (i.e., ferroan dolomite overgrowth on detrital non-ferroan dolomite grains and ferroan calcite overgrowth on detrital non-ferroan calcite grains). This was accompanied by major quartz overgrowth on detrital quartz grains as the second type of cementation. Subsequent event was the dissolution of carbonates and probably feldspar grains and the conversion of feldspars into kaolin minerals. This phenomenon led to the formation of significantly secondary porosity. The following event was pore-fillings of kaolinite/dickite and minor illite in the secondary pores. Siderite or ankerite cement probably was the latest in diagenetic sequence occurred by replacing earlier minerals along the grain boundary and stylolitic surface which eventually appeared locally as siderite or ankerite nodules when replacement became rather massive.

Resource Issues Paper 1b1

Can Permian limestone in Central Thailand be the source of hydrocarbon?

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An outcrop of Permian limestone in central Thailand has been known to exude a hydrocarbon odour when freshly broken. The limestone was found in a shallow water well where the oil film was observed in the water well. This discovery has raised a question whether the pre-Tertiary carbonate rocks could have been a source of hydrocarbons in central Thailand. Therefore A core of 226 m. was taken in the area of pre-Tertiary basement rocks in central Thailand. The cores display a 40 m. section of dark grey limestone on top of quartzite, mudstone, sandstone and conglomerates. The limestone in the upper part contained Middle Permian microfaunal assemblages, but the underlying clastics were palynological barren and could not be dated. The severely carbonized black wood fragments are found in the limestone. The geochemistry of the limestone shows no significant source potential because of its extremely high maturity. Most samples display very low residual TOC. One exceptional sample shows high residual TOC which appears to be from a zone of localized organic richness within the limestone unit. Based on these findings as well as the fact that most Permian limestone was undergone through strong diagenetic alteration earlier, these have negated the possibility of such rock to be a source rock in central Thailand.

Resource Issues Paper 1b2

Organic petrographic characteristics of the Crocker Formation, NW Sabah, Malaysia

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The deep marine Crocker Formation in NW Sabah, Malaysia has been well studied in terms of sedimentology, stratigraphy and structural geology. However, not much is known about its potential as a petroleum source rock. This study partly addresses this subject by means of petrographic analysis to characterise the Crocker sediments in terms of its organic matter content and thermal maturity. Crushed rock samples mounted in resin blocks were examined under reflected white and ultraviolet light. Petrographic analysis indicates that the Crocker Formation samples have low phytoclast content (<2%). The mostly indigenous phytoclasts (microscopic plant fragments) can be divided into 4 groups based on their reflectance values; vitrinite with dark inclusions (lowest reflectance), vitrinite, oxidised vitrinite and inertinite (highest reflectance). These phytoclast groups exhibit a reflectance profile of 0.6, 0.8, 1.0 and 1.2%Ro respectively. Such an approach (measuring the reflectance of different phytoclast groups) can aid the petrographer to evaluate and validate vitrinite reflectance measurements in samples such as the Crocker that has a variable phytoclast assemblage. The average vitrinite reflectance is 0.82%Ro, which indicate that the Crocker sediments analysed were once buried to a depth of 4.1 km on average. Although its thermal maturity is within the oil generation window at present day, the Crocker Formation is considered a poor petroleum source rock because it is poor in phytoclast content (<2%) and appears to lack oil-prone liptinitic macerals. However, favourable source rock units could exist within the Crocker in the form of slump or mass-transport units, if the organic or phytoclast content is high enough and oil-prone organic matter is sufficiently present. Further geochemical analysis and regional data need to be incorporated for a more comprehensive analysis and assessment of the Crocker as a petroleum source rock and/or an analogue for subsurface geological units.

Resource Issues Paper 1b3

Lexicon of Philippine Stratigraphy 2008

Rolando Peña

Chairman, Committee on Stratigraphic Nomenclature
Geologic Society of the Philippines

The Lexicon of Philippine Stratigraphy 2008 is an update of the previous Lexicon of Philippine Stratigraphy which was compiled by Juan S. Teves in 1954 for submission to the 19th International Geologic Congress. The present Lexicon was compiled in the course of editing the Geology of the Philippines (MGB, 2004, 2005 draft versions). Most of the entries were therefore lifted from the above draft versions of the revised edition of the Geology of the Philippines. The Lexicon of Teves (1954) adhered to a standard format that includes the following information:

- Name of stratigraphic unit
- Author or originator of the name, date, original reference
- Summary of original description
- Subsequent changes in the usage or acceptance of the unit term or name
- Present admitted definition of the unit, stratigraphic range, type locality
- Brief resume of geographical distribution
- Principal characteristic fossils
- Main reference other than the original

In the present Lexicon, capsule information for the main stratigraphic names in current use was adopted from the Geology of the Philippines (MGB, 2004, 2005 draft versions), following the main entry (name of stratigraphic unit). The capsule information includes:

- Lithology
- Stratigraphic relations
- Distribution (including type locality, if known)
- Age
- Thickness
- Author or originator of the name
- Renamed by (if applicable)
- Correlation / Synonymy (if applicable)

The above information is followed by a description of the unit, and other information pertinent to the nature of the unit.

Other entries in this Lexicon are names which may not be in current use anymore but mentioned in relation to those in current use. There are also entries that are not strictly speaking stratigraphic units but could be used as reference with respect to surrounding rocks units. Examples are the Acoje and Coto blocks of the Zambales Ophiolite and active volcanoes and volcanic complexes.

The Lexicon is by no means an exhaustive compilation of stratigraphic names. However, the names used in the 1981 edition of the Geology of the Philippines (MGB, 1981) are included in the Lexicon, which also adopts many of the names used by Corby and others (1951).

Aside from the main entries, there are entries on associated units (sub-units, facies, units that are not in current use or used by other authors). For example, Pau Sandstone. At the end of the entries, the reader may be prompted to look up the main entry with the phrase in parenthesis and italics. Example, (*see Malinta Formation*)

Lithology – Aside from mentioning the rock types represented in a stratigraphic unit, sub-units with the corresponding lithological make-up may also be included. For example, under Malinta Formation:

Lithology: Lower Pau Sandstone – sandstones with minor tuffaceous shale, conglomerate and lapilli tuff.
Upper Aparri Gorge Sandstone – sandstones with shale stringers and conglomerate lenses

Distribution – The type localities of many stratigraphic units are not reported. When the information is available, the type locality is included in the information on the geographic distribution of the unit.

Age – The age is generally given in terms of epochs or stages (e.g. Late Miocene, Tortonian). But the basis for the dating of the units, if available, is mentioned in the text, including radiometric dating and foraminiferal and nannofossil zonation

Correlation refers to equivalent units in other areas or adjacent provinces

Synonymy refers to the same unit but known by other names as used by other authors.

Stratigraphic columns are appended to provide a clearer picture of the position of one unit with respect to other units. These columns are from MGB (2004, 2005) and include only the units currently used or proposed by the Mines and Geosciences Bureau.

The printed copy of the Lexicon comes with an interactive CD by which one can view a geologic map of the Philippines divided into stratigraphic groupings based on affinity, namely, sedimentary basin, arc, ophiolitic, continental, metamorphic. The geologic map of the area belonging to a certain stratigraphic grouping can be viewed at a click, and the corresponding stratigraphic column may be accessed. Descriptions of the units in a column will appear with the click on the corresponding name in the column. The CD also contains a listing of units in the Lexicon in alphabetical order, a digital copy of the 1954 version of Lexicon of Philippine Stratigraphy and the Philippine Stratigraphic Guide. Thus the CD is a handy reference tool for fieldworkers who may find the book too bulky to bring to the field.

Resource Issues Paper 1c1

Characterisation of fine mica (sericite) from Coldstream, Bidor Area, Perak State, Malaysia

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The Coldstream fine mica (sericite) is located just behind the Coldstream village, at KM10, Tapah – Teluk Intan Road and is about 5 km south-west of Bidor town. The aim of this research is to characterise and study the differences on physical and chemical properties between raw and processed fine mica (sericite) from Coldstream, Bidor area. Furthermore, it is intended to determine the potential industry applications of this fine mica (sericite) by comparing with the currently-worked fine mica (sericite) deposits from overseas.

The area studied is mainly covered by alluvium and topographically they are low-lying and undulating. The undulating hills are generally less than 10 metres high and the bedrock underlying the alluvium is metasediments and Changkat Rembian granite. The metasediments consist mainly of quartz-mica schist, graphite schist, and phyllite. Quartzite and marble are interbedded in places with these rocks. Its age is probably Devonian to Ordovician. The Changkat Rembian granite occurs to the east and to the north of the study area and its age is probably Late Triassic. The Changkat Rembian granite is an elongated outcrop about 15 km long (Ingham, 1938). The fine mica (sericite) in Bidor is probably derived from hydrothermal alteration of this metasediments due to the intrusion of a granitic stock near Tapah.

Samples and methodology

The raw fine mica (sericite) samples were collected from the mining pit which was located about 200m to the north of the processing plant of Bidor Mineral Sdn. Bhd. These samples were mixed and sorted to form a representative composite fine mica (sericite) samples. The processed samples were collected from the Bidor Mineral Sdn Bhd. In the Bidor Mineral Sdn. Bhd., the raw fine mica (sericite) samples were processed by using wet method. Both raw and wet processed samples were tested for chemical and mineralogical content, microstructural observation and physical properties. The texture of the underlying rock was determined by preparing thin section while minerals composition was investigated by using LEITZSM-LUX POL microscope with the light source from the bottom.

Chemical analyses for major element concentration of the fine mica (sericite) samples were determined using a Philips PW 1480 x-ray fluorescence spectrometer, whilst the mineralogical analyses was performed on a Siemens D-5000. The microstructural analysis was performed using FSEM Supra 45 VP. Subsequently, the fine mica (sericite) samples were fabricated into button specimens for firing at four different temperatures, namely, 900^oC, 1000^oC, 1100^oC and 1250^oC. Individually fine mica (sericite) sample which were represented by four fired samples and one unfired sample were test for their brightness using Technidyne Brightmeter, S4-PL.

Results and discussion

Chemical analysis results for the raw fine mica (sericite) samples from Coldstream, Bidor area show high SiO_2 content, ranging from 60.25% to 66.70%, Al_2O_3 content from 19.21% to 21.82% and low Fe_2O_3 content of less than 2 %. TiO_2 content ranges from 0.99% to 1.19% whilst CaO and Na_2O content are generally less than 1%. The MgO content varies from 1.46% to 1.56% whilst K_2O content is within the range of 7.94% to 8.09%. The loss on ignition (LOI) value is between 5.91% to 6.624%. The processed sample shows slightly lower value of SiO_2 and higher in Al_2O_3. The TiO_2 is also slightly higher in the processed samples, but K_2O and Fe_2O_3 content is marginally the same in processed and unprocessed samples.

Mineralogically, results from the XRD determination indicate that the type of minerals present in the fine mica (sericite) is principally muscovite, with quartz and kaolinite occurring in subordinate and trace amounts. Considerable amount of pyrite is also present. The black colour of rock is due to the presence of amorphous carbon, as no graphite was detected. The rational analysis based on XRF observation was used to estimate the minerals content in the samples and shows that the raw samples contain 68% muscovite, 28% quartz and 3% kaolinite. After processing, the samples contain 66% muscovite, 19% quartz and 14% kaolinite, respectively. These shows that the coarse grained mica (muscovite) was also discharge during the processing and accumulate the fine particles, particularly the kaolinite.

When compared to a fine mica (sericite) samples from Chuzhou Grea Mineral Co. Ltd for both dry and wet processed, the processed samples from Bidor is found to be similar to the wet processed samples in both SiO_2 content and the LOI. Generally from this comparison, it is found that the processed fine mica (sericite) from the Coldstream is promisingly and potentially suitable for use as filler applications for welding rod, rubber, plastic and anti rust paint industries. However, on the other hand this fine mica (sericite) need to go for further process to reduce the iron content before it can be considered to be used in porcelain (after comparing with the sericite from the Bureau of Indian Standards,2006, sericite from Jan San, Korea and sericite from Wenzhou City, China.

Resource Issues Paper 1c2

Investigating the differences of characteristics of the tin deposits between Bangka and Belitung Islands

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Bangka and Belitung Islands are known as tin producer places which form a part of South East Asia Tin Belt, the richest tin belt in the world which is ranged from South China – Thailand – Myanmar – Malaysia to Indonesia. Tin deposit in both of the islands shows different pattern of dispersion.

In Bangka Island, mineralizations are formed around the granite body, and tin deposits (Sn) are found mainly in contact zone. On the Tertiary and Quaternary Period, Bangka Island lay on high altitude above the sea level, so weathering and erosion are very intensive. It forms secondary deposits (placer) in paleo rivers which are not only rich, but also available in large amount and can be found in many places. A high intensity erosion leaves a few primary deposits which don’t have better quality than those secondary deposits.

In Belitung Island, mineralizations are formed far from the granite bodies. On the Tertiary and Quaternary Period, Belitung lays on lower altitude above the sea level. Weathering and erosion are not as intensive as in Bangka, so the indication of the primary deposit can be found in many places and the forming of secondary deposit is not as good as in Bangka Island.

Some factors are guessed influence the difference of the tin deposit forming in the both of the islands. Among them are the characteristics and existences of the primary tin deposits. Besides that, the altitude of the island above the sea level on the tertiary and quaternary period which contribute to the weathering intensity, also influence that differences.

Resource Issues Paper 1c3

Sunda shelf as potential area of tin deposit

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Bangka Belitung was the biggest tin production in South East Asia. Tin deposits in Bangka Belitung have granitoids associated and show spasial and temporal relation in orogenic period. It shows fold belt type with main feature the intrusive complexes volcanic character which influenced the concentrated. The type of it, have relation with metallogenic provinces in South east Asia which showing the distribution of granitoids in the tin belt of South East Asia which is about 3500 km long and 400-800 km wide from Phuket,Thailand to Bangka Belitung,Indonesia. Besides the fold belt type which included to primary deposit, there are secondary deposit, placer deposit, which also increase the tin production in Bangka Belitung. It was influenced by Permian magmatic arc which extend from east Malaysia to west Kalimantan and from west Malaysia to Sumatera. It also make possibility the increasing of cassiterite concentrated as ore mineral in the alluvial to continental shelf.

In 1979 R.D Beckinsale said that 35%of tin production in Indonesia was derived from offshore operations which has done in the waters around Bangka Belitung. The waters around Bangka Belitung is a part of Sunda shelf. Sunda shelf is stable flatform (continental shelf) which can be sedimentation basin. It area is included Karimata strain and north of java sea. It also had been influenced by transcurent fault tectonic which extend in Sumatea island. Stability of sunda shelf was create an appropriate area to become potential area of placer deposit the ore mineral around it. In this case, sunda shelf are potential to have tin deposit with high concentrates and economical which support by modern deep mining operations.

Resource Issues Paper 1d1

Trade liberalisation and sustainable energy resources

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The global economy is dependent upon oil and other fossil fuels, and this dependency is fed through international trade. These three broad areas: trade, climate change and energy are however frequently addressed in isolation from each other. Trade liberalisation and the mitigation of and adaptation to climate change are currently managed under separate and complex legal regimes.

The integration of these regimes is essential to ensure that domestic and international measures to address climate change and the international trade system are integrated and mutually supportive. Infusing climate-friendly measures such as incentives for climate standards, strategically targeted subsidies and liberalisation in environmental goods and services could make a major contribution toward a sustainable energy transition, and climate change mitigation and adaptation.

The total primary energy supply (TPES) for the Asia-Pacific region is projected to more than double to 5,569 million tonnes of oil equivalent (Mtoe) in 2020, up from 2,671 Mtoe in 1997. Meeting the future energy demand and consumption without significantly changing current electricity generation technologies would have major environmental implications, especially in relation to climate change and global warming, not to mention the huge investment requirements.

Governments must move quickly to make a rapid transition in the sources of energy on which we rely, whilst balancing social, economic, and environmental concerns.

Resource Issues Paper 1d2

Characteristics of Sub-Microscopic Gold and Trace Element Geochemistry of Pyrite in the Long Chieng Track and Ban Houayxai Epithermal Deposits, Lao PDR

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The Long Chieng Track (LCT) and Ban Houayxai (BHX) epithermal deposits are located in the Phu Bia Contract Area, on the confluence of Loei and Truongson Fold Belts in the northern Lao PDR (Tate, 2005; Manaka *et al*., 2007, 2009). The mineralisation at LCT occurs as stockwork vein systems, whereas the BHX has at least three main mineralisation stages including early stockwork vein system and late structurally-controlled, shear-zone. The deposits are hosted in Carboniferous-Permian units, dominantly characterised by volcano-sedimentary sequence locally intruded by Early Permian intrusive rocks. In this paper, we report the gold and trace element geochemistry in pyrites using laser ablation inductively-couples plasma mass-spectrometry (LA-ICPMS) technique. The LA-ICPMS results show that there is a wide range of gold concentration in pyrite ranging from <0.1 ppm to several tens of thousands ppm, and close associations of the gold in pyrites with other elements such as Ag, As, Sb, Tl, Co and Pb are also identified. Additional correlations of Au with Ag and As reveals that these elements play a significant role in characterising the ore-bearing fluids. The relationship of Au and As indicates that a large amount of gold is hosted in pyrite as invisible nanoparticles in structure as well as occurring as inclusions of pyrite, whereas the Au and Ag association suggests that the pyrites of different mineralisation stages have distinct and consistent Au/Ag ratios, which may be due to the nature of the ore fluid chemistry. This study indicates that the trace elements in pyrites can be used as a vector for mineral exploration and to characterise the similar mineralised system in the region.

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Resource Issues Paper 1d3

Geology and mineralization characteristics of Meyon gold deposit, Mon State, Southern Myanmar

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The Meyon gold deposit is located within the Mogok Metamorphic Belt (MMB), about 9 kilometer north of Kyaikhto in the northwestern part of Mon State, Myanmar. Structurally, the Meyon gold deposit is located between the Papun Fault in the north and Three Pagoda Fault in the south and occurs in close proximity to the major NNW-SSE trending structure. Gold-bearing quartz veins are developed within a thick Carboniferous sequence of slate, argillite, phyllite, schist and minor massive turbiditic greywacke of Mergui Group. The skarn and hornfels occur at the contact zone between the granite and the sedimentary rocks of Mergui Group. The rhyolite, possibly of rhyodacite composition, also occurs in close association with mineralization, occurring within the mineralized zone. A distinct hydrothermal alteration mineral assemblage is recorded adjacent to mineralized veins within the Meyon deposit including silicification, argillic alteration and propylitic alteration. There are two mineralized zones named as Guku Prospect in the north and Kyaukpon Prospect in the south. Gold and sulfides were found in quartz vein and altered wall rock. Gold also occurs as free grains in oxidized zone and inclusions and fracture fillings within pyrite, and intimately associated with arsenopyrite associated with strongly altered wall rock. Rare pyrrhotite and chalcopyrite are also found. Pyrite occurs as two generations as large idiomorphic crystals as well as disseminated grains. Sulfur isotope analyses of pyrite indicate that the gold-ore forming fluids vary in sulfur isotopic values from -2.80 to 4.43 per mil suggesting a magmatic source of sulfur. The preliminary analysis of fluid inclusion study indicates presence of carbonic fluid inclusions and yielded homogenization temperatures of 240 to 370^{o}C and salinities of <10 wt % NaCl equiv. and the carbonic gas phases (CO_2 and CH_4) were detected by Laser Raman Spectroscopy analyses. The geological setting and mineralization characteristics of the Meyon deposit are consistent with an orogenic style of gold mineralization.

Resource Issues Paper 1d4

Geophysical electrical resistivity signatures on non-volcanic hosted geothermal areas in Indonesia

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Indonesia is blessed with abundant geothermal resources, one of sustainable and clean energy sources. Geothermal areas all over the country are mostly distributed along volcanic arcs. Geothermal energy resources in Indonesia are mainly utilized to generate electricity. Current electricity generations from geothermal energy sources in Indonesia are producing from volcanic hosted geothermal systems, resulting in a total geothermal power capacity of 1052 megawatts as of 2008. As the country face a problem in increasing electricity demand, diversify energy sources from fossils to geothermal energy sources is an important since their huge potential. Government of Indonesia, therefore, promotes geothermal utilizations for power generations by a national energy policy in which geothermal energy sector is to contribute a minimum of 9500 megawatts in 2025 or about 5% of national energy demand of the year. Government is also planning to develop ten thousand megawatts running from 2010 to 2014 by using geothermal energy as one of major sources. To further increase the capacity of geothermal electrical generations in achieving the demand and to contribute rural electrification programs, we should develop geothermal powers from non-volcanic geothermal environments since about 20 % of geothermal surface manifestations all over the country are clustered in these non-volcanic environments.

Electrical resistivity of rocks is one of the most useful geophysical parameters in the prospecting for geothermal resources. Resistivity methods have been used as an exploratory geophysical technique for geothermal prospecting in volcanic areas with results of showing 'low resistivity anomalies' that generally delineated high temperature geothermal reservoirs and were generally accepted as the best indicator of a geothermal promising zone. Therefore, these low resistivity anomalies are generally accepted as the best indicator of a geothermal promising zone in the volcanic areas. Nevertheless, applications of the methods we used in non-volcanic areas result unsimilar resistivity patterns with those of the volcanic. The low resistivity anomalies of the non-volcanics were hardly understood to be associated with geothermal indications. The patterns seems to be controlled by distribution of rock units constitute the study areas rather than by rocks – geothermal fluids interactions which occur mainly in the volcanic areas.

This paper summarizes result of applications of the Schlumberger resistivity method for geothermal prospecting in central part of Sulawesi Island. The study area is interesting since most of non-volcanic geothermal areas in Indonesia are located densely in central part of the island. An application of a magnetotelluric resistivity method in a geothermal area associated with heat source rocks of intrusive domes suggest us a necessity of the use of the method in the prospecting for the non-volcanic geothermal resources. The method could penetrate much deeper than the dc method, hence it would give better pictures of resistivity structures and, therefore, better understand of the geothermal system of the area.

Since we have less experiences on understanding non-volcanic geothermal system rather than the volcanic system, we will emphasize joint-researches with abroad institutions which would have sufficient experiences on developing the non-volcanic geothermal systems.

Resource Issues Paper 1e1

Review of alluvial gold potency relation to the local people mining in Indonesia

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Indonesia is a country with rich and diverse mineral resources especially gold deposits either as primary and secondary (placer) type deposits, placer deposit is known as alluvial deposit. The both types have attracted many big industrial mining and small scale mining activities or local people mining.

Base on fact that the areas of alluvial gold deposit in Indonesia have been discovered by the industrial mining and local people mining, but mostly have been mined by local people mining by using simple technology and equipments with permitted or not. and they hope could to mine continually for long time.

To anticipate for the impact of national economic crisis involvement of central and or local governments to give more attention to the management of the Indonesian mineral resources as well as in cultivating and inspecting the activity of people gold mining. Especially law enforcement in the implementation of good mining practice. Hopefully this action can be expected to contribute to the national socio-economic development especially in reducing unemployment and increasing the community welfare in the vicinity of the people mining areas.

Resource Issues Paper 1e2

Geology, structure and mineralization of the Tersang Hill Mine, Pahang, Malaysia

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The Tersang Hill Mine lies within Triassic rocks dominated by tuffaceous sandstone and shale with intrusions of rhyolite porphyry. The tuffaceous sandstones are interbedded with yellowish to grey siltstone and black shale. To the south, the tuffaceous sandstone is overlain by shale. In the southern part of the hill mine, the presence of a shear zone cut by two normal faults controls the gold mineralization. Sulphide mineralization is associated with gold occurrence in shear zones and fault zones. Fault breccia occurrence has shown sulphide mineralization. The sulphide in quartz veins are found in tiny fractures. Quartz veins featuring pinch and swell structure show sulfide mineralization within the shear zones. Sulphide mineralization occurred in quartz veins oriented ENE-WSW, ESE-WNW and SSE-NNW. Based on the above-mentioned data, gold mineralization is structurally controlled at the Tersang Hill Mine. Gold in mineralized quartz veins are associated with galena, pyrite and chalcopyrite.

Study Area

The Tersang area is located approximately 16 km north of Raub town (Figure 1). It is found in the northwestern part of the geological map of the Raub sheet, Pahang (Richardson, 1939). The area is situated between 812,500 m and 813,100 m easting and 440,300 m and 441,400 m northing (UTM WGS 84).

Geology

The Tersang Hill Mine lies within Triassic rocks dominated by tuffaceous sandstone and shales that were intruded by quartz porphyry. Field mapping was undertaken at the scale of 1:2000. The geologic map of the Tersang area shows three types of lithofacies including shale, quartz porphyry and volcanic rocks mainly tuffaceous sandstone. The area shows remarkably well exposed outcrops especially at the quarry. The mine geology shows that the tuffaceous sandstones are interbedded with yellowish to grey siltstone and black shale. The tuffaceous sandstone is overlain by Triassic weathered shale to the south.

Structure

Sulphide mineralization occurred in sheeted quartz veins cutting across bedding. The quartz veins, in general, are less than 1.2 m in thickness; numerous veins are 10-40 cm in thickness while some are merely 3-20 cm wide or less than 1-2 cm wide. In the western side of the pit some beds dip slightly to the southwest probably due to shearing movements, that affected the sedimentary rocks. This tectonic signature would have been caused by tilting of the country rocks in the southwestern part during or immediately after the shearing event. Five directions of quartz veins are recorded from the Tersang Hill Mine, namely:

- The first set (TQV1) of quartz veins strike N060°-90° dipping 20° to the south when parallel to bedding and dipping 30°-88° to the north and northeast when crosscutting bedding.
- The second set (TQV2) of quartz veins strike N098°-104° and dip 50°-64° to the north crosscutting bedding.
- The third set (TQV3) of quartz veins strike N108°-118°

dipping 54°-88° to the north and northeast crosscutting bedding.

- The fourth set (TQV4) of quartz veins strike N148° dipping 60° to the northeast crosscutting bedding.
- The fifth set (TQV5) of quartz veins strike N168°-174° dipping 48°-70° to the northeast crosscutting bedding.

Mineralization

Quartz veins striking N58° and dipping 68° to the northwest show sulfide mineralization. Quartz veins oriented N170° dipping 48° to the northeast show sulfide mineralization at the vicinity of faults. Quartz veins oriented N100° dipping 20° to the north and N168° dipping 70° to the northeast at the point of their intersection show sulfide mineralization. Quartz veins featuring pitch and swell structure show sulfide mineralization in the shear zone. Placer gold grains comes from the quartz veins. Gold in quartz veins is associated with galena, pyrite and chalcopyrite. The mineralization is structurally controlled by zones of shearing and faulting at Tersang Gold Mine in the Central Belt (Wan Fuad & Heru Sigit, 2001; 2002).

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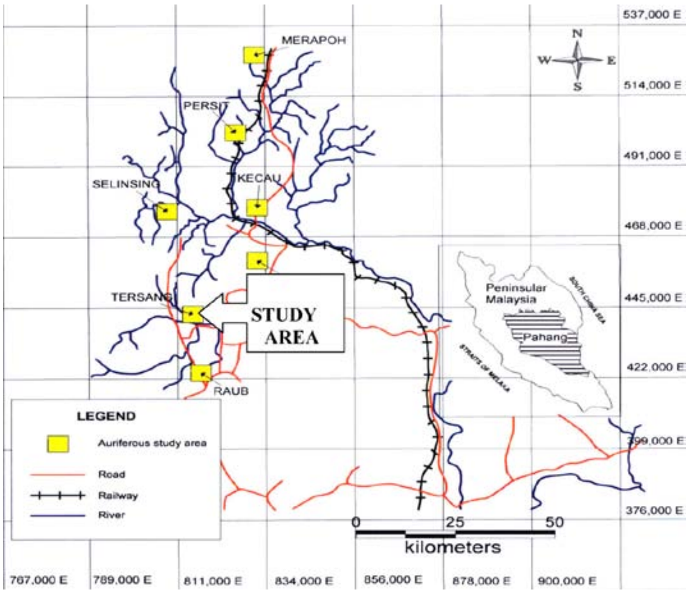

Figure 1: Sketch map showing location of study area in the state of Pahang, Peninsular Malaysia.

Figure 2: Structural style of gold-bearing quartz veins in tuffaceous sandstone at the Tersang Gold Mine, Pahang, Peninsular Malaysia. Quartz veins are white elongated bodies.

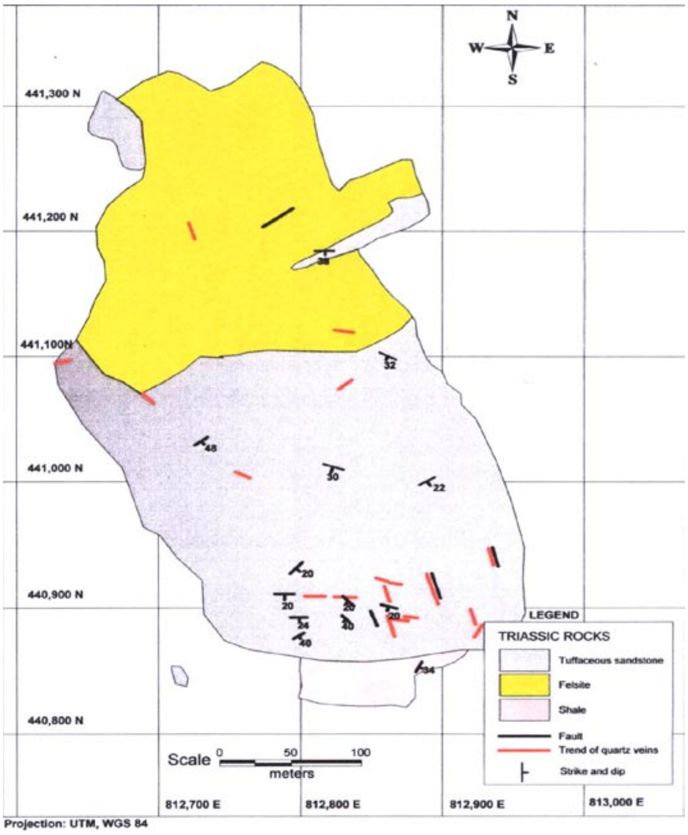

Figure 3: Structural geologic map of the Tersang Hill Mine, Pahang, Peninsular Malaysia.

Resource Issues Paper 1e3

Coal bed methane potential of Tanjung Formation in Tanah Bumbu South Kalimantan

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Coal deposits are distributed extensively in Indonesia, mainly in Sumatera and Kalimantan islands. These deposits become a lead for a huge amount of coal-bed methane (CBM) potency. As an environmentally friendly source of energy, CBM could be one of Indonesia's future energy sources. Center for Geological Resources (CGR) already starts exploration for this energy since 2005, until the last research in 2008 at Tanjung Formation in Tanah Bumbu Area, South Kalimantan.

CSAT-1 well was drilled at the end of 2008, in purpose to provide CBM resources and deep coal mine potency data for Tanjung Formation (Eocene) in Asem-asem Basin. This well get through 12 coal seam with three main seam, which is E seam at 212.34-213.30 m depth, I seam at 261.93-264.20 m, and J seam at 270.20-275.35 m depth. Calorific value from this three main seam categorized as high rank coal, various from 6197-6745 cal/gram (adb), with moisture between 4.51-7.11 %, adb.

Total coal resources that used for CBM resources quantification is 112,733,226 tons (between 300 to 1000 meters depth). Based on desorption test and gas chromatograph measurement from samples at various depth from three main seams, those coal gives maximum methane fraction (CH4) 10.6% from total gas. Gas resources calculation gives a total of 402,255,325 cuft (402 MSCF) of CH_4, with various methane contents between 1.2 to 5.8 cuft/ton coals.

Resource Issues Paper 1e4

Cu-Fe-(Au) mineralization at PUT2 deposit, Loei Province northeastern Thailand

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The PUT2 or Phu Thong Daeng deposit is located in the Loei Fold Belt, 20 km southeast of the Loei city, northeastern Thailand. The ore bodies are hosted by Paleozoic carbonate and clastic rocks which were intruded by Triassic granodioritic and granite intrusions. The early garnet skarn was formed along quartz-rich veins in the carbonate host rock, whereas the propylitic and argillic alteration took place within the granite intrusive body. Pyrite and chalcopyrite are the main sulfide minerals found as veins and veinlets in the carbonate and intrusive bodies. Magnetite, malachite and azurite are present along the contact between carbonate and intrusive rocks. Up to 16 ppm gold in pyrite and chalcopyrite was found using LA-ICP MS analytical technique. δS^{34} values in pyrite and chalcopyrite range from -3.88 to +1.34 per mil, which are similar to those of magmatic sulfur signature suggesting that the magmatic fluids are responsible for the formation of pyrite and chalcopyrite. Results from fluid inclusion microthermometric measurement of aqueous-carbonic (L-L-V) and highly saline (22-23 wt.% NaCl equivalent) aqueous (L-V-S) inclusions suggest that the pyrite and chalcopyrite mineralized veins were formed at 250°C to 300°C. These temperature and salinity ranges are agreeable to those of magmatic fluids source. The presence of low salinity aqueous (L-V) inclusions may be responsible for the late meteoric water influx. A combination of data from fluid inclusion microthermometry and sulfur isotope analyses implies that the ore deposit modeling at the PUT2 (Phu Thong Daeng) deposit is similar to those of intrusion related skarn Cu-Fe (Au) deposits.

Resource Issues Paper 1e5

Hydrothermal alteration and mineralization of porphyry-skarn deposits in Geunteut area, Nanggroe Aceh Darussalam, Indonesia

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The research area is located 55 km south of Banda Aceh. The research was conducted in Geunteut area are to find out hydrothermal alteration and mineralization of porphyry-skarn deposits, including association and zonation of hydrothermal mineral, alteration intensity, texture and paragenesis of ore mineral.

Porphyry-skarn deposits in Geunteut area caused magmatic activity on Middle Miocene by Granodiorite and Diorite Intrusion (Intrusion Rock Units) that resulting of hydrothermal alteration and mineralization. Hydrothermal alteration grouped to five zones : biotite-orthoclase-actinolite, epidote-chlorite-actinolite, garnet-clinopyroxene-tremolite, quartz-sericite and chlorite-calcite-clinoptilolite. Forming temperature of hydrothermal alteration are 120 – 360 °C with intensity from very weak until total altered. Mineralization take place on two episode: early and late episode. Early episode related with hypogene mineralization that showed by formed of magnetite, ilmenite, chalcopyrite and pyrite. Late episode related with supergene enrichment that showed by formed of chalcocite, covellite, iron oxide and malachite.

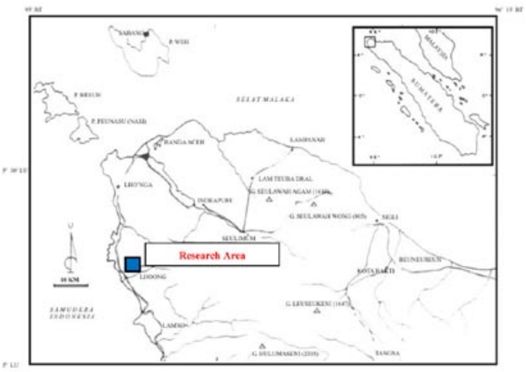

Figure 1: Location of the research area.

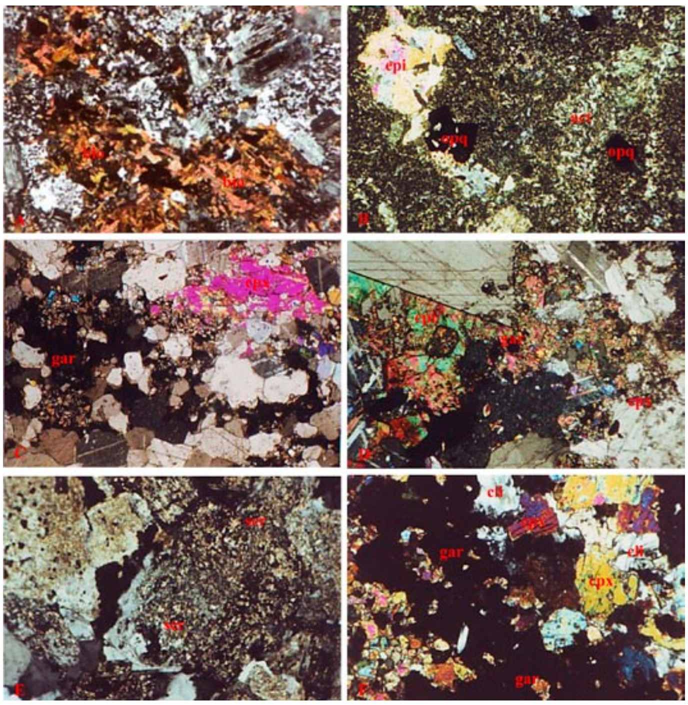

Figure 3: A. Diorite, plagioclase altered by secondary biotite (bio). B. Pyroxene basalt, mafic mineral altered by epidot (epi) and opaque mineral (opq), groundmass altered by actinolite (act). C. Marble, calcite altered by garnet (gar) and clinopyroxene (cpx). D. Marble, calcite altered by epidote (epi), epidote overprinted by garnet (gar) and clinopyroxene (cpx). E. Granodiorite, plagioclase/k-feldspar altered by sericite (ser). F. Skarn composed by garnet (gar) and clinopyroxene (cpx), than overprinted by clinoptilolite (cli).

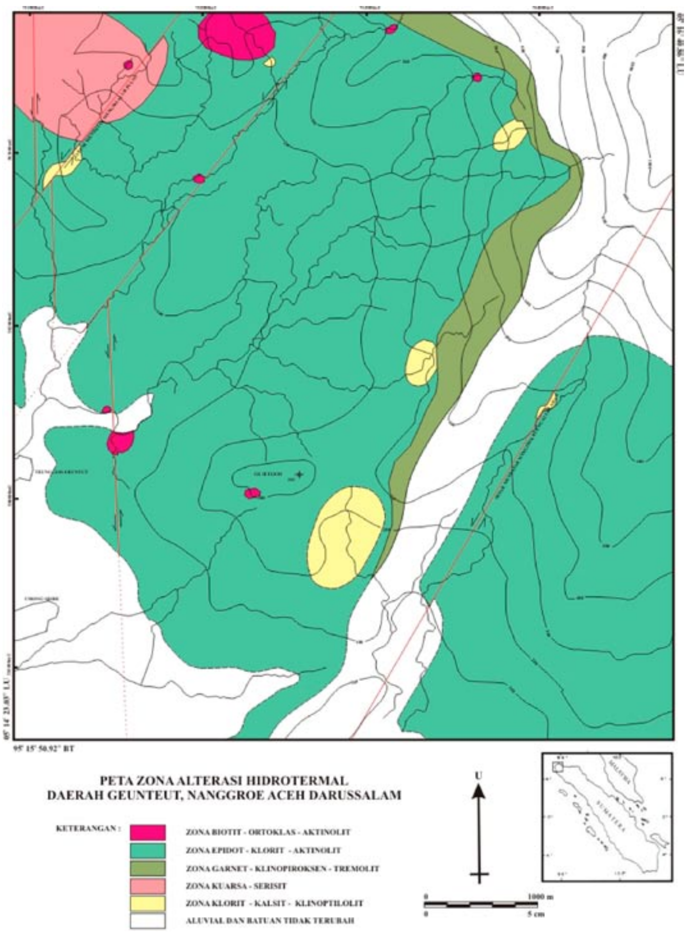

Figure 2: Hydrothermal alteration zone map of the research area.

No.	Ore Mineral	Paragenesis
1.	Magnetite	
2.	Ilmenite	
3.	Chalcopyrite	
4.	Pyrite	
5.	Chalcocite	
6.	Covellite	
7.	Iron Oxide	
8.	Malachite	

Figure 4: Paragenesis of ore mineral.

Evolution of Skarn Deposits (Corbett and Leach, 1997)		Evolution of Skarn Deposits in the research area
Prograde Isochemical Skarns		Occur contact metamorphic that forming hornfels and marble, also sequence of alteration zone in intrusion and non-reactive wall rock from biotite-orthoclase-actinolite zone (potassic) and epidote-chlorite-actinolite zone (inner propylitic)
Prograde Metasomatic Skarns		Occur metasomatic processes overprint and replace earlier metamorphic phases, characterized by garnet-clinopyroxene-tremolite zone (skarn)
Retrograde Skarns	*Phyllic Overprinting*	Characterized by quartz-sericite zone (phyllic) that overprinting biotite-orthoclase-actinolite zone (potassic) and epidote-chlorite-actinolite zone (inner propylitic)
	Sub-Prophylitic Overprinting	Characterized by chlorite-calcite-clinoptilolite zone (sub propyilitic) that overprinting garnet-clinopyroxene-tremolite zone (skarn)
	Mineralization	Occur mineralization of skarn deposits, consist of magnetite- ilmenite- chalcopyrite- pyrite-chalcocite-covellite-iron oxide -malachite

Figure 5: Evolution of skarn deposits in the research area.

Resource Issues Paper 1e6

The environmental effects of small scale tin mining in Bangka Island, Indonesia

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The Bangka Island is located in the western part of Indonesia, It belongs to Southeast Asian Tin Belt that elongates from Myanmar, Malaysian Peninsula, Sumatera and West of Kalimantan. Tin-mining in this island is the most productive in Indonesia, even in Southeast Asia, after Malaysia.

The occurrence of tin deposits in Bangka-island is correlated with pneumatolytic hydrothermal alteration as the granite host rock interacts with fluorine-bearing volatile gaseous fluids. This Late Mesozoic – Early Tertiary alteration is indicated by the presence of alteration minerals such as quartz aggregate, topaz, tourmaline, and lepidolite that can be derived from the alteration of feldspar and muscovite. Weathering process due to tropical climate disintegrate the granite to become more easily been eroded, and then transported as clastic materials to the low-lands, including the tin-bearing minerals, to form placer type deposits. This type of deposits is not too difficult to be exploited, Hence the local people carry it out in small scale and unconventionally exploitation/mining.

The small-scale mining as previously mentioned are causing significant environment disturbance. The exploration/mining is often carried out without the ability to restore the environment fertility. Generally, the soil condition is undergone quite significant physical and chemical changes due to the presence of tailing and rock waste. The tailings which consist mostly of quartz sands and gravels, contain insufficient nutrients for plants to grow normally. The organic-carbon content in soil decreased from 1.68-3.51% to 0.1%, and cation exchange capacity that correlates to soil fertility diminished as well. Natural recovery on soil fertility goes slowly, 40 years after the mining, organic-carbon content can only reached 0.95%, and cation exchange capacity only shows 3.9 ml/100g from originally of 6.9-11.3 ml/100g.

Some recovery activities are being done by the local government and related institutions. Some of them are reclamation of the damaged lands, replanting them, and improve the regulation and policy concerning the small scale tin mining, in order to minimize the negative effects and to manage the land-use after the mining activity.

Resource Issues Paper 1f1

The Mengapur gold-bearing Cu-Fe skarn deposit, Pahang, Malaysia – Geology and mineralisation

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The Mengapur deposit is recognised as a gold-bearing copper-iron skarn in the Eastern Gold Belt of Peninsular Malaysia. Geochemical exploration surveys recognised gold mineralisation associated with a Cu-Pb-Zn-Mo anomalies with subordinate anomalies of Fe, As, Sn and W.

A late Permian volcanic rhyolitic tuff and a Lower Triassic adamellite intrusion has metamorphosed the associated thick Permian sedimentary rocks to a skarn with an aureole dominated by diopside, garnet and wollastonite.The primary NNE fold axial trend in the Permian beds implies a WNW primary stress direction, while field evidence on faults in the area imply that the tectonic episode coincided with the Mid to Late Triassic orogeny which is generally recognized to have been effective in Peninsular Malaysia. The predominant NW fold axial trend of the Mesozoic rocks likewise implies a 045°NE primary stress orientation resulting in the development of the first order NNE tension and NNW shears,

The ore minerals present in the Mengapur skarn deposit include pyrrhotite, chalcopyrite, arsenopyrite, sphalerite, pyrite, geocronite, cassiterite, galena, bornite, molybdenite, magnetite, stibnite, bismuthinite, nagyagite (Pb-Au-Te-Sb-S), scheelite, covellite, digenite, hematite and gold. Gold is found associated with galena and tellurides. The gangue minerals are mainly quartz, carbonates (calcite and minor dolomite), cordierite, and skarn minerals.

The fluid inclusions study of the Mengapur deposit indicates it is a distal skarn deposit, with relatively shallow depth (52 to 1152 m) and low salinities (2.42 to 8.02 equiv. wt.% NaCl). The homogenization temperatures of the fluid inclusions range from 169.2 to 313.7 °C, rather similar to the suggested temperatures of 210 to 350 °C by Kwak and Tan (1981) for distal skarn. The trapping pressures obtained from the P-T diagram varied from 6 to 98 bars.

Resource Issues Paper 1f2

Geology and mineral resources of the area between Nogmung and Kan Paiti, Northeastern Kachin State, Myanmar

Nyunt Htay

Myanmar Geosciences Society

Nogmung and Kan Paiti areas lie in the northeastern Myanmar closed to the Myanmar-China border in the east. It is built up of gneiss, schist and marble of Mogok Group, mudstone, sandstone, slate and quartzite of Mergui Group intruded by granites with apalitic to basaltic dykes and green schist, amphibolite and meta-diorite with granodiorite and basalt. The area indeed is part of the Eastern Himalaya Syntaxis, and structural belts of Mogok Metamorphic belt, Slate belt and Tagaung-Myikyina belt partially occupy the area. Mogok Gneiss is traditionally believed to belong to Archaean age which is still in debate and needs confirmation. Sediments and metasediments of the area are mainly correlated with the lithologic similarity of the Mergui Group which covers whole of the Tenasserim area of Sothem Myanmar and the age of the group is Carboniferous to Lower Permian by fauna evidences. The green schist, amphibolites and metadiorite of Tagaung-Myikyina belt are tentatively proposed as pre-Upper Triassic to Lower Cretaceous in age. In northern Kachin State, radiometric dating has been sparsely attempted to the large-scale post metamorphic granitoid intrusion emplaced during Mesozoic to early Tertiary. The mineral resources of the area are: (1) lead-zinc mineralization, hosted in schist, quartzite and limestone some of which are skarn-type; (2) gold in slate and phyllite of mesothermal type; (3) skarn type of bismuth mineralization in limestone; and (4) residual and primary iron mineralization related to the skarn. Boulder float with copper carbonate and copper sulphide are noticed only in places.

Rocks potential pesources used for K-fertilizer from Ringgit Beser Complex area, Situbondo Regency, East Java Province, Indonesia

Kusdarto

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Fertilizers are increasingly demanded as to improve crop yields in line with the growing population of the world. Fertilizer is a substance applied for soil to enhance its ability to produce plentiful and healthy plants. Manufactured and natural fertilizers contained nutrients needed to improve soil fertility. Nitrogen, phosphorus, and potassium are of the three most important nutrients for crop growth.

Ringgit Beser Complex is located in Situbondo Regency, East Java Province, Indonesia where one of its rocks categorized into Quaternary Volcanic which is rich in potassium (K_2O). The rocks having high content of K_2O will serve as a major element for crop growth.

Ringgit Beser Complex belongs to Ringgit Formation that consisting of lava, volcanic breccia, tuff and basaltic tuff and intruded by diorite, trachite, basalt and leucite as a dyke. The resources of rock which is rich in potassium element approximately 45 millions m^3 containing 5.76-9.30 % K_2O.

Bioleaching experiments using leucite concentrate and the microorganism *Penicillium expansum* and *Aspergillus niger* showed that between 21% - 27% of the potassium contained in the leucite mineral could be leached by microbial means.

Environmental and economic considerations are the driving forces in the move from highly reactive and soluble fertilizers towards the use of slow release fertilizers. The present used K-fertilizers are not only soluble and easily available but are also easily leachable nutrient sources, especially in sandy soils with little clay and organic matter.

Earth & Health Paper 1g1

Kelang Valley Quartz Ridge – A Geological Monument to be Preserved

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The Kelang Valley Quartz Ridge is a natural monument dominating the landscape of northern Kuala Lumpur. It has been an attraction to visitors due to its accessibility, the challenges it provides and its natural landscape provides an escape from the hustle and bustle of nearby city life. The 16 km long quartz ridge fills part of the 60-kilometre long Kuala Lumpur Fault Zone that trends WNW. Closer observation in the field reveals five different quartz crystal shapes that are interpreted as a sequence of different phases of crystallization throughout the ridge history of evolution. While these crystallizations are magnificently exposed along the top of the ridge, evidences of the long history of the ridge formation can be observed along the wall. Numerous cracks that were produced tectonically during the intrusion of the ridge are exposed and this gives more understanding to the history of the landscape evolution of the ridge itself and its immediate surroundings. Important and rare structures such as release fractures that were formed with the reduction of overburden during the intrusion are also observed. Parts of the ridge also show areas where the main quartz body had been severely deformed during the ridge long history of development. All the findings add more value to this geological monument in terms of scientific, educational and aesthetic aspects to the readily available information, and therefore enhance the importance of the ridge to be preserved as geological heritage.

Earth & Health Paper 1g2

Mount Rinjani as first geopark in Indonesia

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Mount Rinjani (+3726m) is located in Lombok island, Nusa Tenggara Barat as a second highest volcano in Indonesia after Mount Kerinci (+3800m) in Sumatera island. The Rinjani volcano grew in the eastern part of the caldera. The Rinjani caldera has a crescent-shaped crater lake, and within the caldera formed an active volcano, called Mount Barujari. Based on the researches, Mount Rinjani has been erupted of several large eruptions formed a morphology of the caldera that had been developed by the Rinjani National Park comprises rock variations, and naturally forms a spectacular secene.

Mount Rinjani as part of the Rinjani National Park (TNGR) is now managed by local governmen, private companies, communities and tourist agencies, named Rinjani Trek Management Board (RTMB). Since it was managed by RTMB, Mount Rinjani has been granted several national and international awards, such as "World Legacy Award" (2004), and the finalist of "Tourism for Tomorrow Awards" in 2005 and 2008. Rinjani has a potential geotourism, such as panoramic caldera, beautiful lake, summit, crater, active volcano, water falls, hotsprings, caves, rock exposures, and historical eruptions. In this case, Rinjani is suitable promoted as "Geopark", and as the first geopark in Indonesia. If it succeed, then Rinjani Geopark will adds the geopark number in the world that had 53 geoparks, distributed in 17 countries under coordinated by UNESCO, and Rinjani Geopark will become a second geopark in Southeast Asia after Langkawi island in Malaysia.

To reach the aim, RTMB coordinates collecting data and informations of geological aspects, also to analyse data for developing alternatives. In this activity, geologists are very responsible beside the other experts of related scientists to carry out this project, in order to improve the community within the geotourism in Indonesia when the geopark has been published in international level.

Earth & Health Paper 1g3

Geological landscape and public perception: Case study of landscape view from Dataran Lang, Langkawi

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The study of the Geological landscape based on the view from Dataran Lang included landscape mapping and public survey on their perception regarding landscape beauty. Landscape mapping carried out at specific view point by identified type of landform, the associated geological formation, and general classification based on natural and man made landscape. This data later transform into a basic sketch relate the landscape and the rock type that formed the landscape. Public perception survey carried out using this sketch to find out public understanding towards the landscape beauty and their relationship with geology. This survey was conducted based on 35 individual who visited the area. Based on the survey most of the visitors are from outside of Langkawi and more than half are women and almost 90% are in for holiday. Most dominant group involve are at 40% age between 25-34 year old. 63% of participants are those travels by sea as the location of Dataran Lang is next to ferry terminal. The results indicate that the tourist consider the landscape seen from Dataran Lang have scenic view. Based on the sketch, most of them can relate the landscape that they are seeing have an association with different geological formation. They can also relate the sketch with the natural topography, man-made landscape and the panoramic perspective in the sketch. This study revealed that the geological sketch of the landscape is important for enhancing public education in understanding geological landscape.

Superimposed displacements on record in the Bukit Tinggi Fault Zone, Pahang, Malaysia

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The Bukit Tinggi Fault Zone is an established Northwest - Southeast regional fault zone, mapped as a several kilometres-wide fault belt that extends for 80 kilometres in Selangor-western Pahang and Negeri Sembilan (Figure 1). A series of weak tremors of not more than magnitude 3.5 shook Bukit Tinggi town from November 2007 until May 2008. No bodily harm was reported and structural damage was slight Most of the epicenters occur around Bukit Tinggi village, Pahang and also locate in a northerly trend. The village occupies the intersection of the regional fault zone with this northerly striking weak zone. Peninsular Malaysia is located on Sundaland and had only epicenters of weak tremors induced by initial filling of a large reservoir in the northeast in the early 1980s. Effcets of strong subduction earthquakes to the west of Sumatera and wrench earthquakes on the Sumatera fault zone has caused ground shaking and some events were probably associated with sinkhole development in the peninsula. The outcrop as the focus of this presentation was discovered during ongoing field studies by geologists from MGD offices of Selangor-Federal Territory, State of Pahang, and State of Negeri Sembilan.

A strand of the Bukit Tinggi Fault zone that crops out as a more than 80 metre long but low highway roadcut in fresh quartz diorite, a few kilometres to the east of the Genting Sempah tunnels.In this study it is referred to as locality BT 17 (N 03° 21.176' East 101° 48.649'). Fractures exhibit four major sets, three striking easterly and the fourth representing horizontal fractures (Figure 2). The three inclined fracture sets have vertical, sixty and thirty degrees dips. These fracture sets suggest a stress system in which the maximum or minimum principal stresses were orientated horizontal or vertically. On many of the fault surfaces are subhorizontal to horizontal striations consisting of slickensides and associated markings of reliable displacement sense. Horizontal and lowly inclined fault striations clearly resulted from tectonic activity. The outcropping fault surfaces are extraordinary in that multiple sense of displacements may occur on the same fault plane or an adjacent parallel plane. Opposed sense of fault displacement may occur on the same surface albeit with different pitch (Figure 3). At least two fault planes exhibit reverse up-dip sense occurring together with down-dip fault-plane markings (Figure 4). On this equal-area projection of the lower hemisphere, are plotted the various senses of displacement.

The superimposed senses of displacement are interpreted in the following manner:

1. The younger sense of displacement is best represented; the earlier sense of fault displacement occurs in smaller isolated patches.
2. At least three senses of displacement are shown in the outcrop: the earliest was the result of tectonic compression orientated within the sector 155° - 190° (335° - 010°). The succeeding tectonic compression acted in East-West direction, whereas the latest fault displacement was caused by gravity and produced normal faulting.
3. One case of reverse faulting that succeeded earlier normal faulting represents the third latest period of compressional tectonics..

Conventional wisdom makes geologists believe that fault-plane markings should represent the latest activity on that plane, while products of earlier displacement activity are generally erased. The Bukit Tinggi fault strand at this locality definitvely proves otherwise.

In view of the excellent condition of fault-surfaces adorned with distinct markings of displacement, this particular outcrop presents a geological monument of superior quality to serve educational and research purpose.

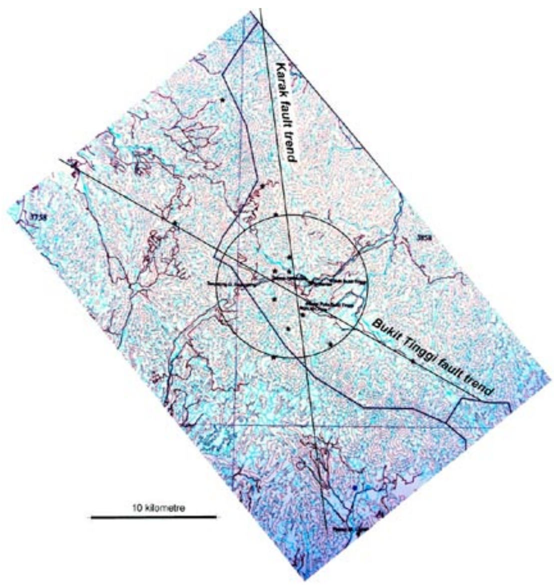

Figure 1: Bukit Tinggi Earthquake Study. The thirteen epicenters of the Bukit Tinggi earhquake swarm. Note the concentration of the epicenters about Bukit Tinggi village.

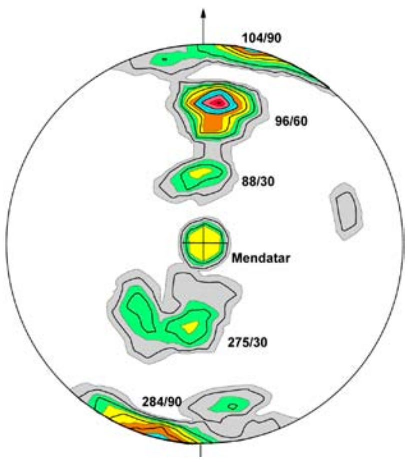

Figure 2: Thirty two slickensided fault surface at locality BT 17 plotted on equal-area, lower hemisphere. MGD Pahang.

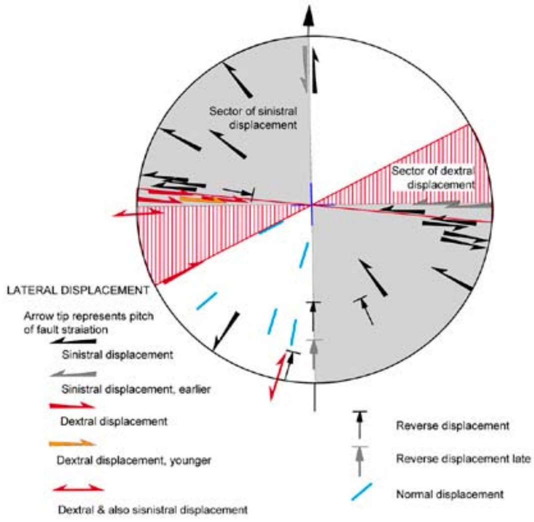

Figure 3: Equal-area plot, lower hemisphere, of pitch of displacement sense of wrenching, (half-tipped arrows), reverse motion, and normal motion. The tips of half-arrows and arrows indicate the corresponding pitch value. Locality BT 17; rock is faulted quartz diorite in the Bukit Tinggi Fault Zone.

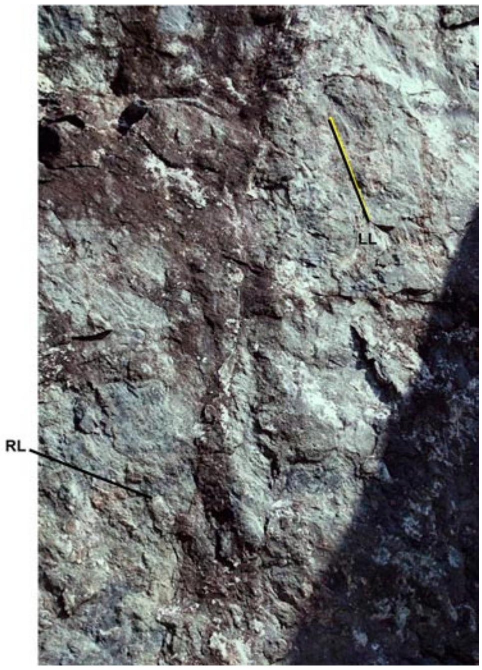

Figure 4: Fault-plane markings indicating right-lateral and left-lateral sense crossing each other and thus represent different displacement periods. Locality BT 17, rock is medium-grained quartz diorite.

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Deep Earth Paper 2a2

Adakites rocks from Sintang, West Kalimantan and Una-Una Island Central Sulawesi, Indonesia: Evidence of slab melting subducted young oceanic crust

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Adakites rocks found in Sintang, West Kalimantan (Proteau, *et al*., 1996) and Una-Una Island, Central Sulawesi (Sendjaja and Sucipta, 2008) (Figure 1). Adakite is a relatively new petrologic term that was designed to refer to a group of silicic arc igneous and volcanic rocks primarily produced by direct melting of the basaltic portion of subducted / subducting young (<25 ma) oceanic crust (Defant and Drummond, 1990). Geochemical characteristic of adakites are high silica (SiO_2 >56 %), high Al_2O_3 (>15%), low MgO (<3%), high Sr content (>300 ppm), low Y (<15ppm) with ratio Sr/Y (>20). (Castilo, 2006).

Proteau *et al*., (1996) proposed that the Miocene magmatism in Sarawak and Kalimantan might be attributed to the subduction of a narrow Proto South China Sea. This palaeo-subduction zone reconstructed from the Palawan Trench to the front of the Crocker Range could be traced westward in Sarawak. The evolution of the now disappeared Proto South China Sea has been subject to controversy. During the Early Miocene, the collision of the Sulu-Celebes block with Sula microblock induced rapid subduction of this basin along the Palawan/Borneo trough. It resulted in the island arc volcanism of the Cagayan Ridge. The Lava of this arc, which extend eastward in the Panay, Mindoro and Tablas Island are dated from 23 to 14 Ma. The collision at 15 Ma between the Cagayan Ridge and the rifted margin of the South China Sea marks the complete subduction of this basin.

Quarternary volcanism at Una-Una Island has been subject to controversy too, this active volcano is separated from the Indonesia's volcanic belt that stretches from the north end of Sumatera - Java - Nusa Tenggara - Maluku to North Sulawesi (Chaniago *et al*., 2004). According to Katili and Sudrajat (1984), Colo Volcano is part of the extinct volcano located in Togean Island. The activity of this volcano shifted northward and forms Mount Colo.

Sendjaja dan Sucipta (2008) proposed the Una-Una volcanic rocks are products of subduction with shallowing subduction angle of the Sulawesi Sea crust which is still young beneath the Northern Arm of Sulawesi. The geochemical results of the lava and pyroclastics have the adakitic signature, with Sr and Nb enrichment to explain the great distance (± 250 km) from the trench in the north the Una-Una Island.

This paper compare of six samples of Middle Miocene adakites granodiorite from Sintang, West Kalimantan and eight samples of Quarternary adakites volcanic rocks from Una-Una Island, Central Sulawesi (Table 1) base on petrology and geochemical constrain.

Both of adakites shows the similarity pattern, all rocks display strongly LREE-enriched, depletion in high field strength elements as compared to primary mantle, which is a typical signature of island arc, confirming that these rocks were produced in a convergent margin environment. The Sintang Adakites coeval with early stage of subduction of the Proto South Cina Basin and Una-Una adakites product of subduction of Sulawesi Sea crust beneath the Northern Arm of Sulawesi.

Figure 1: Location of adakites in Indonesia region.

Table 1: Geochemistry of Quarternary volcanic rocks from Una-Una Island and Midle Miocene adakites granodiorite from Sintang, West Kalimantan.

	Una-Una Island, Central Sulawesi								Sintang, West Kalimantan					
	UNA/008	UNA/010	UNA/006	UNA/016	UNA/002	UNA/014	UNA/004	UNA/024.A	BLU1	BL3	BL1	BLA1	BG1	BR1
SiO_2 (%)	60.11	57.12	53.45	64.05	58.82	61.85	61.86	61.47	70.00	68.80	67.00	67.30	64.50	68.00
TiO_2	0.36	0.47	0.62	0.34	0.75	0.34	0.37	0.44	0.25	0.31	0.29	0.30	0.38	0.31
Al_2O_3	19.37	19.95	20.02	17.09	21.32	17.80	18.24	18.05	15.70	15.60	16.10	16.20	16.60	15.70
Fe_2O_3	0.53	0.57	0.86	0.44	0.62	0.53	0.47	0.56	0.32	0.39	0.39	0.39	0.51	0.37
FeO	2.72	2.89	4.41	2.22	3.17	2.69	2.39	2.85	1.64	1.99	1.97	2.00	2.62	1.90
MnO	0.13	0.17	0.13	0.09	0.02	0.11	0.09	0.10	0.04	0.04	0.04	0.05	0.05	0.04
MgO	2.25	3.64	4.71	2.20	1.39	3.09	2.63	2.76	1.11	1.65	1.43	1.49	1.90	1.59
CaO	3.77	4.28	3.54	3.14	2.19	2.68	3.39	3.94	3.33	4.02	4.16	4.06	4.50	3.90
Na_2O	5.25	4.97	3.95	5.17	2.18	4.95	5.42	5.12	4.27	4.00	4.05	4.22	4.55	4.20
K_2O	3.07	2.90	3.08	3.34	2.71	3.19	3.04	3.16	1.62	1.43	1.35	1.41	1.27	1.42
P_2O_5	0.39	0.51	0.63	0.29	0.52	0.33	0.33	0.45	0.10	0.13	0.12	0.12	0.16	0.13
LOI	1.31	1.79	3.75	0.52	5.63	1.72	1.03	0.35	1.13	1.88	2.76	2.33	2.82	2.18
Total	99.25	99.27	99.15	98.89	99.33	99.27	99.26	99.25	99.52	100.2	99.65	99.88	99.86	99.75
Ba (ppm)	251	188.8	183	235	188	305	236	174	390	380	316	327	260	365
Cr	53	37	15	36	51	101	53	62	16	43	20	22	37	37
Pb	39	52	25	50	25	45	50	32						
Rb	43	25	59	47	75	49	47	45	48	47	48.5	44	32	46
Sr	2180	2300	149	2300	1340	2150	2220	2100	700	810	810	800	1110	835
V	88	81	165	69	190	85	69	116	33	46	45	47	60	45
Y	10.8	13.59	10.32	5.70	6.25	7.38	6.5	7.50	3.2	4.4	4.5	4.5	3.8	4
Zr	195	210	172	186	178	196	187	172						
Co	22	29	51	24	26	27	25	39	4.5	8	7	7	9	7
Ni	19	17	17	36.75	46	80	35.16	21.29	14	32	18	19	37	29
Cu	16	29	35	22	69	61	10	43						
Zn	61	72	96	44	66	55	52	52						
Ga	22	22	22	22	22	25	19	25						
Sc	1.77	0.49	8.81	0.22	8.09	3.75	1.65	1.12	3.8	5.00	4.5	4.7	5.5	4.6
Nb	21.56	19.85	21.90	18.32	21.35	24.24	19.33	16.13	2.5	2.50	2.2	2.6	2.6	3.1
Cs	1.32	1.74	4.47	1.82	1.12	4.92	2.38	2.60						
La	15.05	16.03	22.62	6.83	10.76	21.99	8.99	12.94	12.2	14.60	12	12.3	15.5	15.4
Ce	37.97	37.47	51.72	17.09	31.35	43.46	21.71	27.99	21	27.50	22	23	29	28.5
Pr	3.74	4.00	5.51	1.95	3.07	4.57	2.34	3.19						
Nd	14.62	15.49	21.06	8.15	12.22	16.41	9.20	12.86	8.6	11.00	9.5	9	12.5	8
Sm	2.64	2.93	3.60	1.61	2.32	2.63	1.61	2.22						
Eu	0.92	0.93	1.48	0.71	0.84	1.20	0.70	0.81	0.46	0.46	0.42	0.48	0.6	0.55
Gd	2.72	3.07	3.73	1.62	2.17	2.70	1.77	2.17						
Tb	0.31	0.41	0.41	0.21	0.25	0.28	0.22	0.25						
Dy	1.78	2.46	1.86	1.19	1.26	1.26	1.26	1.49	0.6	0.90	0.8	0.8	0.8	0.8
Ho	0.37	0.51	0.39	0.25	0.26	0.26	0.29	0.28						
Er	1.08	1.49	1.10	0.73	0.70	0.71	0.78	0.84	0.3	0.35	0.25	0.4	0.3	0.4
Tm	0.17	0.23	0.16	0.11	0.11	0.11	0.16	0.13						
Yb	1.11	1.55	0.94	0.75	0.66	0.63	0.82	0.84	0.19	0.29	0.3	0.33	0.27	0.29
Lu	0.16	0.22	0.15	0.11	0.11	0.11	0.14	0.13						
Th	5.95	6.28	6.78	4.24	4.14	8.24	5.18	5.19						
U	1.84	1.78	1.80	1.47	1.84	3.03	1.68	1.81						

Deep Earth Paper 2a3

Age, origin and exhumation of the Mount Kinabalu Granite, Sabah

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Mount Kinabalu is the highest mountain in SE Asia at 4100m. It is a granite body that intrudes rocks deformed in the Early Miocene Sabah Orogeny following subduction of the South China continental margin beneath the north Borneo margin. Ice action during Pleistocene glaciations has resulted in excellent exposure of the summit area. The granite has previously been interpreted as a compositionally zoned, steeply sided pluton with a central biotite granodiorite, surrounded by hornblende granite and a marginal porphyritic facies. New thermochronological data from zircon and apatite record emplacement and crystallization of the granite body, and suggest a new interpretation of its structure; they also record exhumation of the granite, which is linked to young orogenic development on land that continues today offshore.

High-precision U-Pb SHRIMP analyses of concentric growth zones in zircon date crystallisation of the Kinabalu granite at between ~7.9 and ~7.2 Ma. The ages support models relating the Kinabalu granite to anatexis not subduction. The entire pluton was emplaced and crystallised within a period of less than 700,000 years. At least four pulses of magmatism are recognised, each lasting about 100,000 years. The oldest ages (from the biotite granodiorite) coincide with the highest elevations of the western plateau and the youngest ages (from the porphyritic facies) are found at the edges of the body at lower elevations. Based on these new age data and field observations we suggest the central biotite granodiorite, main hornblende granite and porphyritic facies are Upper, Middle and Lower Units of a sheeted laccolith-like body comprising at least four dyke-fed granite sheets that young downwards.

Inherited zircon ages suggest melting of deep crust, including South China continental crust and arc basement rocks. The Upper Unit biotite granodiorite requires a source that includes old zircons, possibly the subducted attenuated continental crust of the South China margin. Inherited zircon ages from the Middle and Lower Units imply melting of the crystalline basement exposed today in parts of Sabah, with little or no contribution from underthrust South China crust. Cenozoic inherited zircon ages probably indicate some contribution of arc material formed during subduction of the Proto-South China Sea.

Zircon fission track data record post-crystallisation cooling but abundant dislocations make apatite fission track data unreliable. Apatite (U-Th)/He ages show a broadly positive relationship between age and elevation, complicated by NE-SW trending extensional faulting on the south side of the body.

The thermochronological data indicate that there was significant topographic expression by around 6 Ma. They indicate cooling of the granite was a response to growth of topography and rapid exhumation of the orogen. The Kinabalu granite is the product of collision-related thickening in the Sabah Orogeny. Thermochronological data record rapid, regional exhumation since the Late Miocene, driving fold and thrust deformation offshore, possibly following loss of a deep lithospheric root.

Deep Earth Paper 2a4

A petrographic study on diagenesis of reef-associated Rajamandala carbonate rocks, Padalarang area, West Java, Indonesia: preliminary results

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The carbonate rocks of the Rajamandala Formation extend in a northeast-southwest trend in the vicinity of Padalarang area. The carbonate rocks were deposited in a land-attached platform setting during Oligocene, overlying the shale-siltstone predominated lithologic unit.

About fifty samples of the Rajamandala Formation from Padalarang area were studied to determine their depositional environment as well as the sequence of diagenetic processes. Samples were selected from eight locations based on field observation to represent different depositional environment in reef-associated setting, i.e. reef, fore reef basin slope and back reef. This preliminary study was carried out by detailed hand specimen and thin section observation. The studied samples are mudstones to packstones to grainstones and floatstone to rudstones. For wackestone and pacstone, coral, coraline red algae and foraminefera are the dominant bioclasts, whereas echinoids, bivalves and ostracods are less abundant; they are set in a micrite matrix. For floatstone and rudstone, the fragments are mainly of coral and lithoclasts, with dark rounded pellets and sand-size bioclasts; they are embedded in a carbonate matrix.

Petrographic studies confirmed the presence of different carbonate facies in the carbonate platform during the deposition of the Rajamandala Fm. Reef and near-reef, as well as fore-reef to upper slope facies were represented by various samples. Nine carbonate microfacies have been identified and can be grouped into five: (1) quartzose bioclastic facies, consisting of abundant quartz grains (>10%) and bioclasts predominated by benthic foraminifera and red algae, deposited probably in a shallow, near reef environment by strong currents that carried terrigenous materials; (2) mudstone-wackestone facies, predominated by micritic matrix (>50%) and contains reworked sediments and intraclasts, represents a low energy, platform interior environment that was intermittently disturbed by storms; (3) bioclastic facies, consisting abundant shallow-marine bioclasts in a micrite matrix, deposited in interior platform, most likely lagoon, and in a shallow marine, high energy near reef to upper slope environment; (4) lithoclastic facies, containing abundant lithoclasts (>20%) and shallow-marine bioclasts in a micritic matrix, deposited in upper basinal slope; (5) planktonic foraminifera facies, which represents deposition in the distal slope and basin.

Diagenetic fabrics indicate two stage processes: 1) early marine to vadose; and 2) late meteoric (phreatic) to burial diagenesis. They include early marine cementation by isopachous fibrous aragonite, compaction, aragonite dissolution and/or neomorphism, precipitation of pendulous calcite and micritic cement in a vadose environment, precipitation of equant-grained calcite cement in a phreatic environment, dissolution to form moldic, vuggy and channel porosities, dolomitization-dedolomitization, the formation of stylolites and fractures, and precipitation of coarse, blocky calcite during burial.

Several samples from different localities show evidence of subaerial exposure, suggesting that subaerial exposure probably occurred more than once. Subaerial exposure of platform top might have been caused by temporary sea level drops or local tectonic events, which in turn would have triggered intensive erosion in the landward areas. Quartzose-bioclastic and some lithoclastic-bioclastic deposits in near-reef to upper slope setting might have been formed during these events.

Several stages during diagenetic processes could create secondary porosities, e.g. subaerial exposure, dissolution during burial, dolomitization, and stylolite and fracture formations. Although precipitation of calcite cement reduced porosities, current observations identified intraparticle, moldic, vuggy, channel and fracture porosities in various amounts in different samples (from ~1 to 20% in total).

Deep Earth Paper 2a5

Post-collisional granitoids in Central Sulawesi, Indonesia

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The K-shape island of Sulawesi is situated in the center of a complex region where an on-going triple junction collisional process between the Eurasian, Indo-Australian and Pacific plates occurs. The Western arm consists of volcano-magmatic rocks which geographically shows specific distribution of its Late Miocene to Recent magmatic-volcanic products. The potassic/shoshonitic products are concentrated in the Southern parts, the Potassic Calc-Alkaline products are concentrated in the Central parts, whereas the Calc-Alkaline products can be found in the Northern parts.

In the Central parts of Sulawesi, notably along the Palu-Koro Fault Zone (PKFZ) the Potassic Calc-Alkaline (KCA) plutonic products are represented by the abundant granitoids, while the volcanics by dacitic-rhyolitic pyroclastics. The KCA rocks, whose trace element ratios show that they are cogenetic, present SiO_2 = 61.7-76.5 % and contain more than 20% of normative quartz. With the presence of small amounts of normative corundum, all these suggest for an anatexis or crustal contribution. REE patterns display their regular relative enrichment, which varies with time, along with increasing degree of incompatibility. Negative anomalies in Ta, Nb and Ti indicating traces of subduction-related characters, which are accompanied by high concentrations of the incompatible elements of continental characters as Pb and Th.

Our data show that there are, at least, seven types of granitoids that can be distinguished on the basis of their petrology, association with other rocks/formations, degree of alteration, and chemistry. From old to young, they demonstrate a systematical change in their features : from coarse and KF-megacrystal bearing granitoid to very fine and mafic-poor granitoid.

The systematic distribution of variety of KCA-granitoids in time and space along PKFZ may lead to an interpretation that their emplacement took place under the concomitant stress regime producing the mentioned fault. The geochemical comparability of these granitoids with fragments of lower crustal rocks (garnet peridotite, basic- and felsic-granulite : occurring as both loose blocks and xenoliths in the granitoids) would suggest for their parental magma relation. The occurrence of Neogene KCA magmatism is closely related to the collision of the Banggai-Sula micro-continent against the East Arm of Sulawesi, their emplacement and exhumation to the surface were largely controlled by the activity of PKFZ.

Deep Earth Paper 2a6

Recent Pliocene volcanism recorded at Mount Popa, Central Myanmar

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A Potassium-Argon age date from hornblende within a hornblende phyric basaltic andesite flow unit which dominates the flanks of the Mount Popa volcano in Central Myanmar has revealed that volcanic activity was ongoing at 4.30 ± 0.55 Ma. Field traverses of the 1150 m volcano, which covers an area of 153km² has shown that mixed explosive and effusive volcanism was followed by mafic to intermediate composite cone building eruptions in the Popa district. The onset of volcanism is recorded by the presence of laterally discontinuous pyroclastic fallout deposits and alternating intervals of latite and trachyandesite flows that occur in the poorly lithified, fluvial sandstones of the Arrawaddy Formation. Unconformably overlying this formation is the Early to Late Pleistocene volcanic rocks which build the main composite cone volcano of Mount Popa. The rocks have been formed by effusive and explosive eruption processes. Hornblende phyric basalt and olivine-hornblende phyric basaltic flows are overlain by the 4.3± 0.55 Ma hornblende phyric basaltic andesite which makes up the main cone. The andesite alternates with basaltic and andesitic lithic breccias and pumice breccias which record fragmentation and redeposition of the coherent facies and small scale explosive eruptions. At the volcano summit large amount of scoriaceous and andesite feeder dykes cross cut the crater wall. The 1.6 km wide and 850 m deep crater has undergone major sector collapse at its northern flank, emplacing 3 km³ of andesitic and basaltic boulder breccia covering an area of 27 km². This major un-dated collapse event marks the end of volcanic activity in the Mount Popa region.

Deep Earth Paper 2a7

Chemical weathering of igneous rocks in Mount Kinabalu, Sabah

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Mount Kinabalu, the highest point of the South-East Asia was formed when a large mass of molten rock intrude the Crocker Range which is consist of sedimentary rocks from Trusmadi Formation and Crocker Formation. The rocks outcrop observed from Mount Kinabalu are adamellite, granodiorite, ulrabasic and sedimentary rocks. The glaciations during the ice age which is Pleistocene Period left a varied topography and polished the surface of the rock. The glaciations process had erode and remove the rock to the lowland area. Furthermore, the glaciations process was produced the water and act as an agent and generate the hydrolysis process. The chemical weathering changed the mineralogy of rocks especially on the surface an in the fractured rocks. Based on the field observation and the hand specimen, it was found that the oxidation was occurred as indicated by the reddish yellow colour. The hydrolysis developed the clay minerals from feldspar especially in the fault zone and joint plains. From the petrography analysis, the alteration of primary minerals like biotite and hornblend was clearly observed by the formation of iron oxide whereas plagioclase and K-feldspar mineral produced sericite and clay mineral. The result obtained from this research shown that even at the latitude about 3,660m and at temperature about 8ºC, the chemical weathering of the rock still occur.

Deep Earth Paper 2b1

Geochemistry and petrogenesis of mafic magmatic rocks of the Betul Supracrustals, Central Indian Tectonic Zone: Tectonic implications

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The ENE–WSW trending Betul supracrustal belt is exposed between Mahakoshal belt in the north and Sausar belt in south respectively (Figure 1). The 1.5 Ga basement rocks known as the Tirodi Gneissic Complex (TGC) have been dissected by numerous Proterozoic mafic dykes and mafic volcanic flows. The mafic magmatic rocks comprise volcanic and hypabyssal rocks such as basalts, dolerite, amphibolites and acidic volcanics and plutonic mafic–ultramafic rocks including gabbro, pyroxinites and peridotite. The mafic volcanic rocks show beautifully preserved pillows, although their tectonics of eruption is being debated (Figure 2a). The pyroxenite and gabbros show euhedral laths of plagioclases and pyroxene (Figure 2b), indicating slow cooling at depth. The presence of mafic –ultramafic rocks on one hand and acidic volcanics on the other indicate bimodal volcanism, a not so uncommon feature during the Proterozoic world over including the Central shield e.g. Sakoli bimodal volcanism (Ahmad *et al*. 2009: Island Arc, 18, 155-174). These dykes and basic volcanics are dominantly sub alkaline, ranging in composition from basalt through basaltic-andesite. Overall synthesis of data probably indicates some sort of chemical heterogeneity and partly it may be due to alteration effects. These mafic magmatic rocks show enriched LREE-LILE and depleted HFSE characteristics (Figures 3 a & b), commonly observed in continental rifts as well the continental arcs. We will present the geochemical data and discuss their genesis and possible tectonic settings of eruption / emplacement.

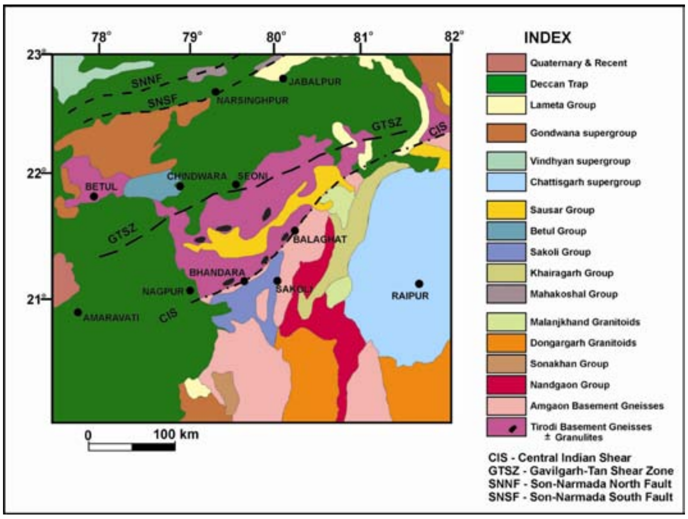

Figure 1

Figure 2a

Figure 2b

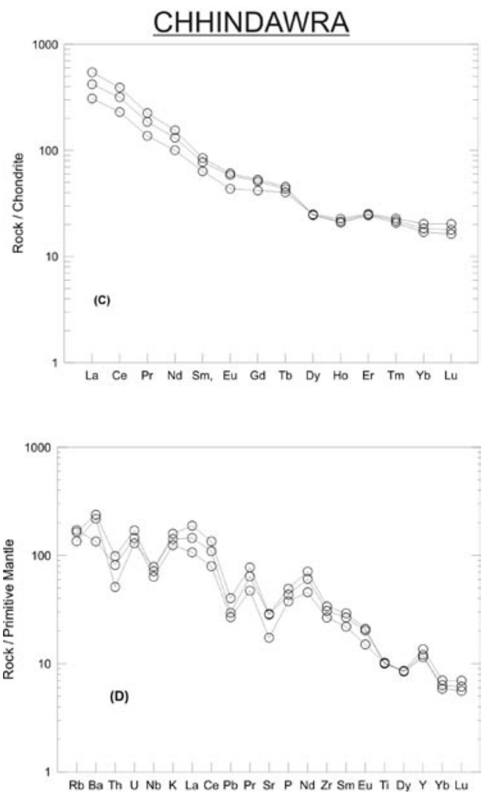

Figure 3a

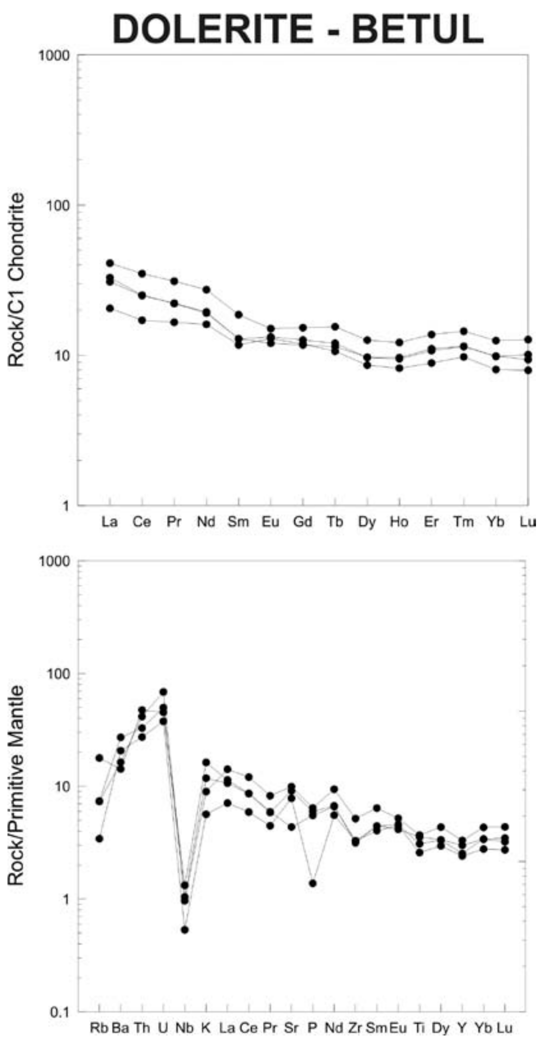

Figure 3b

Deep Earth Paper 2b2

Noble metal contents of high-Mg arc basalt from Galunggung Volcano, Indonesia

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Galunggung is a magmatic-arc front volcano of the Sunda-Banda island arc. It is a product of subduction of Indian-Australian plate underneath the Eurasian continent. This volcano has erupted several times, with the latest eruption in 1982-1983 producing high-Mg basalts (MgO>10 wt.%) lava. We have measured the noble metals element content of these primitive arc basalts in order to determine the primary noble metal characteristics of mantle-derived arc magmas.

Samples of Galunggung High-Mg basalt have porphyritic textures with medium- to coarse phenocrysts of olivine, clinopyroxene, plagioclase and fine magnetite in a glassy groundmass containing plagioclase, clinopyroxene and olivine microlites. Olivine and clinopyroxene phenocrysts contain Cr-spinel and sulfide mineral inclusions, as well as melt inclusions. The trace element patterns of the basalt are generally similar to those of mid-ocean ridge basalt (MORB), although slightly enriched in Sr, K and Ba. Galunggung basalts were generated during partial melting of subduction-modified arc mantle and experienced limited assimilation or fractional crystallization prior to eruption.

The metal content of 7 fresh Galunggung high-Mg basalts average: 2.0 ± 0.3 ppb Au, 4.0±0.9 ppb Pd, 5.1±1.1 ppb Pt, 0.08±0.02 ppb Ru, 0.08 ±0.02 ppb Ir, 0.07±0.03 ppb Rh, 84 ± 4 ppm Cu and 169 ± 4 ppm Ni. The noble metal contents do not vary significantly from those determined in sulfide-saturated MORB. In comparison to high-Mg basalts from oxidized, shoshonitic island arc suites, there is no evidence for enrichment of Au, Cu, Pd and Pt in the Galunggung arc magma.

Deep Earth Paper 2b3

Tectonic geomorphology of the Walat Fault at Sukabumi area of West Java, Indonesia

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The Walat Fault in this study, is situated along the NE-SW trend, occupying the Walat mountains of the Sukabumi area, West Java. Geologically this Walat Fault is a thrust fault of a Tertiary age. The goal of the study is to asses the tectonic activity of the Walat Fault using geomorphic and morphometric approaches. Based on the five parameters used such as drainage basin asymmetry (AF) hypsometric curve, stream length gradient index (SL), mountain front sinuosity (S_{mf}), and valley floor width - valley heigh ratio(V_f) showing that the Walat Fault is an active fault with the following criteria : AF more than 50 indicating the presence of tectonic tilting, the hypsometric analyses reveal that most of the Walat Fault belongs to young topography. The calculation of geomorphic indices such as S_{mf} & V_f (in succession) giving a value of less than 2 and of less than 4. All of these results indicate that this Walat Fault is an active fault. Besides, several events of the earthquake happened in Sukabumi are believed to be closely related with this fault (include the destructive earthquake occured on July 12, 2000 with a magnitude of 5.1 Richter Scale) demonstrating such phenomenas of an active fault.

Deep Earth Paper 2c1

Sagaing Fault of Myanmar: A brief overview

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The “Sagaing Fault” is a north-south-trending fault through the Sagaing Hills, located several kilometers to the west of the Shan Scarp, extending both north- and south-wards, bisecting the Myanmar territory all the way. It is the longest and the most active fault in the country. It is also a continental transform fault connecting the East Himalayan Syntaxis with the spreading center in the Andaman Sea, displaying right-lateral strike-slip features and generating earthquakes. The Sagaing Fault splays out a few fault strands along its course, and terminates in horse-tail pattern at both ends. The estimated and calculated offset displacement across the Sagaing Fault varies from 100-150 km to ~460 km, depending on the criteria used; but the total offset was recalculated by Curray (2005) to be between 203 and 460 km, and more likely to be 332 km. Recent GPS geodesy indicates slip rate along this fault is 18 mm/yr dextrally in average and is accommodating half of the strike slip motion between India and Asia (Vigny, 2003).

Seismicity along the course of the Sagaing Fault is quite well known in Myanmar since the days of the Myanmar kings, because many of the ancient royal capitals of Myanmar, such as Hanthawaddy (Bago) and Kaetumadi (Taungoo) were incidentally located on the highly seismic lowland of the Sittaung Valley between the Shan Plateau and the Bago Yoma of Central Belt, where the southern segment of the Sagaing Fault is located, and Ava (Innwa), Pinya, Sagaing, Amarapoura, Mandalay, Hanlin and Tagaung on the upper reaches of the Ayeyawaddy River where the Sagaing Fault was followed by the river to a considerable extent. In fact Ava (Innwa), Pinya, Sagaing and Tagaung are almost squarely located on the active fault zone. These royal capitals were perhaps the most densely populated areas of the country in those days. Memory of several disastrous earthquakes which repeatedly damaged the most venerable religious shrines in and around the old capitals still reminds about earthquake hazards of the country.

The Sagaing Fault is also regarded as a sliver fault which detached a block off the frontal part of the Sunda Plate or the Sibumasu Block, because of the highly oblique subduction of Indian and Australian Plates underneath. The linear block thus bounded by the Sagaing Fault, Sunda Megathrust on the west and the Andaman spreading center is known as the *Burma (Myanmar) plate*. It is rifting along the Sagaing Fault northward relative to the eastern Myanmar belonging to the Sibumasu Block, by the Andaman spreading alone or by coupling with the northerly Indian Plate motion as well. The Burma Plate is also in collision with the northeastern edge of the Indian subcontinent which indented deep inside Asia in the East Himalayan Syntaxis, around which the thickened continental crust of the Asian Plate is extruded laterally eastward and southeastward, following India/Asia collision in early Tertiary and continued convergence ever since.

Deep Earth Paper 2c2

Characteristic of S-type, continental collision magma from the Main Range Granite of Peninsular Malaysia

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The Western and Eastern Belt granites of the Peninsular Malaysian also separated by a line which is parallel to the Bentong-Raub suture (Hutchison, 1975). The Main Range granite of Peninsular Malaysia has been regarded to be constituted by exclusively 'S' type granites (e.g. Liew, 1983; Hutchison, 1996) in contrast to the Eastern Belt granite which is dominated by 'I' type with subordinate 'S' type granites (Liew, 1983). However, studies and reviews of granitoid batholiths (Pitcher, 1979 ; Shaw and Flood, 1981) suggest that 'S' type granitoids may display a wide range of mineralogical and chemical characteristics and that the criteria adopted for identification of granitoid type in one terrain may not strictly hold true in another.

The Western Belt granite consists of coarse to very coarse grained megacrystic biotite muscovite syenogranite to monzogranite with subordinate granodiorite. Mineralogy of the granite in decreasing abundance are K-feldspar, quartz, plagioclase, biotite, muscovite, allanite, zircon, sphene, apatite, secondary epidote, tourmaline, ilmenite, amphibole, andalusite and garnet. Texturally the granites are coarse to megacrystic primary textured granite but secondary or two phase variant also common. The granite grades from mildly metaluminous to peraluminous. ACNK value increase with increasing SiO_2 and this is contrast to the trend observed in the S-type granite from Lachlan Fold Belt. The P_2O_5 content increases with increasing SiO_2, which also contrast to the S type characteristic.

Deep Earth Paper 2c3

Filters integrated for the extraction of lineaments from Landsat TM-5 in the Sungai Lembing – Maran area, Malaysia

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Remote sensing is a useful tool to obtaining information about earth surface features or phenomena through the analysis of data acquired and interpretation without any contact with the object or the area under investigation. The application of remote sensing technology may cover many fields of studies, especially in structure geology, and mineral exploration, where the remote sensing is a useful for lineaments and structure features extractions. Apply different type of filters are the most useful techniques to enhance the features in the satellite images. Combination of different type of filters such as prewitt kernel filter with sobel kernel filter can provide us better results for lineament extractions. Prewitt filtering has been applied in the X axis and Sobel filtering has been applies in the Y axis to filter the band 4 of Landsat TM – 5 image of the study area. Binary image has been created from filtered image with DELTA function. The result of lineaments show that there are four sets as NW-SE, N-S, NE-SW, and E-W of lineaments in the investigation area and those lineaments have been compared with field study by using the orientations and rose diagrams. This study indicates that the total number of lineaments is 267 and the total length is 1235 km.

Earth & Life Through Time Paper 2d1

Lithostratigraphic and biostratigraphic corelations of Miocene sediments in the Pinangah Coal Basin and surrounding areas, Sabah

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The Pinangah Coal Basin is located central southern Sabah is a newly established coal basin where there are 58 coal outcrops were discovered during the 8th Malaysian Plan, whereby 12 coal outcrops was discovered in West Middle Block and another 46 were discovered in South Block. However, the orientation of the dips and strikes of these coals are chaotic which require a further detailed investigation to explain such geological phenomena. A combined method of lithostratigraphic and biostratigraphic correlation are used to study the coal outcrop and the host rock formation, the Tanjong Formation. The study was focused in West Middle Block (WMB) because the coal outcrops in this block are as thick as 2m, where in places there are as thick as 7m. The South Block although contained many coal beds but there are very thin, less than 30 cm; not continuous and spread over an extensive area.

As the result of investigation a total 35 new coal outcrops were located in WMB. These coals were analysed are belonged to a the high volatile A to C bituminous (hvAb to hvCb) in coal rank. Based on correlation these coal outcrops are exposed as Seam A, B, C and D. Seam B is thickest where it exposed as 7m thick in the eastern limb and 11 m thick in the western limb of the Susui Anticline. The present investigation has successfully calculated the inferred reserve of coal in West Middle Block which is amounted to 38 mt. The coal is inferred to have been deposited along with the sandstone and shale of the host rock, the Tanjong Formation in Mid Miocene, but folded during late Miocene and Late Pliocene. This resulted the strike of coal beds either in striking NNE-SSW or NNW-SSE direction and dipping at angle of 10 - 40°.

Earth & Life Through Time Paper 2d2

Soft-sediment deformation structures within the Indian Ocean tsunami deposit along the northern coast of Peninsular Malaysia

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Detailed studies of excavated trenches dug within the 2004 Indian Ocean Tsunami deposits at Kuala Melaka, Langkawi Islands and Kuala Muda, Kedah along the coast of northern Peninsular Malaysia revealed the presence of numerous syn-sedimentary soft sediment deformation structures. These includes flame structures, convolute laminations, folds, wisps, mud and sand balls, ball and pillow structures and soft-sediment microfaults found in the tsunami deposits. This paper describes the morphology of the structures and interprets their deformational processes.

These structures were found at the boundary between lower finer-grained layers and upper coarser-grained layers that are related to runup events. The boundary has an irregularly bulging profile, similar to that observed in flame structures and wisps. Some of the protruding flames are truncated horizontally along their upper surface by overlying layers where the contact between the lower layer and the main part of the upper layer is a planar truncation surface. On top layers rip-up clasts are found. They are found as mud and sand balls. Lobate masses resembling ball and pillow structures are found under the finer grained layers. It appears that parts of the upper layer descend into the lower layer to form the lobate masses. In places, these masses are completely detached from the main part of the upper layer, forming circular or elliptical shapes, mud/sand balls and pillow structures. Some of the layers show convolutions and detached into irregular masses. There are mixing of sediments at the sand and mud inter-phase and sand injection structures are found protruding into the finer grained layers. Other interesting features of the deposit are the presence of soft-sediment faults with millimeter to centimeter scale displacements and folding of the tsunami layers.

The mixing of sediments, injection structures, convoluted layers, flame structure, wisps, mud and sand balls and pillow structures are normally attribute to ground shaking-induced liquefaction. The folds, convolutions and mud/sand clasts/balls probably resulted from water and sediment flowing horizontally within the layer during seismic shaking and ripping clasts from the surrounding material. Rip-up clasts are fragments of a cohesive substrate contained within a sedimentary deposit. They indicate high-energy flows and also suggest that the material was not worked for periods of time long enough to break apart the material into individual grains. The structures indicate the syn-sedimentary development of the structure: deformation occurred in association with strong run-up current with sufficiently high shear velocity that formed the upper tsunami layer. The presence of faults associated with folding of the laminations implies there was some ground movement.

The assemblage of soft-sediment structures are indicative of liquefaction and extremely strong current/surges acting simultaneously. It is interpreted that the syn-sedimentary deformation structures are the result of both liquefaction due to ground shaking in association with strong unidirectional run-up current. The structures found may be characteristic of tsunami events that involve strong currents accompanied by tremors rather than other events such as storm surges.

Detrital heavy minerals from the Malay Peninsula and their use as provenance indicators in the Cenozoic Basins of Sundaland

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The Malay Peninsula lies in the heart of Sundaland, the continental core of Southeast Asia, and is surrounded by offshore Cenozoic petroleum-producing basins. Many authors suggest that the deposition of detrital material into these basins occurred simultaneously with the India-Asia collision and assume a Himalayan provenance for the clastic rocks. However, recent field-based studies favour derivation from nearby sources in the Southeast Asian Region. The Malay Peninsula appears to have acted as one important Cenozoic source area, being notably devoid of sedimentary rocks of Cenozoic age. Geologically, the peninsula may be divided into three broad north-south trending regions (Eastern Zone, Central Zone and Western Zone) intruded by two granitic provinces: the Main Range Province (predominantly S-type granitoids) and the Eastern Province (predominantly I-type granitoids). The Eastern Province can be further subdivided into two granitoid belts: the Central Belt and the Eastern Belt. The non-granitic rocks have been metamorphosed at low to moderate grade.

Little is known about the composition of sediments derived from this area and provenance-diagnostic heavy minerals have not previously been identified. The heavy mineral assemblages of 34 modern river sediment samples from the Malay Peninsula were investigated using various techniques. These include optical microscopy, SEM and X-ray semi-quantitative elemental analyses, morphological studies of zircon, microprobe analyses of garnet, and LA-ICP-MS U-Pb dating of zircon.

Heavy mineral assemblages contain variable amounts of zircon, tourmaline, amphiboles, andalusite, epidote, monazite (and xenotime), rutile, and sphene. Cassiterite, apatite, anatase, garnet, Fe-Mg spinel (pleonaste), allanite, and kyanite occur locally in minor amounts. The chiastolite variety of andalusite is common only in the Eastern Zone. Monazite (and xenotime) concentrations are found only in samples collected close to plutons of the Main Range Province and one small area around Kuantan. Abundant brown zircons are typical of the Malay Peninsula, as are pyrope-poor grossular and almandine-spessartine garnets. Detrital zircons are mainly Permian-Triassic, and locally Cretaceous. Early to Late Proterozoic zircons are consistently present, but less abundant. All of these observations are consistent with local granitic and contact metamorphic sources for the modern river sediments.

The scarcity of cassiterite, common in the Peninsula's tin granites, suggests it is concentrated in placer deposits close to the source rocks. Corrosion of apatite and grossular garnets indicates selective destruction during weathering, but the abundance of amphibole and andalusite is inconsistent with the reported instability of these minerals during chemical weathering.

Several provenance-diagnostic heavy minerals are identified for the Malay Peninsula tin belt granites. These include Permian-Triassic brown zircons, monazite (and xenotime), chiastolite and, if present, cassiterite, pleonaste and allanite. However, the distribution of these minerals within the peninsula is not uniform. Dense minerals (e.g. cassiterite) are rarely transported large distances and therefore absence of any of these minerals offshore does not necessitate a different provenance.

Preliminary report of vertebrate fossils in limestone caves at the foot of Batu Caves, Bukit Batu, near Kuala Lumpur

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INTRODUCTION

Bukit Batu housing the famous Batu Caves,at more than 300m high, is the most significant southernmost above-ground limestone outcrop in Peninsula Malaysia. It was first described by Europeans in 1887 with at least 16 caves in the hill other than the present Temple Cave. About 6 of them were lost or destroyed by quarrying (Medway, 1977) and some of them are developed caves for the purpose of religion or tourism while the rest are undeveloped caves.The vertebrate fossils in this report were collected from the small caves (named the Cistern Cave and Swamp Cave) (Fig.1), located at the base of Bukit Batu .

Cistern Cave (3^0 14' 14.73" N and 101^0 41' 04.25"E), is a small undeveloped cave at ground level near to the toilets located east of the Batu Caves Temple steps, It has only one narrow entrance and was used as a rubbish dump. Price (1996, 2001) reported this cave as an ancient cave under the Selangor group of caves. This cave has been mined for guano and mammalian fossil teeth has been found in remnants of calcite-cemented cave-fill sediments left behind by the miners.

Swamp Cave (3° 14' 21.59"N and 101° 41' 24.93"E), was an undeveloped cave without any significant animal life (Yussof, 1997) until recently. It is presently undergoing development for tourism. This cave is located to the east of the Batu Caves Temple next to the Madrasah AL- Rahman. It derived its name from the swamp that came up to the cliff face. It has four entrances connected by the swamp within. Many fossil mamammalian teeth and bone fragments have been recovered from remnants of calcite-cemented stream sediments found attached to the walls and floors of this cave.

OCCURRENCE OF FOSSILS

Ridley (1898) reported that large wild animals including tiger, bear, wild-ox pig, muntjac, deer, and elephant were all found in the forest surrounding the hill but he also noted the absence of any bones of these animals in the caves. He attributed their absence to the preference of primitive tropical humans to live in huts instead of caves and the absence of carnivores such as hyenas that bring back prey to the caves. Yussof (1997) noted that except for humans, the usual trogloxenes like bears, leopards, porcupines, and wild pigs have not been recorded in and around Batu Caves recently.

All the vertebrate samples (bones & teeth) recovered come from the remnants of alluvial deposits in the Cistern and Swamp Caves at the foot of the limestone hill. Most of the fossils tended to occurr in clusters except for a few solitary teeth. A few teeth were recovered loose from the present cave floor in Cister Cave. Five clusters of fosssils were found in Cistern Cave distributed at heights of between 36cm to 1.82m from the cave floor. There were four clusters of fossils in Swamp Cave and three solitary teeth, two of which belong to orangutan. These clusters could have been artificially created by removal of the cave-floor deposits between them during guano extraction or deeping of the cave for ease of walking as in Swamp Cave.

PRELIMINARY IDENTIFICATION

Preliminary identification of the fossil teeth recovered showed that most belong to the wild pig, *Sus scrofa* and bearded pig *Sus barbatus*. Tapir and rhinoceros teeth were discovered in Swamp Cave while deer teeth were collected from both caves. The deer teeth include *Tragulus javanicus* and the sambar deer, *Muntiacus muntjak*. Other teeth recovered are from porcupine, bear, cow, serow, cattle, unidentified primate and bat.

DISCUSSION

There are indications that Batu Caves are part of much larger cave system in Peninsular Malaysia. Not all the caves in Bukit Batu are of the same age. Caves generally form at the water table level hence the oldest caves are those at the top and progressively younger caves were developed with the lowering of the water table as erosion removed the surrounding land as sea-level dropped. The fossils recovered at the foot of Bukit Batu represent the most recent of these cave sediments and fossils from the caves at higher levels if found would be older. Dating the fossils and entombing sediments need to be done in order to interprete the formation of the caves. Studies of the fossil fauna assemblage would have to be extended to more bones and teeth particularly of the smaller bats, rodents and other cave dwellers to work out the palaeoclimatic conditions that existed in the past during the formation of the Batu Caves.

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Figure 1: Location of Cistern and Swamp Caves. Satellite image from Google Earth.

Coal-bearing strata of Labuan: Mode of occurrence and organic petrographic characteristics

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Labuan Island is situated about 8 km offshore west Sabah. The island is comprised entirely of sedimentary rocks that have been studied by a number of workers (e.g. Wilson and Wong, 1964; Lee, 1977; Mazlan Madon 1994 & 1997; Tongkol, 2001; Alsharef Albaghdady et al., 2003). Based on these studies a number of stratigraphic schemes have been suggested, although most involve the Temburong, Setap Shale and Belait formations, the latter being the youngest in age. Coals of Tertiary age occur at a number of localities on Labuan Island. This study describes the mode of occurrence of the coals and characterises the coal macerals based on their organic petrographic characteristics as observed under reflected 'white' light and 'blue' light excitation. Reflectance measurements of vitrinite were performed using a 50x oil immersion objective.

The coals vary from distinct in-situ coal seams to very fine coal clasts occurring in the form of laminae. Two reasonably thick in-situ coal seams of about 1.5 and 2.5 m, respectively, occur at Kg. Ganggarak. These two seams are separated by layers of alternating sand and shale comprising about 10m thickness. Elsewhere within the study area, coal occurs mainly as clasts, which can be very large in size and which appear to have been part of fossilized tree trunks or branches; examples of such are observed at Tg. Kubong. It is interesting to note that although occurring as clasts, most of these coal fragments possess petrographic features that are similar to the in-situ coals, thus suggesting that the original plant constituents that formed the coal clasts were not being transported far from their source thus they can be classified as hypautochthonous deposits.

The coals are dominated by desmocollinite (also known as collodetrinite) with a high abundance of liptinite macerals (approximately 25-45% by volume) as observed under reflected light microscope. In some of the coal samples from Belait Formation, cell wall structure may still be recognized which is typical of low rank coals (Fig.1). In relatively higher rank coals, the vitrinite are predominantly structureless. The liptinite macerals are often well preserved and show bright yellow to dull yellow fluorescence under 'blue' light excitation. Suberinite and its associated macerals, in particular liptodetrinite and bituminite, are among the most common liptinite macerals (Figures 2 - 5). These macerals show intense fluorescence when associated with oil globules and/or hydrocarbon generation, and possess similar oil-prone petrographic characteristics as described by Wan Hasiah (1999; 2003), thus suggesting that these Labuan coals are capable of generating liquid hydrocarbons.

Fluorescing vitrinite is commonly observed in these samples and is mostly associated with liptodetrinite and/or oil globules (Figures 6 & 7), thus suggesting a perhydrous oil-prone nature. On the other hand, the impregnation of the bitumen or the generated hydrocarbon could have enhanced the fluorescence phenomena of the vitrinite particles as well as the liptinite macerals. This is most apparent for the normally dull fluorescing bituminite, but when associated with hydrocarbon generation it shows intense fluorescence (Figure 4). The inertinite macerals which are low in abundance (generally <10%) do not fluoresce. The liptinite inclusions in the lumens of sclerotinite show yellow orange to dull orange fluorescence (Figures 1 & 4).

Based on the petrographic characteristics described and the vitrinite reflectance values obtained from this study, at least 3 distinct units that are associated with coal-bearing sediments can be recognized. The strata with vitrinite reflectance (%Ro) in the range of approximately 0.45-0.50% belong to the youngest unit i.e. the Tg. Layang-Layangan unit within the Belait Formation. The oldest sequence i.e. the Tg. Punei unit of the Temburong Formation possesses vitrinite reflectance in the range of 0.70-0.80%, while the intermediate unit i.e. the East Kiamsan Sandstone/Setap Shale possesses vitrinite reflectance in the range of 0.55-0.60%. Considering that the coals analysed commonly show oil-generative features and that some vitrinitic coal fabric fluoresces (Fig. 6), these values have most likely been suppressed even though the vitrinite reflectance measurement were performed on non-fluorescing particles (Figures 4 & 5).

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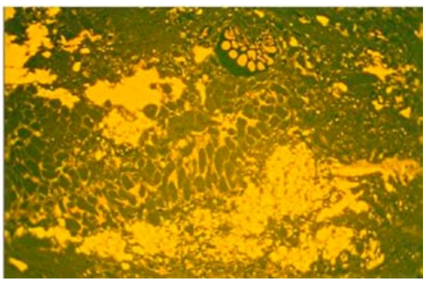

Figure 1: Fluorescing cell associated with vaguely fluorescing phlobaphinite, intense yellow fluorescing bituminite and yellow-orange fluorescing resinite in cell lumen of sclerotinite as observed under 'blue' light excitation in oil immersion; field width is 0.25 mm.

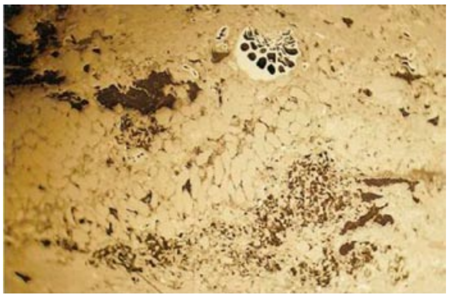

Figure 2: Same view as Figure 1 under normal reflected 'white' light (sample location: Tg. Kubung).

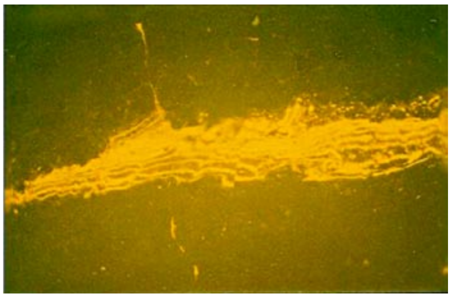

Figure 3: Yellow fluorescing suberinite under 'blue' light excitation (sample location: Tg. Layang-Layangan).

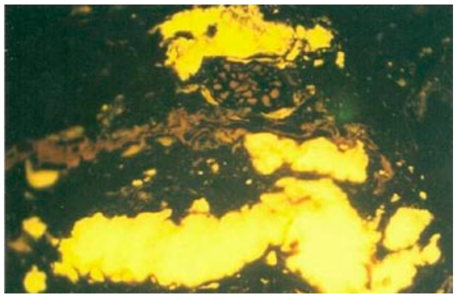

Figure 4: Bituminite associated with oil haze show intense yellow fluoresce whilst other liptinic macerals display dull orange fluorescence in non-fluorescing vitrinite groundmass; blue lighjt excitation; field width is 0.25 mm.

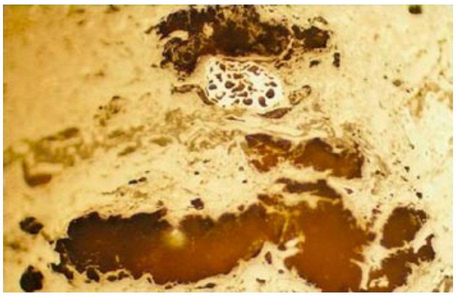

Figure 5: Same view as Figure 4 as observed under normal reflected 'white' light in oil immersion.

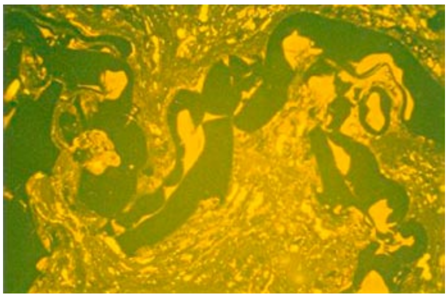

Figure 6: Liptodetrinite and resinite associated with perhydrous vitrinite displaying yellow fluorescence under blue light excitation; field of view is 0.25 mm (sample location: Tg. Kubung).

Figure 7: Same view as Figure 6 as observed under normal reflected 'white' light in oil immersion.

Earth & Life Through Time Paper 2e2

Provenance of Neogene Sandstones in Sabah, NE Borneo

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There have been few provenance studies of Cenozoic sediments from North Borneo. Recent studies of the Paleogene Crocker Formation show likely source areas are Cretaceous granites of the Schwaner Mountains in SW Borneo and Permo-Triassic granites of the SE Asia Tin Belt, rather than mainland Asia. The provenance of Neogene sandstones is less clear, although they are commonly interpreted to be recycled from the Crocker and older formations.

The Tanjong and Sandakan Formations in eastern Sabah and Kudat and Bongaya Formations in northern Sabah are thick sequences of fluvial to shallow marine sandstones, siltstones and mudstones deposited above the Early Miocene Top Crocker Unconformity. The textural and compositional maturity, heavy mineral assemblages, and types, morphology and U-Pb ages of detrital zircons of these sandstones have been studied to determine their provenance.

This new work suggests that the Lower–Middle Miocene Tanjong Formation was largely recycled from the Crocker Formation and the Middle–Upper Miocene Sandakan Formation was recycled from the Tanjong Formation. Zircon, tourmaline and rutile dominate, and garnet and chrome spinel are present in all sandstones. As well as older sedimentary rocks, detrital grains were derived from the local metamorphic basement and ophiolitic rocks. In the Sandakan Formation there are elongate zircons usually interpreted to have a volcanic source. U-Pb ages show these are Cretaceous and were not derived from the nearby Neogene volcanic arc.

The Lower Miocene Kudat Formation is subdivided into the lower Tajau Member and the upper Sikuati Member that have different source areas. The lower member contains up to 40% of garnet and metamorphic minerals such as kyanite. Potential high pressure–temperature source rocks are present on Palawan to the north. In contrast, the upper member contains abundant zircon, tourmaline and rutile whereas garnet is uncommon and kyanite is absent suggesting a Paleogene sedimentary source to the south. There are 56-42 Ma zircons throughout the Kudat Formation reworked from an Eocene volcanic source. The Mio-Pliocene Bongaya Formation is compositionally mature and is dominated by weakly abraded zircon, tourmaline and garnet with minor rutile. These features suggest it was recycled from the nearby and similar lower member of the Kudat Formation.

Tropical climate was an important influence on sandstone composition. Mature quartzose compositions reflect tropical weathering, causing breakdown of feldspar and lithic fragments, as well as recycling. Apatite is often absent or shows signs of corrosion; it is generally a stable mineral but is susceptible to acid weathering. Apatite could have been removed during erosion and transport, or by chemical weathering after deposition. The scarcity of volcanic heavy minerals is striking because of the close proximity of the Neogene sandstones to the Dent-Semporna peninsula where there was volcanism from the Middle Miocene to Pleistocene.

Palaeogeographic reconstructions show that during the Earliest Miocene rivers carried sediment southwards from metamorphic terranes on Palawan to the Kudat Peninsula. At the same time, rivers draining the Crocker Ranges and locally exposed ophiolitic basement moved sediment north to the Kudat Peninsula, west into the offshore West Neogene Basin, and east to the Tanjong Formation and offshore Sandakan. Input of material from Palawan ceased during the Middle Early Miocene and most sediment to the Kudat peninsula came from the Crocker Ranges to the south. During the Middle Miocene the Sandakan Formation was fed by large rivers draining northeast which continued to erode the Crocker Ranges and reworked the recently deposited Tanjong Formation. Reworked Kudat Formation dominates the younger Bongaya Formation.

Earth & Life Through Time Paper 2e3

Tectonostratigraphy of the Phanerozoic continental province succession in Southern Papua, Eastern Indonesia

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Papua which is located on the eastern Indonesia has the most complete stratigraphic succession and contain the oldest rock that is up to Cambrian in Indonesia. Eastern Indonesia is one of the most active tectonic regions in the world. Three major crustal plates converge in this area (the Pacific, East Asian and Australian plates) and have caused a complex pattern of subduction zones, volcanic arcs, mountain ranges and sedimentary basins. The landscape of Eastern Indonesia is a reflection of this active tectonics. Volcanoes, raised terraces, fault escarpments and deep valleys characterize it. Eastern Indonesia consists of a core of drowned oceanic crust (Banda Sea) that is surrounded by continent (Australia). The islands of Eastern Indonesia are active belt at the boundary of the Banda Sea, Pacific and Australia. Most of the non-volcanic islands in East Indonesia contain fragments of continental crust have stratigraphically much common with the Australian NW shelf. The resemblance to the Australian margin forms the basis for the generally accepted idea that many islands of East Indonesia are the deformed and displaced fragments of that margin. Papua contains extensive Paleozoic basement that consists of clastic sediment and dolomite with occasional gabbroic intrusions. The small island like Seram and Buru contain extensive units of metamorphosed continental basement rocks. The overlying Mesozoic and Tertiary sedimentary sequences have stratigraphic features resembling that of the Australian continental margin. The features characteristic for the geology of the "Australian" fragments in East Indonesia are: a metamorphic basement, an early Mesozoic period of rifting with graben development, followed by a deepening of marine environment, a late Mesozoic and Early Tertiary period of open, deep marine sedimentation and in the Neogene, the fragments are involved in deformation processes around the Banda Arc.

The plate tectonic evolution of Papua has involved a complex interaction of the Pacific Plate, Indo-Australian Plate, which has split the stratigraphy into a number of megasequences. The tectonostratigraphic divisions these events produce are as follows: ***A Pre-Rift phase:*** The period between the Middle Ordovician and the beginning of Silurian was a time of pre-rift in Gondwanaland. This tectonic event in Eastern Papua including resulted in the deposition of Silurian – Devonian Modio Dolomite, Kemum and Kora Formations. The Kemum Formation in Papua was intruded by Permian-Carboniferous granite, volcanic rocks were also erupted. ***Syn-rift phase:*** A broad transgressive cycle was initiated in the Late Carboniferous period to Early Permian with shelf depositional environment ranging from estuarine to a shallow marine. At the end of the Paleozoic, geologically, the northern margin of the Australian craton, contiguous with western Australia. Sporadic Permian and Triassic igneous activities were preceded Triassic and Jurassic rifting and extension of the Papua margin. ***Passive margin phase-I:*** During the Cretaceous period these regions was characterized by a more quiescent tectonic regime with continuing subsidence along passive margins and drift sedimentation. Marine deposition is mostly fine-grained clastic (Kembelangan Group) that is predominated in Papua. Sediments of the Kembelangan Group formed in beach systems down into an outer shelf. ***Passive margin phase-II:*** The breakup and separation of the Antarctic plate to the south, resulted in a marked change in the Late Cretaceous, when clastic sedimentation gave way almost everywhere along the western–northwestern Australian margins to carbonate deposition. The largest basal unconformity occurs in the western part of the Bird's Head area (Salawati and Bintuni Basins), where the uplifting of the Mesozoic sediments and Late Cretaceous Salawati Granite resulted in erosion. ***Convergence phase:*** In the Oligocene time, the northwest portion of the Australian Plate began to collide with and underthrust the Pacific Plate. In Papua is a time of emergence or non- deposition and was also a major tectonic event where the Mesozoic and Lower Tertiary through sediments along the northern margin of the craton called Derewo Metamorphic, were regionally metamorphosed. Further north within the Pacific Oceanic Plate the rocks of the Auwewa Volcanic Group (Upper Cretaceous to Lower Oligocene) are intensely deformed. At this event is manifest in several ways in western Papua. A middle / upper Oligocene drop in sea level on the northwestern margin of the Australian continent allowed erosion and local re-deposition of clastic sequences. ***Compression phase:*** In Miocene, a time of eruption of magmatic arc, Australian Plate collide with the westward moving Pacific and Philippines plates, incorporating a Cretaceous-Eocene Island Arc, the Sepic Arc, into the present day northeast margin of New Guinea. The New Guinea Trench began forming with the collision. In Papua sediments of the Klasafet Formation was deposited in a deep marine environment with some turbidite current influences in the western part while to the east area deposited limestone. ***Late Miocene to Pleistocene (Melanesian Orogeny)***: At this time a huge compression force was generated due to southward convergence between the Pacific Oceanic on the north and the Australian Continental Plate on the south. The resulting pattern of crustal response has been very complex, and has given the island of New Guinea its unique "Bird-like" shape, which is controlled by major transgressive structures that accommodated greatly different crustal responses in the west and east. The mainland area was exposed above sea level at this time and the overall south and southerly movement was taking place terrigenous detritus deposition (Buru and Steenkool Formations) began to be poured into the basin formed to the south. The Buru/Steenkool Formations were accumulated as molase type deposits with a marine influence in part.

Most of the Paleozoic-Mesozoic sediments in southern Central Range of Irian Jaya and Arafura area have been envisaged to have been formed on restricted basin of the northernmost Australian passive continental margin. Such a continental margin is considered to have developed in relation to rift-drift stage. This basinal area, therefore, was associated with northwesterly source areas.

Tectonic evolution of Papua has been started from Pre-Cambrian to Recent time. Five major evolutions have been proposed here, i.e. Pre-Rift, Synrift, Passive margin, Convergent and Compression. The pre-Rift phase has expressed the evolution of northern margin of Australia since pre-Cambrian to Carboniferous ages representing the evolution of Australian continent when the three main continents (Australia, Antarctica and India) maintained their integrity into a single super continent called as Gondwanaland. Synrift phase explained the change of the northern Australia during the breakup time (Permian-Early Jurassic) subsequently passive margin phase (Late Jurassic-Early Tertiary). This phase represents the development of seafloor spreading and northward movement of the Australian continent. Compression phase (Oligocene-Mid.Miocene) shows increasing movement of the Australian continent followed by a change in movement of the Pacific plate. This phase resulted in gradually uplift of Papua and followed by erosion and deposition of clastics into the foreland. Compression phase encompasses the reorganization of a number of continental fragments in eastern Indonesia and the collision between Papua and Pacific plate generated orogeny and metamorphism.

Sedimentary environment and facies analysis has revealed the paleogeography of Papua. Reconstruction of rock distribution has been provided and showing that the area appears to contain source, reservoir and seal rocks for hydrocarbon accumulation.

Five major megasequences have been recognized in the region. The megasequence-1, consisting of the Aiduna Formation, Tipuma Formation, the Kopai-1 and Kopai-2 units. The megasequence-2 comprises Kopai-3 unit, Woniwogi, Piniya, Ekmai and Jass Formations. The megasequence-3 is composed of Lower Yawee, Waripi, Faumai Formations and Adi-1 unit. The megasequence-4 consists of Upper Yawee, Klasafet Formations and Adi-2 unit. The last one is the megasequence-5 comprising the Buru and Steenkool Formations. In general, the megasequence boundary is defined by broadly unconformity plane.

The Aiduna Formation, the Kopai-2 & 3 are the units categorized as good source rock for gas and oil prones. These units have also been mature to over mature. The good to marginally favorable reservoir rocks are expected in the sandstone beds of the Tipuma, Woniwogi and Ekmai Formations. The Yawee Limestone is categorized as marginally favorable reservoir rock.

Earth & Life Through Time Paper 2e4

Tectonic Setting of Pondaung Sandstones, Southern Chindwin Basin, Myanmar: Evidence from XRF-major and trace element geochemical analysis and LA ICP-MS U-Pb zircon geochronology

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Detrital information preserved in the Eocene clastic sequences of Southern Chindwin area in the northern part of Central Myanmar Basin revealed an "Erosional Unroofing History" of a calc-alkaline continental magmatic arc during the fluvial sedimentation of Pondaung Formation in Late Middle Eocene (Bartonian). The XRF-immobile trace element plots and LA ICP-MS U-Pb zircon geochronology of the volcaniclastic Pondaung sandstones document that the arc was originated along the convergence continental margin in Early Middle Eocene (Lutetian) and their detritus were deposited in the fore-arc of Central Myanmar Basin. Sandstone modal analysis and provenance studies provide a significant change in petrofacies spectrum from the older to the younger units; the volcaniclastic, Late Middle Eocene Pondaung sandstones (Q_{37}-F_{22}-L_{41}; Lm_{25}-Lv_{72}-Ls_{3}; Qm_{47}-P_{40-} K_{13}) at one extreme, quartzo-feldspathic and quartzolithic, and Late Eocene Yaw sandstones of plutonic-metamorphic derivatives (Q_{65}-F_{22}-L_{15}; Lm_{57}-Lv_{38}-Ls_{5}; Qm_{68}-P_{8-} K_{24}) at other extreme. The Pondaung sandstones were derived from transitional to dissected magmatic arc, whereas the Yaw sandstones are the derivatives of recycled uplifted continental margin provenance. The detrital components of sandstones characterized by volcano-plutonic and green-schist

to amphibolite metamorphic derivatives are the characteristics of erosional unroofing of a magmatic arc and deeper level of erosion down to the plutonic root at an uplifted continental margin. XRF-immobile trace element plots (Zr/TiO_2-Nb/Y; Zr/Y-Zr; Rb-Y+Nb; and Nb-Y) for the volcaniclastic components of Pondaung sandstones characterized by plagioclase feldspar-phyric volcanic lithic fragments suggested an andesite and minor rhyodacite/dacite composition indicating a geochemical characteristic of a calc-alkaline continental volcanic arc related to syn-collisional tectonic setting. The radiometric dating on the detrital zircon grains found in the volcaniclastic Pondaung sandstones by using LA ICP-MS U-Pb zircon method gave mostly Early Middle Eocene (during 51.6 and 43.3 Ma or average age around 47.2 Ma) indicating an active volcanic activities originated in a convergence continental margin setting. These data combined with the mean paleo-current direction suggest that there was a magmatic arc situated to the north-east (relative to present position) of the southern Chindwin Basin (i.e., analogous to the present plutonic belt along the western margin of Shan Plateau).

Earth & Life Through Time Paper 2e5

Radiolarian biostratigraphy of Peninsular Malaysia — An update

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Studies of radiolarians in Peninsular Malaysia began in early 1990s. The early study focused on the Semanggol Formation northwest Peninsular Malaysia where thick sequence radiolarian chert was well-exposed. Subsequently, researches on radiolarians were extended to other radiolarian bearing chert formations such as the Kubang Pasu Formation, Kenny Hill Formation, Kodiang Limestone, the chert units from Pahang, north Perak, and chert blocks from the Bentong-Raub Suture Zone. More than 1,700 chert samples were collected from various localities in Penisular Malaysia. More than 200 taxa of radiolarians were identified and sixteen radiolarian assemblage zones were recognized.

Trilonche minax Zone

The zone is chracterised by the occurrence of *Trilonche minax* (Hinde), *Trilonche davidi* (Hinde), *Trilonche vetusta* Hinde, *Trilonche* cf. *echinata* (Hinde), *Trilonche* cf. *parapalimbola* Wang, *Trilonche tretactinia* (Foreman), and *Stigmosphaerostylus herculea* (Foreman). *Trilonche minax* (Hinde) and *Stigmosphaerostylus herculea* (Foreman) are indicators of Frasnian, early Late Devonian. The assemblage was discovered from the chert blocks in the Bentong-Raub Melange. This is the oldest radiolarian assemblage discovered in Peninsular Malaysia.

Albaillella deflandrei Zone

The occurrence of *Albailella deflandrei* Gourmelon, *Albaillella cornuta* Deflandre, *Albaillella paradoxa* Deflandre and *Albaillella undulata* Deflandre is indicative of the *Albaillella deflandrei* Zone, Tournaisian, Early Carboniferous. The assemblage was discovered from several chert samples collected from Langkap, Negeri Sembilan and Pengkalan Hulu area, north Perak.

Albailella indensis Zone

Eight Radiolarian taxa discovered from the Kubang Pasu Formation consists of *Entactinia variospina* (Won), *Entactinia inaequoporosa* Won, *Callella hexatinia* Won, *Callella* cf. *parvispinosa* Won, *Treanosphaera hebes* Won, *Cubaxonium octaedrospongiosum* Won *Duplexia foremanae* (Ormiston dan Lane) and *Duplexia parviperforata* Won. The zonal marker *Albailella indensis* is absent but the presence of *Entactinia variospina, Callella hexatinia, Entactinia inaequoporosa* and *Cubaxonium octaedrospongiosum* is indicative of *Albaillella indensis* Zone, late Tournaisian- early Visean, Early Carboniferous (Won, 1991).

Pseudoalbaillella lomentaria Zone

The zone is characterized by the occurrence of zonal marker *Pseudoalbaillella lomentaria* Ishiga and Imoto, *Pseudoalbaillella ornata* Ishiga and Imoto, *Pseudoalbaillella sakmarensis* Kozur, *Pseudoalbaillella scalprata scalprata* Ishiga and *Pseudoalbaillella scalprata postscalprata* Ishiga. The assemblage is indicative of late Asselian-early Sakmarian, Early Permian. The assemblage was found from chert block at Pos Blau, Ulu Kelantan.

Pseudoalbaillella scalprata rhombothoracata Zone

The assemblage zone is defined by the presence of zonal maker *Pseudoalbaillella scalprata* m. *rhombothoracata* Ishiga, *Pseudoalbaillella scalprata* m. *scalprata* Ishiga, *Pseudoalbaillella scalprata* m. *postscalprata* Ishiga and *Pseudoalbaillella elongata* Ishiga dan Imoto. This is the oldest radiolarian assemblage recorded in the Semanggol Formation of north and south Kedah. The assemblage is assignable to late Sakmarian, late Early Permian.

Pseudoalbaillella longtanensis assemblage Zone

The assemblage consists of *Pseudoalbaillella longtanensis*, *Pseudoalbaillella aidensis*, *Pseudoalbaillella fusiformis*, *Pseudoalbaillella* cf. *longicornis* and *Pseudoalbaillella* sp. The assemblage was discovered from the Semanggol Formation. The zone represents Kungurian, Middle Permian.

Pseudoalbaillella globosa assemblage Zone

The zone is characterized by the abundance of the zonal marker, *Pseudoalbaillella globosa* together with *Pseudoalbaillella yanaharensis, Pseudoalbaillella fusiformis, Pseudoalbaillella* cf. *longicornis*, *Latentifistula texana, Raciditor inflata*, *Pseudoalbaillella* sp. and *Ishigaum* sp. *Pseudoalbaillella yanaharensis* is a good indicator for the zone. The assemblage is found in the Semanggol Formation. The zone represents Roadian, Middle Permian.

Follicucullus monacanthus Zone

This assemblage comprises abundant of *Follicucullus monacanthus* Ishiga dan Imoto with a few *Entactinia* sp. and

Quadriremis sp. This assemblage is assigned to Wordian, Middle Permian. The assemblage is found in the Semanggol Formation and in the chert sequence from Jengka Pass, Pahang.

Follicucullus porrectus Zone

The assemblage was discovered from the Semanggol Formation. The assemblage contains zonal marker *Follicucullus porrectus* Rudenk, *Follicucullus scholasticus* Ormiston dand Babcock, *Follicucullus elongatus*. *Quinqueremis* sp. dan *Entactinia* sp. The zone indicates Capitanian, late Middle Permian to early Late Permian.

Neoalbaillella ornithoformis Zone

Nineteen species radiolaria were recorded from this zone. The zone is recognized based on the occurrence of *Neoalbaillella ornithoformis* Takemura and Nakaseko, *Albaillella protolevis* Kuwahara, *Albaillella levis* Ishiga, Kito and Imoto, *Albaillella lauta* Kuwahara, *Albaillella excelsa* Ishiga, Kito and Imoto, *Neoalbaillella grypus* Ishiga, Kito and Imoto, dan *Octatormentum floriferum* Sashida and Tonishi. This assemblage is indicative of Wuchiapingian, Late Permian.

Neoalbaillella optima Zone

The zone contains zonal marker *Neoalbaillella optima* Ishiga, Kito and Imoto, *Albaillella triangularis* Ishiga, Kito and Imoto, *Albaillella flexa* Kuwahara, *Albaillella excelsa* Ishiga, Kito and Imoto, *Albailella levis* Ishiga, Kito and Imoto *Copiellintra fontainei* (Sashida), and *Foremanhelena triangula* De Wever and Caridroit. The assemblage indicates Changxingian, Late Permian.

Entactinia chiakensis Zone

The zone is characterized by the occurrence of *Entactinosphaera chiakensis* Sashida and Igo, *Cenosphaera andoi* Sugiyama dan *Archaeosemantis cristianensis* Dumitrica, *Entactinia nikorni* Sashida and Igo and *Thaisphaera minuta* Sashida and Igo. The assemblage represents Spathian, Early Triassic.

Triassocampe coronata Zone

The zone is based on the presence of zonal marker *Triassocampe coronata* Bragin together with *Pseudostylosphaera japonica* (Nakaseko dan Nishimura), *Eptingium manfredi* Dumitrica and *Acanthosphaera awaensis* Nakaseko and Nishimura. The assemblage is indicative of middle Anisian, Middle Triassic. The assemblage was discovered from the Semanngol Formation in south Kedah.

Triassocampe deweveri Zone

The assemblage consists of *Triassocampe deweveri* (Nakaseko and Nishimura), *Eptingium manfredi* Dumitrica, *Pseudostylosphaera japonica* (Nakaseko and Nishimura), *Pseudostylosphaera coccostyla* (Rηst) dan *Oertlispongus inaequispinosus* Dumitrica, Kozur and Mostler. This assemblage indicates an age of late Anisian, Middle Triassic. This assemblage is found in the Semanggol Formation.

Oertlispongus inaequispinosus Zone

The assemblage is composed of *Oertlispongus inaequispinosus* Dumitrica, Kozur and Mostler, *Muelleritortis cochleata* (Nakaseko and Nishimura), *Triassocampe annulata* (Nakaseko and Nishimura), *Baumgartneria retrospina* Dumitrica dan *Baumgartneria lata* Kozur and Mostler. The zone is indicative of Ladinian, Middle Triassic.

Capnodoce Zone

The zone is recovered from the Kodiang Limestone. The occurrence of *Canoptum laxum* Blome, *Capnuchosphaera triassica* De Wever, *Palaeosaturnalis triassica* Kozur and Mostler, *Xenorum* and *Latium* is indicative of the *Capnodoce* Zone, late Carnian-early Norian, Late Triassic.

To date, the radiolarian biostratigraphy is the most reliable tool for the stratigraphy of the deep marine sediments of Peninsular Malaysia. The biostratigraphic zones reflect the productivity of the radiolarians, which was very high during late Devonian-Early Carboniferous, late Early Permian, Late Permian and Triassic.

Earth & Life Through Time Paper 2e6

Microfacies and diagenesis of Setul limestone in Langkawi and Perlis

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The Setul limestone outcrops in Langkawi and Perlis show a variety of facies consisting of thickly bedded mudstone, wackestone, packstone, grainstone and dolomitic limestone. Seven microfacies have been recognized comprise dolomicritic mudstone, bioclastic wackestone, peloidal wackestone, intraclastic wackestone, pelletoidal packstone, pelletoidal grainstone and dolomitic limestone. The presence of bioclasts such as brachiopod, trilobite, ostracod, bivalve, crinoid and the microfacies spectrum reflect that the sediments were deposited in broad environments ranging from tidal flats to lagoon and shallow subtidal of a carbonate ramp. The diagenetic processes that have taken place include cementation, dolomitization, stylolitization, neomorphism, dissolution, compaction and micritization. Petrographic studies show that diagenesis took place in wide diagentic environments including freshwater freatic zone, marine freatic zon, mixing zone and deep burial zone. Geochemical analysis of samples from perlis shows that in general, the limestone is impure and having low purity.

Geoscience Tools Paper 2f1

Investigation of subsurface limestone kastic features in Hulu Kinta, Perak

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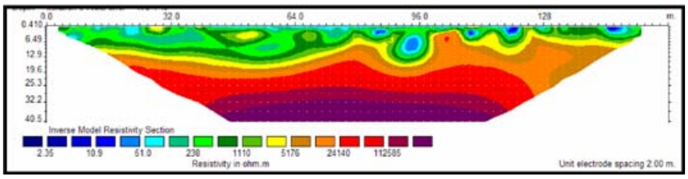
The site is located on a flat sandy land close to a lake and Gunung Datuk limestone hills complex. All 9 (NINE) boreholes drilled in this area encountered solid limestone rock at various depth ranging from 14.30 meters to 41.50 meters, indicating the presence of karstic features. High resolution 2D resistivity survey was conducted to outline the limestone head or karstic features as well as to detect the presence of possible hazardous underground cavities. Using 2m spacing cable and 4 system cable, we be able to image the subsurface to about 40 to 50 meters deep. Resistivity images clearly show that this area is a limestone area with karstic surface features, such as pinnacles and cavities. The depth of this zone is ranging from 8 to 35m. In some cases, some boreholes penetrated pinnacles, thus giving a false impression that the solid limestone is very shallow.



Geoscience Tools Paper 2f2

Electrical resistivity survey of oil-spilled sandy soil at an abandoned Seberang Prai TNB power supply station

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The detection of organic contaminants spilled such as light nonaqueous phase fluids (NAPLS) in the subsurface soil using geophysical techniques particularly electrical imaging has been of much interest in recent years by many geophysicists. Their detection using geophysical methods is dependent on their electrical properties of low conductivities compared to their higher conductivities of background soil and groundwater. In this study, a 2D electrical imaging survey has been carried out on several profiles at an abandoned TNB power supply station in Seberang Prai Penang purposedly to investigate the nature and extent of oil spilled from the old transformers into the sandy soil and groundwater underneath the power station. Geologically, the 40 m X 60 m size power station area is located on an old Quaternary alluvium containing dominant shelly medium to coarse sand with some clay. Based on several hand-augered shallow boreholes, the water table is at 1.5 m depth and shallower towards the sea coastline which is about 50m from the site. The multi-electrodes electrical imaging survey was carried out using Wenner and Schlumberger array and data from each profile were inversed for final true resistivity 2D sections. Figure 1 below shows a section of profile number 5 indicating the presence of several oil plumes in the upper part of the section. These are the positions of the transformer oil-spilled in the study area located on top of the water table at approximately 1.5 meter depth. The resistivity of the oil plumes are found ranging from 1000 to 3000 Ωm. The low resistivity zones below the water table are interpreted as saline water saturated sand as a result of sea water intrusion. The resistivity of the sand is ranging from 10 to 50 Ωm.

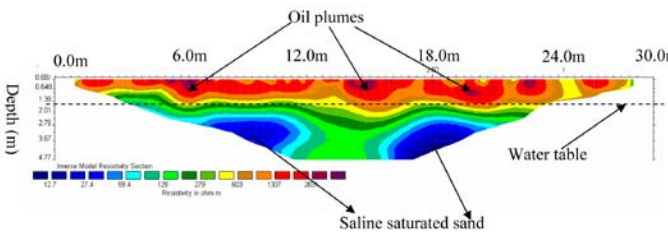

Figure 1: Resistivity inversed model section of line 5 showing the oil plumes, water table and the saline saturated sand.

Geoscience Tools Paper 2f3

Investigation of saltwater intrusion in Marang, Terengganu using the resistivity method

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Saltwater intrusion is one of the main problems associated with groundwater extraction along coastal area. This study was carried out in Marang, Terengganu using the electrical geophysics method to determine the type of water in the subsurface area. Sounding was done at 11 locations to determine the lateral variation of resistivity along. Both sounding and imaging utilizes the Wenner configuration. The data is then integrated with resistivity imaging done at four locations, geological data and hydrological data such as TDS and salinity collected from seven wells within the study area.

The results showed that there are areas that were invaded by saltwater. Zones saturated with saltwater is characterised by resistivity values lower than 5 ohm.metre (Wm); the low resistivity is due to the presence of ions and electrolytic processes in the saltwater. Fresh water zones show resistivity of more than 100 Wm. Any values between 5 and 100 Wm are denoted as brackish water zones. The results suggested that the saltwater intrusion occurred about 400 to 1100 metres from the coast. The depth of intrusion ranges from 5.7 to 11.5 metres from the surface. Most locations do not display resistivity associated with fresh water, suggesting that saltwater has been seeping in this area gradually over the years.

Geoscience Tools Paper 2g1

Characterizing granite and basalt of different weathering grades using the resistivity method

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Often times, geologists only have access to the materials on the surface. Subsurface information is usually obtained intrusively using boreholes. Another alternative would be by using geophysical methods. In this study, the electrical resistivity method is used to characterize weathering grades in igneous rocks which ranges from I for fresh bedrock to VI to totally weathered rocks (soil). Weathering increases the porosity in rocks which could in turn be filled with moisture. Increase in moisture would lower resistance; therefore, a grade VI would have lower resistivity value that a grade V rock. The influence of grain size distribution on resistivity values is also investigated. Another aspect of this study is to look at the difference in values between soils from granitic and basaltic rocks. Basaltic soils have higher iron and clay content, which should translate to lower resistivity values.

This study is done in Kuantan, Pahang and the surrounding areas where slopes exposing granite and basalts of different weathering grades are readily found. The results showed that it is possible to ascertain subsurface weathering grades using this method. Weathering grades within granite rocks are more easily identifiable than in basalt. There is a little difference in resistivity values between granitic and basaltic soils but the basaltic soils consistently have lower resistivity values. This study also found that the soil with larger grains has lower resistivity than one with smaller grains. Larger grains mean bigger pore spaces between the grains that can be filled with water and lower the resistivity. Presence of clay also serves as a factor in lowering the resistivity values.

The gravity and magnetic anomaly in North-West Malaka, Malaysia

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A gravity and magnetic study have been carried out in North Werst Malacca. The study was carried out mainly to determine the relationship of the geophysical anomalies with respect to the geological setting and relationship between the teo geophysical anomalies. This correlation is hope to provide information the underlying deeper features within the study area.

The area is underlained by granite and metasedimentary rock. The metasedimentary rock which made up of metaquartzite, filite, and quartz mica schist is of Lower Palaeozoic age (Jones, 1968) include the shaley unit (sedimentary in the map). The granite however, is of Upper Triassic or Middle Lower Jurassic (Hutchison and Gobbett, 1973). There are two type of granite. They are the coarse and medium grained porforitic biotite granite. The coarse grained granite probably formed the main pluton while the fine grained forms as later activities such as in a dikes.

The gravity data had been acquired using a Woden gravity meter. While the magnetic data was acquired using a proton magnetome. The Bouguer grevity map is given in Figure 1. This data has not been correlated to any international level hence gives only the relative gravity variation within the area. The magnetic map (Figure 2) as measured using the proton precession magnetometer gives the total earth magnetic field. Hence, a typical magnetic anomaly due to to a source having normal magnetization in the area has the anomaly high and low pair at north and south respectively.

The gravity anomaly map indicates that the variation in the gravity value occurs largely towards the southern part of the area near Mesjid Tanah and Terendak Camp. The anomaly near Mesjid Tanah area is almost circular with diameter of about 2.5 meters. The anomaly at Terendak Camp is elongated almost east-west with length and width of about 2,5 km by 0.5 km respectively. The magnitude is, however only about half the Mesjid Tanah anomaly. To its south east The anomaly is relatively low. Towards the north from Kuala Sungai Baru to Sungai Baru Hilir the anomaly forms a distinct east-west trending contours with two small anomaly high. This is markedly different from the anomaly distribution at the southern part. Along the coast distinct gravity low occurs.

The distinct gravity low along the coastal areas can be directly associated to the granite which outcrop along some part of the coast. Some areas along the coast which is underlain directly by the metamorphic rock has the grabite intrusion underlying the metamorphic rock. The gravity low along the coast is however cut by the east-west trending anomaly at Terendak Camp. This east west trending gravity high might be associated to later intrusion which is probably basic in nature. This basic intrusion carries high density minerals like ferum shows as the circular gravity anomaly high is over the metamorphic/sedimentary rock at Mesjid Tanah.

The magnetic map shows two distinct anomaly region, one at the southern part of vthe area and the other to the north. The south anomaly near Mesjid Tanah correspond well with the location of the gravity anomaly. The northern magnetic anomaly , however has no equivalent with the gravity anomaly. Both the anomaly is typical of magnetic in the region with their magnetic high towards the north and the magnetic low towards the south.

On closer inspection the anomaly near Mesjid Tanah is due to the high magnetite and hematite content of the metasedimentary rock there. The iron bearing rock is limited in area as indicated by both surface mapping and both the magnetic and gravity anomalies. The other magnetic high (Kuala sungai Baru) has no equivalent gravity anomaly. This area has been mine for tin (casseterite, Scrivnor, 1927) and the tin may be associated with the high density ferum which gives the magnetic signature here.

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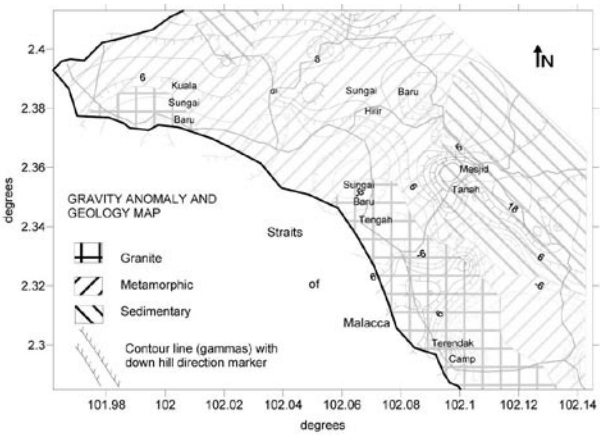

Figure 1: Gravity map.

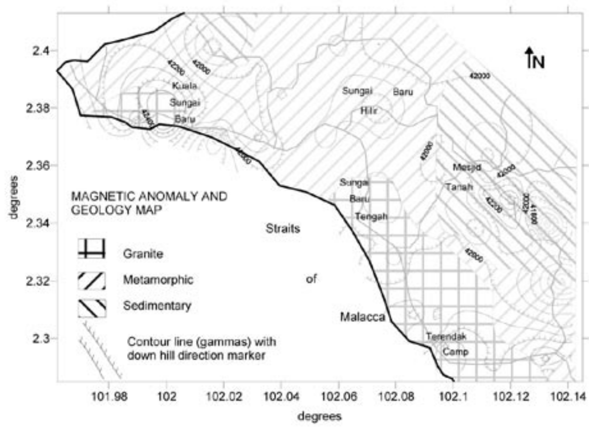

Figure 2: Magnetic map.

Geoscience Tools Paper 2g3

Application of spectral analysis of surface wave (SASW) for characterization of rock mass in engineering geology: case study in Malaysia

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In order to execute a construction project such as tunnel, dam, highway and building, a geotechnical study needs to be carried out to determine the engineering parameters of the rock mass at the project site. Design and safety factor of a construction project are depended on soil and rock engineering parameters which are usually determined by in-situ test such as Standard Penetration Test (SPT) and seismic tests. The SPT test which normally involves drilling and laboratory works always incur high operating cost. Meanwhile, seismic test is a fast, cheap, non-destructive and easy to operate method for rock mass characterisation. This paper discusses the application of the spectral analysis of surface wave (SASW) method in rock mass characterization as an alternative to in-situ test. The aims of the study are to determine the Rock Quality Designation (RQD), anisotropy of rock mass and excavation classification as well as stiffness properties of the rock mass by using SASW method. The study of SASW is being emphasized currently because it is more effective than the conventional compressive wave application. This is because in the application of shallow seismic method, two over three (67%) of the energy of wave sources are transformed into surface wave. By definition, Spectral Analysis of Surface Waves (SASW) is a seismic method that uses the properties of Rayleigh waves travelling within the subsurface material of the earth. The SASW method is an in situ and nondestructive as well as rapid and cost effective method for site characterization compared to conventional drilling method. WINSASW2.0 was used for inversion process of the SASW data to produce shear wave velocity versus depth profiles. The profiles are then analyzed and correlated with other rock mass engineering geological parameters such as stiffness, rock quality designation (RQD) and anisotropy as well as the excavating properties of the rock mass. The analysis of the SASW data is done with an assumption that the rock mass is an isotropic and homogeneous material with various intensity of discontinuity which influenced the velocity of surface wave propagation within the rock mass.

Twenty four SASW tests were conducted on the granitic rock mass at JKR Quarry at Bukit Penggorak, Kuantan Pahang and four tests had been carried out on cut hill of sedimentary rock at Bukit Tampoi, Dengkil, Selangor. RQD value was computed based on shear wave velocities derived from SASW tests and ultrasonic velocities of intact (fresh) rock. The differences between RQD from SASW method and those from discontinuity surveys were found to be less than 10%. Anisotropic analysis had been performed based on shear wave velocities which were measured in four different directions. Based on linear regression approach from distribution of shear wave velocity (Vs) versus Nspt, an equation of Vs = 11.27 Nspt + 410.03 was deduced for the sedimentary rock at the Dengkil site. Excavation properties of the granitic rock mass at JKR Quarry was empirically determined using both SASW and ultrasonic velocities as well as RQD values of the rock.

Geohazards & Megacities Paper 3a1

Tsunami inundation modeling for Eastern Sabah, Malaysia

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The coastal area of Eastern Sabah facing the Celebes Sea and Sulu Sea is exposed to potential tsunami generated by earthquake along the seismically active North Sulawesi Trench, Cotabato Trench, Sulu Trench and Negros Trench subduction zones. Records of tsunami event database at the National Geophysical Data Center (NGDC) of the National Oceanic and Atmospheric Administration (NOAA) show that there are at least 16 tsunami events recorded in the Celebes Sea and four in the Sulu Sea. The closest tsunami events occurred off Tawi-Tawi Island on 1 January 2000. A wave as high as 20m left about 5,000 people homeless. The 21 August 1976 tsunami generated by 8.1 M_w earthquake in the Gulf of Moro resulted in the death of around 8,000 people and left about 90,000 people homeless. The 1 January 1996 tsunami generated by a 7.9 Mw earthquake north of Sulawesi killed 9 people, injured 63 people and destroyed 163 buildings.

To evaluate the influence of tsunami on the coastal town areas of Sandakan, Lahad Datu, Semporna and Tawau propagation and inundation model using TUNAMI-N2 method was employed. Several potential earthquake sources with M_w 8 located along the subduction zones was used as input to the model to simulate different scenarios. The fault parameters used at different locations include slip (10- 20 m), dip (15-30 degrees), rake (45-90 degrees), length (100-150 Km), width (50-100 Km) and depth (15-30 Km). The results of the tsunami propagation and inundation model (90-m resolution) show that the coastal towns are impacted by waves between 0.5-2 m with inundation distance between 10-500 m. The wide shallow continental shelf

(80-100 Km) fronting the coastal areas of Sandakan and Lahad Datu results in insignificant run-ups (less than a meter) whereas the relatively narrow continental shelf (20-30 Km) fronting the coastal areas of Semporna and Tawau show locally significant run-ups (more than a meter) (Figure 1). Tsunamis generated along the Negros, Cotabato and North Sulawesi trenches reached the coastal areas of eastern Sabah within 50-90 minutes. The speed of the simulated tsunami decreased drastically as it reached the shallow shelf of Sabah (Figure 2). The small inundation distance and flow depth suggests that the coastal towns of eastern Sabah are only mildly exposed to tsunamis.

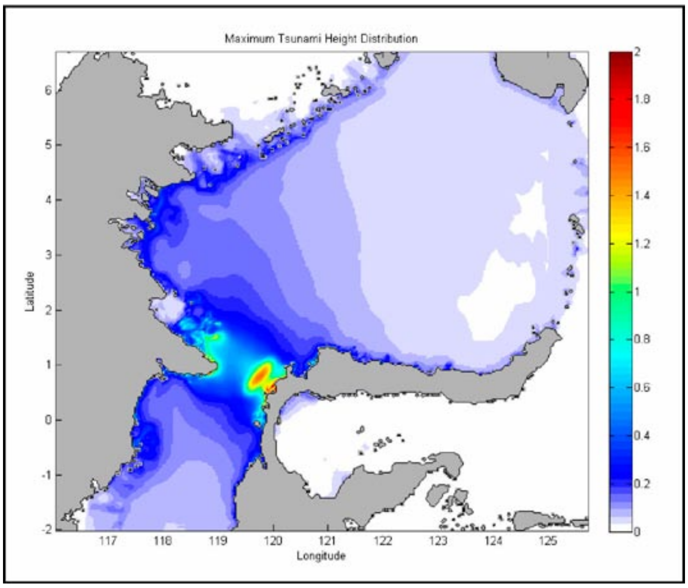

Figure 1: Maximum tsunami heights distribution of simulated tsunami from the North Sulawesi Trench.

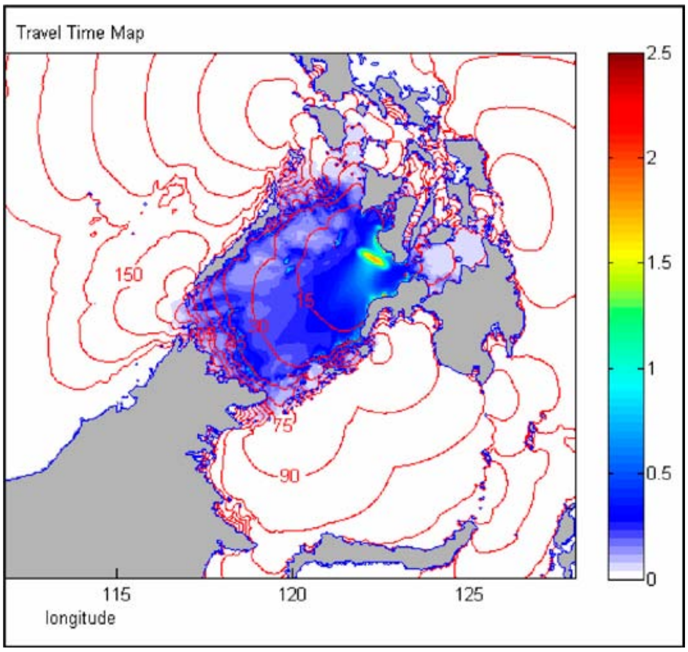

Figure 2: Travel time and maximum tsunami heights distribution of simulated tsunami originating from the Negros Trench.

Geohazards & Megacities Paper 3a2

Deterministic karst cavity distribution prediction through geospatial analysis: A case study of SMART tunnel project, Kuala Lumpur, Malaysia

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In this paper, a methodology for producing karst cavity distribution zonation based on the geotechnical database containing data from geological mapping and boreholes drilling for a newly developed tunnel, the 9.7 km long SMART tunnel, where it is predominantly routed in the karstified limestone formation is presented. Preparation of such maps will provide some insight into the characterization of karst, as much of the commercial centre of Kuala Lumpur is founded on heavily karstified limestone of the Kuala Lumpur Limestone Formation and boreholes give no guarantee of finding all the karst. This paper mainly deals with the integrated analysis of data obtained from geological map, fieldwork data and borehole records. The preliminary prediction was made based on the existing geological map, which was then investigated in the field, using the two sited exposed for the construction of the SMART tunnel. Much detailed analysis was made based on the borehole records using three nearest method to represent percentage of karst in one unit triangle of area and one unit triangle of volume of ground. The results indicate the spatial distribution of dissolution features significantly explained by the structural domains, the effects of scale and the alignment of drainage trellis. As an application, two possible predictive tools for the cavity karst are outlined; the structural domains map and the patterns of frequency distribution map. The evidence for this is given and the method used for these studies are described.

Geohazards & Megacities Paper 3a3

Gravity method and its contribution to geological mapping and cavity detection in Peninsular Malaysia

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The gravity method is one of the geophysical tools used for geological, engineering and environmental investigations where the detection of geological boundaries, cavities, subsurface karstic features, subsoil irregularities, or landfills is essential. Successfully delineation of geological boundary of Bukit Arang Tertiary Basin in the east of Perlis and north of Kedah illustrates its usefulness as an efficient geological mapping tool.

In higher accuracy measurements, the microgravity method has been widely and successfully used for locating and monitoring subsurface voids. Since microgravity methods measure gravity variations at the surface, they are directly influenced by the density distribution in the subsurface and particularly by the presence of voids, which create a mass deficit relative to the density of the surrounding terrain. In many cases, deep or small-scale heterogeneities generating low-amplitude anomalies can be detected and the reliability of further interpretation requires highly accurate measurements which are carefully corrected for any quantifiable disturbing effects.

Most of the microgravity surveys in Malaysia were carried out by the Mineral and Geoscience Department mainly to detect the occurrence of subsurface cavities in limestone areas of Klang Valley in Federal Territory and Kinta Valley in Perak. Results of the sinkholes occurrences studies at the sites of a proposed public library building in Baling, Kedah and at the compound of the KTM Quarters, Ipoh, Perak showed that the low amplitude of gravity values located exactly or slightly adjacent to the sinkhole positions.

Good correlation of borehole data with several results of microgravity survey such as at Mahkota Wira Condominum site, Jalan Sultan Azlan Shah, Ipoh, Perak and at the proposed Light Rail Transit Station in Jalan Ampang, Kuala Lumpur showed that the cavity location can be successfully determined by the microgravity measurement technique.

Although the gravity method can be used successfully in locating the subsurface targets but it's still a non unique interpretation and the results need to be confirmed either by drilling or by other geophysical methods.

Geohazards & Megacities Paper 3a4

Evidences for Quartenary to present seismicities in Malay Peninsular

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The Malay Peninsular which form part of the core of Sundaland is considered to be very low seismicity and relatively stable for a long period. These are due to its tectonic setting, situated within a region that are not significantly elevated but surrounded by extensive shallow seas. Prior to December 2007, the peninsular was experiencing only low to medium seismic activity level tremors due to seismic waves generated with epicentres located in Sumatra or rarely the induced seismicity near Kenyir Lake. The maximum observed intensities of the tremors that originate from the Sumatran epicenters on the Modified Mercalli (MM) scale are VI for Peninsular Malaysia.

The widespread assumption that the Sundaland is a long-term stable region is beginning to be questioned by some authors. They noted that Cenozoic and Quaternary deformations of Sundaland are recorded in the numerous offshore sedimentary basins and onshore basins alongside elevated highlands. Similarly there are evidences for very young crustal movements in the form of reactivation of older pre-Tertiary deep-rooted faults. This paper outlines further evidences to question the popular assumption that the Malay-Thai Peninsula is seismically stable. These include the recent Bukit Tinggi earthquakes and the Quartenary, active tectonic activities, recorded in the form of basaltic volcanism area and deformation of Quaternary alluvial and boulder beds.

Active seismicity have been recorded in the Thai part of the peninsular, but the Mw = 2.7 to 3.7 earthquake occurrences near Bukit Tinggi, Malaysia, from November 2007 to January 2008, which occurred right at the core of supposedly stable Sundaland has stimulated considerable interests and debate. The earthquakes are located at or near to the intersection of three sets of major lineaments trending N-S, NE and NW. This corresponds to the NW Bukit Tinggi and Kuala Lumpur Fault Zones and the N-S and the NE faults mapped in the region. It is interpreted that the earthquakes are due to the reactivation of the above faults.

This paper further report the increasing evidences for Quaternary deformation and faulting in Peninsular Malaysia. These are found at 1) Gajah Puteh, Kedah where Quaternary alluvial deposits are found within a fault-controlled graben, 2) Kangkar Pulai, Near Johore Baru where gently dipping Quaternary Boulder Beds are transversed by dextral strike-slip fault, 3) Tg. Punggai, Southeast Johore where faulted colluvial deposits are found. Further evidenve for active tectonism in Peninsular Malaysia is the presence of 1.6 Ma Kuantan basalt volcanism. The basalt is highly fractured suggestive of recent deformation.

The Bukit Tinggi earthquake occurrences and the Quartenary to Recent deformations indicated that the core of Sundaland is also deforming and earthquakes do occur in Peninsular Malaysia.

The paradigm of plate tectonics predicts concentrations of earthquakes, volcanism, and other tectonic activity within narrowly defined plate boundaries, but no significant deformation within the rigid plates. The seismicity is believed to be the result of stress build-up due to the Tertiary to the present-day tectonics in SE Asia (Sundaland), especially the oblique, north-northeast-oriented subduction of the Indian–Australian plate under the Sundaland. It also implied that the intraplate deformation zone associated with the Sumatran Subduction Zone is wide and encompasses Peninsular Malaysia.

The Sundaland stability is a myth. The region is today surrounded by subduction and collision zones, and merges with the India-Asia collision zone. The Quaternary to Recent seismicity have revealed that Malay Peninsular is vulnerable to the earthquakes originating from active plate boundaries but also within-plate in terms of tremors. Bridges, high-rise buildings and dams are greatly exposed to these seismic activities during their lifetime. Hence, it is suggested that the design of large engineering structures must take into consideration the possible seismicity due to reactivation of ancient major faults zones in addition to the seismicity due to tremors from seismic waves generated with epicentres located in Sumatra.

Geohazards & Megacities Paper 3a5

Geological factors contributing to the landslide hazard occurences in the Trusmadi Formation slopes, Sabah, Malaysia

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This paper describes the geological inputs, appreciation of the complex geology, examination of material properties under specific laboratory tests, verification of the mechanism and the deduced possible causes of the landslide hazard occurrences in the Trusmadi Formation slopes, Sabah, Malaysia. The Trusmadi Formation regionally shows two major structural orientations NW-SE and NE-SW. It consists mostly of dark grey shale with thin bedded sandstones, typical of a turbidite deposit. This unit has been subjected to low metamorphism, producing slates, phyllites and meta-sediments and intense tectonic deformation producing disrupted or brecciated beds. Quartz vein, calcite vein and matrix (clayey components) are quite widespread within the crack deformed on sandstone beds. The shale is dark grey when fresh but changes light grey to brownish when weathered. The weathered materials are unstable and may experience sliding due to by high pore pressure and intensively geomorphologic processes. Physical and engineering properties of fifty five (55) soil samples indicated that the failure materials mainly consist of poorly graded materials of silty clay soils and characterized by intermediate to high plasticity, containing of normal to active clay, very high degree of swelling, variable moderate to high water content, low permeability and soft to very stiff of undrained shear strength. The rock properties of twenty five (25) rock samples indicated that the point load strength index and the uniaxial compressive strength range classified as moderately week to strong. The geological inputs influence had transformed the slopes to be highly unstable and susceptible to landslide occurrences. Much of the findings could not have been ascertained without sound understanding of the site geological evolution, inherited unfavourable geological relics and the peculiar but hazardous engineering properties. In terms of slope remedial work and slope designs, these geological inputs should be taken into consideration for better assessment of the slope material, geometry and behaviour characteristics. The geological factors evaluation should be prioritized and take into consideration in the initial step in all infrastructures program and it may play a vital role in landslide hazard and risk assessment to ensure the public safety.

Geohazards & Megacities Paper 3a6

Engineering geology of rock slopes – Some recent case studies in Malaysia

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Rock slopes are often encountered and form an important part of many civil engineering projects. The engineering of rock slopes would require input on engineering geology, such as the lithology or rock type constituting the rock slope, geological structures (joints, bedding planes, faults, etc.) and the weathering profile of the cut slope. This paper begins with a brief discussion of these engineering geologic factors, and then covers half a dozen recent local (Malaysian) case studies as illustrations. The lithologies involved in these case studies include granite, sandstone/shale, quartzite/phyllite, limestone, and graphitic schist. The projects of concern include highways, housing/condominium development, water tank sites, and damsite.

Geological significance of landslide occurrences in Canada Hill, Miri, Sarawak

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Canada Hill, in Miri, is a narrow northeast-southwest trending hill ridge, which overlooks Miri town at its northern side. The hill is generally low, about 80-85m high and in many parts the hill crest is flat, plateau-like and occupied with human activities. On one of Canada Hill's crests is situated the first oil well in Malaysia, Miri Well No. 1, nicknamed the Grand Old Lady, now developed into a petroleum science museum.

Many landslide occurrences along the hill slopes of Canada Hill have been known to occur. However, in January 2009 incidents, Miri town folks were awakened by two landslides that not only killed but devastated many hill slopes residents. The first incident occurred on 16th January at the Shell Petrol Station in the northwestern slope of Canada Hill, where 2 lives perished. Two weeks later, on 30th January another landslide occurred at Kampung Lereng Bukit, about 3km NE of the earlier landslide. This second landslide affected 8 houses, in which 3 houses were damaged; one badly and was also completely displaced from its original location. The local authority immediately evacuated 342 people from 26 houses from the village to safer area.

The hill slopes failures in Canada Hill areas could be attributed much to the geological factors apart from human induced causes and rainfall pattern experienced. The geology of the Canada Hill is basically made up of sandstone and shale sequences of the Miri Formation, of Miocene age. The sandstone and shale sequences are divided into 2 lithostratigraphic units, namely the Sandy and Shaly alternation, where the former is represented by more than 50% sandstone and the latter more than 50% shale (Banda, 1998). The shale in the shaly alternation shows the presence of marine fossils bivalves and trace fossil *Orphiomorpha* sp. which indicate that the shale is formed in marine environment and uplifted ever since. The shale is not well indurated and easily saturated by subsurface water infiltration.

The Canada Hill is made up of complex and diverse geological structures. The Canada Hill structure consists of a NE-SW elongated anticline, the Miri Anticline, bound to the east by a steep NW dipping fault, known as the Shell Hill Fault. Earlier studies have described that the downthrown block of the Shell Hill Fault is dissected by a series of steep NW dipping subsidiary faults and a series of flat SE dipping faults, while to the east and underneath the Shell Hill Fault, three NW dipping thrusts faults are present; the Canada Hill Thrust and the Inner and Outer Kawang Thrusts (Lesslar and Wannier, 1998). It has been indicated that the Miri oil field consisted of some 78 separate fault blocks, oil accumulations are found at different levels in the various blocks. Van der Zee and Urai (2005) reported over 450 normal faults with throws ranging from several centimeters to over 25m, exposed in an outcrop near the Airport road. The many fault structures recognized in the Miri Formation has been classified as a composite fault system formed as a result of dextral strike-slip deformational events (Mustaffa Kamal Shuib, 2001).

The aerial photograph interpretation indicates that the Canada Hill ridge is faulted in many places. Strike-slip faults had transected the flat hill-top ridges, and at Kampung Lereng Bukit area closely spaced faults as noted in the earlier studies, are also identified.

The engineering geological survey carried out immediately after the landslide incidents identified numerous tension cracks and several relics or scars of previous landslides near the failed areas. The Kampung Lereng Bukit landslide measured 234m long and 80m in width, while the Shell Petrol Station landslide measured 80m long and about 30-60m in width. An estimated 30,000m^3 sediments had slide down at Kampung Lereng Bukit, while at Shell station about 20,000m^3. At the Kampung Lereng Bukit landslide it is observed that the sandstone bed had acted as the sliding plane on which the failed loosed debris had slide upon. The bedding planes at the failed slopes respectively showed 20-25° and 25-28° northwest dipping beds. The results of the resistivity survey had interpreted high porosity and faulted subsurface geological structures as indicated by the low resistivity values (<200 ohm meter). It is observed that in many localities along the hill slopes water had seeped from cracks between the jointed planes and also between the bedding planes.

Geohazards & Megacities Paper 3b1

Assessment of rockfall hazards at a construction site, Gunung Panjang, Ipoh, Perak

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The construction of three high-rise condominium towers and a show-house near steep limestone hills at the northern end of Gunung Panjang in Ipoh was recently proposed. A study to assess the risks from falling limestone blocks to the construction site and the planned structures was conducted and mitigating measures were proposed.

The three condominium towers are located on flat sandy ground next to a pond. One of the towers is to be erected about 25 m away from a 10 m high karstic limestone knob at the northeastern edge of the pond. This karstic knob has two prominent undercuts on its northwestern cliff and overhangs on the other faces of the knob. Should there be a 'gravity failure' on the northwestern cliff face, the falling block would topple in a westerly direction into the pond. The overhangs from the other sections of the knob are highly fractured and might detach from the knob. In the event of this happening, some of the debris would fall into the pond and others, onto empty land away from any building.

The show-house is to be built at the bottom of a scree slope at the foot of two 100 m high karstic limestone hills. Investigations revealed that fractured overhangs are present near to the top of these two hills. The overhang on the hill facing the car-park of the show-house runs over 75 m; should this overhang detach from the hill, the debris would roll down-slope in a northeasterly direction towards the car-park. Another overhang measuring about 40m in length was observed on the hill further to the east and obliquely facing the show-house; falling debris from this overhang might affect a corner of the show-house.

To ensure the safety of residents in this project, mitigating measures which are viable and will allow the preservation of the natural setting are proposed. These measures include: (1) A ditch of about 1 to 1.5m wide at the foot of the scree slope and a piled boulder retainer of about 1.4m high to protect the show-house. (2) Adjacent to the piled boulder retainer, a cable fence would be installed along the length of the car-park. (3) The undercuts in the northwestern part of the karstic knob would be treated with 'dental infilling' or alternatively, underpinning columns would be installed. (4) As an additional safety measure, a cable fence would be installed between the knob and the nearest tower block.

Detailed geological mapping of the proposed project site and the implementation of complementary engineering mitigating measures will enable the residents to live in a safer and close-to-nature environment.

Geohazards & Megacities Paper 3b2

The value of Rock Mass Rating (RMR) system for heterogeneous flysch deposit of the Crocker Formation from Tamparuli, Sabah

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This paper discuss the value of Rock Mass Rating (RMR) system of the rock cut slopes for heterogeneous flysch deposit of the Crocker Formation in CPSB Stone Quarry Sdn Bhd, Tamparuli, Sabah. Higher RMR value contribute to good or very good rock mass condition which indicate as a stable slope and need less mitigation measures for engineering structures on it. Higher RMR value reflected by higher intact rock strength, narrow discontinuity spacing, good discontinuity condition, dry discontinuity and very favourable orientation and dip between discontinuity with slope. The result of this study show a 'very poor' and 'fair' rock mass conditions for the four rocks cut slope in the study area.

Geohazards & Megacities Paper 3b3

Quantification of discontinuity surface roughness: stepchild of rock mechanics in Malaysia?

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The role and influence of geological discontinuities on the stability of rock masses, whether for cut rock slopes or in underground excavation has been long established. In addition to the orientation of the major discontinuity sets within a rock mass, the characterisation of surface roughness of discontinuities also plays a major role in controlling the rock mass's stability. This latter parameter however has generally been neglected in Malaysia. To address this shortcoming, a systematic programme of testing and quantification of the surface roughness of discontinuities for different lithologies has been started and this presentation deals with the results of the initial investigations. Tilt tests as well as direct shear tests on both artificially sawn surfaces as well as natural surfaces are being conducted.

For fresh granite, the basic friction angle, as determined for sawn surfaces, had an average value of 30º ± 2 º for tilt testing. As expected, this basic friction angle was independent of the direction of testing. By comparision for the direct shear tests, the average basic friction angle was slightly higher at 33º ± 2 º. For natural rough surfaces, in addition to the tilt test, the joint roughness coefficient, JRC was also determined. For the natural rough surfaces, a wide range of values was obtained, ranging from 42º to up to as high as 75º. Generally, the Joint Roughness Coefficient, JRC and the peak friction angles exhibit good correlation. For low JRC values, lower peak friction angles were determined, increasing progressively to a maximum average value of 75º ± 2 º for the highest JRC value.

Geohazards & Megacities Paper 3c1

Cracks mapping: A case study on applying geologic skills in dilapidation survey

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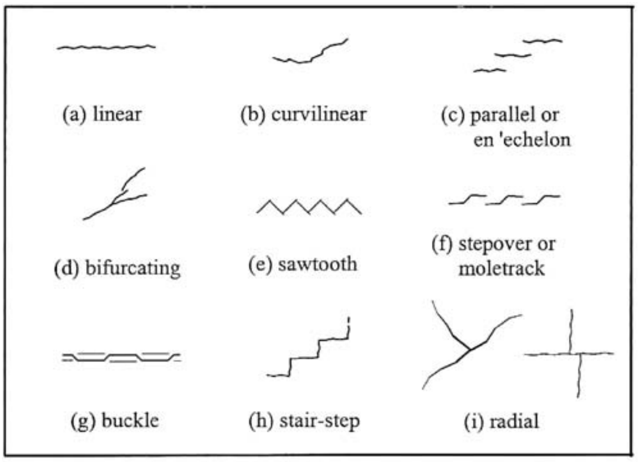
Dilapidation survey is commonly known as pre-construction condition inspection in Malaysia. Any construction activities adjacent to existing development, requires dilapidation survey. It is the responsibility of a contractor to appoint a specialist to carry out physical inspections to existing neighbouring buildings. A contractor shall ensure that the buildings likely to be affected by the construction works are covered by this inspection. The main purpose of a building inspection report (with photographs) is to record the original condition of properties around construction site. If any dispute on building damages in the later stage of a construction project, the report with photographs will be strong evidence to solve the dispute. This paper presents a case study of dilapidation survey on defected completed building which experienced excessive settlement.

Cracks patterns in exterior plaster walls, interior dry-walled walls, and concrete slabs can aid in the determination of the geologic conditions responsible for ground movement and building distress. Cracks play a significant role in the assessment of building stress and they are the important indicators that provide supporting evidence to any geotechnical study involving building movement. Simply identifying a crack without specifically conveying its geologic significance was a very unscientific approach to the interpretation of cracking in buildings. Discussion on the occurrence of cracks in building materials related to shrinkage, structural vibrations and others are beyond the scope of this paper. This paper also attempts to highlight the application of geologic skills in a non-conventional works of an engineering geologist.

The objectives of the works in this case study were to carry out visual inspection, record and mapping of damages existing includes all damages like crack, spalling of concrete, signs of corrosion of steel, etc. All measured defects were photographed by conventional film type photographing. The surveyed and mapped areas cover all exposed structural elements only. The works covered the following:

- Inside and outside of structures;
- Surrounding services and grounds within 10m of the perimeter of the structures;
- All structural and non-structural elements;



Patterns (a) and (b) are found in both plaster and drywalled walls. Patterns (c), (d) and (e) are found in plaster walls. Patterns (f), (g) and (h) are found in drywalled walls. Crack pattern (i) is found in slabs.

Figure 1: Types of ground movement induced crack patterns commonly found in walls (plaster and dry-wall types) and slabs (after Audell, 2004)

- Measuring the cracks dimension and mapped with photographic records;

This study used two main references i.e. by Audell (2004) and Building Research Establishment (1989a and 1989b). Based on studies carried out, all the defects were recorded in form of photographic and/or sketch. The summary of the findings, lay-out plan, sketches and images of the damages are presented. Visual inspection, mapping and record of existing damages were done by observation and walk over survey. During the mapping process, any sign of cracks were identified, recorded and photographed. Crack description was simplified as follow for ease of understanding.

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Geohazards & Megacities Paper 3c2

Engineering properties of limestone from Pandan Indah, Kuala Lumpur

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This paper highlights typical engineering and physical properties of Limestone obtained from various types of laboratory tests. The tested samples were obtained from substrata investigation in Pandan Indah, Kuala Lumpur, where construction of an elevated intersection has been proposed. Sixty-five boreholes were sunk within the project site, which is divided into three areas; Site S1, S2 and S3. As part of the design process of this major structure, relevant properties of the *in situ* bedrock are required. The laboratory tests carried include uniaxial compression, Brazilian, Schmidt's hammer, point-load, ultrasonic velocity and dry density tests. More than 500 rock samples, of various shapes and sizes, were prepared for the tests and mostly were fresh (Grade I) samples. In the compression test, axial and radial strains of the samples (measured using strain gauges) were used to determine rock constants E and υ. Effect of moisture content on compressive strength of the samples was also investigated by undertaking test on saturated cores.

The test results show that the compressive strength (UCS) of Limestone varies between 14 and 139 MPa. Its tensile strength is between 0.5 to 14 MPa, which is less than 10 % of its UCS. Its Point-load index strength is between 0.4 and 6 MPa, while its surface compressive strength (based on R) ranging between 23 and 105 MPa. The modulus E is in the range of 10 to 88 GPa and υ is between 0.04 and 0.53. There are general trends indicating reduction in the samples strength due to saturation. The reduction is about 5 to 50 % lower than dry samples. However, being natural materials and tested using laboratory machine, this reduction may also be contributed by samples variation and machine accuracy. Based on the three areas (Site S1, S2 & S3), samples from site S3 seem to exhibit the highest strengths (compressive, point-load and tensile) while samples from site S1 exhibit the lowest strengths. Observation made indicates that the cores from site S1 display small-scale fractures/cracks. These existing fractures may have induced premature failure in the samples. In fact these fractures have also contributed to erroneous strain data in a number of tests, consequently resulting in the E and υ value that are lower than expected.

Geohazards & Megacities Paper 3c3

The significance of relict structures in slope failure geoforensic investigation – A case study from Serendah Selangor, Malayisa

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Several common methods of site investigation have been carried out in a geoforensic investigation of a slope failure at Taman Desa Melor, Serendah, Selangor. This includes boreholes, seismic reflection survey, slope movement instrumentation and monitoring, as well as surface geological mapping. The main objectives of the whole investigation were to identify the cause of the failure to facilitate the design of the slope rehabilitation works.

The slope is apparently cut in a granite hill slope, extending over 55m in length, about 102m in height, and consisted of 20 berms. The slope geometry is somewhat peculiar because in the first 7 berms from the bottom, the slope face is protruding out at about the middle section of the slope. Based on its appearance, this protruding section looks like a buttress or fill slope. It was designed and constructed in such a way perhaps to provide an extra support to the very high and steep cut slope. The protruding section also has a 17-20m wide berm on its top, possibly to serve as "catch berm" for any mishap from the upper slopes. However, it was in this section where the slope failure has occurred. The slope failure is marked by a large tension crack, extending over

40 m long and some 20-30cm wide, which was well-developed on the top of the protruding section of the slope. The failure is a deep seated one as indicated by ground heaving on the road and the broken road-side drain at the toe of the slope. Due to highly weathered nature of the granite, coupled with thick overburden soils and dense vegetation cover, it has become a puzzle for the engineers to decide whether the protruding section is a cut or a fill slope. The boreholes data and results of the geophysical survey initially provided some clues into the nature and lithologic type of the protruding slope-forming materials, but still gave no convincing answer. To answer this uncertainty then a geological mapping was carried out on the slope.

From a close-up surface mapping, notably along the tension crack and the limited exposed surfaces and within the erosion gullies, some convincing evidences emerged. The most convincing evidence is the presence of relict structures and others, such as in-situ weathered core-stone boulders within the highly to completely weathered (grade IV-V) rocks, and well preserved granitic texture from the internal wall of the erosion gullies. Field observation also found that the development of tension crack and erosion gullies was largely or partly controlled by relict structures (joints, faults). Available data from the relict structure suggested that the protruding slope section and thus the failed section, is riddled by at least 4 sets of relict discontinuity. In the earlier model which was based on the borehole data, the failed slope were assumed as fill slope and the failure took place along the interface between the fill and cut slopes. The presence of relict structures provided conclusive evidence that the slope under question is actually a cut slope and is not a fill slope. In conclusion, the presence and thus the mapping of relict structures are very important in geoforensic investigation of highly or completely weathered slopes.

Geohazards & Megacities Paper 3d1

Minimizing failures at slope cuts in the granitic bedrock areas of Peninsular Malaysia

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In Peninsular Malaysia, deep weathering profiles are found in granitic bedrock areas as a result of favorable tectonic and environmental conditions that have facilitated prolonged and pervasive chemical weathering. These profiles are all characterized by lateral and vertical variations in the degree of preservation of the minerals, textures and structures of the original bedrock; the variations allowing differentiation of three broad morphological zones that can be correlated with rock mass weathering grades. The topmost morphological Zone I of completely weathered bedrock (equivalent to weathering grade 6) is up to some 12 m thick and comprises stiff to very stiff, gravelly sandy clay that indistinctly preserves the textures but not structures and minerals of the original bedrock. The bottom-most Zone III (weathering grades 1 and 2) consists of continuous bedrock with narrow strips and wedges of very dense, gravelly silty sand along structural discontinuity planes. The intermediate Zone II of *in situ* moderately to highly weathered bedrock (weathering grades 3 to 5) is up to about 40 m thick and comprises medium to very dense, gravelly silty sands that distinctly preserve to varying degrees the minerals, textures and structures of the original bedrock; unweathered coreboulders often being present towards the bottom of the Zone. These morphological zones show variable thicknesses and features that vary not only with the composition of the original bedrock, but also with differences in topographic setting and geomorphic history. Slope cuts in the granitic bedrock areas of Peninsular Malaysia are thus excavated in, and expose, a variety of earth materials ranging from slightly to completely weathered bedrock.

The stability of the cuts is, however, often a matter of concern as failures have occurred at some of them; the type of failure being dependent upon the cut height as well as its regional and local topographic setting. In undulating terrain (<150 m topographic contour), low cuts (<10 m height) only expose the completely weathered materials of morphological Zone I and do not intersect groundwater tables, whilst higher cuts expose the highly weathered to completely weathered materials of morphological Zones I and II and sometimes intersect unconfined groundwater tables. Most of the low cuts are not affected by failures when excavated at moderate bench face angles (<55°), though small (<5 m^3 volume), earth falls and shallow slips have occurred at cuts of steep bench face angles (>60°). The earth falls have only occurred at very steep cuts (>80° bench face angle) and were preceded by the development of tension cracks, whilst the shallow slips mostly occurred at exposed cuts and were preceded by the development of desiccation cracks. These falls and slips have all occurred during periods of intense or continuous daily, rainfall and are considered to result from rainfall induced saturation, and loss of strength with time, of the slope materials. Where high cuts (>10 m height) in undulating terrain intersected unconfined groundwater tables, there have sometimes occurred small (<10 m^3 volume) slumps during periods of continuous rainfall. These slumps, which usually occur at exposed slopes, were preceded by the development of desiccation cracks in the slope materials; their occurrence being attributed to a decrease in strength with time and an increase in pore water pressures due to a rise in the groundwater table.

In hilly to mountainous terrain (>150 m topographic contour), low cuts (<10 m height) and the upper benches of higher cuts only expose the completely weathered materials of morphological Zone I and do not intersect groundwater tables. These low cuts and upper benches of higher cuts are usually not affected by failures when excavated with moderate bench face angles (<55°), though when excavated at steeper face angles (>60°), there have sometimes occurred small (<5m^3 volume), earth falls and shallow slips during periods of intense or continuous daily rainfall; these failures showing similar features as those at cuts in undulating terrain.

In hilly to mountainous terrain (>150 m topographic contour), the intermediate and lower benches of high cuts (>10m height) expose the moderately to highly weathered materials of morphological Zone II and do not intersect groundwater tables. Where these benches have been excavated with moderate face angles (<50°), there have usually not occurred any failure, though where excavated with steeper face angles (>55°), there have sometimes occurred small (<10 m^3 volume), block slides and wedge failures during periods of intense or continuous daily rainfall. These failures have only occurred at cuts where day-lighting, relict structural discontinuity planes with steep dips angles are found; the failures occurring as a result of rainfall induced saturation.

At high (>10 m height) cuts in undulating to hilly and mountainous terrain, there have sometimes occurred large failures (involving several hundred cubic meters of moderately to completely weathered materials from morphological Zones I and II) during, or following, periods of intense, or continuous daily, rainfall. These failures can be classified as slumps, slump-flows and debris flows, though they are gradational into one another. The failures have occurred at cuts with moderate to steep, overall slope angles (usually >45°, though mainly >55°) towards, as well as some months to years after, the end of excavation. Slumps are uncommon and have only occurred at cuts where morphological Zone III is found at the bottom of the cuts. The slump-flows show features of both slumps and flows, whilst the debris flows have incorporated several corestones and coreboulders in the failed materials. All these failures are considered to have primarily resulted from rainfall induced saturation of the slope materials; the saturation leading to a decrease in the negative pore water (or suction) pressures inherently present in the pre-rainfall, partly saturated slope materials. A number of other factors have also contributed to the failures and include increased pore water pressures due to a rise in unconfined groundwater tables at the foots of cuts, the presence of an external triggering factor as traffic vibrations and the clearing of slope vegetation which has led to enhanced infiltration of rainfall.

In hilly to mountainous terrain (>150 m topographic contour), the bottom benches of very high cuts (>30 m height) often intersect unconfined groundwater tables and expose the continuous, slightly weathered bedrock of morphological Zone III. Where these benches have been excavated at steep, face angles (>60°), there have sometimes occurred small (<5m^3 volume), and more rarely larger, rock falls, block and slab slides as well as wedge and toppling failures. These failures have occurred during periods of intense, or continuous daily, rainfall at benches where day-lighting, planar, structural discontinuity planes of steep dips (>45°) were present. The occurrence of these failures is due not only to transient, high pore water pressures during rainfall but also a gradual decrease in strength along the discontinuity planes due to erosion of infilling materials and their dilation with time as a result of 'stress relief'.

Minimizing failures at slope cuts in the granitic bedrock areas of Peninsular Malaysia requires that there be adequate recognition and understanding of the factors that lead to, or result in, the failures. This is especially important as the stability of these cuts is difficult to predict on the basis of field or laboratory tests given the variability in earth materials which also prevents realistic applications of mathematical stability analyses. The field performance of slope cuts is thus an important factor in slope design and it is recommended that low cuts (<10m high), and the upper benches of high cuts, exposing the completely weathered materials of morphological Zone I be excavated with bench face angles not exceeding 60°. The intermediate and lower benches of high cuts exposing the moderately to highly weathered materials of morphological Zone II furthermore, should be excavated with bench face angles not exceeding 55°, whilst the overall slope angle should not exceed 45°. The bench face angles of the bottom benches of very high cuts exposing the slightly weathered bedrock of morphological Zone III can be much steeper, though this will be dependent upon the orientations of the predominant structural discontinuity planes present.

Minimizing failures at slope cuts can furthermore, be achieved through monitoring of the various factors that have directly, or indirectly, resulted in failures at existing cuts; such monitoring not only allowing the undertaking of remedial measures, but also serving to minimize the impacts of the failures. In this respect, the monitoring of rainfall is perhaps the most important feature as most of the failures, especially the slumps, slump-flows and debris flows, have occurred during, or following, short periods (<3 hr) of intense rainfall (with total rainfall >70 mm), or longer periods (>1 day) of continuous rainfall. Monitoring of rainfall can thus minimize the impacts of slope failures through the temporary closure of transport routes or the temporary evacuation of people from sites at the foots of slopes in hilly to mountainous terrain, in view of the increased probability of failures when rainfall events exceed the said threshold limits.

Associated with rainfall is the need for monitoring of the surface and subsurface drainage facilities at slope cuts as these serve to minimize saturation of slope materials by limiting infiltration of rain water, as well as preventing the rise of unconfined groundwater tables. Interceptor, cut-off and berm drains as well as subsoil and horizontal drains have thus to be regularly monitored to ensure their continued effectiveness. Where surface drains have been damaged, there often develop deep gulleys which give rise to minor slips as well as increased infiltration of rain water. At high cuts in undulating to hilly and mountainous terrain, there is also the need to monitor unconfined groundwater tables (where present) so as to prevent their rise through subsoil and horizontal drains.

The development of tension and desiccation cracks within the slope materials at cuts also has to be monitored as they serve to enhance the infiltration of rain water. The establishment of a surface vegetation cover on slope cuts will serve to not only reduce the development of desiccation cracks but also reduce infiltration of rainwater and prevent the development of rills and gulleys. The surface vegetation cover, however, has to be monitored for its removal, or reduction in area, can result in the increased infiltration of rain water as well as surface erosion. There is also often a need to monitor the surface vegetation in areas upslope of the cuts for changes in the vegetation cover here can also result in the increased infiltration of rainwater. For the bottom benches of the very high cuts exposing the slightly weathered bedrock of morphological Zone III, there is a need for continuous monitoring of the structural discontinuity planes present, especially in terms of their decrease in strength through erosion of infilling materials or dilation through stress relief.

It is concluded that continuous monitoring of the slope cuts in the granitic bedrock areas of Peninsular Malaysia based on recognition and understanding of the factors that lead to, or result, in failures at them, and the undertaking of appropriate remedial measures, will serve to minimize the occurrence of these failures as well as minimize their impacts. It is also concluded that the design of future slope cuts cuts in the granitic bedrock areas of the Peninsula be based on the field performance of existing cuts.

Geohazards & Megacities Paper 3d2

Trends in the Southeast Asia earthquake activity

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Data from the USGS online catalog from the last 30 years are analyzed in terms of frequency and magnitude distribution. Analysis on the b-value is also done to study the trend of the seismic activity in this region.

The earthquake frequency plot shows that the total seismicity is decreasing to the average level prior to the 2004 quake. However, further analysis with the seismicity sorted according to the magnitudes reveals that there is a steady, upward trend of earthquake activity in this region since the 1970s. The b-value calculated for this region is 1.00, which is comparable with the b-value for the world. This b-value remains almost constant throughout the decades.

With the conventional frequency plot, the small and large magnitudes are treated equally, thus somewhat distorting the real presentation of the seismic activity of an area. A new way to plot is proposed as an improved way to describe the seismic activity in this area which not only takes into account the frequency but also the magnitude of the events making it more realistic. Bigger events will proportionally carry a bigger weight in this plot thus making the increase in seismicity more obvious and easier to recognize.

Geohazards & Megacities Paper 3d3

Some observation on Earthquake Hazard in Myanmar

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As large part of Myanmar lies in the southern part of the Himalaya and the eastern margin of the Indian Ocean, the country is exposed to the hazards of large earthquakes. Earthquakes in Myanmar have resulted from two main causes: (1) the continued subduction (with collision only in the north) of the northward-moving Indian Plate underneath the Burma Platelet (which is a part of the Eurasian Plate) at an average rate of 35 mm/yr; and (2) the northward movement of the Burma Platelet from a spreading centre in the Andaman Sea at an average rate of 25 – 30 mm/yr (Bertrand *et al*., 1998; Curray, 2005). Very large overthrusts along the Western Fold Belt have resulted from the former movement, and the Sagaing and related faults from the latter movement. Intermittent jerks along these major active faults have caused the majority of earthquakes in Myanmar. The major seismotectonically important faults in Myanmar are some unnamed major thrust faults in northwestern Myanmar, Kabaw Fault along the Kabaw Valley in western Myanmar, the well-known Sagaing Fault, and the Kyaukkyan Fault situated west of Naungcho.

The majority of the earthquakes in Myanmar mainly confined to three zones viz. (1) the zone along the western fold belt of Myanmar with mostly intermediate focus earthquakes; earthquake frequency is much higher in the northern part; (2) the zone along the Sagaing Fault, including the offshore part with shallow focus earthquakes; the earthquake frequency is higher in three segments, namely from south, Bago-Taungoo, Sagaing-Tagaung, and Myitkyina-Putao Segments; and (3) the zone in the north eastern part of Myanmar which is continuous with the earthquakes in southern Yunnan.

The seismic records show that there have been at least 16 major earthquakes with magnitude (M) $\geq$ 7.0 within the territory of Myanmar in the past 170 years. About eighty percent of the Myanmar people are living in the rural areas. Most of their dwellings are still non-engineered structures, which are vulnerable to moderate to high intensity earthquakes. The rate of urban growth increases in some large cities like Yangon and Mandalay. Due to urbanization the vulnerability is increased in cities and the scale of disaster from earthquake increased in major cities. On the other hand, some large segments of the active faults exhibit no seismic activity in last 50 to 75 years; for instance, the southern segment of the Sagaing Fault that is closed to the Yangon City and the northern segment near to the Mandalay City are waiting for a large one. This suggests that a national emergency plan for earthquakes and related disaster is in need, which should also include operating procedure for disaster preparedness and mitigation with strong support of scientific foresight.

Evidence of palaeoseismic slip near Bukit Tinggi, Peninsular Malaysia

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The Bukit Tinggi Fault Zone (BTFZ) is one of the major fault zones in Peninsular Malaysia. This northwesterly trending fault zone was first recognised by Shu (1969) as forming regional-scale lineaments cutting the Main Range batholith, with a total length of some 120 km from central Negeri Sembilan to northern Selangor. Several episodes of faulting have given rise to a diverse assemblage of fault rocks (Ng, 1994). Kinematic analysis indicates that the early ductile to brittle-ductile deformation is related to dextral strike-slip displacements (Ng, 1994), while the later strike-slip faulting in the brittle domain is sinistral (Tjia, 1972; Ng, 1994).

Lately the Bukit Tinggi area has received much attention due to the occurrence of small (Mw=1.7 – 3.7) and shallow (<10 km deep) earthquakes around Bukit Tinggi between November 2007 and February 2008 (Che Noorliza Lat & Ahmad Tajuddin Ibrahim, 2008; Mustaffa Kamal Shuib, 2008a, 2008b). Although, the epicentres are widely scattered, preliminary analysis by Che Noorliza Lat & Ahmad Tajuddin Ibrahim (2008) shows that the quakes fit the characteristics of earthquake swarms associated with motions along a fault line or a fault zone. Since BTFZ has a long history of faulting, some of its motions could be seismic and the evidence of seismic slips could be preserved.

A seismic slip is a shear dislocation on a fault that radiate energy with periods of 10 seconds or less, which are detectable by short-period seismometers and most seismic events are characterised by slip velocities in the order of 0.1 – 1.0 ms^{-1} (Cowan, 1999). Physical evidences that can be used to indicate seismic slip are fault rocks and related materials that are generated by sudden dislocation along a fault plane or fault zone at high velocity.

It is universally accepted that endogenic pseudotachylite formed by frictional melting is the most reliable evidence of localised seismic slip because the high temperature required for local melting cannot be achieved at low strain rates and velocities of aseismic slips (Spray, 1995; Cowan, 1999). Seismic slip can also be indicated by pseudotachylites formed by sintering of finely crushed fault materials (Curewitz & Karson, 1999) and ultracataclasis (Lin, 1996, 1997). However, for the crushing-generated pseudotachylite to be used as an indicator of seismic slip, it should form structures that indicate injection of fluidised materials at seismogenic rates. In this paper, we reserve the term pseudotachylite when frictional melting or sintering is involved, and ultracataclasite for extremely fine-grained crushing-generated fault rocks.

Although pseudotachylite has been observed in BTFZ at northern Selangor (Mustaffa Kamal Shuib, 2009), there is no description on its characteristics that can be used to infer it as a product of frictional melting, sintering or ultracataclasis. In his mapping along the Karak Highway, Ng (1994) recorded a wide range of fault rocks, ranging from incohesive fault breccias to cohesive cataclasites and S-C mylonites, but pseudotachylite remains elusive. During the recent widening of the Karak Highway, several slopes were cut back, forming new exposures. On a new rock slope in the Genting Sempah pluton nearest to Bukit Tinggi, there are several broad zones of cataclasites. Pseudotachylitic cataclasite was found within one of the cataclasitic zones.

The pseudotachylitic cataclasite occurs along an approximately 50 cm wide and 160° trending zone that can be traced only for about 3 m. It is consisting of cataclasite cut by several thin light gray to black ultracataclasite and pseudotachylite veins, as well as veins of quartz, carbonate, chlorite and epidote cementing fragments of protolith. The ultracataclasite, pseudotachylite and hydrothermal veins cannot be easily differentiated in the field due to the fine grain size. They are compact and aphanitic, consisting of extremely fine grained materials enclosing some clasts. They display roughly planar to subconcoidal fractures and vitreous lustre commonly associated with glassy pseudotachylite was not observed. They commonly display banded appearance formed by sub-parallel array of veins.

The ultracatasite forms fault veins, usually only a few mm thick and injection veins that are wedge to irregularly shaped and occur at high angle to the fault veins. Some of the ultracataclasite forming the fault vein are foliated. The contacts between the ultracataclasites and host cataclasite are often sharp. Under the microscope, the ultracataclasite is consisting of angular to subrounded quartz and feldspar clasts enclosed by fine grained matrix. The fine fragments forming the matrix are too fine to be identified, but fragmental texture is often recognisable. Many of the ultracataclasites are affected by hydrothermal activities, the most common being sericitisation. Some of the sericite occurs in very thin bands defining foliations, both parallel and at an angle to the ultracataclasite veins, indicating probable autometasomatism; while others that form veinlets cutting the ultracataclasites are post-deformation.

The pseudotachylite forms discontinuous veins and lenses up to 1 mm thick within and parallel to the ultracataclasite fault veins, as well as fragments within the ultracataclasite. The contacts between the pseudotachylite and ultracataclasite are usually sharp. Under plane polarised light, the pseudotachylite is consisting of featureless and gray to brown matrix enclosing subangular to rounded and sometimes embayed quartz and feldspar clasts. Some of the clasts also have fuzzy or "ghost" boundaries and few are surrounded by a rim of very fine grained minerals. The matrix is consisting of fine microlites of densely packed, interlocking slightly elongated grains, with relatively uniform grain size of about 1 to 4 μm long. The texture of the pseudotachylites is similar to product of sintering and devitrification of glass. No glass or spherulitic skeletal microlites often associated with pseudotachylite formed by quenching of frictional melts was observed. The pseudotachylite is also commonly affected by post-deformation sericitisation.

The morphology and texture of the ultracataclasite and pseudotachylite indicates that they are closely related and probably formed during the same repeating episodes of seismic faulting. During the seismic slip, ultracataclasis occurred along the slip planes and the frictional heat generated locally was sufficient to cause sintering and partial melting of the fine grained clasts. The slip plane was probably not perfectly planar and the widening of gap between the fault walls occurred at curved fault segments at high slip velocities caused the fluidisation and injection of fine clasts into the wallrock to form injection veins. The fault rocks formed by seismic slip are not commonly observed in the field because they were largely obliterated by post pseudotachylitic deformation and hydrothermal alteration.

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Groundwater & Soil Paper 3e1

Geophysical mapping of hydrocarbon-contaminated soil and groundwater at Sungai Kandis, Klang Selangor

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Geophysical subsurface imaging techniques have been successfully used in mapping subsurface lithologies, water saturation, and more recently, the extent of subsurface contamination mapping. For this geophysical investigation ground penetrating radar (GPR), electrical resistivity, tomography(ERT) and vertical resistivity profiling (VRP) were used. GPR and electrical resistivity as the best methods to recognize the geoelectric properties in mapping subsurface geological structures and subsurface to groundwater contaminants and in additional vertical resistivity profiling (VRP) is used extensively in environmental impact studies including hydrocarbon contamination. Geoelectrical study was performed with multi-electrode technology and 2D profile data interpretation. The study area, believed to be a formerly illegal dumping site of hydrocarbon and other chemical waste. Although the contamination grade of the site is low. The vertical resistivity probe revealed high apparent resistivity values ranging from 200 Ωm to 10,000 Ωm in most of the vadose zone, presenting highly residual phase of contaminants. The presence of this layer was also detected in the 2D resistivity sections as a thin band of high resistivity values ranging from 60 to 200 Ωm. In the GPR section, the oil contaminated layer exhibits discontinuous, subparallel and chaotic high amplitude patterns.

The GPR profiles also revealed a strong and continuous reflector which was interpreted as the water table at a depth of 0.5 to 1 m. This is in agreement with known water table measurements. Shallow borehole vertical resistivity data indicate that this GPR reflector is coincident with the top of a layer containing residual product and exhibiting oil staining and a strong oil odor. The 2D resistivity section demonstrated high resistivity in the vadose zone and a gradient to low resistivity. The areas of low resistivity were interpreted as the saturated zone and the clay layer beneath it. In this study, a total of 16 GPR traverses and 10 ERT lines with lengths from 30 to 100m were established. VRP measurements were conducted, in shallow boreholes drilled by hand auger, at random position with a maximum depth up to 1 m.

Fractured rock zones determination for groundwater exploration using electrical resistivity imaging

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Source of groundwater ought to be explored in a manner spread and protected so that the groundwater resource may well be fully used not just simply when the country faced the water crisis but also important for the function of the ecology. Furthermore, over-pumping of groundwater will lowered groundwater levels caused land subsidence and recharging the aquifer until groundwater returned to the original levels would not result in an appreciable recovery of the land-surface elevation. The damages will be great if there is no proper action taken to reduce land subsidence. Precise interpretations of subsurface condition very much depend on boreholes. As an alternative, electrical resistivity imaging (ERI) survey was introduced to take up the challenge. ERI technique for groundwater determination has been stimulated in part by a desire to reduce the risk of drilling dry holes and also a desire to offset the costs associate with poor groundwater production. ERI survey is very constructive to be utilizing in an area of unknown geology and hydrogeology in order to better predict subsurface conditions quantitatively. The use of electrical resistivity imaging (ERI) technique for mapping subsurface conditions enables to determine subsurface material properties based on resistivity values. The broad range of electrical resistivity values acts as an indicator to the heterogeneity of the subsurface materials. As a basis for selecting suitable investigation lines especially for groundwater exploration, a lineament study was performed before carry out the survey. In this study, selection of electrode array depends on depth of interest, data acquired for inversion and field condition. The interpreted ERI inversion show variable resistivity model sections refer to different hydrogeology depositions. It can be predicted as deposition types in hard rock layer or alluvium clay layer. The main outcome addressed in this paper are interpretation of the ERI inversion results reflect to groundwater potential in various rock types and thus helping in determining sites for tubular wells for groundwater exploration. As a result, the images obtained from the ERI inversion showed impressive and reliable results. The ERI results also shows good relationship with two exploration wells carry out after the surveys were conducted.

Heavy metals profile in groundwater system at solid waste disposal site

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This paper presents the distribution of heavy metals profile in groundwater system at solid waste disposal site in Taiping, Perak. In this study several boreholes were constructed within the solid waste disposal site. Soil samples were collected at interval 1 m depth during the construction of the boreholes with a down-hole hammer in alluvial deposits. These samples were then analyzed for their characteristics and pore water of the core samples was extracted in order to determine the concentrations of heavy metals chromium (Cr), manganese (Mn), lead (Pb), iron (Fe), zinc (Zn) and cadmium, (Cd). Beside that, the groundwater samples were collected at several boreholes within the study area. Pore water and groundwater samples were then analyzed their heavy metals concentration by using Inductively Couple Plasma Spectrometer (ICP-MS). In this study, surfer software was used to plot the contouring of heavy metals concentration. From the drilling results, the study area has covered by alluvial deposits of the Simpang Formation that is underlying the residual soil and the completely weathered sedimentary rocks of Semanggol Formation, comprising sandstone and shale. This alluvial deposit consists of silty sand or clayey sand and also a layer of sandy clay. The thickness of these alluvial ranges from 21m to 40m. The study showed that the profiling of heavy metals was obtained at several boreholes. From the profiling results, the penetration of heavy metals into the groundwater system was obtained. Profile of heavy metals concentration in pore water of the core samples at several boreholes within the study area, and heavy metals concentration in groundwater under different conditions were obtained. Some of the heavy metals concentration were quietly high such as chromium, manganese, lead and iron, which exceeded the maximum permissible limits as specified in the Malaysian Drinking Water Standard. Based on the graph, the filtration of these contaminants can be detected up to 15 m depth, depending upon the area.

Groundwater & Soil Paper 3e4

GIS-based weightage overlay for groundwater potential study in Perak, Malaysia

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This study utilized remote sensing and geographic information system (GIS) technologies for locating potential site of groundwater in Perak, Malaysia. Landsat TM and Radarsat are useful in extracting surface information such as land cover and structural geology while underground information are gathered from ancillary datasets. These information are pre-processed, stored and analysed in a geospatial base. Seven parameters involved consist of landuse, rainfall, soil characteristics, elevation, lithology, geomorphology, and lineament density. The weight overlay analysis was applied to identify the potential sites. There are two districts identified with a wealth of groundwater namely Kerian in the northwest and Batang Padang in the south. Pumping test from previous study recorded that the maximum yield is about 20 m^3/hr.

Groundwater & Soil Paper 3e5

Laboratory testing for electrical resistivity measurement for tropical ground material

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The field electrical resistivity method is now commonly used to obtain the information of the subsurface including the profiles and the geo-material index. Mostly the current resistivity index is limited to intact rock, clay and sand. Very little publication produces the index of weathered rock. Furthermore, it is difficult to control the factor that may affect the resistivity value during field measurement. Also, the electrical resistivity method in the present development does not give direct quantitative data to relate with engineering parameters of the ground. There fore to control the factors that may affected the results such as water content, depth of electrode penetration and soil grain size it is a need to conduct electrical resistivity in the laboratory at material scale. Prediction on rock engineering properties in ground investigations using the parameter of electrical resistivity have been done by Giao et al, (2003) and Kahraman (2006). However, Giao’s method hasn’t been applied on any rock material. Kahraman used two current electrodes on intact granite rock to determine the relationships between engineering properties and geo-resistivity of the. In both studies besides using different types of moisture for current conductivity, the methods also cannot be used to test soil and rock simultaneously. This paper describes laboratory set up and procedures for electrical resistivity measurement on material scale using AC current as power source. The purpose of this study is to establish the laboratory testing procedures and to compare the resistivity result from field and laboratory testing. Sandstone cored samples of weathering grade II to grade VI were used. For the purpose of obtaining an ideal frequency, a representative sample was undergone configuration test. Moulded gypsum in cylindrical form by suitable ratio of water and gypsum powder (650 ml of water + 1000g of powder) similar to cored sample of rock with dimension of 55 mm diameter and 100 mm length were used. Samples in several of length were also tested to determine the effect of geometric to resistivity. Electrical resistivity measurement were performed with two wires from four terminals were connected to the two current electrodes. By connecting the two ends of the cables to two current electrodes at the both ends of the sample, resistances reading were recorded. A field resistivity test was carried out to obtain the actual resistivity value. Samples at identified electrode location were tested in laboratory. Both results were validated. Result of the resistivity measurement on homogeneous rock sample (gypsum) at 500 kHz frequency shows that the variations in sample thickness (H:D) do not influence the resistivity value of the material at the moisture content of 55.96% in average. The standard deviation of 0.96 value suggested that the resistivity value clustered closely around the mean value produced a linear horizontal trend line to show the constant value which is at 3.39 ohm-m. By analysis it showed that the length of samples does not affect the resistivity value provided that the samples have same diameters. By validating field and laboratory results, the laboratory set up and procedures for resistivity measurement can be applied to any ground material. As conclusions the geometric effect does not influence the resistivity value. The laboratory set up and procedures are successfully established. Finally the resistivity index of tropically weathered material was produced.

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Groundwater & Soil Paper 3e6

The subsurface profiling comparison of Tawang and Pangkalan Chepa area, North Kelantan

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The study area is located in North Kelantan - Malaysia. The North Kelantan plain is covered with Quaternary sediments overlying granite bedrock. The drainage system is dendritic with the main river flowing into the South China Sea. Geoelectrical resistivity profiling surveys were conducted to determine the characteristics of the subsurface and the groundwater within the aquifer. The resistivity surveys made up of twelve resistivity traverses at five different sites. Each site has two or more line which is perpendicular and parallel to the beach line.

The subsurface profile in site 1, 2 and 3 which is perpendicular to the beach line shows a wavy pattern. The profile which is parallel to the beach line shows almost planar non wavy pattern. In site 4 and site 5, the profile shows an almost flat.

Groundwater & Soil Paper 3f1

Clay minerals in Maha Sarakham Evaporites, Northeastern Thailand

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Maha Sarakham Formation is mainly an evaporate-minerals deposit in Northeastern Thailand. It is forming in two basins; one basin, in the north of Khorat Plateau, is called Sakon Nakhon Basin whereas another south basin is Khorat Basin. The Maha Sarakham Formation is composed of many rock strata which mainly is three salt bed (Upper, Middle and Lower Salt). There are also two clastic layers (Middle and Lower Clastic) and one Potash Zone. Clay minerals in Middle Clastic, Middle Salt, Lower Clastic, Potash Zone, and Lower Salt, totally 13 samples in the Maha Sarakham-Evaporite Formation, are sampled and studied. The clay-size particles are separated from the water-soluble salt by water leaching. Then the samples are leached again in the EDTA solution and separated into clay-size particle by using the timing sedimentation. The EDTA-clay residues were divided and analyzed by using the XRD and XRF method. The XRD peaks show that the major-clay minerals are chlorite, illite, and mixed-layer corrensite including traces of rectorite? and paragonite?. The other clay-size particles are quartz and potassium feldspar. The XRF results indicate Mg-rich values and moderate Mg-Al atom ratio values in those clay minerals. The variable Fe, Na, and K contents in the clay-minerals can explain the environment of deposition comparing to the positions of the samples from the level. Hypothetically, mineralogy and the chemistry of the residual clay assemblages strongly indicate that severe alteration and Mg-enrichment of normal clay detritus occurred in the evaporite environment through brine-sediment interaction. The various Mg-enrichment varies along the various Members which it reflects the sedimentation which is near or far from the hypersaline brine flooding period.

Groundwater & Soil Paper 3f2

Hard rock aquifers in Peninsular Malaysia

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Groundwater resource is underutilised in Peninsular Malaysia. However, the utilisation of groundwater is on the increasing trend. Groundwater is being used in the remote area where public water supply is not available or in areas with low water supply pressure. Most development are in a small scale carried out by individuals or government departments such as the Minerals and Geoscience Department and Health Department of the Ministry of Health.

Peninsular Malaysia comprises of wide ranges of rock types and with geological processes dated as early as Cambrian. During the formation of the peninsular, 3 major orogenies took place within and between the Palaeozoic, Mesozoic, and Cainozoic. Three sets of major faults have been acknowledged in a regional scale. There are normal fault trending north–south direction, sinistral fault trending northwest–southeast and dextral fault trending north northeast–south southwest. These faults serve as major contribution factor for the formation of hard rock aquifers in the Peninsular Malaysia.

From the available data of wells drilled within 100m below the ground, the hard rock aquifers can be generally grouped into three types. Main aquifers in the hard rock are situated within the weathered overburden and fractured bedrock. Depths of these shallow aquifers are encountered in a range from 10-30m below the surface. Most wells abstracted groundwater from this aquifer. The deeper aquifers are normally from 40-50m and from 60-100m situated in the fractured fresh rock.

Well yields from hard rock aquifers are comparatively low compared to sand aquifers in the alluvium . Yields in wells in the granitic rocks ranging from 5.0-12.0 m^3/h. Maximum yield recorded is 40.0 m^3/h. Yields in wells explored in sandstone interbedded with mudstone, siltstone and shale rock ranging from 7.0-20.0 m^3/h. The highest yield recorded is 90.0 m^3/h. Yields discovered from the wells in limestone rock are quite good with an average of 30.0 m^3/h. The highest yield recorded is 100.0 m^3/h. Yields in wells recorded in phyllite and schist comparatively high in the hardrock with average of 20.0-40.0 m^3/h. Several wells recorded yields from 80.0-130.0 m^3/h. Well yields encountered in volcanic rock are low with an average of 6.0 m^3/h. The highest yield recorded up to 33.0 m^3/h.

Water quality is good and complying with WHO and Ministry of Health (MOH) drinking water standards except for slightly high Fe and Mn content. Colliform and *E-coli* were not presence when tested on groundwater directly pumped from the wells. It was introduced to groundwater when it flows into the storage facilities and piping system. Heavy metals are generally below the standard and only presence in very localised area.

Based on available information in JMG, groundwater resource from hardrock in Peninsular Malaysia can be utilised for purposes of domestic, agriculture or industrial. It can be developed in a small scale for localise usage especially in the remote area where cost of the piping system are expensive due to low well yield. Good groundwater quality should be utilised for domestic proposes since less treatment is required. However, indications are that groundwater in the hard rock aquifers could also be developed into much larger facilities for domestic or other purposes.

Groundwater & Soil Paper 3f3

Case study of an extreme rainfall event during 2006/2007 flashflood in the middle and southern part of Peninsular Malaysia: a climate change threat?

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East coast of Peninsula Malaysia has experience high rainfall especially during the northeast monsoon. During this season, some areas facing the South China Sea (SCS) often experience prolonged spells of rain, which may lead to severe flooding (Juneng, 2007). The occurrence of severe weather event in the vicinity of the SCS has been attributed mainly to cool air breaks from the Siberian high which later spread equator ward in the form of northeasterly cold surge winds around the eastern edge of low-level anticyclones over eastern Asia (Chang *et al.*, 2005). During mid-December 2006 to early January 2007 series of heavy storms were affected the middle and southern of Peninsula and bring worst case floods scenarios to the settlements in three states: Pahang, Melaka and Johor. These extreme precipitation events were mainly associated with north easterly wind over the South China Sea. A totals rainfall near the storm centre exceeded 700 mm and led to flashflood, loss of life and severe damage in these areas. The 2006/2007 flood was caused by three episodes of heavy precipitation events and the duration of each episode was only several days but the accumulated rainfall was several times higher than climatological monthly means (Fredolin *et* *al*., 2008), these extreme precipitation episodes were basically part of the deep cumulus and heavy precipitation system in the Maritime Continent during the boreal winter. He added that the 2006/2007 flood was occurred during the peak period of the 2006/2007 El Niño event or it was associated with climate change phenomenon. Climate change is expected to lead to more precipitation coupled with more evaporation whereas flooding is likely to become a larger problem in many regions. Climate change prediction based on General circulation model (GCMs) suggested that a 1.5-4.5°C rise in global mean temperature would increase global mean precipitation about 3-15% (Şen 2009). Previously, the December 2004 extreme event was reported by Juneng (2007) has caused the worst flooding along the east coast of Peninsular Malaysia whereas total rainfall exceeding the 100 years returns period.

Materials and Methods

The 2006 and 2007 daily and total rainfall data, Satellite Imageries during heavy storm that was induced the flashflood along the Pahang, Melaka and Johor states were provided from the official Website of the Malaysian Meteorological Department (MMD), Ministry of Science, Technology and Innovation (MOSTI). The 2006 and 2007 historical daily rainfall and rain-days data were obtained from MMD. Rainfalls data was recorded from 9 meteorological stations that are located all over the three states during first flood episode and 5 meteorological stations during second flood episode. These data were analysis and evaluate through the Microsoft Excel to identify the characteristics of rainfall and relationship between rainfalls and rain-days.

Data

Pahang, Melaka and Johor have experienced first heavy rainfall from Saturday, 16/12/06, and its continuous increase to Wednesday, 20/12/06. The first episode of flashflood was started with heaviest rainfall in Pahang followed by Johor and Melaka. The four highest daily rainfall among the 9 meteorological station are 1. Muazam Shah (21.6, 35.8, 173.8, 211.6 and 125 mm); 2. Senai (46.4, 94,6, 128, 236 and 40 mm); 3. Kluang (o, 53.2, 126.8, 266 and 18 mm) and 4. Kuantan Meterological Stations (28, 80, 84.2, 79.2 and 189 mm) (Figure 1). The accumulated rainfall during 16-20 December 2006 at 9 meteorological stations are (4 top meteorological stations): Muazam Shah (567.8mm); Senai (545 mm); Kluang (464mm) and Kuantan (460.4 mm) (Figure 2). A total of 5 meteorological stations was recorded total rainfall from 66.8 to 181.8 mm during second period of flashflood. A total heavy rainfall was recorded from Johor and Pahang from 11/01 (Thursday) to 14/01/07 (Sunday). The second episode flashflood was characterized by heavy rainfall and dominated by three meteorological stations at Johor (Mersing, Senai and Kluang). Distribution of daily rainfall is continuous decrease from beginning to the end (Figure 3). The total rainfall at these five meteorological stations was ranged from 224.4 to 602 mm (Figure 4). Station Mersing has recorded steady daily rainfall and it was considered the highest total rainfall among the others.

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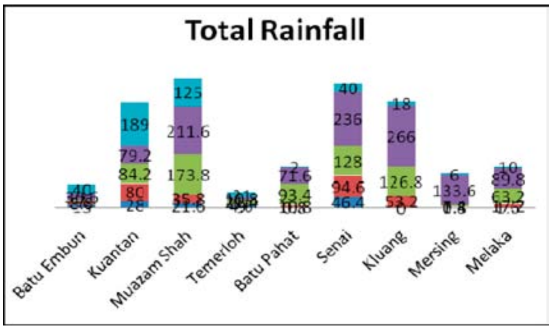

Figure 1: Total rainfall among the 9 meteorological stations at the three states during first flood period.

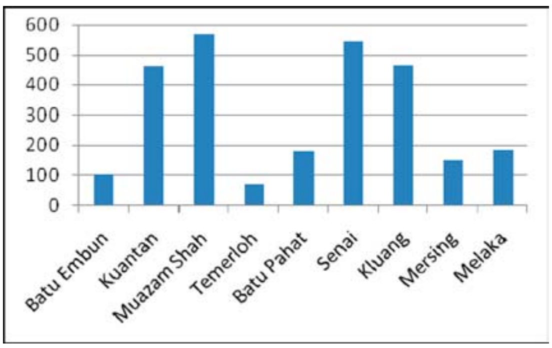

Figure 2: Total rainfall during 5 days heavy storm at 9 meteorological stations during first flood period.

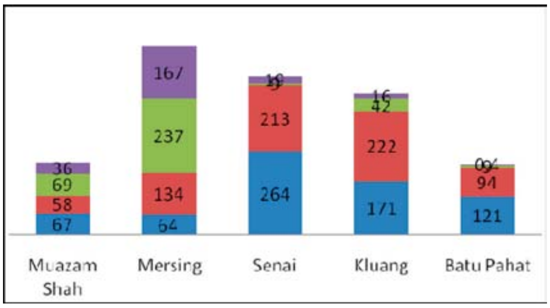

Figure 3: Total rainfall among the 5 meteorological stations at the two states during second flood period.

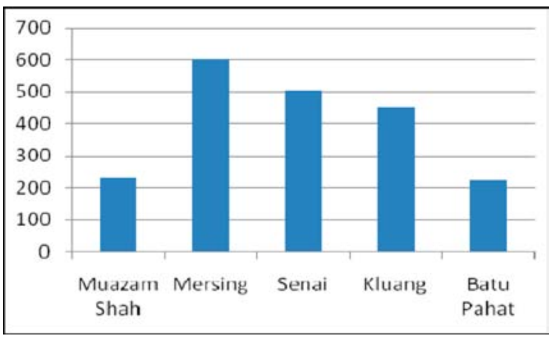

Figure 4: Total rainfall during 4 days heavy storm at 5 meteorological stations during second flood period.

Paper 3g1

Low pressure-temperature Fe-organic matter chelation in the Lambir Formation (Mid – Late Miocene): Impact on carbon-sequestration potentials

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The chelating effect that organic matter (OM) has on iron (Fe) in low pressure-temperature conditions in unconsolidated sediments is well established. Field observations in and around the Lambir Formation (Mid-Late Miocene) indicate that the present-day leaching of Fe and OM is extensive, especially in the coastal regions. The leaching begins on terrestrial parts and ends with leachate mixing with sea water. The lateral extend of the affected zone encompasses the near shore and a good portion of the shallow marine areas. Fe and OM mix together in certain areas only and under certain conditions. This concept is extended to explain the occurrence of chelated forms of Fe-OM complexes in these reservoir rocks. There is need to enhance our knowledge with respect to the influence of Fe-chelation on the possibility of designating reliable marker horizons as well as Carbon sequestration potentials of such rocks.

The Lambir Formation is made up of fine to medium grained sandstone, mudstone and occasionally siltstone. Microscopy studies reveal that the pore space and connectivity are reduced to various extends depending on the quantity of Fe and OM being present during these syn-depositional chelation phenomena. As pore volumes can range up to 20% of the entire rock, 100% saturation by chelated forms could sequester significant amounts of carbon. Mineral boundary alterations, etching or any type of mineral transformation has not been observed in the samples studied. However, Fe-OM coatings can be observed around subangular quartz grains. These coatings can form the nuclei for the formation of concretions. Field observations also indicate that only certain beds appear to have these chelated forms. This is an indication that this is a syn-depositional event that occurs during specific environmental conditions that favor high oxidizing potentials in micro-environmental settings. Storm-related sandstone units do not exhibit such features. Fourier transform infra-red studies of similar chelated forms in unconsolidated sediments indicate that the carboxyl and hydroxyl bonds are involved in this process.

It is concluded that the sandstones of the Lambir Formation with Fe-OM chelated forms, represent a break in the sedimentation cycle with concomitant changes in microenvironmental conditions that favored this chelation event. This provides a reliable basis to designate such beds as marker horizons for stratigraphic correlation purposes. It is further concluded that there is a clear indication that the sandstones of the Lambir Formation have a potential to function as a C-sequestration media.

Paper 3g2

Influence of unsaturated soil hydraulic parameters on nonequilibrium transport of Mn^{2+} under single and multiple metals through lateritic aquifer: A case study of gold mine in Thailand

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Contamination of shallow ground water around gold mining area is usually a great concern even prevention plan has been implemented. Therefore, this study applied a numerical model, so-called HYDRUS-1D, to simulate the transport of Mn^{2+} under single metal and multi-metal systems through unsaturated lateritic aquifer materials which may be used as an environmental monitoring tool for gold mining management. The model was assumed that tailing pond has been cracked and led to contaminations of Mn^{2+} and some elements to the shallow ground water. Soil water characteristic curves (SWCC), described unsaturated soil hydraulic properties of the lateritic soil, derived from previous worker were inputted as flow parameters for the simulations. Sorption parameters fitted by chemical non equilibrium two-site model obtained from the column studies were used as transport inputs for such simulations. Specific objectives of the study are: (1) to analyze the effect of the van Genuthen and neural network prediction soil hydraulic parameters on Mn^{2+} transport under unsaturated condition; (2) to simulate Mn^{2+} transport under single and multiple metal systems with two rainfall consecutive years (2004-2005). The results reveal that saturated hydraulic conductivity (K_s) is more influent on Mn concentration than other unsaturated hydraulic parameters. The simulations show that time to reach the Thailand drinking water standard at a specific depth or shallow groundwater level of Mn^{2+} in multi-metal system is faster than that in single metal system. Moreover, the transport of Mn^{2+} depends on water saturation of the lateritic soil. In addition, heavy metal leaching from tailings will be a main source of pollution for over hundreds to thousands of years. As indicated by the simulation results, the predicted impacts of contamination from the TSF to shallow groundwater quality in the lateritic aquifer indicate that unsaturated soil parameters and sorption parameters must be carefully determined and used in the simulation of heavy metal transport under unsaturated conditions.

Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia
8 – 10 June 2009 • Istana Hotel, Kuala Lumpur, Malaysia
GEOSEA 2009 Kuala Lumpur

Study of leachate migration around Sungai Sedu waste disposal site, Teluk Datok by geoelectrical imaging and geochemical analysis

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Monitoring of water contamination induced by municipal landfills usually includes leachate and water sampling from drilled well network, and chemical analysis of samples taken from and around the landfill disposal under investigation. Leachate is any contaminated liquid or wastewater, which is generated from water percolating through a solid waste disposal site, accumulating contaminants, and moving into subsurface areas. The study is close to Banting town and geologically is underlined by Holocene marine clay of Beruas formation and has been operational since 1989. The dumping area is underlined by Kenny Hill as the bedrock. The size of the open dumpsite is about 10 acres and has an average dumping of 31.3 tones mainly of domestic wastes weekly. The main aim of this study is to identify the leachate migration pattern and content of heavy metals in it around the site by geophysical and geochemical analysis. The geophysical technique used are geoelectrical resistivity imaging and the Vertical Resistivity Profiling (VRP) while for geochemical analysis, soils, surface water and leachate samples are collected for heavy metal identification, anion presence, conductivity and pH identification. Comparison standards used in determining heavy metals in soil was adapted from Kelly Indices Guidelines, Society of Chemical Industry, London. Electrical resistivity method (ERI) is applied because the high conductive nature of leachate compared to the much lower conductivity of the surrounding uncontaminated soil.

A total of 8 resistivity profiles, 33 soil samples, 3 surface water samples, 4 leachate samples and 6 VRP boreholes were acquired in this study. The soil samples were collected by hand auger at depth of 1.2m. The resistivity data were acquired by multi electrode system arranged following Schlumberger array and inversed to produce 2D resistivity sections models for interpretation. The electrode spacing applied in this leachate study is 2m and the total length of the profile is 80m which gives about 16m of depth coverage. Vertical Resistivity Profiling (VRP) was also conducted in the boreholes to determine the variation of vertical resistivity changes in the borehole. For the VRP survey, the probe used was 4 mini stainless steel 2.5mm diameter electrodes. The spacing of the electrodes is 2.5cm and the measurement depth interval was 5 cm.

A total of 8 lines of 2D-resistivity images were conducted. Three of the inversed resistivity 2D profile results section shown (Figure 1) are outside the site, on the waste pile and beside the site to the river bank respectively. Based on the lab research done by Bahaa-eldin (2005) and Vladimir Frid (2007), leachate saturated clay and leachate has a resistivity range of 1.5-2 Ωm and 0.9-5 Ωm respectively. The electrically conductive anomaly ranging from 4 to 5 Ωm on and around the waste disposal site is interpreted as clay saturated leachate plumes. The third resistivity profile is conducted close to the river bank, which showed very low resistivity ranging 1-2.5 Ωm is interpreted the resistivity of salt water saturated clay where a possibility of salt water intrusion nearby river. The second profile was conducted on the waste pile resulted in low resistivity ranging 3-5 Ωm, interpreted to be leachate mixed with the clayey soil. The leachate has migrated approximately to a depth around 3-4 m below the subsurface soil.The VRP results also show that the near surface of the river bank, resistivity decreases gradually away from the waste disposal site and also at the 1m groundwater level. This proves that leachate runoff has occurred towards occurred to the river.

The chemical analysis of soil sample, leachate and surface water of selected results are shown in Figure 2. The heavy metals level in river bank soil, leachate and surface water samples are found to be high in concentration above the background value. The conductivity levels were also high in the river bank soil and leachate samples. The high concentrations of heavy metals and conductivity value in the soil samples indicate the possibility of leachate migration from the dumping site into the surface water and the surrounding area.

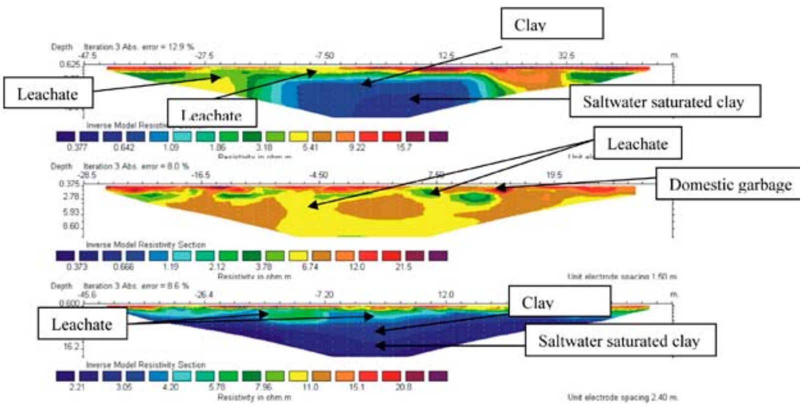

Figure 1: 2D inversed resistivity profile at the Sungai Sedu waste disposal site.

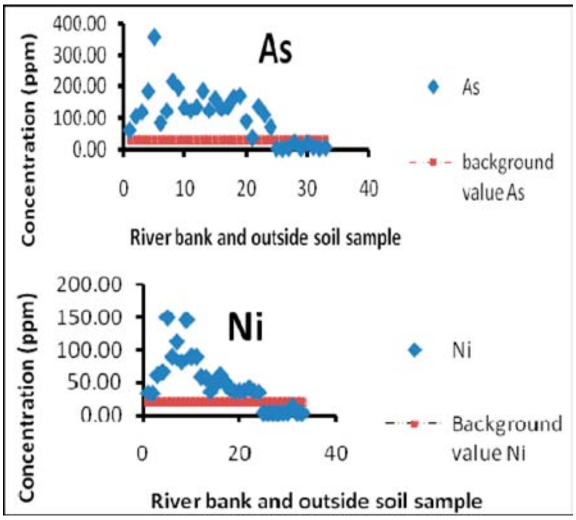

Figure 2: Arsenic and Nickel concentrations in some of the samples in the study area.

Poster 1

Geosciences, landslide risk management and postulated slope safety system for Malaysia

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Malaysia experienced rapid development during the last two decades. Many new townships, industrial areas and housing developments have sprung up in most part of the country. Infrastructure projects such as highways, expressways, light rail transit, etc also took place in line with such development. Development on hillsides is relatively uncontrolled. Many landslide events involved fatalities in the last two decades.

This paper attempts to reveal the interaction between geosciences and landslide risk management. The important of geoscientific knowledge shall be fully utilized in order to achieve optimum landslide risk management. Geoscientists must fully understand the risk management concept in order to develop landslide risk management hence to develop a more comprehensive Slope Safety System.

Geoscientific knowledge and approaches were used to give an account of significant landslide events in Malaysia, to document the existing measures on slope safety management being employed, to evaluate the responses after the disastrous landslide events. The historical archives of landslide events are very important to determine the pattern, trend, consequences and other relationships in order to understand the landslides and ways to prevent or mitigate their effect. It is also important to understand the development of steps or actions taken by government toward reducing the risk of landslide hazards. Based on risk management thinking, a postulated National Slope Safety System is outlined. In order to design a National Slope Safety System for Malaysia, a review on existing established Slope Safety System such as those in Hong Kong was made where the design of such system was based on risk management principle.

A process for handling risk to satisfy the needs of the parties involved, referred to as *'risk management'*, had become well-established in the hazardous industry (Royal Society, 1992) in Malone (1997). Malone (1997) also highlighted that in Hong Kong, the landslip problem was analysed using the risk management approach and such an analysis provided useful insights and pointers for further development of the Slope Safety System. Adopting a risk management approach requires the calculation of risk and the making decision on the level of risk including cost benefit analysis and non-financial cost.

Wong & Ho (2006) stated that *landslide risk* is a measure of the chance of occurrence of slope failure causing a certain amount of harm (e.g. fatalities and economic losses), and can be quantified as the product of the probability and consequence of failure. *Landslide risk assessment* is the process of identifying the landslide hazard and estimation of the risk of the hazard. *Landslide risk management* comprises and estimation of the landslide risk, deciding whether or not the risk is tolerable, exercising appropriate control measures to reduce the risk where the risk level cannot be tolerated. In more global context, landslide risk management also refers to the systematic application of management policies, procedures and practices to the tasks of identifying, analyzing, assessing, mitigating and monitoring landslide risk. Malone (2003) stated that the other common mistake is to forget that landslide threat consists of two components: *likelihood of occurrence* and *consequence of occurrence*. Many systems for ground characterization (or landslides ranking system) only consider landslide occurrence (or landslide "susceptibility"). Many of the so-called risk zonation system do not actually consider consequence in a useful manner. The way to zone landslide risk is to do a Quantified Risk Assessment (QRA) (Ho, et al, 2000).

The common misconception among engineers and scientists on Slope Safety System where they often consider the Slope Safety System is the same as landslide risk assessment or slope ranking system. Royal Society (1992) stated that some have argued that risk assessment and risk management are overlapping, but separate, tasks. The claim is that the former is predominantly scientific and concerned with the establishment scientific and concerned with the establishment of probabilities, whereas the latter is primarily legal, political and administrative. The distinction between 'scientific' assessment and 'political' management is contested by those who argue that it is impossible to disentangle social values and worldviews from the process of identifying, estimating and evaluating risks, and that, at least from a social view point, it is unhelpful to conceive risk as if it were a single uniform substance. In public policy, 'risk management' has been commonly used to refer to an analytic technique for quantifying the estimated risks of a course of action and evaluating those risks against likely benefits. The assumption behind this approach is that a risk-free society is impossible, that all risk reduction involves costs, and that explicit valuation of benefits and costs (including the value of human life) can help to produce decisions that are consistent over different areas of public policy and that balance overall risks against overall benefits. This approach to risk analysis is well-established and influential.

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Poster 2

Determination of efficient neural network learning paradigm to invert 3D electrical resistivity imaging data

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In this paper, we investigate the efficiency of different learning paradigms to train artificial neural networks in order to invert three-dimensional DC resistivity imaging data.

In the present study, we applied the most common learning law that is the back propagation, as a training law. The back-propagation includes several types of paradigms. There are the batch back propagation, gradient descent, conjugate gradient, Levenberg-Marquardt, and resilient propagation. In the these paradigms the weights are updated after each iteration. The main differences between these paradigms are the method of calculating the weights and their updating procedure. Both synthetic and real field had been used in the training and testing

The root mean square (RMS) error as a function of the number of iterations during the training of different ANN paradigms is shown in Fig. 1. According to the variation of the errors, we conclude that the resilient propagation paradigm was the most efficient for training the data set. The network was trained using 36288 synthetic data points and tested on another 24192 synthetic apparent resistivity data points as well as on real field data. The inversion results demonstrated that the trained network was able to invert 3D electrical resistivity imaging data rapidly and accurately. It should be noted that once the network has been trained, it can adequately perform inversion of any 3D electrical resistivity imaging and does not require further training.

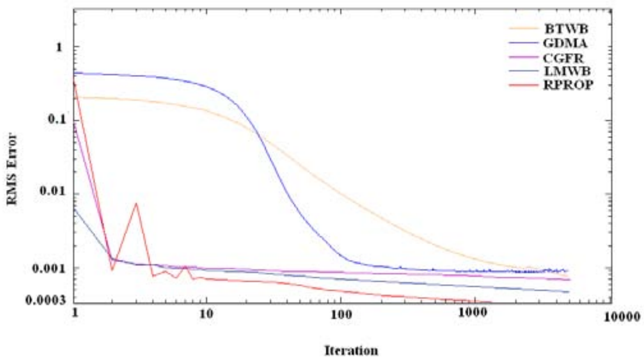

Figure 1: RMS errors as a function of iteration number for different ANN paradigms during the training stage. Batch training with weight and bias learning rules (BTWB); gradient descent with momentum and adaptive learning rate (GDMA); conjugate gradient with Fletcher reverse updates (CGFR); Levenberg-Marquardt with weight and bias learning rules (LMWB); resilient propagation (RPROP).

Poster 3

Sedimentation in an unstable sedimentary environment: A case study from Pahang

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A series of outcrops along the Jerantut- Maran road near kota Gelangi Jerantut reveals beautiful sedimentary structures associated with unstable sedimentary setting ranging from intertidal to shallow sloping subtidal. The rock sequence has been mapped as Kerum Formation of the late Triassic age. The lowest part of the sequence is marked by the occurrence of chaotic deposits comprises mudstone with various kind of clasts including sandstones and limestone. This facies was succeeded by a thick pile of conglomerate which clast and matrix were contributed by volcanic materials. The top part of the sequence consists mainly of sandstone interbedding with minor mudstone facies where a lot of beautiful sedimentary structures such as flame structure, sliding structure, rip up clasts, erosion structure, convolute bedding, ripple mark, soft sediment deformations and a lot other primary structures are found. All of these sedimentary structures indicate that deposition took place in very unstable and fast flowing current conditions in a deltaic shallow marine environment.

Poster 4

Remote sensing and GIS applications in soil classification of IBB Governorate in Republic of Yemen

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Remote sensing provides the basic data to undertake inventory of land, as well as the temporal information required to monitor sustainable land management practices. In this paper, the current use of remote sensing for sustainable land management is reviewed, and the soil resources inventory is conducted, where soil physical and chemical properties were investigated and soil map has been produced for the study area of IBB governorate, Republic of Yemen. This paper involves the mapping of soils and physiography of the study area. However the study will represents an important part of the data base for planning the development and management of available land resources at regional level.

Poster 5

Approach on assessing rippability of rocks

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Disputes often occur between project owners and contractors on selecting suitable method for excavating rocks on site. The root of the disagreement is usually related to the assessment procedures adopted in choosing particular method of excavation. With regard to rock types, sedimentary and metamorphic are among those commonly subjected to disputes. Being rocks of moderate strength, excavation by blasting would be costly and ineffective. In surface stripping, these rocks are usually excavated using ripper dozer. However, without proper procedures in assessing rippability of these rocks, their excavation is often exposed to elements of exploitation. This study is aimed at developing appropriate procedures for assessing rippability of rocks. Such approach is essential in construction work as disputes on excavation method can lead to lengthy industrial arbitration, project delay and costly variation order.

Quartzite, found at a construction site in Dengkil Selangor, is the rock type investigated in this study. Extensive laboratory and field tests were carried out to verify the rippability of this metamorphic rock. The relevant rock properties verified include compressive strength, point-load strength, rebound number and P-wave velocity. Using the rock properties and established graphical methods, quartzite is found to be rippable. For a more specific verification, lab ripping test was conducted on the rock samples. Test results indicate that specific energy (SE) required to rip a given volume of quartzite, under laboratory conditions, is between 3.8 and 5.8 MJ/m^3. To verify the rippability of the *in situ* rock mass, field assessments were undertaken at the study site, which include seismic refraction survey and field ripping test. The *in situ* P-wave velocity is found to be between 1900 and 2000 m/s, implying the *in situ* quartzite is rippable. This is also confirmed by field production rate (Q_r) of about 130 to 300 m^3/hr, obtained from actual excavation using D6 Caterpillar ripper dozer. Through various verifications of lab and field data, correlation between Q_r and SE is established, which quantifies numerically the degree of difficulty to rip this rock in the field, based on laboratory data. The assessment methods used in this study are applied in developing a more objective approach to assess rippability of quartzite and other comparable rocks.

Poster 6

Diorite granite association in southern part of Tioman island, Malaysia

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Plutonic and volcanic rocks in the Tioman island is part of the Eastern Belt rocks of peninsular Malaysia. The study, Kampung Mukut, south of Tioman island consists of both plutonic and volcanic igneous rocks. These main plutonic rocks in this area consists of 90% granitic (hornblende biotite granite & biotite leucogranite) and 10% dioritic. The granitic rock consists of K-feldspar, plagioclase, quartz, biotite, hornblende, sphene, apatite and zircon. Dioritic rock is dominated by plagioclase, quartz, K-feldspar (<5%), hornblende, biotite, apatite and sphene. The presence of hornblende and sphene in most of the rocks indicates that they are I- type. Geochemical data suggests that both granite and dioritic magmas are two different pulses.

Poster 7

Promoting a Safer Geoenvironment in Southeast Asia – Issues and Challenges

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Economic growth and increasing population has exposed Southeast Asia to a variety of geoenvironmental contamination that pose a health hazard. For example, high levels of mercury have been detected in sediment and fish population as a result of artisanal gold mining in Indonesia. High levels of mercury have also been detected in coastal communities in Cambodia and Malaysia and this has been attributed to industrial pollution. High concentrations of heavy metals such as Cd, Cu, Pb and Zn have been reported in sediment and biological samples from the Straits of Malacca, specifically in the coastlines of Peninsular Malaysia. This has been attributed to anthropogenic activities such as shipping, dredging and urban waste water discharge. Communities in Vietnam and Cambodia are exposed to As, Mn and Ba from contaminated groundwater. There is need to evaluate the potential health effects of all these exposures in the region. Research opportunities for promoting a safer geoenvironment are abundant in the region. Geoscientific factors play an important role on health. Unfortunately, there is a general lack of understanding of the importance of geoscience in such relationships. There is a need to increase awareness of this issue among geoscientists, medical specialists and the general public in Southeast Asia and stress the importance of geoscientific factors that affect the health of populations, crops and livestock.

Poster 8

Public survey analysis on community perspectives about landslide hazard and the implementation of guidelines for development in the developing country: a case study from the Kota Kinabalu area, Sabah, Malaysia

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This study analyzed the community perspectives about landslide hazards and implementation of guidelines for development in the Kota Kinabalu town area, Sabah. Questionnaires were distributed to Universiti Malaysia Sabah peoples and others government and private sectors agencies peoples. Statistical Analysis such as Descriptive analysis, Reliability analysis, Independent-Samples t-Tests and Analysis of Variance (ANOVA) were used to analyze the data. From this study, the results showed that there was mean difference for community perspectives between respondents from the government and private sectors or scientist and non-scientist. However, there were no significant mean differences between genders, living area and professions level for all respondent items. Inventory study indicated that the sensitive area for the development is highland, hill slopes and road cut slopes areas. However, the main of the causes is due to the attitude and decision makers who may be poorly advised by the respective authorities that may also lack of the skill and knowledge on the danger and consequences of approving such proposals or applications. Lack of enforcement, supervision, monitoring, non-awareness public and adequate knowledge by the respective officers or developers has raised the risk landslide disaster. A comprehensive and effective long term solution is needed to assist the local authority to avert or manage the landslide hazards and risk assessment.

Poster 9

The 2004 tsunami and palaeo-tsunami deposits in Malaysia – Preliminary observation from Kota Kuala Muda Kedah and Langkawi, Malaysia

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Study on the tsunami and palaeo-tsunami deposits in Malaysia is new and still at its infancy stage. Previously, it received very little attentions mainly due to lack of awareness on its importance, and the low preservation potential of the tsunami deposit. This study aimed to assist in efforts to understand better the nature of tsunamis in general, and to mitigate the impacts associated with future events. The main objective was to establish a "reference frame" for identifying tsunami and palaeo-tsunami deposits in the sedimentary record of Malaysia, which subsequently can also assist in the in developing tools for refinement of models of tsunami generation and propagation.

The December 26, 2004 Sumatra tsunami caused severe damage at the northern coast of Peninsular Malaysia. In Peninsular Malaysia, evidence of tsunami waves is preserved on the beaches in the form of characteristic debris accumulations. This paper presents results of a geological study of the sediments laid down by the tsunami and a probable palaeo-tsunami at the coast of Kota Kuala Muda and Langkawi Islands.

Field study was conducted in some selected areas inundated by the recent tsunami, i.e. Kg. (Kota Kuala Muda Kedah) and in Kuala Chenang, Kuala Teriang and Kuala Melaka of the Langkawi Island on 2 occasions. The first occasion was in early 2005, a few weeks after the tsunami and the second was in mid 2008. Methods of study involved surface observation and digging, augering and trenching near the coastline.

Just after the tsunami the inundated areas shows a progression from intense erosion near coast, to deposition of sediment inland. The inundated areas were blanketed with thin layers of gray to black mud. The deposit is thickest near the shore but thins away landwards. It ranges in thickness from 5 to 20 cm. The main trend in thickness is a tendency to thicken by filling low spots. Although the tsunami deposit contains primarily material indistinguishable from material found on the beach, it also contains grain and compositions unavailable on the current beach. The deposit also contains the unabraded shells of subtidal marine organisms, suggesting that at least part of the deposit came from offshore. Grain sizes within the deposit tend to fine upward and landward, although individual units within the deposit may appear massive, or show reverse grading. The deposits are poorly sorted from the inclusion of various clasts and blocks.

In Kota Kuala Muda Kedah, initial sedimentological studies indicate that the recent tsunami deposit is characterised by at least 2 distinct stratigraphic unit; a) coarse, shelly and sometimes sandy layer of c. 10-15cm thick, often with a sharp erosional basal boundary, generally accompanied by a change in colour, which in turn overlain by, b) fine, dark grey mud of c. 5-10cm thick which sometimes also contained marine shells. However, trenching into the underlying pre-tsunami sediments up to c. 2.0 m below the surface, failed to find any clear indicator for palaeotsunami deposit although lenses of sandy unit of c. 10 cm thick were found in one of the auger hole (Kg Masjid).

In Kuala Melaka, Langkawi near the mouth of Sg. Melaka, the recent tsunami deposit is a laminated sandy deposit with convoluted and rip-up clasts, overlain by post tsunami sandy beach deposit. The difference between the two is characterised by a) sharp erosional boundary between sedimentary units, generally accompanied by a change in colour and often associated with a change in lithology; and b) the tsunami deposit itself contains some classical sedimentary structures resembling rapid, high velocity uprush current. (e.g. chaotic, remobilised laminations, disturbed and agitated sediments). Trenching into the underlying pre-tsunami deposit revealed the occurrence of a unit of poorly sorted dark grey, silty and sandy mud which contains some wood fragments (pieces of boat?) and marine shells, at a depth of c. 2.3m below the surface. This distinct and abrupt change in sedimentary unit, compared to the underlying and overlying sandy beach deposit, might be taken to represent palaeotsunami deposit. The first ever reported from Malaysia.

It is noted that the deposits are distinct and different from one locality to another, showing the contribution of different sediment sources, each of which has its own composition and grain size. There was no one-to-one relationship between the number of waves observed and the number of fining upward sequences presumably because of the complex nature of tsunami deposition including partial or complete successive uprush and backwash wave erosion. In the recent tsunami deposits, the fining upward sequences were likely deposited during periods of waning wave flow whereas their underlying coarser sediment reflected periods of turbulent uprush or backwash deposition.

Poster 10

Geotectonic setting of the Tagaung Taung chromitite deposit, Thabeikkyin Township, Mandalay Division

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The Tagaung Taung chromitite deposit, Thabeikkyin Township, Mandalay Division, is located about 200 km north of Mandalay lying on the eastern bank of Ayeyawaddy River. The chromitite deposit is associated with Tagaung Taung ophiolite of the Eastern Ophiolite Belt (EOB) that extends from Tagaung at the South to Myitkyina to the north. The ophiolite is a dismembered, incomplete ophiolite body comprising serpentinized dunite to serpentinized harzburgite, cumulate peridotite and dolerite dykes. The Tagaung Taung ultramafics are partially or completely serpentinized. The orebodies form as podiform assemblages and subcordant to discordant with respect to their relation with the foliation and lineation of the enclosing rocks. The chemical composition of the Tagaung Taung chromitites are 45 to 62 wt. % Cr_2O_3; 12.89 to 28.87 wt. % Al_2O_3; 14.03 to 19.68 wt. % Fe_2O_3; 5.63 to 13.22 wt. % MgO; and the ratio of Cr/Al is from 1.1 to 3.9; the ratio of Cr/Fe from 2.5 to 4. The chromitites show low Ti content (0.224 to 0.227 wt. %), Cr/Cr+Al ratio of 0.6 to 0.85, and Mg/(Fe +Mg) ratio of 0.4 to 0.6. Plot of Cr-Al-Fe ternary diagram shows that the Tagaung Taung chromitites are podiform type and of the Alpine affinity. The relationship between Cr# and Mg# is noteworthy that the Tagaung Taung chromitites represent as High-Cr type. In TiO_2 vs Cr# diagram, the Tagaung Taung chromitites plot in the boninitic field. The geochemical data suggest that the Tagaung Taung rocks were formed in an island arc setting. The wt % triangular plot of MgO-CaO-Al_2O_3 show that the ultramafic rocks of Tagaung Taung closely approach the field of metamorphic ? peridotite. In the NiO vs Cr_2O_3 plot, the Tagaung Taung ultramafics plot within the field of the Alpine-type peridotite of mantle sequence. Ti remains stable over a wide range of conditions during sea floor alteration and regional metamorphism. The Tagaung Taung ultramafics belong to the low-Ti type which corresponds to boninitic rocks found in the arc setting. In the Ti/Cr vs Ni diagram, the Tagaung Taung ultramafics plots in the island arc tholeiite (IAT) field or Supra-Subduction Zone (SSZ) ophiolite. The Tagaung Taung ultramafics also plot within the depleted field, and high Ni and low Al content correspond to the SSZ ophiolite. The geochemistry of major elements suggests that the rocks of the Tagaung Taung were formed in a back-arc environment rather than that of a Mid-Ocean Ridge (MOR).

Poster 11

Elemental correlationship associated with gold mineralization in Selinsing Gold Mine, Pahang, Malaysia

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Gold mineralization in Selinsing Gold Mine occurs in quartz veins and in the wall rock shear zones. Literatures on gold mineralization of Selinsing are found in Richardson (1950); Lee *et al*. (1986); Chu *et al*.(1991); Gunn (1994), Pereira (1993) and Mohd Basril Iswadi Basori (2008). This work discusses the elemental association and its relationship to the gold mineralization in Selinsing Gold Mine based on geochemical analyses by AAS and ICP-AES on quartz samples taken from the veins and in the wall rocks adjacent to the shear and fault zones. Analytical elemental relationship is observed from plots of Au concentration versus concentrations of other associated elements. Correlation analysis is made using STATISTICA package version 5.0. Samples from quartz veins and wall rocks analyzed show the presence of Au with associated elements of Ag, Cu, Pb and Zn. Highest concentration values are obtained for AS with values ranging from 1.08 ppm to 588.00 ppm. Gold shows Au values ranging from 16.00 ppb to 1386.00 ppb. Ag shows the lowest concentration, below detection limit with the highest value being 0.091 ppm. For the vein quartz samples, high Au values are shown by samples in veins associated with faults and the NS and NE-SW shear zones. Quartz veins in other orientations show low Au values sometimes below detection limit. For the wall-rocks, meaningful Au values are shown in samples taken adjacent to the fault and shear zones trending NS and NE-SW. Based on the statistical correlationship of the elements, it is observed that Au has a direct positive and significance relationship with As while Ag, Pb, Zn and Cu, Au has negative or inverse relations with little significance (Figure 1a, 1b).

The relationship of elements shown is in line with the first phase of the crystallization of sulphides, gold and the gangue minerals in the quartz veins in Selinsing Gold Mine, and similar to the behaviour of mesothermal gold mineralizaations in other parts of the world, e.g. the Au mineralization associated with Ag, As, Sb, Te, W, Mo that are normally low in Cu, Pb dan Zn (Kerrich & Cassidy 1994). The result of this study shows there is a direct positive and significance correlationship between Au and As in Selinsing Gold Mine, i.e. high Au values is accompanied by relatively high As values. Cu, Pb and Zn display negative correlationship, inversely related to Au. Generally, inter-elemental corrrelations of elements associated with Au are in association with the phases of crystallization of sulphides, gold and gangue minerals in the quartz veins and the wall-rock alteration zones in the Selinsing Gold Mine.

	Au	Cu	Pb	Zn	As
Au	1				
	p= ---				
Cu	-0.21	1			
	p=.491	p= ---			
Pb	-0.2408	*0.8451*	1		
	p=.428	*p=.000*	p= ---		
Zn	-0.2255	*0.9923*	*0.8755*	1	
	p=.459	*p=.000*	*p=.000*	p= ---	
As	0.2665	0.2233	0.4898	0.2434	1
	p=.379	p=.463	p=.089	p=.423	p= ---

Figure 1a: Statistical correlationship of Au with Cu, Pb, Zn and As in samples taken from high gold quartz veins.

	Au	Cu	Pb	Zn	As
Au	1				
	p= ---				
Cu	-0.2585	1			
	p=.394	p= ---			
Pb	-0.3014	*0.9876*	1		
	p=.317	*p=.000*	p= ---		
Zn	-0.2528	*0.9848*	*0.9953*	1	
	p=.405	*p=.000*	*p=.000*	p= ---	
As	0.4494	0.2424	0.1586	0.1386	1
	p=.123	p=.425	p=.605	p=.652	p= ---

Figure 1b: Statistical correlationship of Au with Cu, Pb, Zn and As taken from wall-rocks containing gold.

Poster 12

Geochemical characterization of foraminifera limestone and radiolarian chert from Kudat, Sabah

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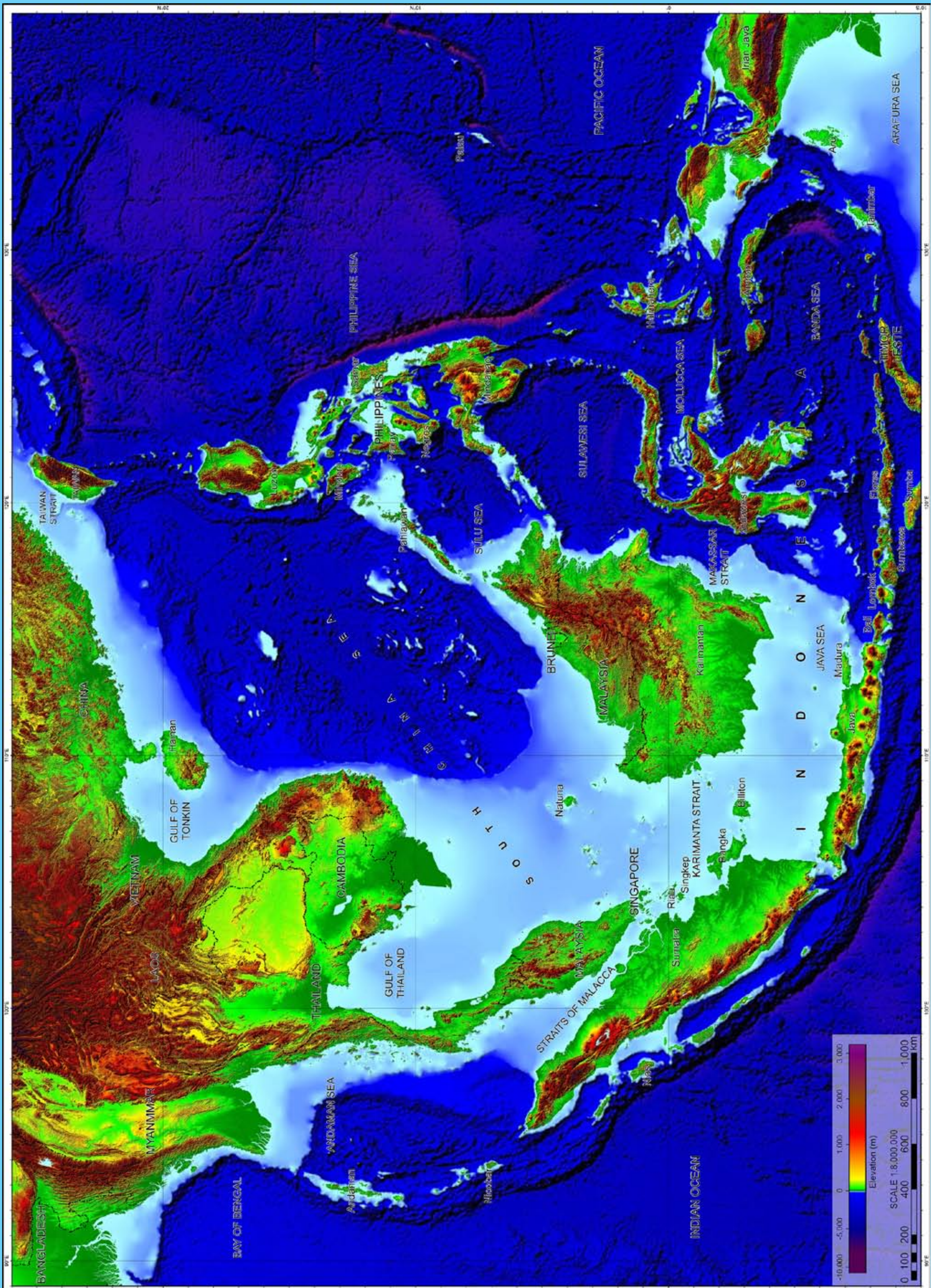
This paper discusses the result of geochemical analysis study on a selected limestone and chert from Kudat, Sabah. The limestone samples were collected from Suang Pai quarry where as the chert samples were collected from Bukit Pangaraban. The calcareous rock samples represented different lithology namely calcareous limestone (L1), sandy limestone (L2) and limestone inter-bedded with shale (L3). Chert samples consist of chert associated with basalt (C1) and chert inter-bedded with shale (C2). The major elements in each sample were measured using XRF techniques. The results of XRF analysis show that the limestone samples has higher concentration of CaO with a range from 35.95-85.00% followed by SiO_2 (10.32-44.05 %) and Al_2O_3 (11.70-13.50%). Other elements such as Fe_2O_3, TiO_2, MgO, Na_2O, K_2O, MnO and P_2O_5 are less than 5%. The chert samples show the highest element of SiO_2 (92.31-95.00%) where as the concentration of other elements less than 5%. The highest percentage of CaO in limestone is due to formation of foraminifers' calcareous shells that dominated 80% of the study area. The high percentage of SiO_2 in limestone represents the appearance of calcareous sandstone which is high abundance in quartz and other silicates mineral. The chert samples have higher percentages of SiO_2 due to the appearance of radiolarian.



Published by

LESTARI

Institute for Environment & Development (LESTARI)
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor, MALAYSIA

Geological Society of Malaysia
c/o Department of Geology, University of Malaya
50603 Kuala Lumpur, MALAYSIA

ISBN 978-983-99102-7-8

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