ABSTRACT BOOK

2017
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Welcome to Brunei Darussalam and to the 1st International Congress on Earth Sciences in SE Asia. It is our pleasure to meet all of you and we look forward to a session of exchanging ideas and keeping ourselves informed of the latest works in the field of Earth Sciences.

Our aspiration was to organise an international congress for Earth Scientists in Universiti Brunei Darussalam, as an effort to mitigate the lack of relevant big meetings in the region. We hope that all of you will enjoy the event and will have the opportunity to brainstorm and network with fellow Earth scientists.

Please enjoy our complimentary social events and we hope you will find some time to experience the beautiful sights of Bandar Seri Begawan.

We would like to extend our special thanks to the sponsors of ICES-2017 for their kind contribution, as well as to the volunteers of ICES-2017 for their invaluable assistance in organising the event.

We wish you a pleasant stay in Brunei Darussalam.

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Professor Robert Hall
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Professor Peter O. Baumgartner
Ir. Gijs C. J. Holstege

ABSTRACT BOOK AND PROGRAMME COVER PAGE DESIGN
Mutiah Yunsi

ABSTRACT BOOK AND PROGRAMME CONCEPT
Elena Ifandi
ABSTRACT BOOK EDITING AND DESIGN
Alkmini Tzoumaka
Elena Ifandi
Chun Kit Lai
Dk Khairunnisa Nazirah binti Pengiran Dr Karim
Nurul Amajida binti Hj Roslim

PROGRAMME EDITING AND DESIGN
Basilios Tsikouras
Elena Ifandi

WEBPAGE, ELECTRONIC FORMS AND EMAIL SETUP AND SUPPORT
Abdul Muiz bin Hamdan
Mohammad Afifi bin Haji Ishak

VOLUNTEERS’ T-SHIRT DESIGN
Wan Ahmad Syahrul bin Wan Mohamad
Mutiah Yunsi
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Robert Hall

Southeast Asia Research Group, Department of Earth Sciences, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK

Borneo tectonics: Subduction, collision, rotation, extension?

Borneo is the third largest island in the world but from a geological perspective possibly also one of the least well-known. It is not particularly elevated but its interior remains an under-explored challenge. Much of our thinking about Borneo retains notions from the period before plate tectonics onto which have been grafted concepts of geosynclines, suppositions about sutures and subduction zones from the early days of plate tectonics, mixed in with arguments about the significance of palaeomagnetic observations, overlain by assumptions about ages and events. From being seen as part of an ancient Sunda Shield Borneo now appears to be a composite and complex region assembled since the Triassic.

Haile (1973) identified many problems with subduction and collision models and the need for new dating, stratigraphic and structural studies. Some of these were undertaken, but in recent years research relevant to Borneo geology has been predominantly hydrocarbon exploration in the offshore areas around the island. These, and previous studies on land, highlight one of the many puzzles presented by the island – the immense volume of sediment derived from it, requiring tectonic explanations. Recent dating has challenged previous assumptions of basement ages, many of which are now seen to be misconceptions and emphasise the need for new studies on land. New sediment provenance studies show the value of integrating studies on land and offshore, and the importance of improved access to offshore information.

Supposed collisions and subduction on the north side of Borneo remain poorly supported by evidence, for example, there are almost no LT/HP metamorphic rocks, and little evidence of volcanic arcs. But during the Cenozoic there were three major deep marine ‘fans’: the Rajang Group, the Crocker Formation and the modern NW Sabah fold and thrust belt. What was their cause? While northern Borneo was active in the Paleogene, eastern Borneo was passively rifting. Significant magmatism in central Borneo in the Early Miocene, and the Pliocene, is difficult to relate to plate movements. Young uplift of northern Borneo is poorly understood. Neogene extension of the Sulu Sea demands some role for extension in northern Borneo. The use of terminology (spilite, flysch, molasse) and ideas (subduction, collision) from distant lands raises questions about what should be imported. Can Borneo fit a tectonic model derived from elsewhere?

Federica Zaccarini

Department of Applied Geosciences and Geophysics, University of Leoben, Peter Tunner Str. 5, A-8700 Leoben, Austria

Chromitites and associated platinum group elements and minerals in ophiolites: An overview

Several ophiolitic mantle tectonites worldwide host economic deposits of podiform cromitites. Based on the chromite composition, the podiform chromitites are classified as Cr- and Al-rich. The Cr-rich chromitites occur in the supra subduction zone ophiolite (SSZO), whereas the Al-rich chromitites can be found in both the SSZO as well as in the middle oceanic ridge ophiolite (MORO). According to literature data, the podiform chromitites show an enrichment in
platinum group elements (PGE), especially in the most refractory IPGE (Os, Ir and Ru),
compared to their host peridotites. Literature data indicate that the total amount of PGE is
higher in Cr-rich chromitites (about 390 ppb) compared to the Al-rich chromitites (about 150
ppb). Consistently with the geochemical signature, the podiform chromitites contain abundant
platinum group minerals PGM mainly sulfides, alloys and sulfarsenides in the Ru-Os-Ir system.
Most of the PGM form small grains, generally less than 10 microns in size, included in
chromite crystal. Therefore they crystallized in the magmatic stage at about 1300 to 1000 °C
degrees, prior or concomitantly with the host chromitite during the increasing of the sulfur
fugacity. Few podiform chromitites, representing only the 7% of all the studied chromitites,
contain also appreciable amounts of PPGE (Rh, Pt and Pd). This enrichment was achieved in
the magmatic system, due to the presence of sulfide-rich melt or the segregation of an
immiscible sulfide liquid, that collected mainly the PPG.
After, PGE sulfides, antimonides, arsenides and PGE-rich pentlandite crystallized and most of
them occur in the silicate matrix, interstitial to the chromite grains.
The primary PGM can be modified after their magmatic precipitation, during serpentinization
and weathering at low temperature. In particular, the magmatic PGE sulfides can be altered in
situ by progressive loss of S and addition of base metals and oxygen, leading to the formation
of PGE alloys or oxides. This process generated also secondary sulfides as well as PGE and Ni-
Fe alloys that sometimes contain tiny blebs of PGE-rich phases that precipitated as low
temperature ex-solution products. The alteration of PGM, generally, caused only re-distribution
of PGE on a small scale. Despite of their relatively PGE enrichment and the presence of
abundant PGM, the podiform chromitites represent only a future target for the recovery of
these metals. The most relevant problems arise from poor recovery of precious metals due to
the minute grain size of their host phases (generally less than 10 μm) as well as from the small
size of the chromitite bodies enriched in the most valuable PPGE.

Giorgio Garuti

Department of Resource Mineralogy, Peter Tunner Str. 5, Montan Universität, A-8700, Leoben,
Austria

Petrogenetic evolution of Ural-Alaskan type mafic ultramafic complexes

The Ural-Alaskan type complexes are a special category of ultramafic-mafic intrusive igneous
rocks which have attracted the attention of modern geologists because they host economic
deposits of platinum, and represent a puzzling geological feature due to their distinctive zoned
structure, peculiar petrologic affinity and uncertain tectonic setting. The erosion of the
ultramafic members (dunite, chromitite) in these complexes have generated a sequence placer
deposits in which platinum nuggets could concentrate mechanically together with other
precious metals (PGE, gold, silver). Noteworthy is the historical event that platinum was first
encountered in placer deposits downstream the Chocò complex (Alto Condoto, Colombia) in
1557, and was chemically characterized by Julius Scaliger, in 1753 (Italy). For more than one
century, before the discovery of the giant platiniferous reefs of South Africa (1927), the great
bulk of the world Platinum production was supplied by placer deposits in the Urals, Colombia,
Alaska, and Canada.
The Ural-Alaskan type complexes consist of kilometers-scale pipe-like bodies or more
extended stratiform lopoliths associated with ancient orogenic belts or deep continental crust
of the five continents. Most complexes are relatively younger in comparison with their host
terranes, spanning Palæozoic (Urals, Asian Far East, East Sayan, Eastern Australia, Africa),
Mesozoic (Alaska, Canada), and Tertiary times (Colombia). Global tectonics indicate
preferential location at modern and ancient convergent plates and subduction-influenced settings, e.g. along the Kamchatka – Aleutian Islands – Alaska – Rocky Mountains – Andean orogenic systems, and the Silurian Island-Arc belts of the Urals and SE-Australia. This observation coupled with geochemical evidence led to conclusion that these complexes were products of syn-collisional igneous activity at the root of island-arc mobile belts, possibly representing the feeder pipes of andesitic volcanoes. Consistently, their ultramafic-mafic assemblages resemble cumulates from hydrous, high-Mg basaltic magmas having andesitic lavas as the complementary liquid fraction. According to other interpretations, the Ural-Alaskan type complexes would be the intrusive correspondents of ankaramitic lavas. Petrographic assemblages indicate successive crystallization of dunite-chromitite, wehrlite-clinopyroxene-magnetite, gabbros with magnetite-ilmenite, and magnetite-rich hornblende, sometimes along with sialic differentiates, granodiorite, syenite. All rocks contain primary amphibole and phlogopite. Bulk-rock and clinopyroxene have high CaO/Al₂O₃ ratio and show negative REE patterns, being enriched in light and middle REE. K-feldspar and nepheline may appear in gabbros, consistent with an alkaline affinity. Dunite typically lacks primary orthopyroxene that locally occurs as reaction rims. Chromitites are characterized by Al₂O₃ < 20wt%, and progressive increase of TiO₂ (0.35-3.5 wt%), Fe²⁺# and Fe³⁺ substitution for Cr, with increasing differentiation. Chromitite initially forms by mixing of new magma with evolved residual liquid after the onset of dunite crystallization (~1200°C): “syngenetic chromitite”. Chromitite formation is protracted down to lower temperatures by infiltration-reaction of most evolved hydrous fluids with solid dunite (~900-700°C). This process generates “epigenetic chromitite” consisting of chromitite-dunite breccias or chromitite-amphibole-clinopyroxenite veins, in which chromite has the highest Fe²⁺#, TiO₂ and Fe³⁺# contents, in front the lowest Cr₂O₃ and Al₂O₃. All rocks, display slightly positive chondrite-normalized PGE patterns, i.e. (Pt+Pd+Rh)/(Os+Ir+Ru) > 1, and show positive Pt anomaly decreasing from dunite to wehrlite, clinopyroxenite and gabbro. Chromitites can be extremely rich in PGE, typically showing “M” shaped PGE patterns, characterized by marked positive peaks in Ir and Pt. Accordingly, PGM mineralogy consist mainly of Pt-Fe and Ir-Os alloys accompanied by accessory Pt-Rh-Ir thiospinels, Ru-Os sulfides, and minor Pd-minerals. The PGM mostly occur as microscopic inclusions in fresh chrome, although spectacular deposition of Pt-Fe alloys forming, massive aggregates of some kilogram in weight is observed in epigenetic chromitite-dunite breccia, while late chromitite-amphibole-clinopyroxenite veins contain abundant potarite (PdHg). The persistent Pt-Ir anomalies in chromitite and dunite may represent a distinctive signature of Ural-Alaskan type magmas, possibly inherited from their mantle source. This is explained by the evidence that asthenospheric melts display significant negative anomalies of Ir and Pt, suggesting that these metals were retained in the mantle source, by accumulation of refractory alloys during partial melting. Second-stage melting of such a mantle source, under the action of metasomatic fluids, may be at the origin of Pt-Ir rich Ural-Alaskan type magmas. The root of Island arcs is the most obvious locus for fluid-driven metasomatism and repeated partial melting of the mantle residing above subducted crustal slabs. However, zoned intrusions of the East Sayan and Russian Far East were emplaced in sub-continental settings, locally associated with alkaline magmatism, thus suggesting that generation of melts with Ural-Alaskan type distinctive signature may be not an exclusive feature of Islands-arc systems. Evidence acquired so far is not conclusive, and several important questions concerning global tectonics and origin of platinum mineralization in the Ural-Alaskan type complexes still remain open.
Panthalassa and Neotethys - two giant oceans facing the break-up of Pangea - Mesozoic ocean history and circulation

Peter O. Baumgartner¹, Rie S. Hori², Maximilian Bole¹

The two largest Mesozoic oceans have almost totally disappeared from the Earth's surface, with the exception of the Eastern Mediterranean Neotethys remnant. Relics of these giant oceans are preserved in accreted Circum-Pacific terranes and in suture zones of Alpine-Himalayan mountain chains. These oceanic terranes contain ophiolites, i.e. remnants of oceanic basement, plateaus and ancient arcs, as well as radiolarites and other radiolarian-rich siliceous deposits, which are the dominant sediments produced in the world oceans over much of the Phanerozoic (Ordovician to Early Cretaceous, Baumgartner 2013, Hori et al. 1993). Mesozoic radiolarian biochronology, developed over the last 30 years (Baumgartner et al. 1995) has largely contributed to the understanding of the relics of Panthalassa and Neotethys. The break-up of the supercontinent Pangea began during the early Mesozoic with the opening of Neotethys (Fig. 1) within Gondwana, probably as a consequence of back-arc spreading related to the subduction of Paleotethys (Stampfli et al. 2003) Hence, Gondwanian terranes merged Eurasia, leaving of Paleotethys nothing but a suture. During the Late Triassic and Jurassic, Gondwana separated from Eurasia by the progression of Neotethyan ocean basins from east to west. N-America and Eurasia separated from Africa by the formation of the Central Atlantic and the Alpine Tethys since the Early Middle Jurassic. While radiolarite sedimentation continued in Neotethyan basins, this sediment never formed neither in the early Central Atlantic, nor in the Late Jurassic - early Cretaceous Proto-Caribbean. Here, Middle Jurassic clay-rich sediments gave way to the first planktonic carbonates since the Late Jurassic. These "Intra-Pangean" nannofossil carbonates were dominated by Nannoconus during the latest Jurassic and Early Cretaceous (Busson & Noël 1991). This nannofossil group was virtually absent from E-Tethys and Panthalassa. During the Late Cretaceous, planktonic carbonates became widespread and radiolarite deposition became episodic, mostly restricted to times of oceanic anoxic events. The main paleo-oceanographic interpretation of this sedimentation pattern is the late onset of a circum-global equatorial current system. In our opinion, it was only effective during the middle-late Cretaceous, when high eustatic sea level and the emplacement of the Caribbean Large Igneous Province between the Americas created a large marine passage. Mesozoic and, in particular, Jurassic radiolarites in Western Tethys have often been interpreted as the result of equatorial upwelling, due to an equatorial current system flowing through the Tethys-Atlantic-Proto-Caribbean Seaway. We have modeled Middle-Late Jurassic global current systems with a global coupled ocean - atmosphere model (Brunetti et al. 2015). We could not detect any major westward flow of water in the trans-Pangean seaway, both with open and closed variants of the Central American gateway. The young Central Atlantic had a lagoonal circulation with a stratified water column implying low surface fertility during the Jurassic and earliest Cretaceous. Upwelling alone cannot explain Mesozoic radiolarite occurrences throughout circum-Pacific terranes now exposed in Japan, Western North and Central America and New Zealand. Si and O stable isotope (Bôle et al. herein) data seem to indicate that the Mesozoic world oceans were less under-saturated in silicic acid than the modern oceans, resulting in better preservation of radiolarians and not necessarily in a higher productivity. This is especially true for the Jurassic and can be explained by more warm/humid continental climates brought about by the Pangea break-up, resulting in increased...
continental weathering, producing a higher input of silicic acid to the ocean. During the Late Cretaceous, planktonic foraminifera began to compete with radiolarians for food, and diatoms were more efficient in extracting silica from sea water, resulting in a quantitative decline of radiolarites.

Figure 1. a. Middle Jurassic (Bathonian) world distribution of radiolarian faunal realms and radiolarian-rich sediments with the hypothetical location of key sections. b. Key sections of Mesozoic oceanic basins with basement and sediment lithologies.
CONTENTS

➢ Session 01: Petroleum Geology  

➢ Session 02: Petroleum Geophysics and Modelling  

➢ Session 03: Geodynamics and Geohazards  

➢ Session 04: Solid Geophysics  

➢ Session 06: Palaeontology and Stratigraphy in SE Asia  

➢ Session 07: Biomineralisation  

➢ Session 08: Palaeo-, Rock and Environmental Magnetism  

➢ Session 09: Hydrogeology, Hydrology and Water Resources  

➢ Session 10: Continental vs. Oceanic Lithosphere: Processes and Evolution  

➢ Session 14: Mineral Resources  

➢ Session 15: Carbon Sequestration  

➢ Session 17: Structural Geology and Tectonics  

➢ Session 18: Earth Sciences in Service of the Environment  

➢ Session 19: Remote Sensing and Geographic Information Systems in Earth Sciences  

➢ Session 20: Artificial Materials and Technology  

➢ Session 21: General Session
Session 01: Petroleum Geology
Chairpersons: Mohamed Ragab Shalaby, Md Aminul Islam, Lisa Thieme & Oliver Swientek

ORAL PRESENTATIONS

Wednesday 15 November 2017

Reservoir characterisation (porosity and permeability) of the Sandakan Formation, Sandakan Sabah, east Malaysia

Yun Yin Chuah1, Muhammad Azfar Bin Mohamed1

1Universiti Teknologi PETRONAS, Petroleum Engineering Department. Bandar Seri Iskandar, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia

Shallow marine sandstone has been well known as porous and permeable rocks to store the hydrocarbon such as oil and gas. A comprehensive detailed reservoir characterisation has to be well understood first before starting hydrocarbon production to reduce the error in hydrocarbon commerciality. However, to date, reservoir characteristics of the Sandakan Formation has not been extensively studied. Hence, a detailed study including sedimentology, petrography and petrophysics were conducted on the outcrop in Sandakan Formation to interpret the sedimentary facies and to analyse the petrographic of sandstones rock of the Sandakan Formation. All these information is used to evaluate the petrophysical characterisation of the Sandakan Formation which emphasised on porosity and permeability. Based on sedimentary logging of the Sandakan Formation, four sedimentary facies have been identified, which are: F1- massive sandstones, F2- Amalgamated Hummocky Cross-Stratification (HCS) sandstones, F3- Shale and F4- interbedded sandstone and shale layers. The textures of the Sandakan Formation are fine to very fine grained sandstones. The finer the grain sizes, the lower the porosity and permeability of the formation since it does not have sufficient pore spaces for fluid to flow through. The petrographic analysis through thin section and Scanning Electron Microscope (SEM) showed that quartz is the most abundant minerals exist in the Sandakan Formation rocks. Besides, silica and iron oxides (cementing materials) and authigenic clay minerals such as kaolinite were found in this formation as well. These authigenic clay minerals are the in-situ minerals contained in the rocks which will swell when in contact with water, thus will block the pore spaces of the rocks. For petrophysical, the porosity of the Sandakan Formation is determined as moderate porosity which range from 13 % to 20 % and high permeability values from 10 mD until 100 mD due to the texture of the sandstones, diageneric processes and role of cementation.

Diagenesis effect and reservoir quality evolution of Shahejie Formation (Es1 Member) in Nanpu Sag, Bohai Bay Basin, east China

Muhammad Kashif1, Yingchang Cao1, Guanghui Yuan1

1China University of Petroleum, East China

Reservoir quality is one of the key controls on prospectivity during petroleum exploration. The Shahejie Formation (Es1 Member) of Nanpu Sag, Bohai Bay Basin is a typical deeply buried high quality sandstone reservoir in China. Main study emphasizes on petrographic study including SEM, CL, XRD, Fluorescence and electron probing analysis as well as quantitative determination of reservoir characteristics. The sandstone of the study area consists of medium to coarse grain, moderate to well-sorted lithic arkose and feldspathic litharenite. They are dominated by quartz, feldspar and volcanic rock
fragments with good reservoir properties. The porosity ranges from 0.4-30% and permeability 0.005mD to 7000mD. The formation has undergone complex digenetic episode due to upic and deep burial. Diagenetic modification were dependent on grains composition, tectonic style and burial depth. Main diagenetic events are identified by compaction, quartz cement, clay minerals, and precipitation of calcite minerals, iron oxide, alteration and dissolution of unstable minerals like feldspar, volcanic lithic fragments and tectonically fractured grains. Porosity decreased by compaction, cementation and precipitation of calcite, and increased by leaching of metastable grain and dissolution of cements. Porosity and permeability data predicts good inverse relationship with cement. Quartz, calcite and clay are more dominant pore occluding cement and generally occur as euhedral to subhedral crystals. Alteration and dissolution of volcanic lithic fragments and feldspar as well as pressure solution were the main sources of quartz cement. Leaching of clay/calcite reduced porosity in the marginal section than the central part. Mostly feldspar grains and lithic volcanic fragments altered to chlorite and kaolinite. Mixed layer illite/smectite and illite reduced the porosity and permeability. Chlorite occurs as pore lining and pore filling cement. It preserved the porosity and permeability at places due to its oil wet nature which helped to inhibit quartz overgrowth and carbonate cement. Similarly authigenic and mechanical cements like calcite, iron oxide reduced the primary porosity whereas the dissolution of feldspar, calcite grains and cement produced secondary porosity. Reservoir quality is mainly controlled by texture, pore ocluding cement, dissolution of unstable minerals and depositional environment. The reservoir partially resumed its pre cementation quality after development of secondary porosity.

Application of well log analysis to evaluate the petrophysical parameters of the Lower Goru Formation, Lower Indus Basin, Pakistan

S.M. Talha Qadri1,2, Md Aminul Islam1, M.R. Shalaby1

1 Department of Geological Science, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Negara Brunei Darussalam
2Department of Earth Sciences, University of Sargodha, Sargodha-Pakistan

The present study deals with the petrophysical evaluation using well log data of Lower Goru Formation from four selected wells namely Nara-1, Kadanwari-3, Kadanwari-4 and Gajwaro-1. The study area is located in the Lower Indus Basin of Pakistan that has proven hydrocarbon potential. Various cross plots were used (i.e. Neutron vs. Density; Sonic versus Neutron and Sonic versus density) to understand the lithological and mineralogical composition of the Lower Goru Formation. These cross plots indicate that the formation of interest is mainly composed of sandstone, shale and carbonates. In addition, clay content is also analysed using potassium versus thorium and PEF versus Th/K ratio plots. These plots indicate that mica is the dominant clay type along with considerable amount of illite and chlorite. Interactive Petrophysics (IP-2013) software were used to assess the petrophysical parameters such as the shale volume ($V_{sh}$), total porosity ($PHIT$), effective porosity ($PHIE$), gross thickness of the reservoir, net pay, net to gross (N/G), water saturation ($S_w$) and hydrocarbon saturation ($S_h$). The volume of shale was estimated between 8.03-14.07% from the studied wells. Similarly the total porosity is observed between 14.6 - 18.02% while the effective porosity ranges between 12.5 - 16.5%. The cross plot between sonic porosity and neutron-density porosity indicate the presence of intergranular porosity within the reservoir. The water saturation is quite low and ranges between 14.05-31.58%. Moreover the hydrocarbon
satisfaction ranges between 89.95 - 68.42% in the studied wells. Nara-1 well having 2 pay zones representing as the most prolific in terms of hydrocarbon saturation which is about 85%. Similarly Kadanwari-3 has 6 pay zones and Kadanwari-4 has 3 pay zones with an average hydrocarbon saturation of 73.2% and 68.4% respectively. The presence of number of pay zones with higher porosity and saturation indicates that Lower Goru Formation is characterized by its higher hydrocarbon potential within the Lower Indus Basin.

**Petrophysical and petrographical analysis of Middle to Late Eocene Mangahewa Formation in Taranaki Basin, New Zealand**

Nurzafirah Hj Zainin¹, Mohamed Ragab Shalaby¹, Md Aminul Islam¹

¹Department of Geology, Faculty of Science, Universiti Brunei Darussalam, Brunei Darussalam

Taranaki Basin, which lies along the western side of the North Island of New Zealand is one of the country’s largest sedimentary basins. It covers an area of about 330,000 km² and is currently the only producing basin in New Zealand. This paper mainly emphasised the results of a study to determine the hydrocarbon potentiality by evaluating the petrophysical and petrographical characters of the reservoir from middle to late Eocene Mangahewa Formation in Taranaki Basin. Mangahewa formation is the lowermost formation of the upper part of Kapuni Group, occurs widely across the basin and is one of the primary exploration targets in the basin. It has lithology consists of a thick sequence of interbedded sandstone, siltstone, carbonaceous mudstone and coal. The petrophysical properties from wireline logs that are computed using Interactive Petrophysics (IP), a PC-based software program for reservoir log property analysis. They include log data loading and editing, calculation of properties include volume of clay, porosity, fluid saturation and net-to-gross values. A total of 16 thin section photomicrographs were analyzed in focusing more detailed description of the rocks. Computed petrophysical parameters on six wells have shown that they have average porosity of 11.6 % with the highest porosity recorded was on Okoki-1 with 26.2%, average hydrocarbon saturation of 69.8% with the highest hydrocarbon saturation evaluated on Pohokura South 1B with 96.6%, average net to gross value of 27% and average volume of clay of 17.9% with the highest recorded value were 82% of McKee 16A and 26.2% of Okoki-1 for net to gross value and volume of clay respectively. From the thin section photomicrographs observed, the combination of quartz and carbonate cementation, compaction and grain contact dissolution are the main diagenetic processes which alters and influence the porosity of Mangahewa formation. Despite these porosity-reducing features, they do not have a major influence and hence, do not affect overall reservoir quality.

**Petrological characteristic and controls oil enrichment of in Lucaogou Formation tight reservoir, China**

Guoheng Liu¹, Zhilong Huang¹

¹China University of Petroleum (Beijing), College of Geoscience

Lithologic identification and classification of reservoirs are the base and keys to oil and gas exploration. Lithology and lithofacies obviously control the distribution of oil and gas in lithological reservoirs, so it is of great significance to describe characteristics of lithology and lithofacies of reservoirs finely. Lithofacies is an intrinsic property of rock formed under certain conditions of sedimentation. Fine-grained sedimentary rocks such as shale formed under different sedimentary conditions display great particularity and distinctiveness. Hence, no constant and
unified criteria and methods exist for fine-grained sedimentary rocks regarding lithofacies definition and classification. Consequently, multi-parameters and multi-disciplines are necessary. A series of qualitative descriptions and quantitative analysis were used to figure out the lithofacies characteristics and its effect on oil accumulation of Lucaogou formation fine-grained sedimentary rocks in Santanghu basin. The qualitative description includes core description, petrographic thin section observation, fluorescent thin-section observation, cathode luminescence observation and scanning electron microscope observation. The quantitative analyses include X-ray diffraction, total organic content analysis, ROCK-EVAL.II Methodology, soxhlet extraction, porosity and permeability analysis and oil saturation analysis. Three types of lithofacies were mainly well-developed in this study area, which is organic-rich massive shale lithofacies, organic-rich laminated and cloddy hybrid sedimentary lithofacies and organic-lean massive carbonate lithofacies. Organic-rich massive shale lithofacies mainly include massive shale and tuffaceous shale, of which quartz and clay minerals are the major component. Organic-rich laminated and cloddy hybrid sedimentary lithofacies contain lamina and cloddy structure. Rocks from this lithofacies chiefly consist of dolomite and quartz. Organic-lean massive carbonate lithofacies mainly contains massive bedding fine-grained carbonate rocks, of which fine-grained dolomite accounts for the main part. Organic-rich massive shale lithofacies contain the highest content of free hydrocarbon and solid organic matter. Moreover, more pores were developed in organic-rich massive shale lithofacies. Organic-lean massive carbonate lithofacies contain the lowest content solid organic matter and develops the least amount of pores. Organic-rich laminated and cloddy hybrid sedimentary lithofacies develop the largest number of cracks and fractures. To sum up, organic-rich massive shale lithofacies is the most favourable type of lithofacies. Organic-lean massive carbonate lithofacies is impossible for large scale oil accumulation.

Diffraction enhancement through pre-image processing: Applications in field data Sarawak Basin

Yasir Bashir¹, Deva Prasad Ghosh¹, Hammad Tariq Janjuah¹, Chow Weng Sum¹

¹Universiti Teknologi PETRONAS, Center for Seismic Imaging (CSI), Department of Geoscience, Bandar Seri Iskandar, 32610, Perak, Malaysia

The future research direction of the industry is to find the small scale reservoir for possibly economic hydrocarbon reserves. These includes the super-resolution of full seismic data including fractured zones, pinch-outs, channel edges, small scale faults, reflector unconformities, salt flanks, karst, caves and fluid fronts or in general these events are called small scattering objects. A new approach which is come in to the industry called Diffraction imaging. This is a new technology for high-resolution imaging specifically designed to image and identify the small scale fracture in shale and carbonate reservoirs that form of increased natural fracture density. Numerical modelling of offset recorded wave propagation suggest that fractures may resemble diffractions. This diffraction data can be enhanced by removing the primary and multiple from reflection seismic data. In this paper, Malaysian basin data is used for enhancement of the diffraction with pre-image processing and an angle stack of the data at near, mid and far (4.5 degree, 22.5 degree and 31.5 degree) is performed for study the amplitude and phase change of diffraction hyperbola. As the amplitude of the diffraction wave achieves its maximum value at the detector positioned vertically above the end point of the reflector, and it drop with offset increasing offset-distance
from this point. The rate of the attenuation of a diffracted wave with offset is greater than that of the normal reflection wave in the same medium. Further, the effect of offset gather on diffraction is enlightened. Angle stacking is used for amplitude versus offset (AVO) in the industry for direct hydrocarbon indicator (DHI) but here these angle stacks are used for the diffraction studies. It is observed in the study that far offset data is gives the better diffraction preservation and far angle stacking provides the poor preservation of diffraction amplitudes. At the last stage the separation of diffraction data is performed that would be the input of the diffraction migration.

Formation microscanner providing better answer for carbonate secondary porosity in Alamein Dolomite Formation, NW desert, Egypt

Mohamed R Shalaby¹, Nurhazwana Jumat¹, Md Aminul Islam¹

¹Universiti Brunei Darussalam

The use of borehole imaging tools has become widespread in recent years with more specialized studies of reservoir properties, particularly in highly-porous and fractured carbonate systems. In this paper, Formation MicroScanner (FMS) borehole imaging tool and conventional well log data have been used to study the secondary porosity of the dolomite Alamein Formation in the Alamein Field, north Western Desert, Egypt. It was observed under FMS that the formation is intermittently vuggy with solution-filled channels. Well log results confirm that hydrocarbon-filled secondary porosity occurs across the formation. Petrophysical results also show good average effective porosity and hydrocarbon saturation. Core samples photographs confirm the presence of hydrocarbon which fluoresces under UV light. All these findings point to the significance of secondary porosity in the reservoir performance of the Alamein Formation.
Reservoir characterization and stacking patterns of Carbonate Grain Bank: A case study of Grain Bank of Cambrian Longwangmiao Formation in the Sichuan Basin, China

Long Wang¹, Muhammad Riaz¹, Khalid Latif¹ ²

¹School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
²National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan

Based on the concept of the stacking pattern of sedimentary cycles to determine and classify sequences, the sequence stratigraphic framework of grain bank of Cambrian Longwangmiao Formation is established systematically in the Sichuan Basin using core and image logging. The results of the study are: (1) the grain bank is composed of two types of meter-scale cycles, i.e. tidal flat and subtidal, and the stacking patterns of these cycles constitute third-order sequence; (2) the grain bank shows significantly different stacking patterns at different depositional phases, including the isolated, superimposed and migrated patterns, which formed at the stage of transgression, normal regression and forced regression, respectively, and (3) the stacking patterns of grain bank have a direct impact on the performance of the reservoir. The migrated pattern grain bank, with medium thickness and high porosity, can be regarded as high quality reservoir. Although, the superimposed pattern grain bank has the largest thickness, it performs as moderate to poor reservoir due to lower primary porosity, however, the strata after undergoing karstification during Caledonian movement can now be considered as a good reservoir, because the dissolution greatly enhanced the porosity. The isolated pattern grain bank cannot be regarded as reservoir because of poor physical properties and thin bedding.

The research provides important clues in exploration and evaluation of the grain bank reservoirs, which is of equal significance to the researchers as well as oil and gas industry.

The Champion subsurface rejuvenation – a fully integrated mapping effort to increase gains through WRFM, improve well targeting, reduce HSE exposure and unlock NFE potential in Brunei’s largest asset

Tom Savels¹, Pieter Huver¹, Gaurav Mahanti¹, Sijmen Gerritsen¹, Jeffry Gunawan¹, Nursyazwani Sani¹, Faridah-Maziah Abd-Malek¹, Farah Azyan Ali Umar Safri¹, Andy Miller¹

¹Brunei Shell Petroleum

The Champion field is Brunei Shell’s largest asset and is key to the Sultanate’s future development. To fill the funnel, the asset is currently focused on infill, workovers, conversions and NFE opportunities of which more than 50 have been identified. Trustworthy maps are key to unlocking this future.

It was recognized in 2015 that the current geological models did not adequately capture the structural complexity of the field. This triggered a “back to basics” approach, aimed at improving the quality of the subsurface framework. In-house reprocessing of legacy seismic data was undertaken in 2013, improving the seismic image quality; this enabled Exploration to redefine the regional structural framework, which also had a positive impact on the understanding of existing wells in these areas. It became apparent however that isolated updates by different teams would not be sufficient to fully unlock the remaining potential of the Champion field, and the need for an integrated, field-wide interpretation and static model update was recognized. The Champion Subsurface Rejuvenation Project was kicked off in 2016 as a collaboration between Exploration,
the Champion asset, the Geophysics department and the Development studies team. Its aim was to generate a set of structurally consistent field-wide maps and velocity model, co-owned across BSP, integrating the new regional framework and seismic interpretation along with well and production data. The project, already mature in some areas, is impacting development decisions in significant ways in terms of HSSE (water flood management and associated H₂S generations and safe well delivery), WRFM (filling the funnel with infill, well workover and conversion opportunities) and NFE potential (7 block targets matured post Step 3 and 5 funnel entries have been added to the funnel). This re-emphasis on the importance of the subsurface has energized the asset; this energy, with the new opportunities it generates, will allow the framework to be kept evergreen as new subsurface data is acquired, novel processing technology is applied and subsurface understanding evolves. After 44 years of drilling there are still plenty of opportunities to chase in the Greater Champion area; for optimal maturation and execution thereof integration across subsurface disciplines is key.

Integrated reservoir characterization study of the McKee Formation, onshore Taranaki Basin, New Zealand

Swee Poh Dong¹, Mohamed R. Shalaby¹, Md Aminul Islam¹

¹Universiti Brunei Darussalam

The Late Eocene McKee Formation is a producing reservoir rock located on the onshore of Taranaki Basin, New Zealand. Integrated study of petrophysical and petrographical analysis are used to evaluate the reservoir characteristics of the McKee sandstone. Petrophysical result of the McKee sandstone showed moderate to good reservoir quality. The average porosity ranges from 10.9 to 15.9%, with high hydrocarbon saturation ranges from 61.8 to 99.8% and clay volume content ranges from 14.9 to 34.5%. Mineralogical study on the McKee Formation classified the sandstone as arkose based on the QFL triangular diagram of the Pettijohn classification. The pore type of the reservoir showed predominant intergranular porosity as identified from the thin section photomicrograph. The good reservoir quality of McKee sandstone is characterized by the presence of secondary dissolution pores interconnected with the primary intergranular network. The presence of clay minerals, cementation and compaction is identified as the main porosity reducing agent of the reservoir quality. Argillaceous samples are found only on certain depths where the pore spaces are filled with either alloigenic or diagenetic clay. Cementation in the form of quartz overgrowth are more common in McKee Formation as their presence are identified even among well interconnected pores with little effect as porosity still retains. Heavily cemented sample are observed on a relative greater depth where they coexist with compaction effect that caused local lithification of the sample with no visible porosity. Lastly, moderate degree of compaction is observed to cause the bending and rearrangement of the grains within the samples. Despite that, pore spaces preserved suggesting its stable grain framework. These features however are observed to occur locally on certain depths and does not affect the overall reservoir quality of the McKee Formation as intergranular porosity are still observed to be prevalent.

Approach towards the classification of microporosity in Miocene carbonate rocks, central Luconia, offshore, Sarawak, Malaysia

Hammad Tariq Janjuhah¹, Ahmed Mohammad Ahmed Salim², Abubaker Alansari², Yasir Bashir¹, Wan Ismail wan Yusof ²
Miocene carbonates from Central Luconia, offshore Sarawak, Malaysia, contains a significant amount of micropores, which occurs in grain, matrix, and cement. For a better understanding of the presence of micropores, it is necessary to consider grains, matrix, cement, and pore types. Based on the qualitative and quantitative knowledge of these components a classification of micropores is proposed and their effect on reservoir quality. These results can reduce the number of assumption made about the internal rock connectivity and quality. For quantitative analysis, 32 high-resolution images of each thin sections were taken under the transmitted light microscopy. Succeeding these 32 images were stacked together as a photo panel to enable quantifying the amount of grain, matrix, cement, pore types and microporosity using Digital Image Analysis and J.Microvision software. Furthermore, Field Emission Scanning Electron Microscopy images were used for the measurement of crystallometry particles, classification of micrite particles and the micropores. Eight facies scheme is introduced based on the detailed lithofacies study of five wells. The qualitative observation of thin sections unveiled that corals, red algae, green algae, foraminifera, echinoderms, sponge, bivalve, and bryozoans are the most dominant components. Foraminifera, red algae, and corals are the far most dominant components covering almost 50% of the total intervals. Regarding porosity types, the mouldic porosity is the far most dominant pore types with converting the total 50% of the interval. Lithofacies observed in these wells indicate a good reservoir quality, but diagenesis plays a vital role in enhancing or reducing their porosity and permeability. Most of the depositional textures of the reservoir are leached, making this location unique to study facies distribution and diagenetic history. Result exhibits that the micrite particles are classified into five classes, which are very fine, fine, medium, coarse and very coarse, with a diameter of 0.1-2μm, 2-4 μm, 4-6 μm, 6-8 μm and 8-10 μm respectively. The texture and morphology of micrite microtexture are classified into six classes. Among these six classes, rounded, subrounded, trigonal, rhombic (micro-sub)-polyhedral micrite are representing porous micrite particles, whereas fitted bounded subhedral, and fitted fused anhedral are interpreted as tight micrite particles. Furthermore, five micropores classes are introduced based on the size of these particles. The empirical porosity-permeability relationship is affected by the presence of microporosity and its influences the assessment of ultimate recovery of hydrocarbons in Central Luconia, offshore Sarawak, Malaysia.

**Onshore wave-dominated sandstone reservoir characteristics in Sandakan Formation, NE Sabah Basin**

Muhamad Firdaus Abd Majid

1Universiti Teknologi PETRONAS

The Miocene shallow marine sandstone of the Sandakan Formation is a prolific area for reservoir quality studies, located in the Northeast (NE) onshore of Sabah Basin. The research deals with the sedimentological description and petrophysical evaluation of some petrophysical properties of core samples obtained from the exposed outcrop in Sandakan, Sabah. The goal of this study is to characterize onshore wave-dominated sandstone reservoir through facies description, petrophysical properties and hydraulic fluid unit. Correlation of mentioned parameters will establish an evaluation of the reservoir quality. The aim
was achieved through conducting facies description on the outcrop, numerous laboratory measurement which include petrophysical properties (porosity and permeability), scanning electron magnetic (SEM), and X-ray diffractometer (XRD) evaluation were carried out in order to determine reservoir characteristics. Massive bedded of wave-dominated sandstone can be defined into 2 facies: (1) Hummocky cross stratified (HCS) sandstone (F1); (2) Interbedded HCS sandstone with mudstone (F2). These facies consist of similar texture which is fine to very fine grained with sub-angular to sub-rounded grained, and moderate to well sorted. Facies F1 represent by slightly white in colour of clean sandstone suggest that high sand content, while Facies F2 shows dark grey in colour of shaly sandstone suggest that high mud content. Facies F1 derived from shoreface environment, while Facies F2 is a part of offshore transition zone. Facies F1 has good potential in reservoir quality, with good porosity and permeability values from 20% to 24% and 15 mD to 82 mD respectively. While Facies F2 with low permeability values 3 mD exhibits poor reservoir quality, probably due to high content of mud. The petrophysical flow unit concept is adopted in this study to categorize reservoir rock quality. Flow zone indicator (FZI) has been computed to quantify the flow character of the Sandakan Formation reservoir rock. Three hydraulic flow unit (HFU1 and HFU2) were determined in the studied outcrop, indicate that FZI values show a broad range of hydraulic properties. HFU2 can be classified as a good reservoir quality correlated to Facies 1. HFU1 in the other hand is poor reservoir quality correlated to Facies 2. Mineralogically, SEM result revealed that the kaolinite is the most dominant pore-filling of those quartz and feldspar minerals, followed by pore-filling illite. The existence of these clay minerals was confirmed by XRD test using clay separation method. Higher values of permeability probably associated with the presence of kaolinite.

**Geological field characteristic of black shales and mudstones of central Sarawak, Malaysia**

Walaa Elnasir Ibrahim¹, Abdul Ghani MD Rafek², Ahmed Mohamed Ahmed Salim³

¹Universiti Teknologi PETRONAS, Department of Geoscience, Perak Darul Ridzuan, 32610 Seri Iskandar, Tronoh-Malaysia

This paper examines the Cretaceous – Upper Pliocene shale and mudstone outcrops in Central Sarawak. Related geological studies focused basically on sandstones and coals of Sarawak Basin, with no comprehensive outcrop study on lithological variations in the black shales and mudstone formations. Detailed lithological variations of these formations will allow us discretize potential gas shale intervals. Therefore, the aim of this study is to investigate the field geological characteristics of the Black shales and mudstone formations of Central Sarawak by using outcrop description, sedimentary log analysis, spectral gamma ray data and geochemical characteristics (TOC %) of the selected mudstones and black shales. The study covers Nyalau, Tatau, Begrih, Liang and Belaga formations. Representative samples of various formations of mudstone and black shales were subjected to detailed description in terms of lithology, structures and stratigraphy to improve the geological understanding of the area. Features such as laminations, sandstone intercalations in the shale, coal lenses, iron nodules, phyllite inclusions and faulting were identified. This study will aid the subsequent analysis of shale fabric and mineralogy using X-ray diffraction (XRD) technique and surface morphology visualization (SEM) to confirm the concentration of the mineral in the rock. The total organic carbon (TOC %) values vary from 0.8% to 3.2%, suggesting that fair to good generative potential.
Geochemical characterization of mass transport complex shale and its potential as a source rock in Jatiluhur Formation, onshore West Java, Indonesia

Ratna Widiarti¹, Epa Prasetya Kusumah¹, Wahyuningrum Angesti Lestari¹, Abang Mansyursyah Surya Nugraha¹, Teuku Lutfhi Maulana¹, Alawy Zulfikar¹
²Universitas Pertamina

Shales in mass transport complex to generate hydrocarbon source rock are poorly understood. This study describes a deep-water slump facies shale of the Early Miocene Jatiluhur/Cifbulakan Formation to understand its potential as a source rock in onshore West Java. The formation is equivalent with the Gumai Formation, which has been well-known as another prolific source rock besides the Oligocene Talang Akar Formation in North West Java Basin, Indonesia. The equivalent shale formation is expected to have some potential source rock towards the onshore of Central Java. The shale samples were taken onshore, 150 km away from the basin. The shale must be rich of organic matter, have good quality of kerogen, and thermally matured to be categorized as a potential source rock. Investigations from petrography, X-Ray diffractions (XRD), and backscattered electron show heterogeneous mineralogy in the shales. The mineralogy consists of clay minerals, minor quartz, muscovite, calcite, chlorite, clinopyroxene, and other weathered minerals. This composition makes the shale more brittle. Scanning Electron Microscope (SEM) analysis indicates secondary porosities and microstructures. Total Organic Carbon (TOC) shows 0.8-1.1 wt%, compared to the basinal shale 1.5-8 wt%. The shale properties from this outcropped formation indicate a good potential source rock that can be found in the subsurface area with better quality and maturity.

Probability of facies occurrence in Mangahewa Formation, Maui gas field, New Zealand

AKM Eahsanul Haque¹, Md Aminul Islam¹, Mohamed Ragab Shalaby¹
²Universiti Brunei Darussalam

For Mangahewa reservoir of Maui Gas Field, Taranaki Basin, New Zealand, eighteen depo-facies were identified. These facies account for a set of particular depositional environment and are further grouped into three broad facies associations. The actual occurrence of a particular facies interpreted on the logs is maintained across the gas field in all available wells and is manually picked following the lag motifs seen from the log response of the studied wells to determine facies and associated depositional environments. The variability of the facies depends on the palaeo-depositional structure, geological conditions, local sea level fluctuation and sedimentation rates. Analyses of the depo-facies distribution and the probability statistics using Data Analysis (DA) process in Petrel 2013.1 along with all possible wells show that estuarine channel sands (32%), shoreface sands and tidal channel fills (44%) are the most frequent facies according to the probability distribution within the model. Whereas shelfal mudstone constitutes only 7% of the total facies. Depo-facies modelling also shows that within marginal marine (MM) environment, tidal channel fill, point bar and mouth bar sands occupy 28% of cells within the facies model and tidal flats (sand flat/ mixed flat/ mudflat) constitute 10% of cells. Whereas estuarine channel sand dominates with 26% of cells on the modelled reservoir. We also have observed that over 90% of the interpreted facies have 10-20m of thickness. It is to be remembered that while generating the model, facies classes, their possible occurrence in logs and distribution in present-day morphology are taken into consideration to logically distribute the
modelled facies in horizontal as well as vertical distribution.

**Application of technology to derisk and reduce structural uncertainty in Anduki field development**

Shafie Alipudin¹, Carlos Nieto¹, Marzuki Daud¹, Oladiran Olarewaju Abidemi¹, Azim Salleh¹, Zayani Zaini¹, Hamzah Hamzah¹, Metassan Metussin¹

¹Brunei Shell Petroleum

The Anduki area has been producing since 1955, it is relatively a less developed area compare to the rest of Seria field. To rest production decline, the asset is currently focusing on future infill and NFE opportunities in this area of which more than 10 drilling wells opportunities have been identified. The most significant increase in drilling activity in the Anduki area today is the DEPO campaign (Darat Early Phase Opportunity Phase 1 & 2). The onshore campaign was started in 2010 and the last well was completed in 2014. As result, a total of 17 producers and 17 injectors were drilled within 4 years. Integrating learnings from the previous campaign into the upcoming development concept is very critical and valuable for the project. From the after action review of the last DEPO campaign, the biggest risk and uncertainty in the Anduki area is structural uncertainty. Structural uncertainties covers inter block compartmentalization, fault positioning and structural dip uncertainties. Intra block compartmentalization has known to ultimately impact reserve and hence the economics of the well by reducing production drainage area and oil producer and water injector connectivity. Structural uncertainties such as fault positioning and dip uncertainty has resulted into sub-optimal well penetration and in some cases well must be sidetracked for recovery (resulting in increased cost). The asset team has come up with numerous efforts to mitigate these uncertainties for the next development phase. For example, 3D DAS (distributed acoustic sensing) VSP (vertical seismic profile) technology. This type of surveys has been proven to provide a sharper image, given the increased frequency bandwidth recorded and the higher spatial sampling (smaller receiver spacing, almost continuous). These images help reduce fault positioning and structural dip uncertainties and hence de-risk well placement. Additionally, these may also provide an image able to resolve sub-compartmentalization caused by intra-block faults, thus further de-risking the location of oil producers and injectors. For shallower depth targets we have used marine 3D high resolution seismic survey to successfully de-risk sub-compartmentalization and to image gas caps. To ensure full block drainage coverage and de-risk compartmentalization a horizontal well concept was proposed to replace the fishhook well concept used in the previous developmental phases. The Anduki drilling campaign demonstrates the importance of technology to de-risk structural uncertainty such as intra-block compartmentalization, fault positions and dip uncertainty. De-risking and reducing these uncertainties is critical for a marginal field development such as Anduki.

**Fluid characterization based on intrinsic properties analysis of fluid using adaptive Batzel-Wang method on field “M” reservoir conditions**

Muhammad Iksan¹, Reza Wardhana¹, M. Syamsu Rosid¹, M. Wahdanadi Haidar²

¹Physics Department, FMIPA Universitas Indonesia, Depok 16424, Indonesia
²JOB Pertamina Petrochina East Java, Menara Kuningan Lt. 18 & 20, Jakarta 12940, Indonesia

Physical properties and phases of the fluid under the reservoir conditions are different from the surface conditions. The value of the fluid property may change as a result of changes in pressure and temperature.
Analysis of the intrinsic properties of the fluid is carried out to obtain fluid model that correspond to the fluid condition in the reservoir. This study uses Adaptive Batzel-Wang model which combines thermodynamic relationship, empirical data trends, and experimental fluid data in the laboratory to see the effect of pressure and temperature on fluid properties. Adaptive Batzel-Wang method is made because Batzel-Wang’s calculations are used less suitable in describing the physics properties of fluid in accordance with the fluid conditions in the field of this research area, so the Batzel-Wang fluid model needs to be modified to get fluid model that adjust to the fluid property conditions in each research area. In this study, the Adaptive Batzel-Wang model can model three types of fluid i.e. oil, gas, and water. By utilizing fluid intrinsic property data such as the specific values of gravity gases (G), Gas-Oil Ratio (GOR), Oil PVF (Bo), API values, Salinity, and Fluid Density obtained from laboratory experiments, Batzel-Wang fluid model was modified to Adaptive Batzel-wang by finding equations to calculate the fluid intrinsic properties corresponding to the fluid properties conditions at the pressure and temperature of the field reservoir. The results obtained are bulk modulus value (K), density (\( \rho \)), and speed of P-wave (v) of the fluid under reservoir conditions. The Adaptive Batzel-Wang model has a correlation coefficient value with experimental fluid data in the laboratory reaching 0.95 so this model is good enough to calculate the fluid properties that correspond to the reservoir conditions in this research area. The Adaptive Batzel-Wang model generates a unique equation solution in calculating the fluid properties in each research area so that this model can adjust to the fluid property conditions under the pressure and temperature conditions of the field reservoir we wish to study.

Therefore, Adaptive Batzel-Wang can be used in various fields that have fluid experimental data in laboratories especially in fields with high reservoir pressure and temperature. Results from fluid modelling can then be used for Rock Physic modelling and Fluid Replacement model analysis.

**Imaging through mega gas clouds in offshore Brunei**

Suni Sulaiman\(^1\), Joshua Turner\(^2\), Andrew Carnell\(^1\)

\(^1\)Brunei Shell Petroleum, Jalan Utara, Seria, KB3534, Brunei
\(^2\)Shell Exploration and Production Company, Houston, USA

The presence of gas clouds has long been recognized as a significant problem in seismic data processing. Gas produces strong absorption, causing wipe out zones and can seriously mask the coherency of the structure beneath it. Prospecting under these gas clouds has long been a challenge in Brunei and the rest of the world alike. In Block A, East Offshore Brunei, the sheer size and complexity of these mega gas clouds pose severe imaging problems to the structure underneath. In 2013, an improvement in imaging quality has been achieved with the help of the advanced QPSDM technology and application of “gas-bags modelling” on the East Deep 3D Broadband survey. However, a very significant uplift was further obtained in 2015 after a more focused re-processing of the broadband data, by replacing normal velocities in geologically rendered “gas-bags” with significantly-slower-than-water velocities in a bracketed and iterative approach. The workflow includes a combination of acoustic Full Waveform Inversion (FWI) and ray-based tomography to address the imaging challenges in the presence of complex gas clouds. This presentation describes how Shell and CGG finally produced an improved and robust coherent image of a large faulted anticline by applying detail velocity modelling and employing the latest FWI & Q-Reverse Time Migration (QRTM) processing technologies.
to its broadband data. The processing package consists of four parts: FWI for the velocity in the shallow gas clouds, FWI-guided Q tomography for a high-resolution absorption model, geology-guided scenario testing for the velocity within the deep gas clouds and Q TTI RTM for the multi-pathing and energy attenuation issues during migration. The result of this seismic reprocessing project allowed recognition of a faulted anticlinal structure with promising internal stratigraphy and lead to the maturation of a prospect and a well to be drilled in Block A East Offshore Brunei. The authors would like to thank SDB, CGG, EIDPMO and Petroleum BRUNEI for the permission to present the data and publish this work.
POSTER PRESENTATIONS

Exploration targets on the deep residual palaeo reservoirs in the Nanpu Sag: Insight from organic geochemical characteristics of source rocks and oils

Lixin Pei¹, Zhilong Huang¹, Wenzhe Gang¹

¹China University of Petroleum-Beijing

Organic geochemistry of source rocks in the Nanpu sag, Bohai Bay basin was studied on the base of the results of Rock-Eval pyrolysis on 140 samples and biomarker analysis on 30 source rock samples. The possible source rocks consist of the third member (Es3) and the first member (Es1) of Shahejie Formation and the third member of Dongying Formation (Ed3) in the Nanpu sag. The Es3, Es1 and Ed3 in the Nanpu sag all have high organic-matter richness and hydrocarbon-generating potential, and can be considered as effective source rocks. The three possible source rock intervals have different biomarker associations and were deposited in different environments. The Es3 is characterized by relatively high gammacerane/αβ C30 hopane (>0.09), high ETR ((C28+C29)/[C28+C29+Ts]) (>0.4), low C27 diasterane/sterane (<1.0) and low C27/C29 steranes (<1.13), and was deposited in and saline-water, anoxic conditions with high contribution from terrestrial organic matter (TOM). In contrast, the first member of the Shahejie Formation (Es1) and the third member of the Dongying Formation (Ed3) were characterized by low gammacerane/αβ C30 hopane (<0.09), low ETR (<0.4), and were deposited in freshwater-dominated, anoxic conditions, but have different C27 diasterane/sterane (0.73-1.08 and 0.72-2.24, respectively) and C27/C29 steranes (0.94-1.47 and 1.12-1.82, respectively). Based on the oil-source rock correlation, the shallow oils mainly originated from the Es3 and Es1 source rocks in the Nanpu sag. Through hydrocarbon generation and expulsion history of the source rocks, trap development history and accumulation history, the shallow oils mainly originated from palaeo-reservoirs in the Es3 and Es1 during the period of Neotectonism, and the residual palaeo-reservoirs in the Es3 and Es1 would be the focus targets in the Nanpu sag; Bohai Bay basin.

Source rock characteristics and its significance on tight oil source and occurrence: A case study of Permian Lucaogou formation in the Santanghu Basin, northwest China

Guoheng Liu¹, Zhilong Huang¹

¹China University of Petroleum, Beijing

In a broad sense, tight oil refers to oil resources accumulated in tight sandstone or tight carbonate reservoirs that are interbedded with, or are close to, source rocks. However, in a narrow sense, tight oil refers to oil resources that have accumulated in tight sandstone or tight carbonate reservoirs in relation to discharge and migration from adjacent source rocks. Significant progress has recently been made in tight oil exploration within the Permian Lucaogou (P2l) Formation of the Santanghu Basin. However, current tight oil exploration deployment of the P2l Formation is mainly based on reservoir prediction, which is high risk for tight oil exploration. In this study, the geological and geochemical characteristics of the P2l Formation source rocks, including the distribution, sedimentary environment, organic matter abundance, kerogen types and thermal maturity were investigated. Hydrocarbon generation and expulsion intensity were evaluated through an improved hydrocarbon generation potential methodology, and the significance of source rocks in tight oil source and occurrence was systematically investigated. Results indicate that P2l Formation source rocks with total organic carbon >1.0 wt% occur widely (an area up to 1500 km²), are

1st International Congress on EarthSciences
thick (up to 160 m), were deposited in a lacustrine weakly reducing sedimentary environment with relatively low salinity, have a high total organic content with a mean value of 3.12 wt%, are dominated by type II kerogen and have reached the early mature to mature stage. Modelling results indicate that the source rocks reached the hydrocarbon generation threshold and hydrocarbon expulsion threshold at 0.48% and 0.86% vitrinite reflectance, respectively. The comprehensive hydrocarbon expulsion efficiency was approximately 30%, and the maxima of hydrocarbon generation and expulsion intensities for P21 Formation source rocks are 1200 × 104 and 425 × 104 t/km2. The tight oil is sourced from adjacent source rocks that are interbedded with, or are close to, the reservoirs. The migration of oil generated from the source rocks occurs over very short distances. The oil filling degree index (oil bearing thickness/P21 Formation thickness) is higher at a closer proximity to the source rocks, and where it is higher the hydrocarbon generation intensity of the source rocks is also elevated. In addition, the greater the hydrocarbon expulsion intensity of the source rocks, the higher the daily oil production values (ton/day) from prospect wells.

Secondary migration related to volumetric flow rates of fang crude oil in oil sandstone reservoir, northern part of Thailand

Sarunya Promkotra¹

¹Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen, Thailand

Crude petroleum migration as the laminar flow in incompressible fluids and hydrocarbon classification is a principal study to crude petroleum flow rate related to Darcy’s law and Hagen-Poiseuille law in mass of flow rates. Crude petroleum classification is apprehensive for its migration from a petroleum reservoir to underground surface. This secondary migration is generated in Fang Basin, northern part of Thailand. Its chemical characteristic can be classified hydrocarbon as paraffinic, intermediate paraffinic, aromatic, and asphaltic classes, in the ratio of 5 : 10 : 4 : 1, respectively. Its property signifies two types of paraffinic and intermediate classes. The volumetric flow rates implicate to petroleum migration which refers to hydrocarbon classifications. These specify possibility of migration with the mass flow of hydrocarbon class. Relationship of their volumetric flow rates can estimate the combination of the volumetric flow rates as a function of mass of flow rates with three classifications: conventional crude oil, heavy crude oil, bitumen. Fang crude petroleum classes are bitumen to heavy crude oil, and can be predicted a trend of the migration zones of heavy crude oil, heavy crude oil-bitumen, and bitumen zone. Thus, evaluation results reveal that the slow volumetric flow rates relates to pressure depths, petroleum migration, and crude petroleum classification.

A study of shallow marine sediments in eastern Brunei, based on outcrop and subsurface data

Nur Munirah Haji Brahim, Syahida Haji Mat Daud Amalul Rahman, Andrew Carnell

Shell Deepwater Borneo
University of Brunei Darussalam

Surface outcrops can provide useful analogues to subsurface geology, providing information on facies interrelationships, depositional architecture and lateral continuity at a scale not possible in the subsurface. This is particularly useful in areas where there is limited well coverage or where seismic image quality is sub-optimal. In this study emphasis was placed on shallow marine to marine marginal sediments with the
modern-day Brunei Bay and its environs being a reasonable modern analogue. Three outcrops in Brunei-Muara were selected to give a range of facies relationships and sandstone continuity. Outcrops were studied in detail, recording details of lithology, grain size, colour, sorting, structure, and sedimentary and biogenic features (burrows, scours, lamination, etc.). Outcrop geology was compared to well logs and time-domain seismic covering four exploration wells located offshore Brunei. Two outcrops were studied in the Sungai Akar Landfill Site, Brunei-Muara District. They are on the eastern limb of the Berakas syncline and are of the Early to Late Miocene Belait Formation. The westerly outcrop is stratigraphically deeper and consists of sandstones and variably carbonaceous shales. The lower (basal 40m) portion of the outcrop is sandstones dominated and shows overall upwards thickening. Sandstones are commonly erosively based and show well developed hummocky cross-stratification. This sand rich section is overlain by thinly interbedded ripple (wave and current) laminated sands and shales (21m) with the latter becoming more prominent and carbonaceous upwards. The uppermost beds mark a return to deposition of hummocky cross-stratified sandstones. The second Sungai Akar outcrop (~300m northeast), is shale rich and comprises a series of upwards cleaning units capped by sandstones with ripple lamination, cross-stratification, clay interbeds, flaser bedding and sand-filled burrows (Prominent Ophiomorpha). Sharp based channelised sandstones are apparent in the shales. The third outcrop is in Madewa, Bandar on the eastern hinge of the Berakas syncline. It is in the Middle to Upper Miocene Miri Formation and comprises sandstones and shales arranged into an overall coarsening upwards succession. Sandstones are typically sharp based and show a range of depositional fabrics (hummocky cross-stratification, herringbone lamination, ripple cross-lamination). Widespread bioturbation masks primary sedimentary structures. Outcrops were compared to wireline logs from offshore exploration wells and allow for a greater appreciation of potential stacking patterns and lateral sand continuity. Outcrops were further compared to seismic reflecting a further loss of resolution, but also illustrating the greater scale of exploration and development.

Seria redevelopment project:
Unconventional approaches to develop the shallow reservoirs of the sleeping Giant-Seria field

Syazwina Rosli1, Steve Brown1, Chantorn Butphet1, David Hill1, Aizulkahar Johan1, Liew Yee Yung1, Metassan Haji Metussin1

1Brunei Shell Petroleum

The Seria Field was discovered in 1929, and is still in production today and has produced ca. 184mlM3 of oil from over 1000 wells during its 80+ years of production history. This contribution however, only came from ~40% of sands available and ~20% of the total number of fault bounded blocks in the field. Maximum oil production since the 1950s has steadily declined- in which the oil was predominantly derived from easy “sweet spots” using primary recovery method of pressure depletion. Efforts of using secondary recovery via waterflooding has also been done in the some parts of the field, but this method proved to be challenging due to several reasons- one of them being the complexity of the faulting in the field. However, in recent years there have been several attempts to rejuvenate the field, with the opportunity to maximize ultimate oil recovery in the shallow reservoirs of Seria Field -the part of the field where they are commonly bypassed to get to deeper reservoir targets, by demonstrating effective low cost development approaches and an unconventional subsurface workflow. A full field structural model was built in 2015.
which combines all the blocks in Seria field which were previously only modelled block by block, according to the business needs. This model provides not only a better understanding of the Seria Field structurally, but also by integrating this newly found geological understanding with petrophysical evaluations, we have the ability to focus on the areas in the field that still has unlocked potentials.

Critical porosity and volume of clay analysis for reservoir quality identification of Cibuakban Bawah Formation, northern west Java Basin

Dona Sita Ambarsari

Institut Teknologi Bandung (ITB)

Rock quality is a method to classify rocks with similar geological conditions, or similarity of physical parameters. The quality of reservoir depends on the value of porosity and permeability. A reservoir with high porosity and permeability classified as high quality reservoir. In petroleum engineering, Kozeny-Carman relation used to classify rock quality based on similarity of pore structure and pore geometry. Rock physics data such as P-wave velocity, S-wave velocity, density and the other supporting data such as routine core, SCAL and XRD data are used as input to obtain physical parameters that can represent the geometry and pore structure, i.e. critical porosity derived from Nur’s model and the volume of clay. Critical porosity represents a grain size that proportional to pore geometry, while volume of clay proportional to pore structure. These two physical parameters, indirectly affect the value of porosity and permeability which leads to determining reservoir quality. The results of this study successfully demonstrated that the critical porosity and volume of clay are the physical parameters that can be used as an indicator to classify the reservoir quality.

Depositional controls on source rock quality and hydrocarbon potential of tertiary deltaic sediments in Brunei Darussalam

N M Gardner1, M Dixon1, I Thieme1, Oliver Swientek1, P Kralert2, Georgios Siavalas2, Lieyana Azffri3

1Brunei Shell Petroleum Sdn Bhd, Brunei Darussalam
2Shell Global Solutions International B V, the Netherlands
3Universiti Brunei Darussalam

Studies to date in Brunei’s Baram Basin have been unable to identify a source rock capable of generating the country’s significant oil and gas volumes. Geochemical characteristics of the produced hydrocarbons indicate a terrigenous organic matter origin. While this terrestrial material is clearly fed from the delta plain, the preservation and burial within the delta front/prodelta is not widely understood. In this study, outcrop samples covering a range of different depositional settings were evaluated and submitted for standard source rock and petrographic analyses. The objectives of the work were to determine how source rock richness and quality vary within a broader depositional context and, ipso facto, to better understand the hydrocarbon potential of Tertiary deltaic sequences under current/future exploitation for petroleum development in Brunei. Samples were collected from eight different outcrop locations. The sample set was classified into in-situ (IC) and transported (TCC and TCF) coal/coaly shales respectively and prodelta shales (DS). The transported samples were sub-divided into two distinct groups to distinguish coal/coaly shale clasts in a sandstone matrix (TCC) versus finely disseminated coal/coaly shales in a sandstone matrix (TCF). IC samples were found to have total organic carbon (TOC) contents of up to 66 wt% and hydrogen index (HI) values up to
259 mgHC/gTOC. TCC samples displayed TOCs up to 61 wt% with HIs as high as 318 mgHC/gTOC, while the TCF group displayed TOCs up to 8 wt% and HIs up to 127 mgHC/gTOC. For the DS category, TOCs were less than 1 wt% and HIs less than 100 mgHC/gTOC. All samples analysed were found to be thermally immature (%Ro≈0.5; Tmax<430°C), free of contaminants and unaffected by weathering. Petrography results indicated vitrinite was the most abundant maceral, liptinite contents between 7 and 24 vol% on kerogen basis for both the IC and TCC/TCF sample sets and cutinites and resinite as the main liptinite maceral groups.

In summary, geochemical and petrographic analyses indicate that source rock and hydrocarbon potential exist in both in-situ and transported depositional settings evaluated. The IC and TCC samples showed higher quality and greater liquid potential over the TCF. However, it is notable that any source or liquid hydrocarbon potential is evident in the delta shelf transported organic matter. These results indicate that the thick Tertiary clastics of Brunei cannot be excluded as being responsible in total or in part for the present day accumulations of liquid and gas in Brunei Darussalam.

Integrated study of lithofacies identification in X field, Sabah, Malaysia

Jia Qi Ngui\(^1\), Maman Hermana\(^1\), Deva Ghosh\(^1\)

\(^1\)Universiti Teknologi PETRONAS, Faculty of Geosciences & Petroleum Engineering, Department of Geosciences, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia

Understanding the subsurface geology is essential for oil and gas exploration. Seismic facies interpretation is very useful in investigating this concept. The interpretation of the depositional setting of the X Field is achieved by integrating the seismic facies characteristics on 3D seismic data and well log data. Both the seismic and well log data are widely used in hydrocarbon exploration to map the subsurface as they complement each other where well logs yield the vertical resolution of the subsurface geology at the drilled wells. The objective of this paper is to demonstrate the integration of seismic data and well log data for lithofacies identification. Interpretation and analysis of lithofacies is carried out through the integration of seismic geomorphology with well logs. Horizons are interpreted based on the variation in seismic reflections on the seismic section, which is caused by the geology change within seismic sequences. Geophysical well logs are as well used to identify lithofacies. Well logs give detailed information at the points where the wells were drilled. Interpolating between these points and extrapolating away from the points into undrilled areas can be helpful in providing a better geological knowledge on the area. The result of this integrated study with lateral and vertical facies distribution constraints depict the lithofacies in the area. This integrated study will provide a better insight with higher degree of reliability to the facies distribution and depositional setting of the X Field. The geological and geophysical aspects of the field will be documented.

Occurrence, distribution and origin of shallow biogenic gas in late quaternary unconsolidated sand deposit of Shahbazpur structure, southern Bangladesh

Morshedur Rahman\(^1\), S.M. Mainul Kabir\(^1\), Badrul Imam\(^1\), AKM Eahsanul Haque\(^2\), Md Al Amin\(^1\)

\(^1\)University of Dhaka
\(^2\)Universiti Brunei Darussalam

Gas occurrences at shallow depth have been a common feature noticed in alluvial plain in shallow water well drillings in southeastern part of Bangladesh. The gas occurs in recent (< 2 Mya) alluvial sediments at shallow depths and flows in a
range of few hours to several days before being exhausted. The only exception is the shallow gas occurrence in Bhola Island, which flows from almost similar depth but has been consistently flowing for more than ten years. This shallow gas occurs within the recent deposit of Holocene age of Shahbazpur structure at the depth of 260m to 290m. This recent deposits are composed of unconsolidated sand with thin clay layers. The individual shallow gas pools is discontinuous and indicates that the shallow reservoir sand bodies have frequent facies change, which implies their lateral extension are limited. Field data collected all over the Bhola island shows that the shallow gas accumulation are only located in Burhanuddin upozila. Entirely composed of methane, very high methane-ethane (+) (>1000) ratio and high dryness value (>0.99) of shallow gas is suggestive of its biogenic origin.

**Relationship of lithostratigraphic unit and petroleum qualities in some gas field and oil field of Thailand**

Namthip Khuncharee¹, Sarunya Promkotra¹, Tawiwan Kangsadan²

¹Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen, Thailand
²Chemical and Process Engineering (CPE) Program, The Sirindhorn International Thai-German Graduate School of Engineering (TGGS) King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand

Natural gas, Sinphuhorm Gas Field (SGF) is placed in Permian carbonate reservoir, and characterized as the anticline fold of carbonate rocks. Another petroleum reservoir, half-graben basins, is Wichian Buri Oil Field (WOF), where accumulates in Tertiary sandstone and volcanic rocks. Both Chemical substances of SGF and WOF are composed of iso-paraffins, cyclo-paraffins, aromatics, and resin in the ratio of 2.5:1:0 and 5:10:4:1, respectively. Thus, SGF and WOF are identified as gasoline and lubricating oil distillate, respectively. The petroleum accumulation in SGF is situated in deeper reservoir and older age than WOF. The structural trap of WOF is controlled by fault, and then the API gravity is lessening. Dissolved gas and viscosity of SGF are found less, but are found more in WOF. The calorific values as a function of methane content indicate that the deeper reservoir of SGF shows the higher calorific value, which is relevant to deeper reservoir than the shallow reservoir of WOF. The contribution of petroleum system in this lithostratigraphic unit initiates from the good reservoir rock of carbonates of SGF and also volcanic and sandstone of WOF. Seal of both petroleum fields is mudstone which covers above the reservoir rocks. Another criterion is mature source rock which is also mudstone.

**A geophysical approach in construing the onshore extension of Penyu Basin:**

**Offshore Tertiary sediments and palaeoenvironment delta connection to Pahang River Delta**

Radziamir Mazlan¹, Abdul Ghani Abd Rafek², Khairul Arifin Bin Md Noh³, Ashley Aisyah Yoong⁴

¹Department of Geosciences, Universiti Teknologi PETRONAS, MALAYSIA
³0 well data from onshore Pekan, Pahang and 5 wells offshore at Penyu basin have shown that the Quaternary sediments are present in both onshore and offshore Pekan with the Tertiary sediments only present in offshore. The absence of the Tertiary sediments can be explained based on the results found on the offshore wells penetrating the Penyu basin. These wells that penetrated the delta structure in Penyu basin suggested a possible linkage between Pekan and Penyu basin through palaeoenvironment evolution where the Tertiary sediments were deposited from continental (older sediments) to marine environment (younger sediments). The
relative sea level history in the vicinity of the study area also suggested that transgression occurred causing the termination of the Tertiary sediments and bringing the Pahang River delta front to be located to where it is in the present day. Thus, to support this theory of a possible basin extension, this paper aims to delineate different basement rocks and its corresponding anomalies of the free-air and Bouguer anomalies at Pekan, Pahang as well as to understand the offshore tertiary sediments and palaeoenvironment delta connection to Pahang River Delta. This paper presents the reprocessing results of available land and satellite-derived gravimetry for Pekan, Pahang and its adjacent area, Penyu Basin. The outcome from the Bouguer anomalies, supported by available well data and interpreted seismic sections revealed that the basement rocks configuration of the area deepens towards the shoreline in the E-W direction. There are two different types of basement rocks that is present in the study area that contributed to the free-air and Bouguer gravity anomalies, namely Granite and Metasediment, with the offshore wells also penetrated the same basement rocks, showing a possible link between the basement rocks of the two areas. Furthermore, the possible termination of the Tertiary sediments in the transition zone between Pekan, Pahang and Penyu basin as well as the presence of overlying Quaternary sediments may correspond to the possible onshore extension of Penyu Basin.
Session 02: Petroleum Geophysics and Modelling
Chairpersons: Md Aminul Islam & Mohamed Ragab Shalaby

ORAL PRESENTATIONS

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Petroleum systems modelling challenges in Brunei

Oliver Swientek 1, Matthias Keym 2, Lisa Thieme 1

1 Brunei Shell Petroleum Co. Sdn. Bhd., Jln Utara, Panaga, Seria KB3534, Negara Brunei Darussalam
2 Shell Global Solutions (Malaysia) Sdn. Bhd., MENARA SHELL, No.211, Jln Tun Sambantham, 50470 Kuala Lumpur, Malaysia

Brunei has a successful history of applying new technical approaches and innovations during the last eight decades of exploration. Until recently, basin modelling has not been considered an effective tool to unlock hydrocarbons in the subsurface. This is primarily driven by the complicated story of stratigraphic and structural complexity that exists in Brunei and our ability to model it until now. The influence of tectonic and gravity driven faults as well as two major rivers depositing huge amounts of sediment in recent geologic history must be unravelled and properly represented in a basin model. The occurrence of overpressure and its modelling, typical for deltaic settings, is another factor which is difficult to address in a basin model and needs detailed input of the stratigraphic variation and distribution of the lithologies before meaningful outputs can be produced. The drive to explore for deeper targets in Brunei highlights the need for understanding the pressure and porosity distribution to optimise the exploration of deeper targets and to make safe drilling decisions. In 2016 a first Brunei-wide basin model was constructed in the BSP Earth Model. Due to its size and respective computational requirements, the resolution was limited to a 500x500m grid cell size that limited the effectiveness for applying the model to exploration efforts. The next phase of the earth model was to create a high-resolution basin model focusing on a smaller area with a grid cell size of 100x100m to improve the resolution and provide a better understanding of the subsurface. Detailed regional seismic interpretation, calculation of seismic attributes for facies assignment and revised fault interpretation underpins the high-resolution approach. Challenges still remain in understanding the source rock facies, fault timing/tectonic evolution, and the influence of compressional tectonics on point after pore pressure evolution. The first step is to use analogues to understand these issues (e.g. Mahakam Delta for source rock definition) and detailed studies for fault timing and tectonic evolution. The high resolution basin model is expected to be the first model to help predict temperature, overpressures, and fluid property distribution.

3D fault framework analysis of Pohokura gas field, Taranaki Basin, New Zealand

Mutiah Yunsi 1, Md Aminul Islam 1, Mohamed Ragab Shalaby 1, AKM Eahsanul Haque 1

1 Universiti Brunei Darussalam

The study area is located in Pohokura Field and is largest gas condensate field located in the Northern coast of Taranaki Basin. The main objective of the study is to generate a structural model using Volume-based Modelling (VBM) for further
understanding of the subsurface in the study area. Initially, 3D seismic interpretation from calibrated well ties was used to pick stratigraphic well tops. The intensity of faults in the northernmost region is more compared to the southernmost part. From cross-sections, it is evident that there are numerous thrust faults. Different phases of tectonic movements resulted in different structural patterns. Dip angle of the study area is between 45° to 75° towards NE-SW.

It is validated from the modelled structural grid that there were major structural development occurred during Middle Miocene as there were found reactivation of extensional faults and it could possibly be due to a change in the local stress regime of the area. Furthermore, the attribute maps, seismic reflectors and the Gas-Water contact (GWC) generated on the model suggest a potential hydrocarbon trapping mechanism.

Evaluation and prediction of the fine production in coal seam gas open hole completions, Surat Basin using petrological data and geophysical well logs

Morteza Jami¹, Stephen Tyson¹

¹University of Technology Brunei Darussalam, Faculty of Engineering, Department of Petroleum and Chemical Engineering, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

Fines production during the dewatering process of Coal Seam Gas (CSG) wells in Surat basin is one of the main concerns of the operators and imposes a significant financial cost on several large development projects. The lower part of the Injune Creek Group, known as Walloon Subgroup in the Surat Basin, eastern Australia is one of the world-class coal bed methane resource. The Jurassic Walloon Coal Measures are between 200-300 m thick and host up to 36 coal seams with seam thicknesses of 0.1 to 5m and a total net coal of 6-25m. The Walloon Coal Measures from top to base is divided into the Juandah Coal Measures, Tangalooma Sandstone and Taroom Coal Measures. These units and associated coal seams are located in a compressive stress regime with depth range from 150 to 1000 m. The main fines production in Surat Basin is sand and silt from the interbedded formations. Coal fines are less abundant. Due to the highly variable depositional environment, the interbedded units are heterogeneous composed of sandstone, siltstone and mudstone with varying degrees of consolidation and high content of smectite. Some of these produced sands are related to smectite swelling due to fresh water circulation or migration of low salinity water. Because of the small number of available cores for petrological and petrophysical tests, the evaluation of the smectite distribution has been correlated based on lithology of well logs and hyperspectral logs of equivalent cores for open-hole completions. The open-hole completion with slotted liners is a low-cost process adopted by many operators in Surat basin. The disadvantage of this completion is exposing a thick interburden to the well. The main other possible causes of sand production, such as unconsolidated and weak formations, water production rates and sudden changes in flow rate; reservoir pressure depletion; and high lateral tensile stress are reviewed. Among these factors unconfined compressive strength (UCS) is by far one of the most important factors in sand production. The rock strength profiles on various depths can be estimated using well logs (acoustic slowness, bulk density and total porosity data) and empirical core-log relationships. This extended abstract compares the well history and geophysical logs to predict the fines-prone zones. These data are calibrated against direct laboratory-measured geomechanical values and hyperspectral measurements to ensure that the results are reasonable.
Modelling the changes in the elastic properties of reservoir with fluid substitution using Gassmann’s equation with MATLAB
Nicholas Jianming Tan¹, Abdul Ghani Bin Md Rafek¹, Luluan Almanna Lubis¹
¹Universiti Teknologi PETRONAS, Geoscience Department, 32610 Bandar Seri Iskandar, Malaysia

Understanding how the elastic properties of rock changes with the type of fluid and saturation degree is an important part of exploration geophysics for identifying and quantifying fluids in reservoir. Fluid substitution plays important role in rock physics analysis as it provides geophysicists the tools to achieve that. Gassmann’s equation is commonly performed for fluid substitution. This paper will be discussing the general theory and steps of performing Gassmann fluid substitution and demonstrate a GUI model created using MATLAB as an application.

Object-based geobody simulation of Farewell Formation, Maui gas field, New Zealand
AKM Eahsanul Haque¹, Md Aminul Islam¹, Mohamed Ragab Shalaby¹
¹Universiti Brunei Darussalam

Object-based simulation involves defining lithology (or facies, architectural element, objects) with a range of dimensions and characteristic shapes that are used to populate the 3D model. This method honours geologic rules for stacking patterns and erosion and user-defined shapes that, in some cases, can produce more geologically realistic models than other modelling methods. For this study on Farewell Formation, Maui Gas Field, New Zealand, the modelled elements are crescent-shaped objects that represent the main reservoir elements (mouth bars) within the studied formation. The thickness of individual channel sands within the grid is modelled using a triangular distribution with values ranging from 2-15m with an average of 8.5m. Individual bar widths range from 200-400m with an average of 300m. The mouth-bar shape was modelled as a scalable crescent-shaped body based on the study of palaeo-channel reconstructions of mouth bars. The volume percentages for the final object-based lithology model were 45% for sandstone, 55% for shale in the final facies model as explained in the earlier section. Because this method uses objects with distinct shapes to control the spatial continuity and distribution of lithologies (i.e., variograms are not used), the resulting models often appear more geologically realistic as compared to the corresponding indicator-based models.

Application of seismic attributes and Wheeler transformation method for geomorphological interpretation of stratigraphic surfaces: A case study of F3 Block, Dutch offshore sector, North Sea
Md. Afifi Ishak¹, Md Aminul Islam¹, Mohamed R. Shalaby¹, Nurul Hasan¹
¹Universiti Brunei Darussalam

In seismic interpretations, accurate identification of geological features builds a better understanding of subsurface geology, which turns a prospect into a success. In some cases geological features are superimposed on a seismic map because of geophysical limitation and geological complexities. In addition, seismic data is always band-limited and it is often hampered by noise. If the geological features such as channels, faults and other structural and stratigraphic features are superimposed together with noise, interpretation and finding scientific explanations can become difficult. This research paper has managed to demonstrate how integrated interpretation of geological information (seismic attributes, sequence stratigraphic
interpretation and wheeler transformation method) allows for accurate interpretation of depositional environment of a basin as well as locating seismic geomorphological features. The research is carried out in a Pliocene interval of southern North Sea F3 Block, Netherlands. The methodology used generating a 3D dip-steered HorizonCube followed by chronostratigraphic analysis, 3D wheeler transformation and system tract interpretation. A dip-steered seismic attribute (similarity, dip and curvature) was perform on each stratigraphic surfaces of interest and isopach maps were generated for each stratigraphic surfaces to help identify maximum deposition. The result from this study shows that similarity attribute is able to identify distinct stratigraphic features such as sand-waves and deep marine meandering channel. However its lateral continuity is poorly understood as similarity attribute does not take into account the true geological dip and curvature of the surfaces. Structural features such as fault are not easily recognizable due to this reason. However, dip-apparent attribute are found to be very useful in identifying both structural and stratigraphic features. The seismic dip map is then improved by rotating the dip measurements to user-defined azimuths. Such optimization has revealed the structural and stratigraphic features that are not clearly evident on similarity and curvature attributes. Maximum curvature attribute is found to be useful in delineating faults and predicting the orientation and distribution of fractures and also subtle structural features.

**Feasibility study of SQp and SQs attributes application for facies classification**

Maman Hermana

1Universiti Teknologi PETRONAS

Formation evaluation is a critical requirement in the oil and gas exploration and production project. Even though it may be costly, the wireline logging needs to be performed in order to produce well log data and as well to understand the subsurface formation by direct measurement. Gamma ray and resistivity are main well log data which are used for the formation evaluation purposes. However, outside the well, it is still difficult to have data which can be derived from other techniques to be equivalent to the Gamma ray or resistivity logs without wire line logging. Thus, complications exist for formation evaluation outside the well such as determination of facies, lithology and fluid content as well as the petrophysical properties of certain area since accurate measurement can hardly be obtained. The objective of this paper is to demonstrate the feasible application of SQp and SQs attributes for replacing the wireline logging data for facies classification purposes. These attribute are derived from attenuation attributes through rock physics approximation by using basic elastic properties; P-wave, S-wave and density. A series of test have been carried out on datasets in Malaysian offshore, results showed that those attributes are very similar to the gamma ray and resistivity responses in different reservoir conditions including low resistivity low contrast environment and coal masking. Further application of this attributes for feasibility on lithology and hydrocarbon prediction, facies classification are presented. In well domain, the motif of SQp is likewise the Gamma ray motif, which means these attributes can potentially be used for facies classification. The application of these attributes as inputs for facies classification workflow in the area of interest showed that the sand body can be distinguished from shale and the distribution of gas sand can be separated clearly from brine sand. The SQp and SQs attributes are able to improve the facies classification and able to transform the single traces of seismic data into pseudo log of lithology (gamma ray) and fluid indicator log (resistivity).
Permeability and porosity prediction from elastic properties through laboratory measurement and well log analysis

Maman Hermana¹, Nur Farinie Mohd Fadzly¹, Santea Munagaran¹, Dana Hlaine Htet¹, Deva Ghosh¹, Chow Weng¹

¹Universiti Teknologi PETRONAS

Permeability and porosity prediction play an important role in hydrocarbon exploration because the concept of permeability and porosity would give us the idea of the fluid characteristics and capacity in the reservoir and it is also one of the factors that weigh in on the exploitability of hydrocarbon reservoir. However, because of non-unique parameters affecting the porosity and permeability such as the diagenesis processes that can alter primary porosity of reservoir rocks are: compaction, cementation and dissolution, the prediction of porosity especially permeability become harder. Besides that, the sedimentological environment plays an important role also in rock fragments content and sorting that contributes to porosity and permeability characteristics of the rock. The difficulty to predict porosity and especially the permeability of a reservoir might slow down the process of exploration and increase inefficiency. A new method needs to be developed to allow rock porosity-permeability prediction to be done in a more accurate, fast and cost effective way. It has always been assumed that porosity and permeability has a direct relationship. However, porosity is also affected by so many other factors that might affect the permeability value as well. Therefore, it is important to develop a relationship between each of permeability-porosity and other parameters. Establishing a relationship between elastic properties and permeability/porosity will enable us to predict permeability/porosity based on the elastic properties changes. The study includes acquiring porosity model for better reservoir characterization. The new attributes namely: SQp and SQs which are derived from attenuation by using rock physics approximation, give some significant improvement in determining the porosity and permeability estimation. Testing of these attributes on real data (Offshore Malaysia), the SQp and SQp/SQs attributes are not only give a better lithology and fluid indicators but also able to improve the porosity and permeability prediction from elastic properties in this field.

A holistic approach to minimise upscaling errors between geological and simulation models

Stephen Tyson¹, Morteza Jami¹

¹Universiti Teknologi Brunei

The challenge of populating reservoir flow simulation models with effective properties that represent the underlying geology and capture the flow behaviour of the system was believed to be an interim requirement when upscaling techniques were developed in the late 1980s and early 90s. There was a belief that more powerful computers would alleviate the need for upscaling by allowing the flow simulation to be run directly on the geological grid. Rather surprisingly, the need to upscale has not disappeared but has become more ubiquitous as engineers have preferred to continue running flow simulations on coarser models, for a variety of reasons, including the need to simulate multiple geological and flow scenarios which wasn’t anticipated in the early 90s. This paper assesses the currently available upscaling techniques then identifies and discusses the single most common source of inaccuracy in upscaling: cell geometry. The impact of geometry errors in geological and simulation grids is covered in the context of currently available software and its limitations. Alternative workflows that minimise errors within the constraints of existing software will be discussed and the suitability of gridding...
algorithms for both the geological and simulation model will be analysed. The impact of the change of scale between the geological and simulation grid is considered and it will be shown that more accurate representations of effective properties will be obtained when there is a significant change in resolution between the fine-scale geological grid and the coarser-scale simulation grid. This leads naturally into a discussion of the requirement for geological grids with billions of cells and some of the issues surrounding this anticipated requirement. Finally, the paper presents a holistic approach to upscaling all geological model properties, in a way that preserves the precise bulk, pore and fluid volumes between the geological and simulation models.

Improving seismic imaging with multiple scattering incorporation in joint migration inversion

Haigal Hazreeq Hairi¹, Abdul Ghani MdRafek¹, Abdul Halim Abdul Latiff²

¹PETRONAS University of Technology, Faculty of Geoscience, Jalan Desa Seri Iskandar, 32610, Bota, Perak, Malaysia

Conventional seismic imaging approach has always considered multiple scattering as unwanted noise and must be removed prior to migration. Due to this understanding, the industry has invested an immense amount of resources into research as efforts to eliminate as much multiple noise as possible in seismic processing. This approach is considered inefficient as a large portion of energy and precious subsurface information is removed before migration process. Today, we are beginning to understand seismic multiples carry indispensable information that should be preserved and could be utilised to improve the final subsurface image. Multiples record more information than primary waves since they travel a longer distance and experience more bounce in the subsurface. As a result, new algorithms have been developed to utilise and incorporate multiple scattering to aid seismic imaging in producing better seismic image. This technique is currently known as Full-Wavefield Migration or FWM. In addition, this newly introduced algorithms could be extended that will also allow autonomous velocity field estimation to be done alongside the migration process, by which it is currently being referred to as Joint Migration Inversion, JMI. FWM and JMI open new possibilities in seismic imaging especially towards improving our subsurface imaging capabilities and towards a fully automated imaging process which the industry is currently striving for. Conventional migration technique makes use of an open-looped approach where multiple scatterings were removed prior to migration, making the output data inconsistence with the input. To handle seismic data in a full-wavefield manner, an open-looped is not feasible anymore, instead a closed-looped approach should be used. JMI works is a way of matching forward modelled seismic data to the measured seismic data in difference minimisation process. The forward modelling module or FWMod is applied in the feedback path of the closed-looped migration approach that will executed iteratively with the inclusion of multiple scatterings. The final output would be an accurate depth section as well as detailed velocity field data used in the migration process. A few of JMI’s strong points include: 1) multiple scattering is utilised to improve seismic image and velocity field determination, and 2) data input and output are more consistent since multiples are incorporated in the migration process, thus less energy is wasted. To meet the challenges of understanding more complex subsurface features – such as a deep reservoir underlying a high contrast inhomogeneous and anisotropic overburden – utilisation of multiples has become more logical and crucial.
Short range permeability prediction of Jurassic Walloon coal seams, Surat Basin, Australia

Morteza Jami¹, Stephen Tyson¹

¹University of Technology Brunei Darussalam, Faculty of Engineering, Department of Petroleum and Chemical Engineering, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

The Jurassic Surat Basin in Eastern Australia hosts the Walloon Coal Measures, one of the major coal seam gas reserves of the world. The Walloon Subgroup has an average 200-350 m thickness and contains up to 36 coal seams with an average 30 m of net coal interbedded with clay-silty rich, fluvio-lacustrine units. The highly heterogeneous nature of the Walloon Subgroup and associated coal seams created a high uncertainty on prediction of the reservoir properties. Permeability is by far one of the most important properties controlling reservoir performance. Understanding the spatial distribution of these heterogeneities in the short range between data points is crucial to the development of these unconventional fields. Permeability as a fundamental rock property, reflects the reservoir’s deliverability and is a function of stress regime, coal properties, depth and cleat system development. Forecasting short-range variation of coal seam absolute and relative permeability through modelling is the key to the reservoir simulation models. This extended abstract evaluates the geological and geomechanical variables which impact the short-range coal permeability. The relative impact of these variables are estimated in a non-parametric model to evaluate the short-range permeability using lateral variability in close-spaced pilot wells. The permeability prediction model was developed using the DST results, geophysical well log data and stratigraphic architecture of closed space drilled pilot wells.
Optimization of rock physics models by combining differential effective medium (DEM) and adaptive Batzel-Wang Methods in “R” carbonate field east Java

Reza Wardhana¹, M. Iksan¹, M. Syamsu Rosid¹, M. Wahdanadi Haidar²

¹Department of Physics, University of Indonesia, Depok 16424, Indonesia
²JOB Pertamina Petrochina East Java, Menara Kuningan Fl. 18 and 20, Jakarta 12940, Indonesia

Pore system in the carbonate reservoirs are very complex than clastic rocks. There are three types of geophysical pores in carbonate rocks, the interparticle, stiff and crack. The complexity of the pore types will lead to changes in P-wave velocity by 40%. Characterization of carbonate reservoir becomes difficult when the estimated S-wave is influenced by the type of dominant pore (interparticle) only. In addition, the geometry of the pores also affects permeability of the reservoir character. Therefore, modelling the elastic modulus of rock taking into account the complexity of type pores in carbonate rocks become very important. Differential Effective Medium (DEM) is a good method for modelling the elastic modulus of rock that has heterogeneity of pores type. The method is done by adding a pore-type inclusions little by little into the host material until the proportion of the material is reached. In addition, to achieve the optimal model, the modelling is created by calculating the bulk modulus of the fluid filler porous rock at the reservoir condition by using Adaptive Batzle-Wang. The fluid model is injected to the rock model in advance using Wood’s equation then count back the value of the P-wave velocity model to estimate the velocity of the S-wave and the percentage of primary and secondary pore type on the rock. To describe the geometry of pores in carbonate rocks we apply an aspect ratio approach. The aspect ratio for crack, interparticle, and stiff pore types are 0.02, 0.15 and 0.8, respectively. The results of our study in the field of “R” show that dominant pore type at well “RZ-14” is still the interparticle which average value is 50%, while for the type of secondary porous of stiff and crack has an average value of 20% and 30%, respectively. So “R” field dominated by crack pore types as the secondary porosity in the reservoir. When the Adaptive Batzle-Wang fluid elastic parameter is apply, the RMS error value of rock model is diminished and has different quantity value of pore-type inversions prior to using the elastic parameter of the fluid. This shows that the use of Adaptive Batzle-Wang fluid elastic parameters is very useful to optimize rock physics modelling of DEM.

Pore pressure estimation in carbonate reservoir by integrating differential effective medium and fluid replacement model

M. Ravdi Hirzan¹, Reza Wardhana¹, M. Iksan¹, M. Syamsu Rosid¹, M. Wahdanadi Haidar²

¹Department of Physics, FMIPA Universitas Indonesia, Depok 16424, Indonesia
²JOB Pertamina-Petrochina East Java, Menara Kuningan Fl. 18 and 20, Jakarta, Indonesia

Pore pressure is one of the main parameters in oil and gas drilling plans. Effect of pore pressure is important to avoid high risks either low pressure zone or blast zone. Therefore, accurately pore pressure prediction of heterogeneous reservoir characters is required. The most accurate prediction of pore pressure is the pore compressibility method (PC) that uses core data. Unfortunately, this approach is limited by availability core data. To solve the problems of heterogeneous characteristic on carbonate reservoir and core data limitation, this research is integrating the DEM method and Fluid Replacement Model (FRM) into the pore pressure prediction PC method. Using DEM, reservoir description is obtainable through mineral analysis and pore type. Pore pressure prediction using PC
method depend on parameters of bulk compressibility (Cb) and pore compressibility (Cp), where each of carbonate reservoir pore types have different value of Cb and Cp. We use the value of both compressibility from a result of DEM process with Gassman equation to overcome the limited core data. Pore pressure is also sensitive for fluids inside the pore. Therefore, fluid that is used for this study is identical with the fluids on the reservoir so that the calculation can be more accurate. The result of pore pressure prediction using PC method on carbonate reservoir Field “M” is about 3000 psi to 4000 psi, which is verified by the FMT (Formation Multi Tester) pressure data and mud log data from the wells. Recommended mudweight for our wells carbonate reservoir is about 12.6 ppg to 13.6 ppg.

In this study, we compared the two methods to determine the similarities and differences of them, and to see how effective and accurate in determination of permeability zones for each pore type of the carbonate reservoir. So that permeable zone can be obtained for each type of pore at R wells. From this result, the permeability value in rocktyping method is 0.013932 - 3617,689 mD on upper Tuban and 0.0002 - 1814,108 mD at bottom Tuban. By using Stoneley wave parameters, the permeability value on upper Tuban is 34,01 - 34,074 mD and 33,99 - 34,082 mD at bottom Tuban. Thus, in the R field it was found that the estimate of permeable zone determination based on pore type more effective and efficient by using rocktyping method.

Opening a new play in eastern Brunei

Andrew Carnell¹, Syahida Mat Daud¹, Kaushal Barfal¹, Joshua Turner¹

¹Shell Deepwater Borneo

Shell Deepwater Borneo and partner Petroleum Brunei Explo are planning an exploration well aiming to test a new play concept in eastern Brunei. If successful it will be a significant addition to Brunei’s hydrocarbon resource base with much associated follow-up potential. The prospect itself is a large faulted anticline located in Block A in eastern Brunei. The recognition of a drillworthy prospect results from innovative working practices and challenging existing dogmas around depositional setting. The prospect is covered by a number of seismic surveys, but the seismic image is consistently poor due to the masking effect of a large gas cloud. In 2014 the Broadseis east survey was reprocessed using QRTM. This lead to some upgrade in image, but did not address the fundamental issue of velocity slow down caused by a gas cloud. The degree of slowdown was unclear and initial reductions in velocity by increments of 25m/s had limited impact. The project
team requested trying much larger reductions at the heart of the gas cloud with velocity as low as 1100m/s. The outcome was startling with structures becoming visible at depth. Subsequent iterations of the velocity model scaled back the velocity reduction, and varied the geometry of the gas cloud. Ultimately 44 iterations velocity model were generated and a final QRTM was applied to this. Seismic reprocessing allowed recognition of an internally stratified faulted anticline. The prevailing model of turbidite deposition suggests a likely shale fill. However, examination of wells and seismic in Brunei and adjacent areas of Malaysia suggests that although this model is widely accepted there is limited supporting evidence. Although thousands of wells have been drilled, relatively few have penetrated the interval of interest. This is particularly the case in the offshore Brunei area. The nearest directly relevant well is 70km south east in Sabah and comprises fluvio-deltaic to shelfal clastics. Deepwater sediments are encountered further offshore to the north. Evaluation of seismic data suggests that shelfal sediments continue out to the Champion-Potter fault before being down thrown to the north and seismic resolution is lost. Outboard of the Frigate fault pre-MMU sediments are considerably shallower but have not been penetrated and seismic quality is very poor. The exploration well aims to test an alternative concept of shelfal deposition extending out to Block A in a manner similar to the modern Brunei shelf. This well is currently in planning and aims to spud in 2018.
POSTER PRESENTATIONS

Phase behaviour modelling of natural gas in northeastern Thailand

Piyaporn Kaewraks1, Sarunya Promkotra1, Tawiwan Kangsadan2

1Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen, Thailand
2Chemical and Process Engineering (CPE) Program, The Sirindhorn International Thai-German Graduate School of Engineering (TGGS) King Mongkut's University of Technology North Bangkok (KMUENB), Thailand

Natural gas in Sinphuhorm Gas Field, a dry gas reservoir, northeast region of Thailand is considered as a relationship of chemical species to predict phase behaviours by thermodynamic simulation. Phase diagrams related to temperature (T) and pressure (P) dominate phase behaviours of natural gas in subsurface. The sub-chemical reactions are assumed by chemical relationship of their components which similar to chemical compositions of natural gas. These diagrams are achieved by thermodynamics simulation based on Peng-Robinson model combined with the Prode Properties program. Critical points as a function of mole fraction of methane are obtained by the phase envelope. Pressures at these critical points are mostly proportional to the increasing mole fraction of methane. While pressures encounter to temperatures, these points concern to the specific mole fraction of methane. Equilibrium conditions at this point are equivalent to methane mass. This circumstantial criterion associated to pressures and also temperatures are found the polynomial relationship. Pressures are more influence to methane (in reactant) at all chemical reactions. At approximately 0.6 mole of methane, the P and T are limited, less than 32,000 kPa.a and 450 K, respectively. These associations are beneficial for prediction and controlling the phase behaviours in the petroleum reservoir.

Rock physics template application on carbonate reservoir

Judy Hilman1, Ignatius S. Winardhi1

1Department of Geophysics, Institute of Technology Bandung

A good petroleum system needs a good reservoir to properly accommodate petroleum. Thus it needs a good characterization to fully understand its properties, in which one of the method is known as utilizing Rock Physics Template (RPT). This method attempts to characterize a reservoir in order to predict the behaviour of the reservoir, such as different porosities and water saturation. However, most of RPT technique applications are limited to granular rocks and not enough on carbonates. Although carbonates generally have good properties as reservoir rocks, it is proven to be more difficult to ascertain. The complex system of carbonates porosities often gives scatter pattern on the porosity and P-wave relationship. Therefore, this research will attempt to use RPT to model carbonate reservoir. This will be achieved by using Kuster Toksoz as the basis for carbonate rock modelling and by the help from Biot-Gassmann equation. The study object of this thesis is on Baturaja formation that is located in South Sumatra Basin. This formation is known to be a carbonate reservoir that has produced gas hydrocarbon. This thesis offers an approach on how to better understand the application of RPT on Baturaja formation. Based on the RPT modelling done in this research, some specific parameter needs to be obtained in order to develop a functional RPT model. These parameters are aspect ratio of the porosities and elastic modulus of the minerals.
Session 03: Geodynamics and Geohazards

Chairpersons: Afroz Ahmad Shah & Ashar Lubis

ORAL PRESENTATIONS

Wednesday 15 November 2017

Preliminary assessment on potential karst geohazards using electrical resistivity imaging

Zaitul Zahira Ghazali¹, Khiruddin Abdullah², Mohd Nawawi², Ismail Ahmad Abir², Mohd Amin Mohd For³, Tajul Anuar Jamaluddin⁴

¹Geoscience Department, Faculty of Earth Science, Universiti Malaysia Kelantan, Locked Bag No 100, 17600 Jeli, Kelantan, Malaysia
²Geophysics Program, School of Physics, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia
³Department of Geotechnics & Transportation, Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia
⁴Geology Program, School of Environment & Natural Resource Sciences, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Limestone consists of calcite and dolomite mineral that easily weathered due to chemical weathering (dissolution) even in slightly acidic water or rainfall. The dissolution process will change and develop karstic features that create various engineering geology and geotechnical problems during construction. If this problem is not identified during or before construction, it may lead to future karst geohazards, such as collapse of the cavities, ground subsidence, sinkhole, etc. Other than threatening existing landuse, karst geohazards will also affect future development planning and urban safety.

Gua Musang is a district in Kelantan surrounded by mogote hills that were metamorphosed due to granite intrusion during the Cainozoic era (~65 million years ago). Currently, the town of Gua Musang is facing rapid development. However, no karst geohazards research has been conducted in Gua Musang. Therefore, this research aims to image karstic features and detect potential karst geohazards surrounding the Mogote hills using Electrical Resistivity Imaging. Resistivity technique is capable to map potential karst geohazards based on its capacity in detecting resistive features and differentiating resistivity distinctions. The resistivity profiles were acquired for eight selected mogote hills surrounding Gua Musang town, which includes Gua Musang, Gua Serai, Gua Batu Boh, Gua Madu, Gua Panjang, Batu Neng, Batu Papan, and Batu Machang. A total of seventeen resistivity profiles were obtained using pole-dipole array with length of 200–400 meters with electrode spacing of 5 meters nearby the Mogote hills. From the field anomaly data, the apparent resistivity was inverted to real resistivity with 2D algorithm using the RES2DINV software. During the inversion, the data smoothness constraints were modified based on the least-squares technique. The inverted resistivity pseudo-section presented a clear view of the weathered rock distribution and class, bedrock, and karstic features. The resistivity values were classified into eight ranges representing different materials (in ohm.m): soil (0–10), freshwater (10–50), highly weathered limestone (50–80), moderately weathered limestone (80–300), slightly weathered (300–550), fresh limestone (550–1,000), dolomite (1,000–10,000), and marble (>10,000). The results show numerous identified potential cavities and sinkholes. Out of seventeen profiles, twelve profiles show karstic features; one profile showing both potential roof collapse and generated cavity/cavities, four profiles showing...
potential of roof collapse, eleven profiles showing generated cavity/cavities and four profiles showing massive weathering. Results demonstrate that resistivity is capable for effective detection and viewing potential karst geohazards.

**Inferring the earthquake interaction using stress triggering concept**

David P. Sahara¹, Nanang T. Puspito¹, Dian Kusumawati¹, Andri D. Nugraha¹

¹Global geophysics research group, Faculty of Petroleum and Mining Engineering, Institut Teknologi Bandung, Jl. Ganesha 10, Bandung 40132

Many aspects of earthquake mechanics remain an enigma, e.g. earthquake interaction and mitigation. One potential bright spot is the finding that simple calculations of stress changes may explain some earthquake occurrences and interactions. This progress is especially lead by abundant studies of stress changes of human-induced seismicity. This work introduces stress triggers, stress shadows, and implications for seismic hazard in Indonesia. We review our work in stress analysis of 2006 Yogyakarta and 2016 Aceh earthquake and presents a compilation of quantitative earthquake interaction studies from a stress change perspective. Those two earthquakes were both deadly, caused more than 1000 causalities, and unpredicted, in the sense that the driving force and the source mechanism are still unclear. No information was present on the extent of the faulting or the direction of propagation of those two earthquakes. Therefore, it requires a stress transfer modelling in order to understand the possible seismic hazard distribution. The results of this study supply some clues about certain aspects of earthquake mechanics. It also demonstrates that much work remains before we can understand the complete story of how earthquakes work.

**Hypocenter relocation of earthquake in central and east Java, Indonesia using the BMKG network data**

Andri Dian Nugraha¹, Sri Widiyantoro¹, Nanang T. Puspito¹, Pepen Supendi²,³

¹Global Geophysics Research Group, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia
²Geophysical Engineering Study Program, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia
³Agency for Meteorology, Climatology and Geophysics (BMKG), Bandung, Indonesia

Central Java and East Java regions have experienced a high seismicity activity due to the subduction of the Indo-Australian plate in the south beneath the Eurasian plate of the island of Java. In addition, in the mainland of this island also have many active faults due this situation. We have successfully relocated earthquake in the area from April 2009 to September 2017 using the BMKG seismic station network data through hypocenter double-difference method. The results indicate significant improvement in hypocenter location, where the initial earthquake focal depths fixed at a depth of 10 km has been updated. A validation through the histogram of travel-time residual depicts good relocation results, in which the residual values are mostly close to zero. The results show the relocated earthquakes at shallow depth show some clusters around the inland active fault, such as in Opak fault, Merapi-Merbabu fault, Kendeng thrust fault, and Wonsorejo fault zones. At the beginning of 2016 there has been a swarm earthquake in southern Kendeng thrust fault zone where these earthquake swarms probably associated with volcano-tectonic activity. The relocated hypocenter is also clearly observed along the intraslab of Indo-Australian.
Application of Gumbel I and Monte Carlo methods to assess seismic hazard in and around Pakistan

Khaista Rehman1,2, Paul W. Burton2, Graeme A. Weatherill2

1National Centre of Excellence in Geology, University of Peshawar, 25120, Pakistan
2School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK

Tectonics of Pakistan is governed by three tectonic plates: (a) the Indian plate; (b) the Eurasian plate; and (c) the Arabian plate. Also the Kutch fault zone in the intraplate region in south east border with India. The former two (a and b) continental plates are colliding throughout Pakistan. This work presents probabilistic seismic hazard assessment in and around Pakistan in terms of Peak Ground Acceleration (PGA). Ground motion is considered in terms of PGA for return period of 475 years using Gumbel first distribution of extreme values and Monte Carlo Simulation. In order to undertake this study the input data contain the instrumental earthquake data from the International Seismological Centre (ISC) and United States Geological Survey (USGS)/Preliminary Determination of Epicentres (PDE) for the period of 1900 to 2007. Appropriate ground motion prediction equations have been used in this study. The results show that for many parts of Pakistan, the expected seismic hazard is relatively comparable with the level specified in the present PGA maps. Major sources of earthquake hazards (e.g. Himalayas, Hindu Kush, Chaman fault system, Makran and Kutch) are identified and appraised in the context of the regional tectonics and current state-of-the-art.

Influence of shear strength on the reactivation of an old landslide: A case study at Three Gorges reservoir

Vera Hui Loo1, Leslie George Tham2, Chak Fan Lee3

1Department of Civil and Construction Engineering, Curtin University Malaysia
2Department of Civil Engineering, The University of Hong Kong
3The University of Hong Kong

Reservoir landslides triggered by reservoir impoundment, drawdown, subsequent fluctuations and rainfall have well been recognized. In this present work, an old landslide located at Three Gorges reservoir areas was chosen to study the influence of shear strength to its stability in response to reservoir impoundment and subsequent fluctuations. This old landslide is a colluvial deposited type with a continuous slip soil of sandy and/or gravelly clay beneath the colluvial deposits and the strata dip into the slope beneath the slip soil. Laboratory tests were carried out on both undisturbed and reconstituted samples to study the effective shear strength of slip soil. The influence of degree of saturation on the effective strength of slip soil was also carried out. From the laboratory testing results, high cohesive value of slip soil was obtained. Stability of this old landslide was analyzed numerically by GeoStudio software. The results showed that the unsaturated shear strength of slip soil above the reservoir level has significant influence on the stability of the slope. The slope would be in a critical state and the reactivation of the landslide could happen if the loss of cohesion of slip soil. The results provide a good reference to the similar natural slope in Three Gorges reservoir area.

Tectonics geomorphology of Borneo

Shah A. A.1, Delson Bin Jumat1, Khairul Zafry1, Navakanesh M Batmanathan2

1Department of Physical and Geological Sciences, Universiti Brunei Darussalam, Brunei
2Curtin Sarawak, Malaysia

We report mapping of major fault zones in Borneo by using freely available Google satellite and global multi-resolution topography data. Our topographic analyses of landforms rely on the
geomorphic expression of faulting. The evidence of faulting is widespread, and visible for more than 900 km throughout the extent of the Island. A large number of rupture zones are mapped, which are characterized by the occurrence of active fault scarps, eye-catching drainage offsets, topographic breaks, deflected drainages, ridge axis offsets, and broken Holocene to Recent sedimentary sequence. Broadly ~NW-SE dextral strike-slip faults dominate the central Borneo Island, and are cut through by ~NE-SW trending sinistral strike-slip faults, and form characteristic diamond shaped landforms. These faults root from the central fault that we infer is a large scale sinistral strike-slip fault that runs for > 900 km throughout the island and forms its backbone. The whole of the Island seems to be controlled by this structure and fits a large scale dextral shear model. The nature, and extent of faulting in Borneo is very large, and therefore we propose a new large scale simple shear tectonic model and demonstrate how the Island’s geology, geomorphology, and seismicity supports our model, and disproves the gravity driven deformation models. Our tectonic model argues the potential of major earthquake occurrences on the newly mapped sinistral fault systems, and less so the normal faults. It also shows that the 2015 Ranau earthquake that struck Sabah, Malaysia occurred on a —northwest dipping normal fault that is part of the regional oblique compression, and lateral extension associated with the major sinistral faulting.

Tectonic plate movement along the fault plane may strike disaster at any given destination without warning, which may be one of the aspects that hamper a destinations image and the people who lives in the vicinity, so to avoid raising any such issues, in a given situation any destination must be well equipped to combat the catastrophe. In light of the disaster that occurred in Nepal which hit by an earthquake with a magnitude of 7.9 on Saturday 25th April 2015 at 11.41 am (local time), the worst in 81 years. As a result of the shallow nature of the earthquake, the impacts have been devastating, toppling buildings, opening gaping cracks in roads and sending people rushing into the open as aftershocks rattled their damaged homes. Every earthquake offers a learning experience, enabling researchers to be prepared for future events. So is the recent pair of large earthquakes that shook parts of Nepal and the northern Indian plains. Even at the face of the tragedy that an earthquake brings along, earthquake scientists must prepare themselves to go through its effects on natural settings as well as built environment. The April 25th and May 12th, 2015 earthquakes in Nepal present themselves as the two major post-instrumentation era events in the Himalayan region and they provide an unprecedented opportunity to study the earthquakes in relation to the seismo-tectonic settings of the Himalayan convergence. It is quite well-known that the present-day structure of the Himalaya has resulted from the progressive under thrusting of the Indian plate, leading to a stack of thrust sheets that get progressively younger, southward. Every earthquake offers a learning experience, enabling researchers to be prepared for future events. In this geometry, the oldest and the northernmost is the Main Central Thrust (MCT), followed by the Main Boundary
Thrust (MBT) and the Main Frontal Thrust (MFT), all of which sole into the Main Himalayan Thrust (MHT). The deeper part of the MHT is believed to be creeping smoothly while the shallower parts slips episodically during great earthquakes such as the 1905 Kangra and 1934 Nepal events. The Ministry of Earth Sciences and the Indian Institute of Science have provided the opportunity to learn from the actual effects of a large Himalayan earthquake. “Disasters are not learning processes. The authorities will have to do all they can do to ensure against such recurrences...the starting point is for the Disaster Management Authority to put place a disaster management plan”. Thus, unforeseen disasters calls for having an effective disaster management plan in place and for the Disaster Management Authority to prepare actionable programmes to deal with disasters.
A series of major normal faults are mapped in Kashmir, NW Himalaya. This is achieved by geomorphic analysis of tectonic landforms on a variety of satellite images that include Google maps, Global earth, and global multi resolution topography. The geomorphic expression of faulting is widespread, and is characterized by mapping of active fault rupture zones, fault scarps, topographic breaks, deflected drainages, ridge axes offset, and broken Holocene to Recent sedimentary sequences. The faults dominantly trend ~NE-SW with some ~NNW-SSE. The nature of faulting clearly suggests ~NW-SE extension on a regional scale, and this is ~orthogonal to the regional convergence between India and the Southern Tibet. This is the first study to argue for the regional extension in this portion of the NW Himalaya, and we propose a new tectonic model for the formation of these normal faults, and prove that these faults are syntectonic. We have produced expected earthquake focal mechanism “beach ball” on each fault, and we show what type of earthquake is possible on a fault. Our model supports the observed seismicity, and corroborates well with the available geodetic, and geologic data in the region.
Session 04: Solid Geophysics  
Chairperson: Md Aminul Islam & Mohamed Ragab Shalaby

ORAL PRESENTATIONS

Wednesday 15 November 2017

Digital rock physics: Effect of image segmentation on the calculation of porosity and absolute permeability of reservoir core plug sample

Chandra Widyananda Winardhi\textsuperscript{1}, Fourier Dzar Eljabbar Latief\textsuperscript{1}, Umar Fauzi\textsuperscript{1}

\textsuperscript{1}Institut Teknologi Bandung, Faculty of Mathematics and Natural Sciences, Department of Physics, Jalan Ganesha, 40132, Bandung, Indonesia

Knowledge about physical properties of reservoir rocks such as porosity, permeability, capillary pressure, and conductivity, is very significant in determining the quality of a reservoir. Measurements of the properties were commonly carried out in the laboratory which sometimes can damage the sample. Digital Rock Physics (DRP) was developed as a new method as a complement to the laboratory measurement. This method uses digital images of rock from CT-Scan to obtain the necessary physical properties to determine the quality of the reservoir. In this study, Bruker SkyScan 1173 CT was used. Image thresholding or image segmentation plays an important role in DRP analysis. Inaccuracy in determining the segmentation can cause error in calculating the physical properties. A one and a half inch core plug was scanned with a 7.83 m/pixel resolution where 30 sub samples were randomly selected with size of 2.5mm\textsuperscript{2}. For the analysis: three image segmentation methods were applied to the sub samples, and the porosity and the absolute permeability will be calculated subsequently. The segmentation methods are Otsu (global-threshold based method), semi-automatic, and Adaptive Mean segmentation. For the porosity calculation, Otsu segmentation produced an average error of 62.04\% and the sub sample porosities are ranged between 12-38\%, the semi-automatic segmentation give an average error of 2.05\% and the sub sample porosities are ranged between 4-36\%, and the adaptive mean segmentation produced an average error of 1.92\% and the sub sample porosities are ranged between 13\% to 21\%. Due to the enormous error for the Otsu segmentation, only semi-automatic and adaptive mean segmentations are used for permeability calculation. The permeability was calculated using Parallel Lattice Boltzmann Solver (Palabos), the permeability is then plotted vs. porosity of the sub sample and compared to the result from laboratory measurement, which is 18.66\% for porosity and 447 mD for permeability. The average permeability of semi-automatic was 5556.57 mD and the average permeability of adaptive mean was 446.23 mD. The distribution of semi-automatic segmentation permeability appears to be significantly dispersed and is quite off to the laboratory measurement. On the other hand, the distribution of the adaptive mean permeability appears to be closer to the result from laboratory measurement. From this study it is concluded that the adaptive mean segmentation gives a better result compared to the Otsu and semi-automatic segmentation and give a more reliable data for physical properties calculation in Digital Rock Physics.

Resolution enhancement of seismic reflection data using S-transform

Sonny Winardhi\textsuperscript{1}, Waskito Pranowo\textsuperscript{2}

\textsuperscript{1}Institut Teknologi Bandung, Faculty of Mining and Petroleum Engineering, Geophysical Engineering Department, Jalan Ganesha 10, Bandung 40132, Indonesia
Range of frequencies (bandwidth) presents in the seismic reflection data, is an important factor that controls vertical resolution of the data. Broader bandwidth enables the data to be interpreted and further analyzed for stratigraphic detail. A number of methods have been proposed in extending the seismic frequency bandwidth using either time-invariant or time-variant approaches. Inverse Q-filtering and Continuous Wavelet Transform (CWT), to name a few, are the time-variant methodologies used commonly for enhancing vertical resolution of the seismic data. However, inverse-Q filtering requires the knowledge of the subsurface Q-values. Meanwhile, CWT assumes that a certain type of wavelet exists in the seismic data. This paper proposes a time-variant methodology for extending seismic bandwidth using Stockwell Transform (S-Transform) which does not require information of the subsurface's Q-values nor assumption that a certain type of wavelets exist in the data. It is a data-driven methodology which is solely based on the seismic data. Time-variant wavelet is extracted from seismic data and used as input in the enhancement process. Results of applying the proposed method to both synthetic and field data show that overall seismic bandwidth can be broadened resulting in higher vertical resolution after enhancement. Better correlation with VSP corridor stack at well location ensures that the result of new reflection detail generated after enhancement is geologically plausible.

Study on P-wave and S-wave velocity in dry sandstones of the Talang Akar Formation, northwest Java Basin, Indonesia

Sonny Winardhi¹, Suryo Prakoso², Dona Sita Ambarsari¹

¹Institut Teknologi Bandung, Faculty of Mining and Petroleum Engineering, Geophysical Engineering Department, Jalan Ganesha 10, Bandung 40132, Indonesia
²University of Pertamina, Faculty of Exploration and Production Technology, Geophysical Engineering Department, Jalan Teuku Nyak Arief, Kebayoran Lama, Jakarta 12220, Indonesia

Laboratory measurements of P-wave and S-wave velocity have been conducted for 116 sandstones core samples of the Talang Akar Formation from the Northwest Java Basin, Indonesia. The samples are predominantly composed of quartz mineral, with a mixture of clay, calcite and other minerals of less than 10 percent. Routine and special core analysis data such as porosity, permeability and petrographic data (thin slices) have also been used in the analysis. The aim of the study is to better understand the behavior of P- and S-waves velocity in dry porous sandstone, related to porosity and permeability. The porosity, permeability, and grain density ranges from 9 to 32 %, 0.06 to 525 mD, and 2.58 to 2.73 g/cc, respectively. Meanwhile, the measured P-wave and S-wave velocity in dry rock samples ranges from 1364 to 3563 m/s and 932 to 2465 m/s, respectively, giving dry rock Poisson's ratio value of 0.004 to 0.258. Since velocity depends on pore space volume and geometry (dry frame) as well as mineral matrix, a number of models which illustrate the relation between the moduli of the dry frame and that of the matrix have been examined. We have applied models from Krief, Nur, Pride, and a modified Raymer-Hunt-Gardner of Dvorkin in order to determine bounds in the mineral matrix moduli. The nature of a relation between porosity, permeability, and velocity is found better by sorting and grouping the rock samples into a number of porous rock types which are calculated from the measured porosity, permeability, grain density, and the estimated compaction factor.
Establishing correlations between rock mechanics parameters and geophysical parameters offers a possibility of estimating one parameter when the other parameter is measured. In this study, a correlation was conducted between the resistivity log responses (RES) and the rock quality designation, RQD from specific zones at different depths. Theoretically, separation between resistivity means the formation fluid is different from the drilling fluid and the formation is permeable to the drilling fluid. RQD values are lower at fracture zones and this cause drilling fluid to permeate the formation, resulting in high resistivity values. However, the drilling fluid used in this well is fresh water which is conductive. Thus, RES values will decrease. High RES values can also indicate tight zones within the well. Since CTW-1 is a non-hydrocarbon well with low porosity, the grains become a non-conductive medium. The gamma ray (GR) and resistivity log have similar patterns corresponding to the lithology of the formation. The results show that symmetrical or cylinder curve pattern of GR and high RES have RQD >75% is classified as tight zone. The intact rock quality is good to excellent but has a very low porosity. Moreover, the log response might vary from different wells with different lithologies. Nevertheless, determining the correlation of RQD values with well logging values enables an estimation of the rock quality of rock mass from a well at the early stage of an investigation.
Structure and facies identification in Towuti Lake through surface related multiple elimination (SRME) and common reflection surface (CRS) methods in seismic data processing

Abd hafidz¹, Satria Bijaksana¹, Wahyu Triyoso¹, James M. Russell², Nigel Watruss³, Hendik Vogel⁴

¹Faculty of Mining and Petroleum engineering, Institut Teknologi Bandung, Jalan Ganesa 10 Bandung, 40132, Indonesia
²Department of Earth, Environmental, and Planetary Sciences, Brown University, 324 Brook St., Providence, RI, 02912, USA
³Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN, 55812, USA
⁴Institute of Geological Science & Oeschger Center for Climate Change Research, University of Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland

Quaternary sediment deposits in Lake Towuti stored the history of that lake. The sediments accumulating in Towuti are draped onto ophiolitic and metamorphic rocks of East Sulawesi. Bedrock topography and basin formation is heavily influenced by active tectonics, which are thought to exert the dominant control on depositional models in Towuti on geological time-scales. A high resolution seismic reflection survey was used to reveal the subsurface sedimentary architecture of the lake. In this study, four crossed seismic lines were subjected to SRME (Surface Related Multiple Elimination) and CRS (Common Reflection Surface) processing methods. SRME and predictive deconvolution were used to attenuate the presence of long and short period multiples, while CRS was used to improve S/N ratio, signal clarity and fidelity. These combined methods were then used to ease the interpretation and sedimentary characterization. The result shows that the basin is bordered by strike-slip and normal fault that subsidence are exceeding deposition by far. The fault can be traced to the surface and its extension can be aligned with the topographic lineament around the lake. Sediment delivered by the Mahalona river, Towuti’s largest inlet, can be traced in seismic profiles and indicate a prograding pattern towards the deep north-eastern basin of the lake. The sediment all indicate highly dynamic tectonic and sedimentary process operating in the lake.

Web application for seismic data processing with an example of Morlet Wavelet transform

Has Priahadena¹, Awali Priyono¹, Permana Citra Adi¹, Rudy Prihartoro¹, Muhammad Yunus¹

¹Geophysical Engineering Department, Institut Teknologi Bandung (ITB)

Geophysical software is often limited only to certain operating system and cannot be accessed remotely (non-internet base). Nowadays, the advancement of web technology has enabled an application to be run on web browser which is an internet base software and can run cross platform among devices (e.g. pc, laptop, tablet and even smart phone). This research presents an alternative approach to develop geophysical application by taking the advantages of web technology (JavaScript) for numerical programming and wide availability of web browser. We have developed web applications for spectral decomposition of Morlet wavelet transform (MWT), Magnetotelluric (MT), Gravity and Well-log (www.surfgaeoid.com). In this article we are going to cover only spectral decomposition of MWT for signal processing analysis. The signal decomposition process of MWT calculated on frequency domain by applying Parseval’s and convolution theorem using JavaScript programming language. The key method in using JavaScript for the calculation of MWT equation relies on the arrangement of the array structures. Unlike
Matlab or the other languages in which array can be presented in the 2D structure of row and column, JavaScript 2D array structure can be achieved with array inside of the array. This technique we found performs quite decent for looping calculation. We also present the modified Morlet wavelet transform equation specifically for the structure of the JavaScript language since it doesn’t support a direct calculation of complex number A*B where A = a + ib and B = c + id. Furthermore, we provide the source code of MWT function for free in our website www.surfgaeoid.com/sources_mwt.js. The web application result is capable of opening, reading and processing data with extension .txt in which widely accepted standard file. Our web application produces the same time-frequency map compared to previous publication of Castagna about spectral decomposition for reservoir gas detection.

Linking geostatistic methods: Co-kiriging principal component analysis (PCA) with integrated well data and seismic inversion, acoustic impedance (AI) for pre-detailed hydrocarbon prospection (case study: Field X)

Ryan Bobby Andika¹, Haritsari Dewi¹

¹Departemen of Geophysical Engineering, Faculty of Mining and Petroleum Engineering, Bandung Institute of Technology Jl. Ganesha No.10, Lb. Siliwangi, Coblong, Bandung, West Java

In this global era, the energy demand is on rise with social and economic development in the world. Current hydrocarbon demand is much more than domestic crude oil and natural gas production. In order to bridge the gap between energy supply and demand, it is imperative to accelerate the exploration activities and develop some new effective and efficient techniques to discover hydrocarbon. Therefore, this research presents a new scenario to integrate seismic inversion data, well data, and geostatistical methods into the new level of processing and interpretation process nowadays. The main part of this paper will play around the input data preparation and processing method, to make a map of Hydrocarbon-potency distribution in certain horizon. It will accommodate by Principal Component Analysis (PCA) output and Co-Kriging method. Co-Kriging is an interpolation method for primary dataset by considering the distribution and the spatial relationship of another particular dataset in a certain field. PCA is multivariate technique to analyze some input dataset, by using linear transformation in some correlated dependent variables, and produce a new single dataset that may have more than one information in interpretation. In the case study of Field-X, we analyze a new single dataset from the application of PCA method for every existing well that contained multivariate rockphysics data. The interpretation that can be extracted from its output, give a multi-information about Hydrocarbon presence in particular range depth. We use that output, for our primary data research, to make our research map by using Co-Kriging method. We also considering an Acoustic Impedance dataset that we have in a certain horizon to fulfil the Co-Kriging interpolation requirement. All of Acoustic Impedance data and output data from application of PCA that we get in particular horizon, give a strong correlation factor number. Our final resulted map also validated with the information of proven hydrocarbon discovery. It’s proofed that the map gives an accurate information to suggest the location of Hydrocarbon potency which needs some detailed technique to enhance its presence probability. This method sure can be considered for hydrocarbon prediction in any area of sparse well control.
POSTER PRESENTATIONS

Ultrasonic tomography imaging from laboratory core measurements using robotic instruments

Tedi Setiawan1, Faktihan1, Fernando Lawrens1, Albertus Ariel Rahadi2

1Seismology, Exploration and Engineering Research Group, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Indonesia
2Geophysical Engineering of Study Program, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung

Ultrasonic tomography is one of many non-destructive methods to image a rock by measuring wave velocities (P or S-wave). Some applications of ultrasonic tomography include research for seismic anisotropy, rock physics, shale gas etc. The method utilizes core specimens at laboratory scale from previous drilling. In practice, the core measurement using ultrasonic tomography is still using the conventional method which is impractical and requires a lot of time. The conventional method may also give different results from one researcher to another due to the lack of uniformity and the high subjectivity of the researcher during conventional measurement. Robotic design is used to increase precision and reduce measurement time by using tools. The robotic design that the author made consists of three main components: stepper motor, microcontroller and actuator such as motor driver. A combination robotic application and a supporting tool can be a solution to get better data quality. Robotic programming derived from a computer can be arranged in accordance with our needs, in order to get fast, precise and uniform ultrasound tomography data. The robotic instrument is not only able to measure but also have feedback controls. As a result, measured data can be more accurate and precise than those of the conventional method. Several rock samples are used for testing measurements using a MSIRT (Modified Simultaneous Iterative Reconstruction Technique) method. Comparing results include error measurements that are shown in graph and table. Findings from laboratory test results show that using the robotic instrument with a programming base from a computer can enhance quality of data, reduce error up to 50% and easier to do.
Session 06: Palaeontology and Stratigraphy in SE Asia

Chairpersons: Robert Hall, László Kocsis, Antonino Briguglio & Peter Oliver Baumgartner

ORAL PRESENTATIONS

Wednesday 15 November 2017

Geochemical and palynological characteristics of Holocene sediments in the southwestern Ganges-Brahmaputra (G-B) delta, Bengal Basin, Bangladesh

Md Aminul Islam¹, Md. Sultam-Ul-Islam², Konica Rahman³, Prasanta Kumar Sen³, Muhammad Neem Khan⁴, Mohamed Ragab Shalaby¹, Md Abdus Salam⁵

¹Geological Sciences, Faculty of Science, Universiti Brunei Darussalam, Gadong BE 1410, Brunei
²Department of Geology and Mining, University of Rajshahi, Rajshahi-6205, Bangladesh
³Department of Botany, Bankim Sardar College, West Bengal, India
⁴Department of Physics, Faculty of Basic and Applied Sciences, International Islamic University, Islamabad, Pakistan
⁵Department of Chemical Engineering, Universiti Teknologi Petronas, Malaysia

The purpose of this study is to carry out geochemical and palynological studies of the Holocene sediments of the southeastern Ganges-Brahmaputra delta, Bengal Basin, Bangladesh in order to investigate the nature of sediments, their provenance, tectonics, climate, weathering and palaeoenvironments of deposition. Holocene sediments of the study area are immature to sub- mature in nature and are rich in SiO₂ content (av. 71.7%) and Al₂O₃ (av. 13.3%) but other oxides are generally low in abundance. Most of the oxides show negative correlation with SiO₂ except Na₂O, ZrO₂ and Y₂O₃. The studied sediments are mainly litharenite or greywacke litharenite type in nature which were formed and deposited in active continental margin tectonic conditions under semi humid to semi-arid climatic condition. Sediments containing shallower and deeper peats were possibly formed during 3000-4000 and 8000-9000 years BP respectively. The sediments were laid down in fresh water to coastal mangrove swampy area in the frontal part of the Ganges-Brahmaputra Delta. Palaeovegetation during those periods were dominated by deltaic fresh water vegetation with tree and non-tree species indicating typical mixed and dense fresh water swampy and mangrove vegetation. It also indicates herb, fern and grass vegetation in open grassland representing fresh water marshy moist ecosystem. Every peat layer indicates the state of marine regression as well as deltaic progradation.

Chemical- and biostratigraphy of Brunei's most fossiliferous Neocene beds: The Ambug Hill outcrop

László Kocsis¹, Antonino Briguglio¹, Amajida Roslim¹, Hazirah Razak¹, Stjepan Ćorić², Gianluca Frijia³

¹Geology Group, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam
²Geologische Bundesanstalt, Neulinggasse 38, A-1030 Wien, Austria
³Department of Earth Science, Sultan Qaboos University, PO 123 Al Khoud, Oman

The Ambug Hill is an exceptional geological site in the Tutong district of Brunei Darussalam. A series of siliciclastic rocks crops out here with some layers that are extremely rich in marine fossils such as foraminifera, mollusks, crustaceans, fish remains (teeth, bones and otoliths) and also plant fossils (e.g., amber). Such fossiliferous outcrops are extremely rare in
the northern part of Borneo and their description is of primary importance as their fossil content can be used to correlate the regional depositional sequences with global biostratigraphic zonations. In this work we present for the first time a detailed sedimentary profile completed with Sr-isotopes and biostratigraphic dating. The succession is divided into four sedimentary units. The first unit is made by bioturbated sandstone followed by a second unit of clay-silt rich levels whose first 9.5 meters contain rich marine fossil assemblages. Calcareous nanoplankton data indicate a Late Tortonian - Early Messinian (NN11) age, which is also confirmed by Sr-isotopes dating derived from bivalve shells giving a numerical age range from 8.3 to 6.2 My. After a major emersion surface, the third sedimentary unit of sand- and siltstone is deposited without suitable fossils for bio- and isotope stratigraphy. The age of emersion and the related sedimentary gap could be either correlated with the Me1 (7.25 My) or the Me2 (5.73 My) sequence boundary. A fourth, thin sedimentary unit is recognized on the top of the profile with silt- and claystone beds without age diagnostic remains and calcareous fossils.

**Studies on late Miocene shallow marine sediments at Ambug Hill, Brunei Darussalam**

Amajida Roslim¹, Antonino Briguglio¹, László Kocsis¹, Stjepan Coric², Holger Gebhardt², Hazirah Razak¹, Gianluca Frijia³

¹Faculty of Science/Geology, Universiti Brunei Darussalam, Jalan Tunghku Link Gadong, BE1410, Brunei Darussalam, ²Geological Survey of Austria, Neulingerasse 38, A-1030 Vienna, Austria ³Department of Earth Science, Sultan Qaboos University, PO 123 AL Khoud, Oman

In this study, 9.5 meters of clay succession from a rich-fossil site have been investigated and check for fossil abundances. The fossil site is known as “Bukit Ambug” (Ambug Hill) in the Tutong District. The site provides one of the best preservation sites of fossils in the country. The fossils fauna collected comprises of molluscs, decapods, otoliths, shark, ray teeth, amber, foraminifera and coccolithophorids.

In this research, each clay sample was taken from 20cm interval from the 9.5 meters clay was treated in peroxide and then sieved through 63 μm and 150 μm sieve sizes to obtain abundance and diversity patterns of microfossils. The distribution trends can also be used in interpreting changes in palaeoenvironment. Results point on microfossil assemblages of mostly dominated by hyaline foraminifera, the most abundant taxa identified which are Cavarotalia annectens and Heterolepa dutemplei. Miliolids, lageniids, bolivinids and planktonic foraminifera are also present but in much lower abundance. The abundance of the rotaliids indicate muddy sea floor that is rich in nutrients, low light penetration and possible growth of seagrass patches, as shown by distribution of the epiphytic foraminifera in the samples.

Coccolithophorids data indicates one horizon of sediment biozone NN11a (Late Tortonion) age range of 7.5 to 8Ma due to the presence of warm water indicators; Discoaster berggrenii and D. quinqueramus.

**A revised carboniferous fossil occurrences at Bukit Bucu, Batu Rakit, Terengganu, Malaysia**

Nursufiah Sulaiman¹, Zakiyah Ainul Kamal¹

¹Faculty of Earth Science, University Malaysia Kelantan Jeli Campus, Locked Bag No 100, 17600 Jeli, Kelantan

Bukit Bucu is located near to the north coast of Terengganu. The whole succession is the interbedded of sandstones and shales, slightly folded and formed an
anticline plunging towards NNW. These interbedded of shales and sandstones are striking NNW and dipping towards ENE or WSW. The rocks in Bukit Bucu are exposed to very low metamorphism grade with well preserved of sedimentary structures with evidenced of slaty cleavage. Fossils assemblages that have been recorded in Bukit Bucu were consist of fossils brachiopods, trilobites, bryozoans, crinoids and bivalves as indication of shallow marine depositional environment. From our recent visit, the sedimentary rocks also yielded some cephalopods, corals and plants fossils. Fossils that been specifically recognized were Edmondia sp. (bivalve), Brachythyrina strangwaysi and Chonetinella sp. (brachiopod), Fenestella retiformes (bryozoan), Poteriocrinus sp. (crinoid), Paladin sp. (trilobite), Hexaphyllia sp (corals) and Rhodea sp. (plant). The most updated age of Bukit Bucu have been assigned as Carbo-Permian where it been correlated to the sequences of metamorphism from the south of Johor to the north of Terengganu. This paper aim to update the fossils occurrences at Bukit Bucu since it last recorded on 1986.

Microfacies analysis and biostratigraphic characterization of the limestone cropping out in Lumapas, Brunei Darussalam

Antonino Briguglio1, Laszlo Kocsis1, Faaiz Ali1, Sulia Goeting1

1Faculty of Science, Universiti Brunei Darussalam Jalan Tunghku Link Gadong BE1410 Brunei Darussalam

Limestone deposits in Brunei Darussalam have been firstly reported during the '60s by geologists from the British geological survey during their mapping for economic deposits in the area of Lumapas. This early study reports three beds with a maximum thickness of around 5 meters each intercalated within the Belait Formation. Since then, no more studies have been carried out on the limestone: its age is unknown as well as its depositional environment. During this study one layer of limestone was rediscovered east of Jalan Lumapas in the Brunei Muara district densely covered by vegetation. The other two layers reported from the '60s have not yet been found. Field work associated with this study confirmed that the carbonate beds are indeed intercalated within the Belait Formation and do not depict angular unconformities with the surrounding sediments. Over 30 samples have been collected and thin-sections were made for microfacies analysis of the coral reefs. These microfacies analyses have been studied for better understanding of the palaeoenvironment and the identification of the age. The outcrop is characterized by large abundance of corals, sponges, molluscs, sea urchins remains, corallineacean and dasycladaceans algae and very abundant foraminifera. Most of the collected corals belong to the family Merulinidae (i.e., Platygyra sp., Caulastrea sp., and Cyphastrea sp.), and the foraminifera are represented by very abundant rotaliids (i.e., Miogypsina sp., Amphistegina sp., and Operculina sp.). The taxon Miogypsina is age indicative in the Southeast Asian realm and it was used for biostratigraphic determination. The only specimen recovered in equatorial section seems to belong to the species Miogypsina globulina, which has its biostratigraphic span during the upper Te5 and lower Tf1, therefore indicating a possible age of upper Burdigalian to basal Langhian. The presence of these symbionts bearing foraminifera and the red algae indicates the environment of the coral reefs in the shallow part of the euphotic zone with high energy conditions due to the preservation state of some of the rotaliids and due to the epiphytic lifestyle of other taxa.

Bay of Bengal oceanographic changes during the last 300 years related to monsoonal variation

Satabdi Mohanty1, Ajoy K. Bhaumik1
A preliminary study of representative benthic foraminiferal assemblage of the Krishna-Godavari basin was undertaken to infer the climatic variation during the latest Holocene period. This study is pursued on offshore sediment samples collected from National Gas Hydrate Program Hole 15A (16°05’ N, 82° 09’ E, water depth 926 m). Climatic variations are evident from benthic foraminiferal population over the last 300 years. The predominant association of species Bulimina marginata, Globobulimina pupoides and Rotaliatinopsis semiinvoluta in between AD 1706 to 1856 indicates cold and oxygen deficient environment which coincides with the Little Ice Age (LIA). In contrast, high productive environment is recorded by the coalition of species Bulimina aculeata, Bulimina quadrilatera, Cassidulina carinata, Fursenkoina bradyi which are predominant within AD 1860 to 2006. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856. A marked changeover of earth’s climate from the Little Ice Age (LIA) to warmer phase has been occurred at around AD 1856.

Implication of the geological and vertebrate palaeontological study of the Pleistocene-Holocene human occupation in the Lusi River Basin, northern Java

Agus Tri Hascaryo1, Yahdi Zaim1, Yan Rizal1, Aswan1, Mika Puspaningrum1, Wahyu Dwijo Santoso1

1Faculty of Earth Science and Technology, Bandung Institute of Technology

In comparison to its central counterpart (i.e. Sangiran, Sambung Macan, Trinil, Ngandong, etc.), the Quaternary Geology of northern part of Central and East Java is still understudied, especially in the correlation with the sedimentological process and palaeoenvironment. The occurrence of vertebrate fossil remains, and human in particular, in this part of Java suggest that the northern part of Central and East Java play an important part as a suitable palaeohabitat of the Pleistocene-Holocene humans and faunas. The fossil remains of human and other vertebrates, as well as artefacts that were found in the sediments in the northern Java is used to establish a vertebrate biostratigraphic scheme of the northern part of Java, which has never been done before. Based on the regional stratigraphy of West and Central Java, the oldest lithological unit of this area is composed of the Mundu Formation, which contains Plio-Pleistocene shallow marine sediments. This formation is unconformity overlaid by the Quaternary sediment, which can be distinguished into the Lusi Formation (131,5±13,2 ka) and Lusi Terraces (5 terraces), dated back from the Late Pleistocene to Holocene. The Lusi Terraces found in this area are consist of a morphological terraces: Lusi Terrace 1, while the other four terraces (Lusi Terrace 2, 3, 4,5 ) consist of Lusi River’s deposits. Changes in sedimentary process during the Pleistocene-Holocene influenced the development of the palaeoenvironment for organisms inhabited the Lusi River Valley Area, including the vertebrate and human, along with their culture development. Fossil faunas found in this area consist of: Famili Bovidae, Elephantidae, Stegodontidae, Rhinocerotidae, Cervidae, Crocidolidae, and Testudinidae. A hominid cranial fossil fragment had been discovered from the conglomeratic coarse-grained sandstone of the Lusi Formation. Based on the tomographic analysis, the cranial fragment is considered as a juvenile Homo erectus, aged 2.5-3 years old. Artefacts are also
found in the study area, made of shells, bones and rocks. The discovery of vertebrate and Homo erectus fossil remains, as well as the cultural artefacts in the Lusi Formation and the Lusi Terrace 3 (94.9±12.6 ka), suggests that this area was a suited environment for the Quaternary human occupation.

Sedimentology and geomorphology analysis of coastal areas along Pantai Rhu Sepuloh, Penarik, Terengganu: Monsoonal effect on the coastal area

Muhammad Nazrin Nor Kadim¹, Mohamad Shaufi Sokiman¹

¹Universiti Teknologi PETRONAS, Department of Geosciences, 32610 Bandar Seri Iskandar, Perak, Malaysia

The coastline of Terengganu, including Pantai Rhu Sepuloh, Penarik were geographically situate don the east coast of Peninsular Malaysia were exposed to the natural wave, wind and tide actions all the time. The high wind intensities during northeast monsoon has caused the coastline to experience greater wave action thus affecting the sediment transportation and lead to serious coastal erosion. Several methods are used to identify the effect of monsoonal change to the beach. Total station was used to collect the data on coordinate and elevation of the beach and generate beach profile to observe the changes on the beach morphology before and after monsoon. Beach sediment sample is collected and were properly label according to the transect line and sampling point. The collected samples later will be treated and proceed with laboratory analysis by dry sieving method to identify the sediment distribution of the area and detect any changes on the sediment distribution caused by monsoonal change. The sediment texture is also viewed using petrographic method to identify the monsoon effect to the beach sediment. It can be observed that the beach slope becomes less steep and lower elevation after monsoon. This shows that the beach has been eroded by high wave action during monsoon. There is more sediment with coarse material found after monsoon season which support that the wave energy is higher during the monsoon period. The sediment texture mostly changes from sub-angular and low sphericity to sub-rounded and high sphericity. It shows that the wave action during northeast monsoon is strong enough to change the sediment texture during the monsoon period. In that sense, the monsoonal changes do affects the coastal area along Pantai Penarik.

Sedimentological & geomorphological analysis of coastal area along Pantai Penarik, Setiu, Terengganu: Monsoonal effect on the coastal area

Mohamad Nazim Bin Azmi¹, Mohamad Shaufi Sokiman¹

¹Universiti Teknologi PETRONAS, Department of Geosciences, 32610. Bandar Seri Iskandar, Perak, Malaysia

Pantai Penarik located at the coastline of Terengganu state and any changes to the beach structure is the result of the energy from the water and waves originated from the South China Sea. It is widely accepted that coastal erosion occurred along the coastline of Terengganu is caused by the strong waves during the northeast monsoon seasons. In this study, we have collected sand samples along the selected transect line at Pantai Penarik and we also measure the beach profile using total station method in order to investigate the changes on the beach along the selected transect line in terms of sedimentology and geomorphology. The collected sand samples were analyses using dry sieving methods in order to determine the mean grain size, sorting and also skewness of the sediment. Heavy mineral in the samples also being evaluated to determine the possible provenance of the mineral. In general, Pantai Penarik, Terengganu consist mainly of medium to fine grained sand. Other than that, based on the grain size analysis after northeast monsoon
season the sorting is being better and the grain size become coarser and skewness results also show negative value that indicate it being influenced by coarse size particles. The geomorphology study is done using total station data and cross section of the beach at every 100 m interval is produced. The cross section of the beach after Northeast monsoon season is shorter and steeper at most points that could indicate erosion of the beach. Based on heavy mineral analysis that has been made it can be conclude that the mineral deposition at Pantai Penarik, Setiu, Terengganu is coming from the igneous body from the Eastern Belt. Based on type of minerals being trace at Pantai Penarik such as magnetite, hematite, andalusite, tourmaline and ilmenite a hypothesis can be made that the sediment is originated from granite body of Eastern Belt. Other supporting details for this argument is based on the landform of Terengganu and direction of Sungai Terengganu flow that work as supply of sediment to the coastal area.

\textbf{Provenience studies of Manchar Formation, central Kirthar Range, Pakistan: Conflict between western and northern Himalayan source}

Muhammad Hassan Agheem\textsuperscript{1}, Abdul Jabbar Channa\textsuperscript{1}, Sarfraz Hussain Solangi\textsuperscript{1}, Muhammad Ali Solangi\textsuperscript{1}, Ghulam Mustafa Thebo\textsuperscript{1}

\textsuperscript{1Centre for Pure & Applied Geology, University of Sindh, Jamshoro, Pakistan}

The sediments of Manchar Formation were deposited at the time of mid-Miocene to Pliocene in the Lower Indus Basin. During this time, the remnants of Neotethys were completely consumed even in the Lower Indus Basin. It is generally accepted that the source of sediments of time equivalent rocks of Manchar in the Upper Indus Basin is from northern Himalayas. Manchar Formation records an important interval of tectono-sedimentary events of regional change from marginal marine to fluvial depositional systems. It is exposed all the way through the eastern flank of Kirthar Range and on both the eastern and western flanks of the Laki Range. The present study shows that both the source and depositional environment of Manchar Formation in the Lower Indus Basin is not same as considered earlier. The field and petrographical data for Manchar Formation is evaluated to know about the source and depositional environment. The field studies disclose that the formation is...
mainly comprised of six major sandstone and siltstone units with interbedded minor clays/shales and are separated by thick yellow-brown mudstones. The distinct facies are grey to greenish siltstone, yellow-brown mudstones of flood plains, massive silica and off-white to cream coloured sandstones of beach environment. On the other hand, fine to medium grained, sub-angular to sub-rounded, moderately sorted grey sandstone sequence with hematitic/limonitic alteration, trough cross bedding, wood logs and terrestrial vertebrate fossils are pointing a fluvial depositional environment. Primary sedimentary structures; for example trough cross bedding, planar lamination and tabular cross bedding obviously shows fluvial system. However, the features such as hummocky cross stratification, ripple cross lamination and bioturbation are some evidences of transitional environment. Petrographic data indicate that majority of the samples are sub-arkose to sub-litharenite while a few are quartz-arenite. The microphotographs and SEM images show that the shape of quartz is commonly sub-angular to sub-rounded and the grains are moderately sorted. Such textural data indicate that the source of sediments was not far away as is thought earlier. It is therefore proposed that the sediments of Manchar Formation could probably come from the western highlands of Axial Belt and Balochistan Basin rather than the northern Himalayas.
Miocene shark and ray teeth from six different localities around Brunei Darussalam

Hazirah Razak¹, Laszlo Kocsis¹, Antonino Briguglio¹

¹Geology Group, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE 1410, Brunei Darussalam

Unique fish faunas have been recently discovered from six different sites in the Bandar-Muara and Tutong districts of Brunei Darussalam (Ambug Hill, Penanjong beach, Kampung Keriam, Tutong 2, Tanjung Nangka and Subok outcrops), consisting mainly of dental elements. The teeth come from shallow marine successions with an age ranging from middle to late Miocene and from three different lithostratigraphic units: the Belait, Miri and Seria Formations. The Ambug Hill outcrop is the youngest, whereas Subok is the oldest. The Penanjong beach outcrop is characterized by reworked upper Miocene beds of the Seria Formation mixed with faunal elements of younger deposits. Hundreds of shark and ray teeth have been found from these sites and the remains were picked from the easily weathered surfaces and in some cases the sediment was screen-washed for micro-fossils. Among all, Ambug Hill is the most fossil-rich locality where many macro as well as micro teeth have been collected. At the other sites the teeth are less frequent, still they allow us to see a wider spatial distribution of certain fish groups. Several selachian and batoid taxa have been identified, with the help of modern and fossil comparative materials. Our results show that in all outcrops the fauna is dominated by the Carcharhiniformes shark order and specifically by the Carcharhinidae family. Only one more order, the Lamniformes, is represented in our fauna by a single species: the large shark Otodus (Megaselachus) megalodon. Besides the sharks, the remains of two batoid orders, the Rhinoprimitiformes and Myliobatiformes, have been discovered. The latter is more abundant and especially the Dasypodidae family. The fauna is quite diverse and such fossil chondrichthian assemblages have never been reported before especially from Brunei as well as from the tropical region of Southeast Asia.

Studies of Middle to Upper Miocene shallow marine sediments from Tutong district in Brunei Darussalam

Amajida Roslim¹, Antonino Briguglio¹, László Koczis¹, Hazirah Razak¹, Izaz Fahad Bahrein¹

¹Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link Gadong

The geology of shallow marine deposits has always been studied thoroughly in the past and is important. The shallow marine sediments in Brunei Darussalam have been deposited since the Oligocene and some of them are well exposed in the Tutong District. In this study, six localities have been investigated along the Tutong road in the Tutong District; they are named T1, T2, T3, T4, T5 and Ambug Hill outcrop. For each outcrop, a sedimentary profile was recorded and used to interpret the depositional environment. Additionally, a total of 46 clay-rich samples were collected from these localities and microfossils were extracted in order to establish the biostratigraphy and to attempt to reconstruct the palaeoecology. The results point out that most of the profiles can be divided into progradational parasequences from offshore transitions to shoreface environments. However one outcrop (T5), the sedimentary environment shows distinctive tide dominated signatures with sandy and muddy tidal flats and a tidal channel. These types of sedimentary environments are very common in the region and have been triggered by large and complex deltaic systems that were
active since the early Miocene. Such systems were mainly wave dominated during most of the transgressive system tracts and could pass into tide dominated settings during the late highstands causing locally important forced regressions. In terms of micropalaeontology, foraminifera have been found in T1, T2, T4 and Ambug Hill but not in T3 and T5. The absence of foraminifera shows deposition in a very restricted environment indicating fluvial influence or preservation bias due to late diagenesis. The foraminifera found are mostly benthonic rotaliid foraminifera whereas planktonic ones are rare. Among the rotaliiids, the most common taxa are the genera Ammonia, Nonion and Bolivina found in the oldest part of the section (T1, T2 and T4), whereas in the younger sediments of the last investigated outcrop (known as Ambug Hill) the respective assemblages are different; the most common taxa are Cavaroatalia, Heterolepa and Bolivina. The abundance of the rotaliid foraminifera in the studied localities suggests a precise depositional environment in shallow marine settings that can potentially be used for biostratigraphic indexes in determining the age of rock formation.

Reconstructing Neocene stratigraphy and palaeogeography of SE Sulawesi, Indonesia

Abang Mansyursyah Surya Nugraha¹, Robert Hall²

¹Universitas Pertamina and Southeast Asia Research Group
²Royal Holloway University of London

Neogene sediments in the SE Arm of Sulawesi have been assigned to the Celebes Molasse considered as a post-orogenic unit deposited unconformably on pre-Neogene sedimentary, metamorphic, and ophiolitic rocks. As a result the Celebes Molasse includes numerous poorly defined formations of uncertain Neogene age. We present a revised stratigraphy and interpreted history of deposition for the Neogene sediments in SE Sulawesi based on new data from fieldwork and laboratory studies, including light and heavy mineralogical, palaeontological and zircon geochronological analyses. Facies interpretations have been integrated with biostratigraphic and provenance data to interpret the sedimentation history and consider lateral change and correlation across a large area. The Miocene to Pleistocene successions in SE Sulawesi can be subdivided into the Bungku, Pandua, Eemoiko and Langkowala Formations. Lower Miocene carbonates and deltaic serpentinite-rich siliciclastics were assigned in this study to the lower and upper parts of the Bungku Formation respectively. They are unconformably overlain by the Upper Miocene Pandua Formation that consists of deltaic-coastal serpentinite-rich siliciclastics. The base of the Langkowala Formation is a latest Miocene correlative conformity with an angular unconformity inland. The unconformity surface is overlain by the uppermost Miocene-lowermost Pleistocene Langkowala and Eemoiko Formations. Langkowala Formation sediments were deposited in a predominantly terrestrial to marginal marine environment and interfinger with carbonates of the Eemoiko Formation. They both record transgression in the Pliocene. The unconformity is marked by a change in sources recorded by serpentinite-rich sandstones of the Pandua Formation overlain by quartz-rich sandstones of the Langkowala Formation. Heavy mineral and zircon geochronology analyses also show pronounced differences in provenance at this change. This integrated study is depicted on palaeogeographic maps to give a better understanding of the complex geology and new insights into the similarities and differences between different formations included in the Celebes Molasse. The Neogene sediments were deposited in various depositional environments from terrestrial to deep marine and reflect sediment-routing systems from hinterlands to basins. The sedimentation history is
closely related to late Neogene extension-related uplift and subsidence which followed Early Miocene arc-continent collision in eastern Sulawesi.

**Depth distribution of modern larger benthic foraminifera offshore Brunei Darussalam**

Sulia Goeting1, Antonino Briguglio1, Rosnani Kusli1, Laszlo Kocsis1, Wolfgang Eder2

1Universiti Brunei Darussalam, Faculty of Science, Department of Geology, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam
2Department of Palaeontology, University of Vienna, UZA II Geozentrum, Althanstrasse 14, 1090 Vienna, Austria

Brunei Darussalam is located at the periphery of the so-called Coral Triangle: the modern biodiversity hotspot on Earth. Recent studies have shown that there are number of sites off-shore Brunei Darussalam with abundant and diverse foraminifera assemblages. In this paper, the depth distribution of the symbiont bearing larger benthic foraminifera (LBF) of six sites offshore Brunei Muara is investigated. The six sites investigated are Pelong rocks, Abana Reef, Oil Rig Wreck, American Wreck, Australian Wreck and Bluewater Wreck. The purpose of this study is to quantify the depth distribution of LBF and to compare it with different environmental and ecological conditions. This is very important because LBF depth distribution is strongly influenced by light penetration in the water column and sea bottom substrate type. Brunei waters are generally rich in suspended material due to rivers discharging in the Brunei Bay and the sea bottom is largely made of fine mud. Therefore, the results here presented strongly deviate from those collected in regions where light penetration is more intense and the seabottom is sandier. Among the taxa observed from the different offshore locations, the most common families are the Amphisteginidae, Calcarinidae and Nummulitidae and they all represent a very typical depth distribution of an eutrophic environment with much shallower depths than those found in oligotrophic waters.

**High and low energy ooids from Zhangxia Formation at the Qingshuihe Section in Huhehaote City, Inner Mongolia, north China Platform**

Muhammad RIAZ1, Khalid LATIF1,2, Enzhao XIAO1, Long WANG1

1School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
2National Centre of Excellence in Geology, University of Peshawar, 25130, Pakistan

The Zhangxia Formation at Qingshuihe section in Huhehaote city, Inner Mongolia in the North-China Platform belongs to Cambrian series 3 and can be divided into three fourth order sub-sequences on the basis of the depositional trend reflected by the cyclicity of sedimentary facies succession. These depositional sequences are made up by the drowned unconformity, which are constituted by a generally shallowing upward succession from a condensed section made up by both calcareous mudstones of the shallow shelf facies and marls of the deep ramp facies in the lower part to a shallow-water carbonate succession belonging to the mid and shallow ramp facies in the upper part. Oolitic bank of different morphologies i.e. even and uneven radial-concentric ooids with or without nuclei, composite ooids, crystalline ooids, micro-boring ooids, pseudo and pseudo-deformed ooids are the dominant features present in the first and second fourth order sub-sequences, while the bioherm of massive biologic limestone in fourth third order sub-sequence comprises radial, Girvanella cortex and Girvanella nuclei ooids. Different environmental factors, including water chemistry, physical agitation and abrasion (turbulence), and biochemical factors, including metabolism and
microbial activities, are involved in their formation. Transition between the individual cortex, crystal fabric, size and shape, concentration of organic matter, and development of different composition of biofilm in the formation of ooids make the differences from the high energy to low energy setting ooids. Consequently, the forming pattern of oolitic banks that developed in late highstand system tract (LHST) indicates the varying depositional settings controlled by the energy condition within the Zhangxia Formation.

The Eocene depositional history and stratigraphy of Kutch Basin, India: Nannofossils and foraminiferal evidences

Hema Srivastava¹, Ajay K. Bhaumik¹

¹Department of Applied Geology, Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand-826004

The Eocene sedimentary successions in Matanomadh area, western Kachchh, are well developed. The late Palaeocene to early Eocene is characterized by the presence of lignite deposits over the Deccan trap. Middle Eocene to late middle Eocene are consists of fossiliferous grey shales and limestone. The present study is carried out to decipher the depositional environment of the sedimentary beds deposited within Eocene sequences of Kutch basin on the basis of foraminifera and nannofossil assemblages. The core samples represent the 3 major lithological units as Unit-1, 2 and 3. Weathered trap is present at the base of the core with a thickness of 7 m considered as unit-1 (85.17 to 92 m), which is overlain by the alternate bands of shales (grey, dark grey and carbonaceous) and lignite. This alternate appearance of shales and lignite covers a thickness of 46 m assigned as unit-2 (41.50 to 85.13 m). Depth between 32.70 to 41.50 m depth represent the lithological assemblage of calcareous limestone, fossiliferous grey shale, grey shale with alternate limestone bands considered as unit-3. So far, 60 numbers of core samples were collected from an exploratory drilling site of near Matanomadh lignite mines, out of which 10 samples are productive in terms of foraminifera and nannofossils. Unit-1 and 2 are barren and did not contain any age diagnostic foraminifera and nannofossils. On the basis of lithological assemblages of unit-2 is equivalent to the Early Eocene of Narbedi formation. Unit-3 contains ample number of benthic (Halkyardia minima, Triloculina bhallai, Valvulineria rugosa, Cibicoides spp, Elphidium spp, Nonion spp, Quinqueloculina spp, Linderina kutchensis, Rotalia sp.), planktic (Orbulinoides beckmanni). Presence of Halkyardia minima, Linderina kutchensis and Orbulinoides beckmanni clearly indicates the age of this segment of sediments as middle Eocene. The nannofossil assemblages are reported from this unit-3 are Cyclicargolithus floridanus, Reticulofenestra dictyoda, Reticulofenestra minuta, Reticulofenestra bisecta, Reticulofenestra lockeri, Sphenolithus perpendicularis, Braarudosphaera biglowi Sphenolithus keempii, Nannotatrina fulgens. Nannofossil assemblages represent the warm to a temperate water temperature of middle Eocene age. Based on the presence of these microfossils, it is surmised that the core samples of unit-3 belonging to the Fulra limestone of middle Eocene age, which were deposited in the inner shelf environment.

Depositional environment of glauconite associated Cambrian strata of north China Platform

Muhammad RIAZ¹, Enzhao XIAO¹, Khalid LATIF¹,², Long WANG¹

¹School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
²National Centre of Excellence in Geology, University of Peshawar, 25130, Pakistan
Numerous studies fail the law of “Present is key to past” by explaining the different depositional environments of modern and ancient glauconitic mineral. Glauconite developed within oolitic limestone in Cambrian Gushan Formation of Series 3 in Kelan section, Shanxi province, North China Platform. Stratigraphic, geochemical and petrographic data indicate that the glauconitic mineral is autochthonous. The glauconite mineral developed inside these oolitic limestone, which represents the depositional record of forced regressive system tract of third-order sequence, usually indicate normal to high rate of sedimentation and high energy environment. The presence of glauconite in fabric of ooids also demonstrates that this mineral precipitated alongside the precipitation of calcite or aragonite. In marked contrast to the modern environments of deposition, these glauconite bearing Cambrian strata formed under high energy tidal-flat conditions. Thus, glauconitic mineral alone cannot be adopted as an environmental indicator; instead its association with the surrounding facies may decide the sedimentary depositional environment.

An appraisal of the development of stratigraphy from temporal and spatial perspectives

Long Wang¹, Rui Zhang¹, Khalid Latif¹,², Muhammad Riaz¹

¹School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
²National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan

The philosophy of time and space has always been the main line of all stratigraphy branches and runs through the appraisal of sedimentary strata. It can be the chronostratigraphy, which is established strictly on an isochronal framework, the lithostratigraphy, in which the diachronism occur due to the superposition of vertical and lateral accretion, or the sequence stratigraphy, with concepts of both isochronism and diachronism. From the Steno’s Laws stating that rocks laid down in vertical order with younger strata on the top of the older to the Walther’s Phase Law suggesting that the contiguous relation in space can be transformed into the chronological sequence in time, the stratigraphy not only expresses the concept of space by using top, bottom, left and right, but also reveals its time attribute. The unconformity, once supposed to be a structure-induced concept from the beginning, which represented its spatial incongruity caused by folds or orogeny, is now defined with the help of time attribute i.e. the prolonged absence of stratigraphic record. Similarly, the stratigraphic cycle, a term previously describing the repetition of strata, after the confirmation of the Quaternary Milankovitch cycle is redefined as the transgressive and regressive sequences bounded by unconformities in the stratigraphic record. The stratigraphic record is a space-time structure, in which the time factor is often disturbed by external forces, and its cycle is often broken by the geologic events, thus forming unique stratigraphic strata. The discovery and restoration of the spatial and temporal order in the complex stratigraphic record is therefore becoming the driving force in promoting the development and integration of all stratigraphy branches.
The Middle - Late Miocene Lambir Formation is extensively exposed along the road from Bekenu to Miri near the Bukit Lambir National Park. This formation is characterized by a succession of interbedded sandstone and mudstone, passing into heterolithic interval in several exposures. Palynological analysis was carried out on the exposed Lambir Formation outcrops around Bukit Lambir National Park. There are eighteen (18) samples were subjected for palynological analysis. These samples were collected from three different outcrop locations mostly from the mudstone facies with few samples from sandstone facies. Most of the samples yielded moderately to well-preserved palynomorphs with at least 100 palynomorphs taxa were identified. In general, mangrove species are dominant in all samples dominated by Zonocostites ramonae. This followed by Florschuetzia group pollen represented by Florschuetzia meridionalis, Florschuetzia levipoli and Florschuetzia trilobata. The Zonocostites ramonae tends to present in great number especially in mudstone samples and overwhelming the pollen count. Other mangrove species present in the samples include Acrostichum aureum, Excoecaria aggulocha, Spinizinicolpites echinatus, Avicennia type and Oncosperma type. In addition, other palynomorph sources are derived from peat swamp and riparian vegetation including montane, coastal and seasonal pollen component. However, their occurrences are scarce. Some of dominant species which is originated from peat swamp vegetation includes Palaquium sp., Dactylocladus sp., Blumeodendron sp., Stemonurus sp., Calophyllum sp., Cyrtostachys sp., Pandanus sp., Eugenia sp., Ilex sp., and Elaeocarpus sp. Some taxa of open marine dinoflagellate cysts were also recorded represented by Operculodinium sp., Lingulodinium sp., and Spiniferites sp. The acme of mangrove palynomorphs which is dominated by Zonocostites ramonae including high proportion back mangrove pollen suggests a former mangrove belt was developed and associated with back mangrove swamps within coastal areas. This event probably associated with transgression phase or relative sea level rise. The presence of F. trilobata, F. levipoli and F. meridionalis are very significant at least in providing relative age for the Lambir Formation in particular. The occurrence of palynomorphs from the study area is compared to the palynological zonation published by Germeraad et al., (1968) and Morley (1978) which was developed for South East Asia region. The comparison results show the samples can be assigned into Middle Miocene-Late Miocene palynostratigraphic zones.

Late Miocene Otodus (Megaselachus) megalodon from Brunei Darussalam: Body length estimation and habitat reconstruction

Hazirah Razak¹, László Kocsis¹

¹Geology Group, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam

Shark teeth are very common vertebrate fossil due to the large number of teeth each shark has and loses during their lifetime and due to the composition of the teeth (crystalline bioapatite) that has a high
preservation potential. In the past 2 years, hundreds of shark teeth were found and identified from Brunei’s Late Miocene shallow marine sediments, among them the famous macro-predator the Otodus (Megaselachus) megalodon. So far three teeth are known from Brunei: 1) It is reported in the book of Sandal (1996) from the Penanjong beach; 2) It is found at the Ambug Hill in Tutong by our group and it is in the collection of the Universiti Brunei Darussalam and 3) It is kept in a private collection found at the same locality as the previous one. All these teeth are relatively small in size and the question rises on how big were the sharks were that lost them. The actual body size of this large shark has always been an appealing issue and many efforts had been previously done in this direction (e.g., Shimada, 2003, Pimiento et al., 2010). In this study, determination of body sizes is solely based on the height of tooth crown with the help of its tooth position in the jaw. Such work was already done for the great white shark (Shimada, 2003) and has been adapted to the O. megalodon in various ways (e.g., Pimiento et al., 2010). Our results show that, all the studied teeth belonged to juvenile O. megalodon sharks. This might indicate that these smaller specimens frequented in shallow coastal waters that probably consisted easy food source habitats or juvenile sharks might have grown up in these shallow environments and the region was used as a nursery ground.

Sedimentological characterization of sea bottom sediments offshore Muara and Tutong

Norhanizan Zaini¹, Qawiy Ya’kub¹, Sulia Goeting¹, Amajida Roslim¹, Antonino Briguglio¹

¹Universiti Brunei Darussalam, Faculty of Science, Department of Geology, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

The objectives of this project are to look for sea bottom variations trough time next to the sunken wrecks and how such variations are affecting benthic biodiversity offshore Brunei. In this study five sea bottom cores are presented and collected from offshore Brunei Darussalam: two cores were taken nearby two sunken WWII wrecks (so called Australian wreck at 34 m and the American wreck at 32.6 m respectively), one core was taken near to a recently sunken wreck (Dolphin wreck at 25.3 m) and the other two cores were taken at water depths of 30 m and 20 m in an undisturbed environment few km away from the wrecks. Each core recovered 40 to 60 cm of sediment and each core was sliced at 2 cm interval. In addition, a total of 33 sea bottom sediment samples were also collected along the two transects line offshore Muara and Tutong ranging from water depth of approximately 9 m to 60 m. Each sample was wet sieved to examine the content and the variation in terms of the sedimentological characteristics. Beside standard granulometric analysis, we run statistical correlation analysis, correspondence analysis and cluster analysis in order to characterize and correlate the studied samples to observe whether significant differences are present among the investigated samples and to recognize variation trends and ecological niches. The results reveal that the change of grading patterns of the cores taken near the wrecks as well as the two cores taken at 10 m depth difference have a similar fining upwards pattern. In addition, the presence of biogenic materials such as corals, bivalves, gastropods and foraminifera within the cores clearly separate wrecks samples from those collected in the undisturbed environment. Results also show that the amount of planktonic foraminifera increases with increasing depth which is surprisingly due to the relatively shallow environment of the samples.

Late Miocene gastropods from the Seria Formation, Brunei Darussalam
Antonino Briguglio¹, Mathias Harzhauser⁷, Han Raven³, László Kocsis¹, Asiqqin Adnan¹, Martin Zuschin⁴, Oleg Mandic⁶

¹Faculty of Science, Geology, University Brunei Darussalam, Jalan Tungku Link Gadong, BE1410, Brunei Darussalam
²Naturhistorisches Museum Wien, Burgring 7, A-1010 Vienna, Austria
³Naturalis Biodiversity Center, Leiden, The Netherlands
⁴Department of Palaeontology, University of Vienna, Althanstrasse 14, 1090 Vienna, Austria

We present the first systematic description of a Tortonian (late Miocene) gastropod assemblage from the Ambug Hill section in the Tutong District in Brunei Darussalam. The assemblage is characterized by a relative low-diversity as it comprises only 63 species of which 38 are unknown from other Neogene faunas of the Indo-West Pacific Region (IWP); 23 species are formally described as new. The assemblage is dominated by carnivorous, scavenging and detritus feeding taxa and it might be representing a mud-bottom environment of the inner shelf in few tens of meters water depth with reduced vegetation. The small size of most specimens, the frequent occurrence of subadult shells and small size of several species relative to congeneric species might point to suboptimal environmental conditions during the deposition of the Seria Formation. The very low relations with Neogene gastropod faunas from Indonesia at the species level might be explained by the biogeographic isolation between the faunas of the Java and Celebes seas and that from the South China Sea. A severe undersampling and rather spotty taxonomic descriptions of Neogene IWP-faunas and a lack of assemblages from identical depositional environments of Indonesia may also contribute to the seemingly endemic character of the Ambug Hill fauna.

Sedimentary facies and architecture analysis of synrift deposits: An observation from the Lahat Formation of the Jambi Sub Basin, Jambi, Indonesia

Koes Haryanto¹, M. Hafizh Ensya¹, M. Akbar Mulyadi¹

¹University Pembangunan Nasional “Veteran” Yogyakarta, Faculty of Mineral Technology, Department of Geology, Jalan SWK 104, Yogyakarta, Indonesia

Palaeogene synrift deposit notably Lahat Formation have been currently as having high industrial interest related to petroleum exploration, particularly with regard to their reservoir potential. The Palaeogene synrift deposit of South Sumatra Basin is becoming the future exploration target. The Lahat Formation is a good example of a Palaeogene synrift outcrop data but is relatively poorly exposed. Lahat Formation is one of the filler formations in the South Sumatra Basin which has an important role in petroleum system. This paper is composed by using measured outcrop data from the synrift sediments by characterizing detailed analyses of the facies and sedimentary architecture. The sections were divided into facies based on lithology, texture, and sedimentary structures. Large scale patterns in the form of facies associations and facies successions were also identified. Facies analysis was conducted on the succession of the measurement stratigraphy of the Asam river, Jambi. Ten sedimentary facies were distinguished: gravel matrix massive (Gmm), gravel clast massive (Gcm), gravel clast inverse graded (Gci), gravel planar cross-bed (Gp), gravel horizontal imbrication (Gh), sandstone planar cross-bed (Sp), sandstone horizontal (Sh), sandstone massive (Sm), sandstone scour (Ss), fine silt massive (Fsm). Five architectural elements were identified: Channel (CH), Sediment Gravity Flow (SG), gravel bars and bedform (GB), sandy bedform (SB), and overbank (OB). The lithology characteristics of Lahat Formation are discovered showing immature texture which characterized by dominantly boulder-size grains, thick, very poor...
sorting, contain of matrix and grain supported, and few sedimentary structures. Fragments of detritus derived from basement such as subangular quartzite, in some places are found volcanic rocks as andesite and basalt. These outcrop show imbrications to east-northwest which associate to debris deposits. The facies succession is interpreted as representing of Alluvial Fan system.

**Updates on the refinement of the Oligocene-Miocene calcareous nanofossil biostratigraphy of Hole U1490A in the northern Eauripik Rise of the west Pacific**

Yvonne Ivy L. Doyongan¹, Allan Gil S. Fernando¹, IODP Expedition 363 Scientists¹

¹National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City

Several studies in relation to the refinement of nanofossil biohorizons are continuously being developed, although studies focusing on the west Pacific are lacking (e.g., Raffi et al., 2006; Agnini et al., 2014). An Oligocene-Recent sedimentary succession was recovered in Hole U1490A in the Eauripik Rise (West Pacific) during a recent International Ocean Drilling Program (IODP) Expedition. The hole contained moderate- to well-preserved calcareous nanofossils throughout the 380-meter sequence. Based on the preliminary calcareous nanofossil biostratigraphy established onboard, the identified nanofossil marker taxa are correlated well with planktonic foraminifer and palaeomagnetic data (Rosenthal et al., 2017). In an effort to contribute to the refinement of existing nanofossil zonation schemes, calcareous nanofossil biostratigraphy using higher resolution sampling interval was done on Hole U1490A, focusing on the nanofossil assemblages of the Oligocene-Miocene units. This data will serve as a reference section for future biostratigraphic studies in the western Pacific, as well as studies on biostratigraphy of the Oligocene-Miocene sedimentary successions in the Philippine basins.

**The genus Heterostegina (Eocene to recent) in the american bioprovince: A larger foraminifer of the open marine environment**

Claudia Baumgartner-Mora¹, Jorge Cortés², Peter O. Baumgartner¹

¹Institute of Earth Sciences, University of Lausanne, CH-1015 Switzerland
²CIMAR, Universidad de Costa Rica, San Pedro, 2060 San Jose, Costa Rica

Heterostegina is widespread in open marine, well-oxygenated conditions in the modern tropical/subtropical oceans. In oligotrophic environments this genus is most abundant at 30-40 m depth, but ranges from almost 0-100 m. In mesotrophic areas its depth range may be much reduced. Here, we report on the Modern occurrence of Heterostegina depressa found during a general study of benthos in shallow reef environments of the Caribbean coast of Costa Rica. The sample is from Puerto Vargas in the Cahuita National Park. Puerto Vargas is situated SE of Punta Cahuita in the lagoon area of the largest coral reef of Costa Rica’s Caribbean coast. Heterostegina was found hidden in a plastic sponges fixed artificially at 6 m depth in the outer part of the inner coral reef crest. The conditions of the Cahuita Reef depend much on the precipitations in the Atlantic basin of Costa Rica. There is no real dry season and precipitations may be very abundant from May to November. Suspended sediment from nearby rivers affect very much the reef environment. It is therefore, in general, mesotrophic with seasonal changes to oligotrophic conditions. The reef is characterized by an outer crest extending for 5 km around Punta Cahuita. The reef crest is dominated by *Millepora complanata* and coralline algae, *Acropora palmata* died off in 1983 and has slightly recovered since. A smaller inner crest
extends for 500 m around Puerto Vargas and is built mainly of *Agaricia agaricites* and *Porites* spp. The lagoon is mainly covered by coral rubble and coralline algal oncoids, with a few seagrasses and algae. The occurrence of Heterostegina in the Cainozoic fossil record on Central America and the Caribbean is dissentious in space and time due to short-lived optimal conditions for photozoan carbonates in the frame of volcanically and tectonically active margins, in addition to global climate and sea level changes. Small scaled Upper Eocene limestone occurrences in Costa Rica (Las Animas, Punta Cuevas, Peñon de Arío, Fila Costeña) contain several morphotypes of Heterostegina along with abundant nummulitids and *Lepidocyclina* spp. These photozoan, pure carbonate palaeo-environments developed on offshore shoals and/or on oceanic islands sheltered from detrital input from the rising volcanic arc. Upper Oligocene/ Lower Miocene occurrences include 1. Carbonate shoals in tectonically active areas such as Punta Peladas, Costa Rica; Ciénaga de Oro Formation, San Jacinto Belt, Caribbean Colombia, Carriacou, Grenadines; Antigua. 2. Extended carbonate platforms such as Florida and Puerto Rico.

**Biochronostratigraphy of onshore Brunei stratigraphy update using microfossil assemblages**

Dk Hjh Amal Azemah Pg Hj Jamaluddin¹, Nadhirah Mohd Sahrip¹, Dk Hjh Siti Hajar Pg Hj Zaenal²

¹Brunei National Petroleum Company, 2nd Floor, Blocks A, B & C, YSHHB Complex, Jalan Pretty, Bandar Seri Begawan

Construction of updated biochronostratigraphic framework for onshore Brunei, the prime objective of the study, has been achieved through integration of legacy well data, new 3D seismic data, new well data and analyses from new outcrop samples. Outcrop samples have been analyses for foraminifera, nanofossils and palynology. Microfossil assemblages are described and their vertical distribution within is discussed. The techniques of the study include: 1) Nanofossils and planktonic foraminifera as age-diagnostic taxa, 2) benthonic foraminifera as palaeoenvironmental indicator, 3) palynomorphs, palynomacerals and combination of foraminifera and palynology are used to find palynofacies, palynosignals and helped to define paleoenvironments. Benthonic Foraminifera prove essential for palaeoenvironment determinations, especially for water depth determination (Paleobathymetry).

Common biostratigraphy data limitation encountered such as less optimal facies control of microfossil, few age-diagnostic taxa or biozones and sediment reworking. Integration of Foraminifera, Palynology and Palynofacies assemblages helped to define Paleoenvironment and comprehensive biochronostratigraphic framework for Onshore Brunei Stratigraphy. The study suggests that onshore Brunei chronostratigraphic framework consists of marginal marine and non-marine Early Pliocene to Late Miocene marine section. The new work also offer additional benefit in providing a better understanding of reservoir architecture, potential regional paleo shelf identification and identifying regional and local unconformities.
Session 07: Biomineralisation
Chaiperson: David John Marshall

ORAL PRESENTATIONS
Saturday 18 November 2017

Calcified microorganisms bloom in Cambrian Furongian series: The evidence form microfacies of microbialitic-bioherm in Qijiayu section, Hebei Province, north China Platform

Enzhao Xiao¹, Khalid Latif¹,², Muhammad Riaz¹, Yinglun Qin³, Hao Wang¹

¹School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
²National Centre of Excellence in Geology, University of Peshawar, Peshawar 25130, Pakistan
³Oil and Gas Survey, CGS, Beijing 100083, China

Cambrian Furongian series at Qijiayu section in Laiyuan City, Hebei province is comprised of three third-order sequences i.e. DS1 in Changshan Formation, and DS2 and DS3 in Fengshan Formation. The variation tendency of sedimentary facies in DS1 and DS2 is analogous, having a generally shallowing upward trend of sedimentary facies ranging from the mudstone of shelf marls to micrite of shallow ramp facies and therefore, constituting a third-order depositional sequence of the drowning-unconformity type. Two beds of the massive limestone of shallow ramp facies developed in the Furongian series in the study area. One, in the upper part of Changshan Formation, while the other, in the first third-order sequence of Fengshan Formation. These beds contain multiple dome-shaped carbonate structures within their distribution, appearing like a string of beads. These structures can be described as leiolitic bioherms, which suggest evidence of forced regression for the carbonate deposition. A variety of calcified microorganisms such as Epiphyton, Girvanella and Renalcis were discovered from the leiolitic bioherms. The discovery confirms that the cyanobacteria-dominated microbial mat gave rise to leiolitic bioherms, which bear the signs of the first episode of “cyanobacteria-calcification event” in Cambrian time. The complicated microbial sedimentation also facilitated the development of benthic ooids in the leiolitic bioherm, which together with the presence of calcified microorganism, embedded in the ground mass of micrite and microspar, inform about the complex mechanism of bioherm formation.

Role of microbial mat and biofilm induced calcification in ooids development: Examples from the Cambrian Oolitic Bank Facies of north China Platform

En-Zhao Xiao¹, Muhammad Riaz¹, Khalid Latif¹,², Ying-Lun Qin³

¹School of Earth Sciences and Resources. China University of Geosciences. Beijing 100083, China
²National Centre of Excellence in Geology. University of Peshawar. Peshawar 25130, Pakistan
³Oil and Gas Survey. CGS. Beijing 100083, China

The formation mechanism of ooids is worthy of attention as ancient limestones composed of these distinct grains store large volumes of hydrocarbons. The Cambrian Series 3 in Kouquan section of Yuxian City, Hebei Province, North China Platform is made up of Xuzhuang, Zhangxia and Gushan formations, which from the middle to the upper parts comprise grainstone of the oolitic-grain bank facies. While obvious in the thin sections from the carbonate rock samples, standard microfacies analysis showed well-developed ooids, implicating microbial
biofilms in their formation. Incompletely-developed ooid grains, similar to the ones morphologically described as distorted ooids or pseudooids, which are widespread in the oolitic limestone of Xuzhuang Formation, indicate that microbial biofilms were involved in the formation process. Cortices of cerebroid ooids within the limestone of Zhangxia Formation show strong association with the calcification of microbial mats, and therefore, represent the precursor of radial ooids that were widespread in the Cambrian oolitic limestone in North China Platform. These phenomena show that the microbial processes contribute directly or indirectly in forming ooids, which come from the limestone of oolitic-grain bank facies in the early Palaeozoic, as well as provide a new dimension for insight into the intricate formation mechanism of these glamorous carbonate-coated grains in the ancient stratum.

Sequence stratigraphy of the Upper Cambrian Changshan Formation in Datong, Shanxi, north China platform with special emphasis on the cyanobacteria signatures from the leiolitic bioherm

Khalid LATIF1,2, Enzhao XIAO1, Muhammad RIAZ1, Long WANG1

1School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
2National Centre of Excellence in Geology, University of Peshawar, 25130, Pakistan

The microbial buildups are studied for their sedimentary features in stratigraphic relationship to the surrounding lithofacies to determine the depositional environments suitable for microbialite development. This study examines the sequence stratigraphy, and occurrence and distribution of microbial fabrics in the Upper Cambrian Changshan Formation exposed in Kouquan section of Datong city in the North China Platform. The formation is comprised of one third-order carbonate depositional sequence DS1 of the drowning-unconformity type, with a variation tendency of sedimentary facies characterized by a generally shallowing upward succession, ranging from the mudstone of shelf marls to massive micrites of shallow ramp facies. The massive limestone of deep ramp facies in the middle part of the formation contains multiple dome-shaped structures made up of cyanobacteria dominated dense undifferentiated microbial boundstones, which can be described as leiolitic bioherms. Microscopic-scale analysis of these bioherms reveals Epiphyton, Girvanella and Renalcis, the recognizable skeletal calcimicrobes having good potential for preservation. These calcified microorganisms contribute towards a variety of textures and fabrics preserved in the microbialitic bioherm, and define the first episode of “cyanobacteria calcification event” in the Cambrian time. The current research provides a reasonable understanding of the marine depositional settings significant for developing leiolitic bioherm, where the calcimicrobes embedded in the ground mass of micrite and microspar give rise to microbial buildups in North China Platform.

Coastal geochemical acidic discharge causes shell dissolution in marine gastropods: A potential biomonitoring tool

David J. Marshall1, Azmi Aminuddin1, Nurshahida Atiqah Hj Mustapha1, Liyanage Chandratilak De Silva2, Dennis Ting Teck Wah1

1Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam
2Faculty of Integrated Technology, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

The significance of pH in marine ecosystems has come to the fore with the realization that anthropogenic CO2
emissions can radically alter the chemistry of the oceans. However, acidification of coastal marine environments can derive from several different sources, including discharge from pyrite-rich (FeS$_2$) soils. Acid sulphate soils (ASS) are pervasive in Brunei, and are known to significantly lower the estuarine and marine water pH. Here we investigated the link between predicted acidic outflows in the open coastal system and attributes of common gastropod inhabitant species, in particular shell and tissue masses and shell dissolution. Allometric relationships were computed to correct for sample size differences. These showed that shell mass did not vary between predicted low and high pH sites, whereas surficial dissolution was far more sensitive to pH change. Tissue mass correlated with anticipated pH exposure, presumably relating to the overall energetics of individual organisms. We conclude that gastropod shell dissolution potentially provides a cost-effective biomonitor tool to capture accumulative pH change at the spatial scale of the organism. This could be very useful considering that coastal discharges are highly spatially and temporally variable, and monitoring their impacts using conventional protocols and instruments is logistically difficult and financially prohibitive.
Traces of past microorganisms activity in stalactites from the Perama Cave, Ioannina, NW Greece

Elena Ifandi¹, Alkmini Tzoumaka¹, Basilios Tsikouras², Konstantin Hatzipanagiotou¹

¹ University of Patras, Department of Geology, Section of Earth Materials, GR-265 00 Patras, Greece
² Universiti Brunei Darussalam, Faculty of Science, Physical & Geological Sciences, Jalan Tungku Link, Gadong BE1410, Bandar Seri Begawan, Brunei Darussalam

Structures related to fossilised microorganisms are infrequent in speleothems but it has been suggested that the first play an important role in the development of the latter. Therefore, study of mineral-microorganisms interactions are of great interest. In this study, we show evidence for the activity of microorganisms during the growth of several stalactites, in the aphotic zone in the Perama Cave. Various structures indicating such an activity were observed in stalactites, which were identified with the aid of Scanning Electron Microscope (SEM), using the Secondary Electron Image (SEI) mode. More specifically, some of the main fabrics that have been identified are: reticulate filaments, smooth, round microorganism, blocky calcite crystals with deep etched zones, microbial mat covering the columnar calcite faces and surface coating of loose micrite and minmicrite grains. Fossilisation of these microorganisms resulted in partial obliteration of the original fabrics and moreover prevented us to identify the exact species. However, their traces on the stalactite fabrics are unlike any known inorganic formation. Future interdisciplinary research is required to better clarify the species and to unravel the details of the influence of microorganisms to the development of inorganic matter.
Session 08: Palaeo-, Rock and Environmental Magnetism
Chairpersons: La Ode Ngkoimani & Eleonora Agustine

ORAL PRESENTATION
Wednesday 15 November 2017

Magnetic characterizations of nickel hyperaccumulating plants from ultramafic region, Halmahera Island, Indonesia

Abdul Mujahid Hamdan¹, Satria Bijaksana¹, Aiyen Tjoa¹, Darharta Dahrin¹

¹Institut Teknologi Bandung

Nickel (Ni) hyperaccumulators are plants that could accumulate high concentration of Ni in the tissues. These plants are prospective not only for environmental remediation but also for Ni mining in the process termed phytomining. The identification of new Ni hyperaccumulator species as well as the characterization of known species are important. This study is aimed to characterized two species of Ni hyperaccumulator, i.e., Rinorea bengalensis and Planchonella oxyhedra that grown naturally in the ultramafic region of Halmahera Island, Indonesia. Leave samples from these two species were subjected to magnetic susceptibility measurement as well as to frequency-dependent magnetic susceptibility. These magnetic measurements were supplemented by SEM-EDAX (Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy), AAS (Atomic Absorption Spectroscopy), XRF (X-Ray Fluorescence) and XRD (X-Ray Diffractions) analyses. The magnetic susceptibility of both species varies from 23 and 156 (x 10^-8 kgm^-3) for P. oxyhedra and R. Bengalensis respectively. These magnetic susceptibility values correspond to the Ni content of the samples. These results infer that magnetic properties can be used as proxy indicators for Ni content in Ni hyperaccumulators or as inexpensive methods to identify new hyperaccumulators.

Magnetic susceptibility investigation in laterite sediment on ultramafic complex of southeast Sulawesi, Indonesia

La Ode Ngkoimani¹, La Ode Safiudin², Ramlia Ahmad¹, Suryawan Asfar³, Andi Makkawaru⁴

¹Natural Magnetism Laboratory, Faculty of Earth Sciences and Technology, Halu Oleo Universitas, Indonesia
²Postgraduate Physics Program, Halu Oleo University, Indonesia
³Geology & Mining Laboratory, Faculty of Earth Sciences and Technology, Halu Oleo Universitas, Indonesia
⁴Energy and Natural Resources Services, Southeast Province Government, Indonesia

Magnetic susceptibility measurements have been carried out within the Southeast Sulawesi laterite sediment. The result has shown that low field magnetic susceptibility (χLF) within the laterite sediment varies between 4,421 x 10^-6 to 26,906 x 10^-6 m^3/kg. while χFD values ranged from 0.2% to 5%. the increase of χLF and χFD value is related to the increase of percentage of element content of Fe, Al, Cr, Zn, P and Mn. otherwise χLF and χFD values tend to enclose along with the increase percentage of element content values of Ni, Mg and Si. The differences in the pattern of χLF and χFD values change over the abundance of certain elements in the laterite soil are thought to be related to the mineral form factors in laterite soils that are the result of weathering of ultramafic rocks.

Magnetic properties and mineralogy of sedimentary rocks in a karst area, Pacitan City, east Java, Indonesia
Pacitan is one of the cities in Indonesia which is dominated by karst. In this city there are many caves and the rivers that appear on the surface are lost and cut off into the ground. Studies on the magnetic properties and mineralogy of sedimentary rocks in karst areas are still rare in Indonesia. Rock magnetic methods have been used widely in environmental studies as they are useful among others in inferring heavy metal pollution, palaeoenvironmental reconstruction and climate change. This study aims to characterize the magnetic properties and mineralogy of sedimentary rocks in karst area and correlate these characters to the process of karst formation in Pacitan, East Java, Indonesia. Samples of sedimentary rocks were taken around the caves then measured through a series of magnetic measurements (magnetic susceptibility and hysteresis parameters) and X-ray Diffraction (XRD). From measurement of hysteresis parameters using Vibrating Sample Magnetometer (VSM), we can determine the domain of the magnetic grains (Single Domain, Pseudo-Single Domain or Multi Domain) contained in the rock samples. We also know the mineral contents of the rock samples using analysis of XRD. Results of the measurements and analysis will be presented.

Comparing magnetic and electrical properties of volcanic soil and compost derived from organic materials
Dini Fitriani¹, Widawati¹, Eleonora Agustine¹, Kartika Hajar Kirana¹, Joko Kusumo²

¹Department of Geophysics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km 21, Sumedang 45363
²Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km 21, Sumedang 45363

Compost from various organic materials is often used to fertilize soil. Combining compost and soil could also restore soil quality since soil structure and texture can be improved. In this research, we have studied magnetic and electrical properties of compost derived from different type of organic materials which are tree leaves and food wastes. We measured magnetic susceptibility in dual frequency and electrical conductivity (EC). As comparison, we also identified magnetic susceptibility and EC of volcanic soil. Tree leaves-derived compost has magnetic susceptibility at low frequency ($\chi_{LF}$) ranging from 607.7-733.3 ($\times10^{-8}$ m$^3$/kg). The $\chi_{LF}$ value of compost from food wastes shows lower values than those of tree leaves compost. The relative difference of magnetic susceptibility measured at two frequencies or $\chi_{FD}(\%)$ varies from 5.21% - 6.03% and 2.13% - 3.44% for tree leaves compost and food wastes compost, respectively. Volcanic soil has magnetic susceptibility of 1100-1400 ($\times10^{-8}$ m$^3$/kg) and $\chi_{FD}(\%)$ of 0.15%-1.82%. According to $\chi_{LF}$ value, it inferred that volcanic soil and compost contain ferrimagnetic minerals as predominant magnetic mineral. The EC value ranged from 4.3 to 6.6 dS/m for tree leaves compost, food wastes compost has EC values of 3.3 - 4 dS/m, whereas the EC of volcanic soil is 1.9-2.3 dS/m.

Magnetic tale of sediments from two tectonic lakes in Sulawesi
Satria Bijaksana¹, Gerald Tamuntuan², John King³, James Russell⁴, Silvia Jannatul Fajar¹, Kartika Hajar Kirana¹

¹Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung 40132, Indonesia
²Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km 21, Sumedang 45363
³Department of Geophysical Engineering, Institut Teknologi Sepuluh Nopember, Faculty of Civil Environmental and Earth Engineering, Department of Geophysical Engineering, Jalan Arief Rahman Hakim, Surabaya, Indonesia
Magnetic minerals are proven indicators of environmental change, but can be affected by a diverse array of processes including biogeochemical cycling in lakes and their sediments. To investigate the controls of environmental magnetism in lakes, we compared the mineral magnetic behaviour of sediments from two tectonic lakes in Sulawesi, namely Lake Towuti and Lake Matano, located in the Eastern Sulawesi Ophiolite belt, Indonesia. These are the largest lakes in the Malili lake system: Lake Towuti is 561 km² in size with maximum depth of 203m, while Lake Matano is 164 km² in size with maximum depth of 590 m. Two cores namely MAT10-2B (from Lake Matano, 9.07 m in length) and TOW10-9B (from Lake Towuti, 11.50 m in length) were subjected to rock magnetic analysis to test the possible environmental and sedimentary processes that control the magnetic properties of their sediment. Despite their differences in size and in depth, the results show that these two cores have three distinct magnetic zones that are similar in their age and magnetic properties. In both cases, the magnetic properties of the sediment differ from the magnetic properties of the soils, suggesting that despite the large differences in depth of Lakes Towuti and Matano they experienced similar limnological changes through time. Diagenesis in the form of magnetite precipitation and/or magnetite dissolution is likely the major process in the formation of magnetic minerals in these two lakes.

Investigation of the impact of Sidoarjo mud volcano ("Lusi") on the subsurface based on magnetic data at Sidoarjo district, Indonesia

Adi Susilo¹, Sunaryo¹

¹Geophysics Engineering, Physics Department, Sciences Faculty, University of Brawijaya Malang, Indonesia

Magnetic research has been carried out on the Sidoarjo Mud Volcano (LUSI = Lumpur Sidoarjo), Sidoarjo District, East Java, Indonesia. This mud volcano has a large impact, both on the surface, environmentally and on subsurface conditions. Studies and evaluations on environmental impacts have been largely undertaken through various disciplines; on social, economic, and environmental aspects. However, investigation and evaluation on the impact of subsurface structures is not widely known. The study was conducted in the area around the source of mud volcano. More than three hundred magnetic data were collected in the area of about 5 km x 5 km. Field measurement value data is called total magnetic field, which is in the range from 43,700 to 46,500 nano Tesla (nT). There are at least two kinds of magnetic data processing, which are daily correction and IGRF Correction (International Geomagnetic Reference Field Correction). When both corrections were applied, the final value is called residual anomalous. After all corrections were undertaken, the results of residual anomalous were between -160 nT and 120 nT. Qualitative interpretation, based on closure dipole anomaly (positive and negative) and zero crossing of residual anomaly iso-intensity, indicates that the presence of local dipole zone of residual anomaly was at the center area of mud volcano (LUSI), which has a diameter of about 1km. The conduit is likely circular. Quantitative modeling/interpretation was performed by connecting a pair of dipoles closure (magnetic is a dipole, while gravity is monopole). This was conducted by taking line from maximum (high intensity) and minimum (low intensity) closure. This is called as AA' cross section. It is obtained that the magnetic anomaly source
dimension (body) has a contrast value for the first body is -0.005 unit. This first body is between 100 m and 1340 m from the surface in one place, and the second body which has contrast value of about 0.008, was between 407 m and 1526 m from the surface. This second body was located in another place. From the both of the results above, it indicated that there is connection between two bodies, and when viewed on a geological map, there is an indication of fault line in this area.

Characterization of lava through whole-rock geochemistry and rock magnetism analysis at Ijen Volcanic Complex, Banyuwangi, east Java, Indonesia

Aditya Pratama¹, Satria Bijaksana¹, Mirzam Abdurrahman²

¹Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung
²Faculty of Earth Sciences and Technology, Institut Teknologi Bandung

Lava in general has complex geochemical characteristics based on differences in eruption sources, eruption events, and emplacement of its flow. Identification of lava characteristics is useful in understanding the geological conditions of volcanic region. Recently as complement to geochemical methods, rock magnetic methods have also been employed to characterize lava. To explore the potential uses of rock magnetic methods in lava characterization, series of magnetic measurements were carried out in lava samples from 13 locations in Ijen Volcanic Complex (Banyuwangi, East Java). These locations were grouped in 3 eruption centres. The magnetic measurements include frequency-dependent magnetic susceptibility, thermomagnetic, anhysteretic remanent magnetization (ARM), isothermal remanent magnetization (IRM), and hysteresis curve analyses. These measurements were also supplemented by XRF (X-ray Fluorescence) and petrographic analyses. The lateral lava variation is well represented by low frequency magnetic susceptibility and IRM saturation curves. The vertical lava variation, meanwhile, is represented by frequency-dependent magnetic susceptibility and magnetic hysteresis parameters.
Correlation analysis of anisotropy of magnetic susceptibility and porosity from μCT imaging in igneous rock from Ijen Volcanic Complex, East Java, Indonesia

Fadhli Ramadhana Atarita, Reyhan Fariz Taqwantara, Satria Bijaksana, Aditya Pratama, Fourier Dzar Eljabbar Latief

1Institut Teknologi Bandung

Anisotropy of magnetic susceptibility (AMS) has been used in various studies related to the interpretation of lava flow direction. Some previous studies showed there is an ambiguity regarding the interpretation of lava flow direction using AMS data. To solve this problem, we proposed a new parameter that can be used to determine lava flow direction. In this study, we used rock porosity images to support the interpretation of lava flow direction using AMS data. Porosity image can be used to determine lava flow direction by observing the direction of the long-axis of the pore inside rocks. The images are generated using microcomputed tomography (μCT) method. The rocks used in this study are lava flow type igneous rocks from Ijen Volcanic Complex, East Java, Indonesia. These rocks have similar characteristic, with differences only in porosity presentation and size of opaque minerals. Magnetic susceptibility measurements were performed using Bartington Susceptibility Meter MS2 instrument, meanwhile porosity imaging using μCT method was performed using Micro – CT Scanning Devices – SkyScan 1173 instrument. The correlation between AMS and porosity is examined from the inferred lava flow direction from these parameters. This study shows a positive correlation between AMS and porosity in 5 out of 6 rocks that were studied.

Identification of Sidoarjo mud (Lusi) flow subsurface structure using magnetotelluric method

Sunaryo, Adi Susilo

1Geophysics Engineering, Physics Department, Sciences Faculty, University of Brawijaya Malang, Indonesia

Research on the Sidoarjo mud flow to get subsurface structure using a magnetotelluric method has been carried out. The Sidoarjo mud (commonly called LUSI) flow has been ongoing since May 29, 2006 which had a large impact on the environment and subsurface conditions. Studies and evaluation on environmental impacts related to social, economic, and environmental quality aspects have been widely implemented. However, studies and evaluation on the impact of subsurface structures have not yet been implemented. Based on this case, the study on the impact of subsurface structures has been conducted by using magnetotelluric method. This study was conducted in an LUSI which located at coordinates 112.705E; 7.541S and 112.729E; 7.518S. Twenty data were obtained on the grids with the distance between grids about 500m. Data acquisition was performed using 3 frequencies: 128Hz, 4000Hz, and 6000Hz. An analysis and data processing was carried out in order to determine the relationship between frequency and phase, and frequency and amplification. The resistivity was also determined and found to be in the range of 0-256Ωm with depth to bottom is 4500m. Based on the distribution of resistivity values it is suggested that there is a structural alignment in a northeast-southwest orientation. Furthermore, the subsurface structure of the Sidoarjo mud flow zone can be divided into a three type of rocks as organizers of the lithology structure of LUSI location, i.e. an upper from surface to 1000 m (with resistivity value <100 Ωm) depth is alluvium rocks, a central section from at depth of 1000m to 3500m (with resistivity value 100-250Ωm) represented by sandstone and mudstone, and the bottom at depth of >3500m (with resistivity value >250Ωm) representing volcanic
rocks, possibly basalt. The results also suggest the presence of a conduit-like structure with the direction perpendicular downward until 1000m, but at depth between 1000m and 2750m which turns southeastward relatively, and after 2750m with the direction perpendicular downward again.

**The magnetic properties of volcanic ashes in guano deposited from caves in east Kalimantan, Indonesia**

Hamdi Rifai¹, Erni², Christopher M. Wurster³

¹Physics Department, Universitas Negeri Padang, Jl, Prof. DR. HAMKA, Padang, Sumatera Barat 25132, Indonesia
²Physics Department, Universitas Sriwijaya, Jl. Palembang-Prabumulih, Indralaya, Sumatera Selatan 30662, Indonesia
³School of Earth and Environmental Sciences, James Cook University, PO Box 6811, Cairns, QLD 4870 Australia

Indonesia consists of many guano caves distributed on islands such as Sumatra Java, Sulawesi and Borneo. Here, the magnetic properties of guano that contain volcanic ash transported from the environment should be unique relative to guano sediments, and has the potential to record individual events. However, the production of long palaeoeruption records from guano deposits is still a major challenge. Fresh guano does not contain magnetic minerals, and any magnetic minerals in guano sediment were thus transported into the cave. Changes in the distribution and properties of magnetic material through a deposit are likely a proxy of environmental change, most particularly that of volcanic eruptions. This study aims to test the hypothesis that volcanic eruption events are recorded in guano deposits via variations of magnetic properties. We looked at guano from Bau-bau cave East Kalimantan profiles. The concentration of magnetic minerals and magnetic susceptibility was measured every 5 cm for each profile. Magnetic properties such as type, grain and domain size were used to identify magnetic minerals, confirmed by X-Ray Diffraction (XRD) and scanning electron microscopy (SEM). Based on that analysis, magnetic minerals such as Iron Oxide (Fe3O4) and or Iron Titanium Oxide in guano from Bau-bau caves were found. Identified peaks of magnetic susceptibility triggered by magnetic minerals in the caves were interpreted as environmental change events that ranged from ~15–5 cal kyr BP. We found that peaks in magnetic susceptibility were closely related volcanic eruptions that occurred in Indonesia. However, the potential of guano deposits to record volcanic events should be further investigated.
Saturday 18 November 2017

Identifying lithogenic and anthropogenic magnetic components in the river sediments leading to Lake Limboto, Gorontalo, Indonesia

Raghel Yunginger, Satria Bijaksana, Darharta Dahrin, Siti Zulaikah, Abd. Hafidz, Sudarningsih, Kartika Hajar Kirana, Silvia Jannatul Fajar

1Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Jalan Ganesa 10 Bandung, Indonesia
2Physics Department, Faculty of Mathematics and Natural Sciences, Malang University, Malang, Indonesia

Lake Limboto in Gorontalo, North Sulawesi is one of the major lakes in Indonesia that is undergoing rapid environmental changes leading to its current critical condition. One of the major problems is its rapid sedimentation brought by several rivers that empty into coming from streams and rivers that empty into this lake. As these rivers passed through agricultural and residential areas, some of the sediments are anthropogenic rather than lithogenic. In this study, sediments from upstream and downstream of three rivers (Alo, Bionga, and Talumelito) that empty into Lake Limboto were studied to identify their lithogenic and anthropogenic components by characterizing their magnetic properties. The study includes magnetic analyses, such as measurement of magnetic susceptibilities and measurement of magnetic hysteresis. These measurements were supplemented by AAS (atomic absorption spectrometer), SEM (scanning electron microscopy), XRD (X-ray Diffraction) as well as ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrophotometer) analyses. The results show that there clear are differences in the magnetic signatures of lithogenic compared to that of anthropogenic components. Such differences are also supported by the SEM and other non-magnetic analyses.

Scanning electron microscopy and magnetic characterization of magnetic minerals suspended sediments from Citarum River, west Java, Indonesia

Sudarningsih1, Satria Bijaksana1, Wododo1, Irwan Iskandar1, Silvia Jannatul Fajar1, Kartika Hajar Kirana1, Abd Hafidz1, Raghel Yunginger1

1Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung

Citarum River in West Java is one of the vital rivers in Indonesia supporting three major dams as well as providing water, not only to the capital region, but also to major rice producing regions in Java. Earlier studies show that the magnetic properties in the suspended sediment from the relatively pristine upstream area of Citarum River are stronger than that from the polluted downstream area. In this study, the lithogenic and anthropogenic components of magnetic minerals taken from the suspended sediments were studied. Samples were subjected not only to magnetic analyses such as magnetic hysteresis measurement but also to AAS (atomic absorption spectrometer), SEM (scanning electron microscopy), and XRD (X-ray Diffraction) as well as ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrophotometer) analyses. The results show that main magnetic mineral is low coercivity ferromagnetic minerals, such as magnetite. The shapes as well as the compositions of these magnetic minerals were also found to be unique so that lithogenic component could be identified readily from that of anthropogenic component. This finding supports the prospect of using magnetic methods as (proxy) indicators river pollution.
Distribution of magnetic minerals in the surface sediments and the configuration of riverine system in Lake Towuti, Sulawesi, Indonesia

Silvia Jannatul Fajar¹, Satria Bijaksana¹, Kartika Hajar Kirana¹, James Russell², Hendrik Vogel³, Martin Melles⁴

¹Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Jalan Ganesa 10, Bandung, 40132, Indonesia
²Department of Earth, Environmental and Planetary Sciences, Brown University, 324 Brook St. BOX 1846, Providence, RI 02912, USA
³Institute of Geological Sciences, & Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland
⁴Institute of Geology and Mineralogy, University of Cologne, Zülpicher Str. 49a, 50674 Cologne, Germany

Lake Towuti is the largest tectonic lake in Indonesia with surface area of 561 km² surrounded by ultrabasic rocks which is a part of the Eastern Sulawesi Ophiolite Belt. Eighty four samples of surface sediment were collected in 2015 using a sediment grabber to identify the pattern of magnetic mineral distribution in this lake. The samples were then subjected to a series of magnetic measurements that include measurement of mass-specific magnetic susceptibility, frequency-dependent magnetic susceptibility, ARM (anhyysteretic remanent magnetization), IRM (isothermal remanent magnetization), and magnetic viscosity. The results show that the predominant magnetic mineral is pseudo-single domain magnetite. High magnetic susceptibility values of up to $534.3 \times 10^{-8}$ m³kg⁻¹ were found in places where the rivers enter the lake while the sediments in the centre of the lake tend to have lower values of magnetic susceptibility (lower than $100.0 \times 10^{-8}$ m³kg⁻¹). Distribution of frequency-dependent magnetic susceptibility values infer that the finer superparamagnetic grains tend to be higher in the centre of the lake compared to the other locations. These findings indicate that the distribution of magnetic susceptibility values is associated with detrital influx of the lake. When compared with the magnetic properties of lateritic soils from the surrounding area, the magnetic properties of the sediments tend to be similar suggesting that the majority of magnetic minerals in the sediments were originated from the soils which were then transported into the lake as product of soil erosion. Differentiation of magnetic contents as well as grain sizes was likely to be controlled by the configuration of riverine systems around the lake that in turn depends on the topography and hydrology.

Magnetic properties of lateritic soils around Lake Towuti, Sulawesi Selatan, Indonesia

Kartika Hajar Kirana¹, Silvia Jannatul Fajar¹, Abd Hafidz¹, Satria Bijaksana¹, La Ode Ngkoimani²

¹Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Jalan Ganesa 10 Bandung, Indonesia
²Faculty of Earth Science and Mineral Technology, Universitas Halu Oleo, Kendari 93231, Indonesia

Lacustrine sediment is strongly influenced by detrital influx. One of the sources of detrital influx entering Lake Towuti in South Sulawesi Indonesia is the lateritic soil around the lake. In this study, six samples of laterite soil from two different soil outcrops were studied for their magnetic characteristics. The outcrops are located in the pathways of soil erosion towards the lake. The samples were subjected magnetic measurements as well as SEM (scanning electron microscopy), XRD (X-ray diffraction), and XRF (X-ray fluorescence) analyses. The results show that the magnetic susceptibility values are high and vary with depth. The magnetic susceptibility is also affected by superparamagnetic (SP) grains. XRF analyses show that the Fe content in the samples is high. XRD and SEM analyses indicate that magnetite is the
predominant magnetic mineral in the samples. Such highly magnetic soil may seriously affect the magnetic characteristics of sediment in Lake Towuti.
POSTER PRESENTATIONS

Magnetic properties of natural iron sand in Sarmi Papua

Octolia Togibasa¹, Satria Bijaksana², Gesti Cita Novala²

¹Department of Physics, Universitas Cenderawasih, Jayapura, 99358, Indonesia
²Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Bandung, 50132, Indonesia

Indonesia, a geologically unique country, is well known possess a large deposit of natural iron sand. Higher concentrations were found in West Sumatera, Southern Java and Northern Papua, specifically in the vicinity of Sarmi Regency. To the author’s knowledge, the iron sand originated from Sarmi, Papua have never been studied. In this study, we investigated detail magnetic characterization of natural iron sand from the Sarmi coast area, to explore the possible utilizations of iron sand. Our previous study has revealed that iron sands were highly deposited from Tor River estuary, in Sarmi coast area. These iron sands was having mass-specific magnetic susceptibility values vary approximately from 1.9 to 2.7 × 10⁻⁴ m³/kg, while the particle size values vary from 150 to 200 um. The magnetic properties will be delivered from the vibrating sample magnetometer measurement. Furthermore, the mineral compositions and the crystallographic structure were also will be discussed.
Session 09: Hydrogeology, Hydrology and Water Resources
Chairpersons: Stefan Gödeke & Langping Wu

ORAL PRESENTATION

Friday 17 November 2017

Vulnerability maps: a useful tool for karst groundwater protection: The case study of Ziria karst system, south Greece

Eleni Zagana¹, Eleni-Anna Nanou¹

¹University of Patras, School of Natural Science, Department of Geology, Rion, 26500 Patras, Greece

In the last years vulnerability maps have been used as a tool to highlight the areas with the greatest potential for groundwater pollution based on the hydrogeological conditions and the respective human impacts. Several regions of Greece depend completely or partially on drinking water from karst aquifers, thus the production of vulnerability maps for such karstic areas is considered essential. In the present study, an assessment of aquifer intrinsic vulnerability has been conducted applying the COP method in the Ziria karst system. The latter is located at the Northeast part of Peloponnese in South Greece and is used as a public resource for drinking water. This method, which has been developed for carbonate aquifers, uses the properties of the overlying layers above the water table (O factor), the concentration of flow (C factor) and the precipitation regime (P factor) over the aquifer. The COP method considers karstic landforms as factors which decrease the natural protection provided by the overlying layers of a karst aquifer. With the use of GIS tools the vulnerability map has been produced highlighting the different degrees of intrinsic vulnerability in the karst system of Ziria.

Effect of groundwater salinity on the compressibility of Semarang-Demak aquitard

Dwi Sarah¹, Lambok M. Hutasoit¹, Robert M. Delinom², Imam A. Sadiq¹, Taufiq Wirabuana³

¹Department of Geological Engineering, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung (ITB), Bandung 40132, Indonesia
²Research Center for Geotechnology, Indonesian Institute of Sciences (LIPI), Bandung 40135, Indonesia
³Center for Groundwater Resource and Environmental Geology, Geological Agency, Bandung 40122, Indonesia

Large cities in the Northern Java are mostly located in the coastal areas, like Jakarta, Semarang and Surabaya. The North coast of Java is composed of underconsolidated and compressible Quaternary alluvial sediment, hence susceptible to land subsidence. The groundwater quality in the coastal area ranges from fresh to saline. The high rate of land subsidence in the coastal cities like Jakarta and Semarang raises a question whether the groundwater quality affects the compressibility of the aquitard layer. This paper aims to analyze the effect of groundwater salinity on the compression characteristics of Semarang-Demak clay. Salinity of the groundwater was determined and clay consolidation tests were carried out at various salinity condition. Clay mineralogy and fabric analyses were also performed separately. The results showed that saline clay has higher compressibility, consolidation rate and hydraulic conductivity. The clay fabric analysis revealed that saline clay particles have parallel alignment that facilitates faster dissipation of pore water as compared with the flocculated alignment of the fresh water clay.
Seasonal trace elements concentration in domestic groundwater wells in parts of Kelantan, Malaysia

Mohammad Muqtada Ali Khan¹, Kishan Raj Pillai A/l Mathialagan¹, Hafzan Eva Bt Mansor¹, Nor Shahida Bt Shafiee¹

¹Department of Geoscience, Faculty of Earth Science, Universiti Malaysia Kelantan, Campus Jeli, Locked Bag No. 100, 17600 Jeli, Kelantan, Malaysia

Groundwater is one of the main sources of fresh water supply in northern Kelantan region. Groundwater demand for agricultural usage has also shown a steady increase in the region. Return flow from agriculture and domestic water use have the potential for groundwater contamination. The purpose of the present study was to assess the degree of trace element pollution and the suitability of groundwater for drinking. Trace element analysis for thirty-two groundwater and surface water samples were carried out. The groundwater samples were collected from shallow aquifers in the northern part of Kelantan state. A total 15 trace elements (As, Pb, Sr, Ba, Mn, Co, Ni, Cu, Cd, Fe, Zn, Cr, B, Se, and Al) were analyzed. The samples were transported to the laboratory and analyzed using Inductive Coupled Plasma Mass Spectrophotometer (ICP-MS). The study reveals that most of the analyzed samples contain low concentrations of trace elements. Majority of toxic elements are found to be in minute quantities and thus assumed to be harmless. The trace elements concentration from most wells are well below the permissible limit of WHO which points to the unpolluted source of water supply in the area and is thus suitable for drinking and other domestic purposes. Recommendations for the usage of groundwater must take into consideration, factors such as soil categories, type of crops, plantation management practices and proper drainage systems. Appropriate use of regulations and effective water management policies may help in further developing the available groundwater resources for agriculture and other domestic purposes.
Saturday 18 November 2017

Ground and surface water investigations in Brunei Darussalam

Stefan Herwig Gödeke¹, Lee Hoon Lim¹, Nur Hakimah Mansor², Lim Sui Kau Alice²

¹Universiti Brunei Darussalam, Faculty of Science, Department of Geology, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam
²Department of Water Services, Public Works Department, Ministry of Development, Bandar Seri Begawan, BB3510, Brunei Darussalam

Brunei relies almost exclusively (>99 %) on surface water for drinking water purposes. This water is sourced from rivers as well as water reservoirs away from urban centres. However, growth in population size and industrialization as well as emerging contaminants are putting more and more pressure on the importance of reliable water resources. This project plans to investigate the water quality at selected water reservoirs in Brunei Darussalam as well as to explore potable groundwater resources in Brunei Darussalam. Key water quality parameters for the monitoring of the raw water intake for treatment consist of pH, turbidity, colour, and the presence of aluminium as well as chloride ions. These water quality parameters are measured twice daily. In this study, the daily water quality data of river water obtained from the Bukit Layong and Bukit Barun areas of Brunei were analyzed over a three year period (2014 – 2016). Statistical analysis of the data was performed and the geometric mean and average on a monthly basis were calculated and correlation with the average annual rainfall (1901 – 2015) were performed. A threshold analysis was performed to determine the pH at which more aluminium becomes mobilized at lower pH values. Generally the analysis shows a moderate correlation between rainfall and turbidity, as well as rainfall and aluminium, and aluminium and pH. For chloride the correlation between rainfall and turbidity was less significant. The results indicate that strong rainfall events can lead to increased aluminium content in the river water as the aluminium gets washed out from the soil. The soils in this area consist of recent deposits of clay and sand overlain by peat. The threshold analysis indicates that at a pH lower than 4.5, more aluminium is mobilized. These low pH events thus have an important effect on the increase of aluminium in the river water. The moderate correlation between turbidity and aluminium could indicate the importance of the colloidal transport mechanism for aluminium. As a next step rainfall intensity will be utilized to strengthen the statistical analysis of the data.

Chemistry and fluid mineral equilibria of warm thermal waters in the Los Banos and Calamba areas, Laguna, Philippines

Maria Ines Rosana Balangue-Tarriela¹, Angelina Z. Pena¹, Fernando P. Sringan², Karen Ann Jago-On³, Ronald Lloren³

¹National Institute of Geological Sciences, College of Science, University of the Philippines, Diliman 1101, Quezon City, Philippines
²Marine Science Institute, College of Science, University of the Philippines, Diliman 1101, Quezon City, Philippines
³School of Urban and Rural Planning, University of the Philippines, Diliman 1101, Quezon City, Philippines

Water samples from 17 pumped hot springs pools and domestic wells in Los Banos and Calamba areas were collected and analyzed. The thermal waters do not differ much in their chemistry but show increase in some solutes (Na, K, Mg, Ca, Cl, SO₄, and Al) from Los Banos to Calamba hot springs. The Cl-SO₄-HCO₃ and Na-K-Mg ternary diagrams, silica and cation geothermometers, mixing models, and saturation index plots (using SOLVEQ
and stable isotopes were used to characterize the waters and estimate the subsurface temperature. The results show that most of the waters are in not in equilibrium with the rock or are “immature” waters. The hot waters in the study area can be classified as Na-K HCO$_3$-Cl. Cation geothermometers are not applicable in such cases, while the quartz with no steam loss geothermometer is suggested as the most likely useful tool to estimate subsurface temperatures of such systems. The quartz no steam loss geothermometer gives subsurface temperature ranging from 134.4 to 163.8°C. Values for the chalcedony geothermometer and the Na/K geothermometer values do not correspond with each other. Log Q/K plots from solution-mineral equilibrium studies suggest the geothermal fluids from the two hot spring areas are departure from overall equilibrium but some minerals such as quartz, chalcedony, and calcite seem to approach equilibrium with the solution. The hydrogen and oxygen stable isotopes were used to trace and determine the origin of the thermal waters. Thermal waters have more negative deuterium values than cold waters. All the waters are close to the local meteoric line, parallel to the world meteoric line, indicating that the hot and cold waters are of local meteoric origin, with no apparent oxygen isotope ratio shift. This may indicate that aquifer temperatures are not high enough to cause significant shift, or that good permeability exists in the reservoir.

Assessment of multiple groundwater recharge estimation techniques for a Quaternary aquifer in the lower Kelantan

Ismail Yusoff$^1$, Nur Hayati Hussin$^1$, Wan Zakaria Wan Muhd Tahir$^2$, May Raksmey$^3$

$^1$University of Malaya, Department of Geology, Kuala Lumpur, Malaysia
$^2$Malaysian Nuclear Agency, Bangi, Selangor, Malaysia
$^3$University Technology MARA, Faculty of Engineering, Shah Alam, Selangor, Malaysia

Quantification of groundwater recharge is very important for effective groundwater resource management in the Lower Kelantan River Basin (LKRB). The estimation will help to determine the sustainable yield of groundwater exploitation in which 90% of the water supply in LKRB is from groundwater. In this study, various techniques have been applied to estimate the recharge rate such as Water Table Fluctuation (WTF), Chloride Mass Balance (CMB), Temperature-Depth Profile (TDP) and Numerical Modelling (NM). The estimated recharge rates are compared with total rainfall for the area. Recharge obtained by WTF, CMB, TDP and NM ranges from 10-18%, 16-37%, 2-13% and 5-11% from the total rainfall, with an average value of 14%. The variation from the average value for all methods ranges between -3 to 23%. The variation of recharge rate is subjected to the principle of the recharge estimation techniques and the representative data. WTF gives reasonable recharge value and is in good agreement with the NM. The best value should be based on the long term hydrological records and best represent the whole area.

Introducing water quality assessment of Taman Tasik Medan Idaman based on inorganic solids

Nazia Hossain$^{1,2}$, Labiba Mahmud$^2$

$^1$Universiti Brunei Darussalam, Faculty of Integrated Technologies, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam
$^2$International Islamic University Malaysia (IIUM), Faculty of Engineering, Department of Biotechnology-Biochemical Engineering, Jalan Gombak, 53100, Kuala Lumpur, Malaysia.

This study was conducted to assess the water quality of Malaysian lake, Taman Tasik Medan Idaman located beside populated urban area in Gombak,
Selangor. The main objective of this study was to determine total suspended solid (TSS), total dissolved solid (TDS), volatile suspended solid (VSS), total phosphorus (TP), total nitrogen (TN), copper (Cu) and Zinc (Zn). This study measured the water quality and classified according to Interim National Water Quality Standard (INWQS), Malaysia for residential usages and survival of aquatic species. TSS and VSS were measured by conventional weighing method, TDS by TDS meter, Cu, Zn, TP and TN by atomic absorbance spectroscopy (AAS). The experimental result showed that TSS was quite high, 60mg/L that was categorized under class III and classified as polluted water based on water quality index (WQI) Malaysia, which can be utilized only for livestock drinking and tolerant with aquatic species existence. Cu was measured as 0.02 mg/L grouped under IIA/IIB that can be used for recreational purpose, body contact and sensitive aquatic species existence. Zn, TP, TN amount were 1.91mg/L, 0 mg/L, 0 mg/L, respectively that qualified for class I (very clean) water. Moreover, TSS and VSS amount were 165.9 mg/L and 720 mg/L, respectively; TSS can be categorized as class I albeit VSS was recommended to minimize. Therefore, the experimental results proved that this lake water can be used for irrigation, animal husbandry and non-sensitive aquatic life with precaution but cannot be implemented on domestic use. For such case, this study recommended water purification processes such as vacuum filtration to reduce TSS, TDS and VSS as well as adsorption process by activated carbon to lessen Cu and Zn.

Investigation of physio-chemical characteristics of Taman Tasik Medan Idaman water, Malaysia

Nazia Hossain¹,², Labiba Mahmud²

¹Universiti Brunei Darussalam, Faculty of Integrated Technologies, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

³International Islamic University Malaysia (IIUM), Faculty of Engineering, Department of Biotechnology-Biochemical Engineering, Jalan Gombak, 53100, Kuala Lumpur, Malaysia

Water scarcity is a consistent crisis around summer season (April-July) in Gombak area, Kuala Lumpur, Malaysia. Drinking and household water supply in Gombak is usually based on groundwater source. In summer season, the hot-dry climate and the lack of rainfall in key catchment areas usually causes the escalation down of groundwater level and results in water pumping system breaking off and this temporarily stops water supply. Offline water treatment plants shutting down due to ammonia contamination has also been a contributing factor in the water crisis. To resolve this water shortage issue, this study investigated an alternative surface water supply source for Gombak region, the lake Taman Tasik Medan Idaman. The objective of this research was to analyze the physio-chemical characteristics of the lake water and determine the water standard for its potability. This study measured the pH, Dissolved Oxygen (DO), Chemical Oxygen Demand(COD), Biological Oxygen Demand in 5 days(BOD₅), and turbidity; experimental results were 6.97, 18.6mg/L, 82mg/L, 43mg/L and 9.4 Nephelometric Turbidity Unit (NTU) respectively. pH level proved to be within levels deemed safe to consume while other factors were required to undergo purification processes to attain standard ‘Class I’ according to Malaysian EQA (Environmental Quality Act) 2009. Furthermore, this study also investigated the purification approaches to improve the water quality. Alum flocculation to reduce the turbidity level, addition of hydrogen peroxide (H₂O₂) with ozone (O₃) or by H₂O₂ and ultraviolet radiation (UV) application to improve DO, COD, BOD₅ and to reach palatable water standard ‘Class I’.
POSTER PRESENTATIONS

Interpretation of the factors defining groundwater quality of the site subjected to the wildfire of 2007, in Elia prefecture, south-western Greece

Stavroula Dimitriadou¹, Konstantina Katsanou¹, Stavros Haralampopoulos¹, Nikolaos Lamprakis¹

¹University of Patras, Department of Geology, Laboratory of Hydrogeology, Rio-Patras, GR 26504

The present study examines the factors that define groundwater quality of the site subjected to the wildfire of 2007, in Elia Prefecture, SW Peloponnese, Greece, that was the most severe wildfire in Greece for the last decades. This wildfire caused deforestation, urban damages and human losses. It also threatened the stadium in Olympia where the Olympic Games, were held during the ancient times. An extensive sampling was carried out three months after the fire. The 99 samples that were collected, were analysed in the Hydrogeology Laboratory of University of Patras for major and trace elements, immediately after the sampling. The hydrochemical results were processed with R-type factor analysis and each factor was spatially distributed. The bedrock of Elia consists of formations of the Ionian zone, the Olonos-Pindos zone and the Gavrovo-Tripolis zone, which are overlain by Neogene and Quaternary deposits. The Neogene formations host several aquifers. The most productive aquifers are those of Vounargon, Kalathas, and Lallas conglomerates. The study area is characterised by intense tectonic activity. The groundwater samples were classified into three hydrochemical types. The prevailing type is Ca-HCO₃, which is evenly distributed over the study area, is typical of fresh water with efficient recharge. The dilution of the gypsum that is abundant in the Neogene formations of the area leads to samples of Ca-HCO₃-SO₄ water type. The relatively elevated Na concentration in the Ca-Na-HCO₃ type is mainly attributed to ion-exchange processes, to the presence of evaporates and in some cases seawater intrusion. Nevertheless, the aforementioned concentrations were below the permissible limits (Directive 98/83/EC). The statistical analysis resulted in a four-factor model that represents the 75% of the initial-values information. The first factor associates the groundwater-temperature to the presence of Li and B. In the literature, the presence of these elements, along with higher Tw values, has been extensively associated with deep water circulation through tectonic structures, and thus longer residence time. The second factor expresses the relation of Fe and Mn to slightly acid water in the aquifers of Amaliada and Pineia. The third factor relates the increased concentrations of Cr, U and As, to reducing conditions in the central part of the area which has agricultural, livestock, and urban land-uses. The third factor displays high loadings mainly for redox potential. Eh negative values indicate reducing environments that are confirmed by comparing the distribution maps of second and third factor. There was no indication of wildfire’s impacts on groundwater of Elia.
Session 10: Continental vs. Oceanic Lithosphere: Processes and Evolution
Chairpersons: Federicca Zaccarini & Giorgio Garuti

ORAL PRESENTATION
Thursday 16 November 2017

Petrology, structure and alteration of calcium sulphate deposits in Late Palaeozoic rocks of Wang Saphung area, Loei Province, Thailand

Nusara Surakotra¹, Sarunya Promkotra¹, Punya Charusiri², Ken-Ichiro Hisada³

¹Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen, 40002, Thailand
²Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, 10330, Thailand
³Graduate School of Life and Environmental Sciences University of Tsukuba, 1-1-1 Tennodai, Tsukuba City Ibaraki 305-8572, Japan

The gypsum-anhydrite deposit at Loei-Wang Saphung area in northeast Thailand presents only in boreholes with no outcrop exposure. This is a small evaporite sediments deposit with an up to 50 m thick gypsum-anhydrite beds. The gypsum-anhydrite deposits are overlain by cross-laminated and fine-grained sandstone beds and algal boundstone of the Carboniferous to Permian rock units in the Wang Saphung area. This paper documents some characteristics of the deposits, included: lithologies, texture and structure of gypsum-anhydrite and associated rocks in the exploration wells, lithostratigraphy and the relationship between each lithofacies. It is based on the study of cores logging of the exploration wells in the area and petrography of selected samples. The sequences of deposits compose of centimeter-to-meter scale interbeds of gypsum-anhydrite, carbonate rocks and silicic-clastic beds with minor conglomerate and breccia beds. The beds of gypsum and anhydrite have prominent laminae of carbonate mud and clays which are the synsedimentary deposits. The original evaporite sedimentary structures of the beds might have been obliterated by recrystallization of gypsum and rehydration of anhydrite into secondary gypsum. The gypsum-anhydrite associated with carbonate and mud rocks suggest that these beds form in a restricted basin, probably in shallow lagoon setting. The results of studies indicated that the LW sulphate deposits have passed through at least 4 stages of diagenesis; (1) at least the largest portion of the deposits was originally precipitated as gypsum, (2) gypsum-to-anhydrite transformation resulting from burial diagenesis. These alterations are indicated by the corrotopic and felted anhydrite. (3) Rehydration of anhydrite-to-gypsum, indicated by distorted of gypsum rocks, which resulting from the increase of volume due to the rehydration from anhydrite to gypsum, recrystallization of anhydrite and/or primary gypsum to secondary gypsum (alabastrine, selenitic, and gypserarenite secondary gypsum) (4) Uplift and re-expose of gypsum, indicated by the karstification and dissolution cavities and gypasarenite veins.

The Ranau peridotite: Implications on the petrogenesis of subcontinental mantle in Sabah (east Malaysia)

Chee Hui Teo¹, Rahmat Tarif¹, Nur’Aqidah Norazme¹, Thenmalar Rajoo², Elena Ifandi³, Basilios Tsikouras¹

¹Universiti Brunei Darussalam, Faculty of Science, Physical and Geological Sciences, Jalan Tungku Link, BE 1410 Gadong,
Peridotites in the region of Sabah, Malaysia have not been extensively studied and are generally reported as parts of an ophiolite complex. However, the data presented in this study, which have been collected from samples from multiple outcrops in the vicinity of Ranau suggest a different origin. The Ranau peridotites are characterized by the predominance of lherzolites, which exhibit distinct mineral textures and modal composition, as well as mineralogical and whole-rock compositions. Harzburgite is subordinate. Moderately rich in Cr spinels with lobate boundaries suggest that the lherzolite has suffered a low degree of partial melting. Nonetheless, extremely Al-rich spinel coexisting with Al-augite and pargasite in the lherzolite strongly recommends its fertile character and its subcontinental mantle origin. Local symplectites of spinel and orthopyroxene crystals, reminiscent of a garnet precursor, indicate decompression and are in line with the above interpretation. Formation of olivine and clinopyroxene neoblasts along with enrichments in certain incompatible trace elements indicates the refertilized nature of the Ranau lherzolites. Furthermore, sporadic diabases in tectonic relationship with the lherzolite provide strong argument that they were exhumed and exposed in ocean-continent transition zones. It is recommended that the Ranau peridotite comprises a subcontinental mantle type peridotite similar to orogenic peridotite massifs in northern Lanzo and Ronda.

Geochemistry and seismic tomogram beneath Krakatau volcano, Sunda Strait, Indonesia

Mirzam Abdurrachman¹, Sri Widiyantoro², Bambang Priadi¹, Taufik Ismail³

¹Geology Research Group, Bandung Institute of Technology, Bandung 40132, Indonesia
²Global Geophysics Group, Bandung Institute of Technology, Bandung 40132, Indonesia
³Department of Geology, Sekolah Tinggi Teknologi Mineral Indonesia, Bandung 40263, Indonesia

Violent eruption of Krakatoa Volcano located in the Sunda Strait, Indonesia has attracted earth scientists around the world as one of the killer eruptions in human civilization. Although much data have been reported, the interior of subducted slab and mantle structure beneath this volcano is poorly known. We combined geochemical data, major, trace and rare earth elements with seismic tomogram to characterize the interior of subducted slab and mantle structure at the junction of Sumatra and Java subduction systems (Krakatoa Volcano area). Geochemical data are suitable with previous studies of partial melting in subduction system and also show a good agreement with P-wave tomographic model. Whereas, the tomographic image of S-wave suggests that subducted slab has been intruded by hot material of mantle. The presence of both partial melting and mantle plume might be caused by the subduction of tearing India Australian Plate beneath Krakatau Volcano.

Petrographic characteristics of the Jugan gold deposit, Sarawak, Malaysia from core samples

Aubrey Marie R. Villareal-Tirona¹, Ma. Ines Rosana D. Balangue-Tarriela¹

¹Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines 1101

The Jugan Gold Deposit is one of the many mineral deposits found in the northeast trending Bau Mineral District in Sarawak, East Malaysia. This paper presents results from the petrography studies conducted on core samples to characterize the different lithologies of Pedawan Formation and
alteration minerals, to differentiate the various occurrences of sulphide minerals and to identify the characteristics of the Au bearing sulphide minerals. Petrographic study of core samples in the Jugan deposit reveals that several sedimentary rocks such as shale, siltstone, sandstone (greywacke) and interbedded units host Jugan Gold Deposit. Alteration minerals present in Jugan include sulphide minerals, carbonate (dolomite and ankerite), clay (illite and kaolinite) and silica. Sulphide minerals (mainly pyrite and arsenopyrite) were observed to occur with varying morphology, which suggest four origins for the minerals. These are PY1 & APY1 (detrital), PY2 & APY2 (diagenetic), PY3a & APY3a (disseminated hydrothermal) and PY3b & APYb (stockworks hydrothermal). Hydrothermal sulphide minerals occur together with carbonate and silica alteration and are highly associated with high Au values. The hydrothermal fluid that caused the emplacement of ankerite and dolomite veins in shale is inferred to be similar to the carbonate cement in most sandstone/ greywacke because of the similarities in their petrographic characteristics especially the morphology/textures of the carbonate minerals. The difference in the mode of deposition is attributed to the different characteristics such as the permeability, porosity and mineral composition of each rock units. Occurrence of silica is localized, meaning they are not observed in all samples. However, once present it is rather intense forming jasperoid/ chalcedony. Illite and kaolinite are late stage mineralization and is not associated with any type of sulphide minerals. Based on the characteristics of the host rock, sulphide minerals and alteration minerals, it can be stated that Jugan Gold Deposit has undergone several geologic event that may have resulted in the emplacement of two types of Au rich sulphide mineralization. Au in the area is postulated to be a result of both diagenetic and hydrothermal processes. In conjunction with the Au fire assay result, it is suggested that the Au found within diagenetic sulphides are of lesser value compared to the hydrothermal sulphides.

**Platinum Group Minerals (PGM) in chromitites from Sulawesi Ophiolite Belt, Indonesia: Their evolution from high to low temperatures**

Federica Zaccarini¹, Arifudin Idrus², Giorgio Garuti¹

¹Department of Applied Geosciences and Geophysics, University of Leoben, Peter Tunner Str. 5, A-8700 Leoben, Austria
²Department of Geological Engineering, Gadjah Mada University, Jl. Grafika 2

The occurrence of platinum group minerals (PGM) in the Indonesian Archipelago has been previously reported only from Borneo. In this area, the PGM have been discovered from placers deposits, which are considered to have derived from the erosion of ophiolitic chromitites, Alaskan-type complexes and skarn deposits. Borneo is also the type locality of two PGM, the rare vincentite, ideally (Pd,Pt)₃(As,Sb,Te) and the most common Ru-bearing mineral, laurite, ideally (Ru,Os)S₂. Chromite deposits occur in the ophiolite belt of the South and Southeast Arms of Sulawesi, Indonesia. The variation of the Cr# = Cr/(Cr + Fe₃⁺) indicates that the chromite composition varies from Cr-rich to Al-rich. This bimodal composition and the slight enrichment in TiO₂ observed in some chromitites suggest a vertical zonation due to the fractionation of a single batch magma with an initial boninitic composition during its ascent, in a supra-subduction zone. This observation implies the accumulation of Cr-rich chromitites at deep mantle levels and the formation of the Al-rich chromitites close or above the Moho-transition zone. Small PGM, 1–10 μm in size, have been found in both the Cr-rich to Al-rich chromitites. The most abundant PGM is laurite, which occurs included in fresh chromite or in contact with chlorite along cracks in the chromite. Laurite forms polygonal crystals, and it
occurs as single phase or in association with amphibole, chlorite, Co-pentlandite and apatite. Small blebs of irarsite (less than 2 μm across) have been located within awaruite and Co-pentlandite in the chlorite gangue of the chromitites. Our mineralogical observation suggests that all the laurites are magmatic in origin, i.e., entrapped as solid phases during the crystallization of the host chromite at temperature of about 1200 °C and a sulphur fugacity below the sulphur saturation. Irarsite possibly represents a low temperature, less than 400 °C, exsolution product.

Geodynamic Evolution during Eocene to Recent and its implication for Volcanism and Magmatism in Java

Mirzam Abdurrachman¹, Dardji Noeradi¹

¹Department of Geology, Bandung Institute of Technology, Bandung 40132, Indonesia

Volcanic activities in Java occur at least since Eocene time, the first activities took place from 40 Ma to 19-18 Ma. The second activities occurred between 12 Ma or 11 Ma to 2 Ma about ~50 km north of older arc and were overlaid by Quaternary volcanism of Sunda Arc. The movement of magmatic arc was followed by the changing of K₂O content. Although there were some volcanism and magmatism during Middle Miocene, e.g., Pacitan, Cirotan, Pelabuhan Ratu, Kulon Progo, Wonesari, Borobudur, Wayang volcano, Kulon Progo and Selogiri, the volcanism and magmatism during this period relatively decreased or reposed and they have been the subject of many investigations. It is also noteworthy that magmatism in South Sulawesi also terminated at 18 Ma and it was renewed at 12 Ma by post-subduction K-rich magmatism. Our study shows that the changing of subduction rate and arc development that caused northward advance of the subduction hinge are responsible to the movement of magmatic arc during Eocene to Pliocene time that had been followed by gradual changing of K₂O content (low to high). Whereas, the relative reposed volcanism during Middle Miocene was resulted from collision between Indian-Australian Plate and Eurasian Plate margin in the eastern Indonesia. New geodynamic evolution for Java is presented.
Petrographic characterization of volcanic rocks from Mount Bijang, Laguna, Philippines

Gildanel C. Belesario¹, Denise Faye S. Janer¹, Mark Angelo B. Somosa¹, Cleodette I. Lagata¹, Maria Ines Rosana Balangue-Tarriela¹

¹National Institute of Geological Sciences, University of the Philippines-Diliman, Quezon City 1101, Philippines

Mt. Makiling, situated in Macolod Corridor, southwestern Luzon, is a stratovolcano marked by a number of silicic volcanic domes. Five of these, namely Mt. Bijang, Tanauan Hill, San Antonio, Olila, and Bulalo, have been reported to contain similar mineral assemblage and generally occur as glassy and microlitic (Vogel et al., 2006). This study presents preliminary results on the petrography of the rocks found in the Mt. Bijang dome. From limited rock exposures of the dome, hand specimens showed variation in colour, ranging from light to dark, and grain size. Petrographic analysis confirmed similar composition assemblage and generally occur as glassy and microlitic in samples collected. Mt. Bijang rocks are all made up of plagioclase, hornblende, and clinopyroxene phenocrysts set in a volcanic glass groundmass. Using the International Union of Geological Sciences (IUGS) classification of volcanic igneous rocks, Mt. Bijang samples made up of less than 80% volcanic glass were identified as andesite; otherwise, it was identified as obsidian based on Shelley (1993). In terms of texture, petrographic assessment showed that all samples are vitrophyric, with average volume percent estimation of 25% for phenocryst and 75% for volcanic glass. Phenocrysts/groundmass ratio also varies from one sample to another. The phenocrysts occur as fine to medium-grained, with resorbed edges. Plagioclase grains occur both as mega and microphenocryst and exhibit trachytic structure. Moreover, intergranular and poikilitic texture between plagioclase and hornblende phenocrysts are occasionally found in some samples. On the other hand, the volcanic glass groundmass showed a fabric variation, with flow structure either as color banding or flow layering. In some samples, fragmentation in volcanic glass was also observed. These initial observed variations of the volcanic rocks in Mt. Bijang most likely reflect fluctuating physical and/or chemical states during emplacement. More extensive fieldwork to delineate the occurrence of the different rock types and geochemical analysis may be conducted to correlate the bulk composition of the source magma with the textural manifestation observed in the volcanic rocks to better understand the eruption history of the Mt. Bijang dome.

Petrology and geochemical analysis of Bangui Volcanics and Bojeador Volcanics of Ilocos Norte, Philippines

L.P. Olayta¹,², J.M. Nablo¹,³, C.M. Tanpoco¹, B.M. Flores¹, C.R. Gibaga¹,², C. Arcilla¹,²,⁴

¹National Institute of Geological Sciences, University of the Philippines Diliman, Quezon City, Philippines
²Earth Materials Sciences Laboratory, National Institute of Geological Sciences, University of the Philippines Diliman, Quezon City, Philippines
³Earth Materials Laboratory, National Institute of Geological Sciences, University of the Philippines Diliman, Quezon City, Philippines
⁴Philippine Nuclear Research Institute, Quezon City, Philippines

The study area, which covers most of Ilocos Region found northwest of Luzon Island, Philippines, encompasses a major portion of Ilocos-Central Region Basin. Although numerous geologic researches have been conducted in the area, none have focused on the Late Cretaceous Pillow Lavas of Bangui Formation and Early Miocene Volcanics of Bojeador Formation, let alone on the aspect of their magmatic origins.
Twenty-five samples were obtained, initially identified as basalts, andesites, and agglomerates. Petrographical analysis was performed to further supplement the identification of the samples. Samples were subjected to X-ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICPMS) analyses. The whole rock geochemical analysis of the samples reflected rare earth elements (REE) and high field strength elements (HFSE) characteristics of magma from a suprasubduction zone, related to the subduction of Eurasian plate. Furthermore, previous geochemical studies from nearby igneous complexes and volcanic flows suggest similar geochemical imprint with the analyzed samples, suggesting a single parent melt.

**Preliminary results from a new occurrence of a sheeted dyke complex in the Ophiolite Complex of Telupid (Sabah, Malaysia)**

Nur’Aqidah Norazme¹, Thenmalar Rajoo², Chee Hui Teo¹, Rahmat Tarif¹, Elena Ifandi³, Basilios Tsikouras¹

¹Universiti Brunei Darussalam, Faculty of Science, Physical and Geological Sciences, Jalan Tungku Link, BE 1410 Gadong, Brunei Darussalam
²Universiti Teknologi PETRONAS, Faculty of Geosciences & Petroleum Engineering, Department of Geosciences, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia
³University of Patras, Department of Geology, Sector of Earth Materials, 265 00 Patras, Greece

A new outcrop of a well exposed sheeted dyke was discovered in the ophiolite of Telupid, close to the village of Tongod. The outcrop is part of the dismembered Telupid ophiolite and it comprises a dyke swarm consisting of diabase and lesser basalt, as an indication of a slow spreading centre. Structural measurements of the strike and dip of the dykes revealed the existence of two orientations. These measurements were plot on a stereonet and were reset to the vertical position in an effort to determine the spreading direction of the oceanic basin and to elucidate the processes of the ocean opening. Detailed petrographic investigation showed that the diabase includes primary clinopyroxene, orthopyroxene and plagioclase, showing variable degrees of alteration. Whole-rock geochemical analyses in these rocks show major and trace element signatures similar to the underlying gabbros and the overlying basalts. The sheeted dyke complex shows considerable petrographic and geochemical resemblance to the sheeted dyke members of other, well-known ophiolites, however, its size is much smaller than the later. Detailed study of the petrological characteristic of this dyke member will provide new insights in the evolution of the oceanic lithosphere in the region of Sabah.

**Preliminary results on the geochemical evolution of rodingites from Sabah (East Malaysia)**

Thenmalar Rajoo¹, Nur’Aqidah Norazme², Chee Hui Teo², Rahmat Tarif², Elena Ifandi³, Basilios Tsikouras²

¹Universiti Teknologi PETRONAS, Faculty of Geosciences & Petroleum Engineering, Department of Geosciences, 32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia
²Universiti Brunei Darussalam, Faculty of Science, Physical and Geological Sciences, Jalan Tungku Link, BE 1410 Gadong, Brunei Darussalam
³University of Patras, Department of Geology, Sector of Earth Materials, 265 00 Patras, Greece

Rare rodingite dykes occur in variably serpentinised peridotites in the region of Sabah, Malaysia. The rodingites occur as whitish rocks with a homogenous appearance, including a variety of Ca-Al and Ca-Mg silicate minerals, such as grossularitic garnet, chlorite, diopside, prehnite and tremolite. They are nonpervasively altered and their mineralogical associations and reactions
enable us to unravel their petrogenetic evolution. Extensive petrographic study of their textural and mineralogical characteristics suggest that their potential protoliths include gabbroic and doleritic rocks. These lithologies, are their intrusion in the ultramafic country rocks, were metasomatised by fluids percolating through the adjacent serpentinised peridotites. The geochemical exchanges and mass transfer between the rodingite protoliths and their surrounding formations is studied with the aid of isocon analysis. A series of mineral reactions and a possible evolutionary path on a T-XCO₂ diagram is suggested using the TWQ software. The evolution of the rodingites is investigated in the geotectonic framework of the east Borneo.

Preliminary results on the petrogenetic evolution and origin of beluran pyroxenites (Sabah, east Malaysia)

Rahmat Tarif¹, Chee Hui Teo¹, Elena Ifandi², Basilios Tsikouras¹

¹Universiti Brunei Darussalam, Faculty of Science, Physical and Geological Sciences, Jalan Tungku Link, BE 1410 Gadong, Brunei Darussalam
²University of Patras, Department of Geology, Sector of Earth Materials, 265 00 Patras, Greece

The occurrence of pyroxenites near Beluran village, Sabah, is mainly associated with Iherzolites and minor harzburgites. Petrographic observations indicate that they comprise variably serpentised orthopyroxenites. Petrographic observations and geochemical evidence, involving a detailed interpretation of rare earth elements (REE) and other immobile trace elements patterns are in favour for a replacive origin during melt percolation. It is suggested that evolution of these pyroxenites involves a melt-rock reaction between olivine and Si-rich melts to produce orthopyroxene and a relatively Si-poor melt. This is further corroborated by field observations and the alignment of spinel grains in trails, parallel to the foliation of the rocks. Although the suggested reaction does not occur exclusively in continental mantle rocks, the results of this research strongly indicate that the Beluran pyroxenites have a replacive character and are continental peridotites.

An example of isocon analysis on rodingites from the Veria-Naousa ophiolite (north Greece)

Nina Zaronikola¹, Aikaterini Rogkala¹, Petros Petrounias¹, Panagiota P. Giannakopoulou¹, Basilios Tsikouras², Konstantin Hatzipanagiotou¹

¹University of Patras, School of Natural Science, Department of Geology, Rion, GR-26504, Patras, Greece
²Universiti Brunei Darussalam, Faculty of Science, Department of Geology, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

Dykes of rodingites occur in serpentinised lherzolite and harzburgite in the Veria-Naousa ophiolite. Three groups of rodingites have been defined according to their different protoliths. Type I rodingites contain garnet + vesuvianite + diopside + chlorite ± perovskite and are thought to derive from a gabbroic protolith. Type II rodingites include garnet + diopside + chlorite and have an ultramafic protolith whereas type III rodingites contain garnet + vesuvianite + diopside + chlorite and have been derived from diabase. Isocon plots are used to investigate and discuss the geochemical behaviour of certain elements. Ti and Zr have remained immobile in type III rodingites whereas they were largely mobile in types I and II. Cr and Ni were highly mobile; both elements escaped from type II and entered types I and III rodingites. Dissolution of spinel and olivine in the ultramafic precursors are considered the likely source of Cr and Ni amounts that were leached from type II rodingites. Rare earth elements (REE) show
a different behaviour in the rodingite types, as they remained constant only in type III rodingites. Mobilisation of REE, as well as Ti and Zr in the rodingite types I and II can be explained by fluid-rock interaction, and the incorporation of ligands, such as OH-, under alkaline conditions and relatively high concentration of CO₂ in the metasomatic fluid.

Characterization of clay minerals in Liang, Belait and Seria Formations and modern offshore sediments, Brunei Darussalam

Khairunnisa Nazirah Karim¹, Nur Fazrenna Nazzerah Mohamed Kamransah¹, Elena Ifandi², Basilios Tsikouras³

¹Universiti Brunei Darussalam
²University of Patras, Department of Geology, Sector of Earth Materials, 265 00 Patras, Greece

There are limited researches done on the clays and clay minerals found in Brunei Darussalam. This paper aims to determine the mineralogical composition and the geochemical properties of clays and clay minerals found in the Liang Formation, which consists of the Lumut and Berakas Members, the Belait Formation, the Seria Formation and from recent offshore sediments (from the sea-boXom offshore Brunei-Muara and Tutong Districts). A total of twenty samples were collected for this study. This study characterizes the clays from these formations according to their locality, clay colour, moisture content and the clay minerals contained. Study of secondary electron images, spectra acquired with Energy Dispersive Spectrometer (EDS) and X-ray diffractograms revealed that the analyzed samples contain abundant illite followed by kaolinite and chlorite. The results of the analyzed samples do not contradict recent studies, which stated that the northern Borneo fluvial sediments are rich in illites and chlorites. Illite can be formed due to neoformation processes that cause weathering of K- and Al-rich minerals (e.g. muscovite, feldspars).

Moreover, montmorillonite and kaolinite are also identified through the analysis, but are only present in certain formations in Brunei. Transformation and conversion of both montmorillonite and kaolinite plays a major role in contributing to the abundant amounts of illites and chlorites. In the Liang Formation, kaolinite, illite and chlorite are present in the Lumut Member whereas the Berakas Member only has kaolinite and illite. The Belait Formation shows the presence of only illite and chlorite. The recent offshore sediments collected from Muara and Seria Formations contain kaolinite, illite and chlorite whereas the recent offshore sediments collected from Tutong contains kaolinite, illite, chloride and montmorillonite.

Characterization of the volcanic rocks of Nihia area, Milos island, Greece

Panagiota Tsigrou¹, Paraskevi Lampropoulou¹, Ioannis Iliopoulos¹, Angelos G. Kalampounias², Aikaterini Rogkala¹, Panagiota P. Giannakopoulou¹, Petros Petrounias¹, Sofia Karipi¹, Christos Katagas¹

¹University of Patras, School of Natural Science, Department of Geology, Rion, GR-26504, Patras, Greece
²University of Ioannina, Department of Chemistry, GR-45110 Ioannina, Greece

Preliminary results of the study of acid volcanic rocks from Milos island (Nihia area) are presented here. These results based on petrographic, mineralogical and geochemical rock features were obtained via Petrographic Microscopy, ICP, XRD, SEM and Raman techniques. Three distinct groups were established, according to the petrographic analysis of the samples examined. The first group (MIL-I) comprises dark-coloured massive rocks with glassy luster and characteristic conchoidal fracture. They mainly contain sanidine, plagioclase (The second group (MIL-II) encompasses samples characterized by a massive structure with no glassy luster which display conspicuous alternating light
and dark parallel oriented bands, reflecting lava flow. These oriented microstructures of trachytic texture are mainly composed of quartz microlites, while small amounts of plagioclase (mainly (The perlitic-spherulitic texture with its characteristic cracks (commonly prevailing over the vitrophyric luster) is the dominant feature of the third group (MIL-III) established herein. The extensive devitrification also differentiates these volcanic rocks from those of the former groups. Plagioclase (mainly An40), hornblende (magnesio-hornblende to actinolite), biotite and oxides have been detected whilst the “amorphous” phase is less abundant (~60-70%) but richer in silica (~80-92 wt %) compared to the one of MIL-I samples. The hydration of these samples is assumed by Raman analyses too, maybe due to their water content. The combination of the petrographic and mineralogical results presented above with the geochemical data indicates that the studied volcanic rocks have a rhyolitic to rhyodacitic composition and can be classified as glass-sub alkaline and specific calc alkaline volcanic rocks (obsidian, perlite).
Session 14: Mineral Resources  
Chairpersons: Chun Kit Lai, Elena Ifandi & Lisa Thieme  

ORAL PRESENTATION  

Friday 17 November 2017  

Petrography of aggregates in Luzon, Philippines: Identification of components and deleterious materials  
Ma. Ines Rosana Balangue-Tarriela¹, Cleodette I. Lagata¹, Raymond Leuterio¹, Ma. Lourdes Abad¹  
¹National Institute of Geological Sciences, College of Science, University of the Philippines, Diliman  

Aggregates are granular materials, such as sand, gravel, or crushed stone that is combined with asphalt or cement to form concrete which are used as bases of all concrete structures. The quality of aggregates significantly affects the properties of the concrete since it constitutes about 70% of the volume of the concrete (Al-Dulaijan et al., 2002). In this study, aggregate materials were collected either from rock exposures or as alluvial deposits from the four areas near Metro Manila, Philippines: Bulacan, Rizal, Pampanga, and Zambales. These areas are the main sources of aggregates for the different construction activities in Metro Manila. The samples were subjected to petrographic studies primarily for rock identification and secondly, to characterize physical and chemical properties of the aggregate materials that may present potential problems on the structures such as alkali-silica reactivity, pop-out distress and structural weakening to the strength of the aggregate materials. Petrographic assessment showed that the aggregates vary in terms of rock types (e.g., andesite, basalt, gabbro, pyroclastic) with different degrees and types of alteration types and degree of alteration (e.g., oxidation, chloritization, serpentinitization). Samples from Bulacan are mostly porphyritic basalt and fine to coarse-grained sandstone with some cavities, microfractures and cracks caused mainly by vesicles and occurrence of veinlets of silica and carbonate. Rizal aggregates are composed dominantly of basalts and andesites with minor clastic rocks and tuffs. The aggregates collected from Zambales are mainly products of erosion of the ophiolite from the Zambales Range (as observed from the presence of ultramafics and basalts), mixed with the lahar deposits from the Pinatubo eruption. Meanwhile, Pampanga aggregates are also mostly lahar deposits, especially pumice, a poor choice for aggregate composition because of its low hardness, brittleness and vesiculated texture. Aside from the lithological classification, potentially alkali-reactive constituents were observed to be present in some samples in all the four study areas. The quartz from devitrification of groundmass, silica veins, and amygdales of silica add more to the deleterious materials observed. Potential durability of the aggregates may be influenced by the presence of micro fractures, cavities and clay minerals. Further testing of the aggregates for durability and strength suggested as per use of the aggregates. Use of XRDA and other analysis in testing for verification of the compositions can also be used to confirm the presence of potential deleterious materials.

Identifying of peat soil layers using K-means clustering in the south Kalimantan, Indonesia  
Mimin Iryanti¹, Ahmad Aminudin¹, Eleonora Agustine², Satria Bijaksana³, Wahyu Srigutomo³, Tedy Setiawan³  
¹Faculty of Mathematics and Sciences Education, Universitas Pendidikan Indonesia  
²Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran
The various types of soils have been identified by electrical and magnetic properties especially on peat soils. Peat soils are commonly considered being partly decomposed vegetation. In this study, electrical and magnetic properties have been used for K-means clustering to identify layers of peat soils. K-means clustering is a partitioning method that treats observations in the data. Data core were obtained every cm for its electrical conductivity and magnetic susceptibility properties. A 291 cm core was obtained at Tegal Arum Village in the South Kalimantan, Indonesia. The K-means clustering results indicate two different layers at 148 cm and it is supported by Loss on Ignition (LOI) measurement. In the first layers it was found 87.65% LOI that associated with peat soils (above 148 cm) and whereas second layers 26.11% that associated with mineral soils (below 148 cm). The results of this study using K-means clustering can be used to delineate soil layers.

Depositional setting of the Kabubunan coal measure of the Bisling Formation, Bunawan, Agusan Del Sur, Philippines

Raymond G. Leuterio¹, Ma. Ines Rosana D. Balangue-Tarriela¹, Valerio Joseph M. Foronda¹,²

¹National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines 1101
²Philippine National Oil Corporation – Exploration Corporation, Building 1, Energy Center, Rizal Drive, Bonifacio Global City, Taguig City, Philippines 1634

The Philippines’ Department of Energy has estimated 69.55 million metric tons of coal reserves in the Surigao Coal Region. This region is hosted by the coal-bearing Late Oligocene to Early Miocene Bislig Formation. Although there were efforts on publishing papers where data came from coal mining companies (Foronda, et al 2011, Limos-Martinez and Watanabe 2006), no attempt has been made to collect, review, and interpret the geologic data from the coal-bearing sequences of Bislig Formation. The objective of the study is to determine the lithological and geochemical characteristics in one of the identified coal measures of the Bislig Formation.

Kabubunan Coal Measure belongs to the Bislig Formation. Lithological and coal quality studies suggest that the Kabubunan Coal Measure was formed in a delta environment intercalating with fluvial and shallow marine environments. Coal seams are relatively thin (<1m); the dominant lithofacies hosting the coal are mudstones deposited in interdistributary bays. Sandstone interbeds originated from distributary channels and levees were deposited during flooding, and resulted on coal seams with medium to high (10 – 47%) ash yield. The limestones and other calcareous sedimentary rocks which are occasionally found in between the coal seams are interpreted to represent successive phases of delta out-building interspersed with occasional marine incursions. They also overlie the whole coal measure. The low to medium sulphur (0.82 – 3%) content on all the coal seams indicate deposition of coals in a freshwater to brackish water swamp. Coal is classified as Lignite A to Sub-bituminous B (<6,300 BTU/lb – 10,500 BTU/lb) on air dried basis. No variability has been observed with residual moisture (<9%), volatile matter (~27%), and fixed carbon content (~25%) on air dried basis.

Trace element signatures of apatite from Hillside, south Australia

Roniza Ismail¹, Cristiana Ciobanu², Nigel Cook²

¹Universiti Malaysia Kelantan, Faculty of Earth Science, Department of Geoscience, Locked Bag 100, 17600 Jeli, Kelantan
Hillside deposit located on the Yorke Peninsula, is one of the recent discoveries in the Gawler Craton of South Australia. The deposit has the characteristics of an Iron Oxide Copper Gold (IOCG) system but also features skarn alteration. Apatite is one of the most abundant accessory minerals that can be found throughout all stages, spanning igneous to skarn assemblage. It also can incorporate significant concentrations of rare earth element (REE). Thus, it is important to achieve a better understanding of trace elements concentration and distribution in apatite at Hillside because they could be different among the stages. The distinct trace element signatures of apatite possibly represent the alterations. In this study, analyses of apatite by laser ablation inductively coupled plasma mass spectrometry (LAICPMS) were used as a main tool to assess the distribution of rare earth element (REE), incompatible and ore-forming elements in several lithologies. Mineralogical and petrographic studies using electron probe microanalysis (EPMA) and scanning electron microscope (SEM) also were undertaken to support the findings. LAICPMS spot analyses of apatite in Hillside show that apatite is a significant REE-carrier in the deposit, with total trace element values ranging from 200 ppm to >4 wt.%. Variation in trace element signatures and chondrite-normalized REE fractionation trends of apatite has potential application to mineral exploration and can be used as petrogenetic tools and exploration vectors.

Rietveld analysis of south Kalimantan kaolin claystone XRD pattern

Muhammad Saukani1, Muhammad Irfansyah1, Muhammad Firman1, Budi Hartadi1, Ice Trianiza1, Firda Herlina1, Rendi1, Abdurrahim Sidiq1, Gusti Rusydi Furqon Syahrillah1, Jainal Arifin1, Syaifullah Arif1, Mujiburrahman1, Heri Irawan1, Muhammad Suprapto1

It has been estimated that South Kalimantan has 13,116,000 tons of kaolin claystone which spread in several regencies covering Banjar, Tapin, Hulu Sungai Utara and Katabaru. To make use of Kaolin Claystone as geopolymer, characterizing its phases both by using qualitative and quantitatively was conducted. The samples of kaolin claystone were taken based on the largest distribution in the area of Banjar regency which located in Sungai Tabuk (ST) and Cintapuri (CT), while in the area of Tapin regency, the location is in Tatakan (TT). Claystone which had been sampled was prepared by using siphoning method, then, characterized by using X-ray diffraction (XRD) to determine the phase in the samples. Qualitative analysis was used by using search-match of X’Pert HighScore Plus software, while quantitative analysis was based on Rietveld refinement method by Reitica software. The research findings which based on XRD pattern resulted from qualitative analysis showed that there were two main phases: Quartz (SiO₂) and Kaolinite (Al₂Si₂O₅(OH)₄). In addition, quantitative analysis using Reitvel showed that Quartz and kaolinite quantity in the samples subsequently ST 30.42%, 69.58%, CT 23.78%, 76.22% and TT 15.77%, 84.23%. Having percentage of GoF (Goodness of Fit) less than 4%, quantitative analysis was accepted. Therefore, based on this research, the best quality of kaolin claystone in South Kalimantan can be found in Tatakan, Tapin regency.

Mineralogy control for problematic ore at Grasberg Block Cave (GBC) reserve underground mining Freeport, Indonesia

Fence George Aiwoy1, Ildrim Syafriz2, Euis T.Yuningsih3, Bambang Antoro4
Grasberg Block Cave is an underground mine passed under an open mine Grasberg reserve, with the “Cu-Au Porphyry” deposit type, located within the Contract of Work A (COW “A”) of PT. Freeport Indonesia, Ertsberg District, Papua. The reserve in January of late January 2015 was 1.011 million tones with 1% copper (Cu) and gold (Au) 0.77 g / t. Grasberg Block Cave is a porphyry deposit where the highest Cu-Au grade hosted within stockwork material in a horse-shoe shape at the margin of barren core Kali diorite. Metallurgy performance reflected in ore type is need by mine engineer to get an optimal metal target. Clean ore type will produce higher metal recovery compared to problematic ore material. Problematic ore in Grasberg Block Cave is propose to recognize early before mining. The problematic ore study on Grasberg Block Cave reserves was conduct to determine the characteristics and controls of mineralogy in this type of ore in order to reduce losses due to decreased acquisition of valuable ore minerals. The method used is XRD data mapping-field geological sampling, XRD drilling data and metallurgical analysis in the laboratory. The problematic ore type base on geo-metallurgy Freeport Indonesia standard minimum problematic in the Grasberg open pit and predicted to Grasberg block cave is influenced by impurity minerals such as mineral sericite-clay > 10%, pyrite >5%, and mica-silica >15%. Metallurgical test results are helpful in calibrating the early geological model data and actual geological data or mapping in the field used as a reference for determining the type and characteristics of the ore. In general, these impurity minerals produce metallurgical test data with a high yield rate exceeding 15%, and a high mica-sericite mineral content of more than 10%. This can certainly reduce the value of valuable minerals such as copper and gold. The result of metallurgical analysis by float method shows that high mass yield exceeds the threshold value of 12.5%, with high sericite and clay and pyrite mineral content of more than 10%. This result reduces the value of valuable minerals such as copper and gold. Problematic ore at Grasberg Block Cave reserve can classified by Cu and Au recovery data from metallurgical analysis. In addition, laboratory results of Mass Yield values more than 12.5%, minerals including, pyrite and oxides. The presence of impurities usually found in problematic ore types decrease recovery of copper and gold. Therefore, geological observations in the field combined with laboratory analysis are very important to determine the problematic ore at Grasberg Block Cave reserve. To reduce the risk of recovery of copper and gold, mainly due to the detrimental minerals in the problematic ore type, mixing method with cleaner ore types can be adopter. Ore characterization and the blending method has resulted in increased cost efficiency in processing ore for the Grasberg Mine.
POSTER PRESENTATIONS

Characterization of pyrites in an alkaline-hosted deposit

Cleodette L. Lagata¹, Ma. Ines Rosana B. Tarriela², Janice Wayan³

¹National Institute of Geological Sciences, University of the Philippines-Diliman, Quezon City, 1101, Philippines
²National Institute of Geological Sciences, University of the Philippines-Diliman, Quezon City, 1101, Philippines
³FCF Minerals Corporation, Brgy. Runruno, Municipality of Quezon, Nueva Vizcaya 3713, Philippines

The Runruno ore deposit is one of the few known yet less studied ore deposits in the Philippines hosted by alkaline rocks. It is located within a large alkaline volcanic complex with a defined resource of 1.73 million ounces of gold and 45.58 million pounds of molybdenum as estimated by Metals Exploration (2014). The style of mineralization in the area is mainly hydrothermal, with mineralized rocks mostly containing pyritic assemblages or their oxidized equivalent. Evidences from a previous study by Jensen (2008) show that significant gold mineralization associated with strong K-silicate + pyrite alteration. In this study, we investigated the use of pyrite mineral chemistry and crystal morphology as potential indicator of the style of gold mineralization in the Runruno ore deposit. Using the assay data, representative samples with pyrite content were collected from depths with low, intermediate and high-gold content. Secondary electron and back-scattered electron (BSE) imaging in the Runruno samples showed the differences in morphology and textures in pyrites in relation to gold content. Pyrites associated with low gold occur as disseminated fine-grained anhedral crystals and aggregates of anhedral pyrites. Those with intermediate gold content are related to anhedral to subhedral individual crystals of pyrites, while high gold pyrites has coarser subhedral to euhedral individual crystals with distinct oscillatory zoning. Electron Probe Microanalysis (EPMA) results show a negative correlation of As with S in pyrite. This is consistent with the substitution of As for S in the pyrite structure as previously studied by various authors. (Fleet and Mumin, 1997 and Reich et al., 2005) A clear positive linear correlation between gold and arsenic grade is also present in the samples as reported by FCF in a study in 2015. Morphological, textural and chemical studies of pyrite reveal that the fine-grained, disseminated or aggregates of pyrite are “barren” while euhedral to anhedral coarse-grained pyrites contain Au and various trace elements. Gold, more specifically, is present in arsenian pyrite as structurally-bound Au¹⁺ or Au-bearing nanoparticles.

Sulphur, strontium, carbon, and oxygen Isotope Record of calcium sulfate deposits in Late Carboniferous Rocks of Loei-Wang Saphung (LWS) Area, Loei Province, Thailand

Nusara Surakotra¹, Punya Charusiri², Sarunya Promkotra¹, Teruyuki Maruoka³, Ken-ichiro Hisada⁴

¹Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen, 40002, Thailand
²Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok, 10330, Thailand
³School of Life and Environmental Sciences University of Tsukuba, 1-1-1 Tennodai, Tsukuba City Ibaraki 305-8572, Japan
⁴Graduate School of Life and Environmental Sciences University of Tsukuba, 1-1-1 Tennodai, Tsukuba City Ibaraki 305-8572, Japan

Evaporite sulfate deposits of the Loei – Wang Saphung (LWS) area in northeastern Thailand with interbeds of carbonate layers were investigated and analysed for S, O, C, and Sr isotope compositions. The aim of the investigation is to document stable isotope data and to interpret depositional environment as well as age of formation.
Sulphate samples yield average values of δ34S of 14.615‰ while give the 87Sr/86Sr ratio of gypsum of 0.708282 and anhydrite of 0.708288. Carbonate layers yield the average values of δ18OPDB, and δ13C values of -12.52‰, and -0.1‰, respectively. Results from the stable isotope data reveal the LWS evaporite deposit was originally formed from seawater and the negative value of δ18O isotopic signal was a result of meteoric alteration during subaerial exposure of the sections. Additionally, selected samples were analysed for the Sr isotope show slightly higher values with very mild variations. This suggests that the LWS deposit was not affected by subsequent hydrothermal alteration by younger igneous dikes in this area. Therefore these isotope signatures are considered as preserved primary textures, despite the fact that the deposit underwent anchizone to epizone metamorphism. Results of the S and Sr isotope values indicate the depositional age of the LWS sulphate deposit in Middle - Late Carboniferous.

A comparative study of mafic and ultramafic ophiolitic rocks from Greece for their suitability as concrete aggregates

Petros Petrounias¹, Panagiota P. Giannakopoulou¹, Aikaterini Rogkala¹, Alkiviadis Sideridis¹, Basilios Tsikouras², Konstantin Hatzipanagiotou¹

¹University of Patras, School of Natural Science, Department of Geology, Rion, GR-26504, Patras, Greece
²Universiti Brunei Darussalam, Faculty of Science, Department of Geology, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

Mafic and ultramafic rocks from different ophiolite complexes in Greece are assessed for their suitability as concrete aggregates. Cubic test pieces of concrete were prepared using these rocks for the aggregate fraction and were tested for their mechanical properties. The cement paste, which was used for all types of aggregates, was prepared by using carbonate sand. The results showed that the specimens made with mafic aggregates showed higher resistance in uniaxial compressive strength (UCS) than these made using ultramafic rocks, in the majority of studied samples. Detailed microscopic examinations through optical polarized microscope before and after the UCS testing revealed that the mineralogical composition is a critical factor in the behaviour of aggregates, including both their strength and interactions with the cement paste. Serpentine, which is a common alteration product in ultramafic rocks plays a negative role in their performance, whereas primary and secondary minerals in mafic are harder hence explaining their better performance.
Session 15: Carbon Sequestration  
Chairpersons: Diomedes Racelis & Elenita Racelis  

ORAL PRESENTATION  
Wednesday 15 November 2017  

Comparative study of carbon dioxide sequestration efficiency in coal seam gas and depleted carbonate gas reservoirs: The Indonesia field case  
Edo Pratama¹, Mohd Suhaili Ismail¹, Syahrir Ridha¹  
¹Faculty of Geosciences and Petroleum Engineering, Universiti Teknologi PETRONAS  

Injecting carbon dioxide (CO₂) into gas/oil reservoirs will not only provide an opportunity for Indonesia to improve energy supply and security, but will also store the greenhouse gas in a proven subsurface formation. Geological assessment in terms of CO₂ sequestration efficiency is critical to examine the effectiveness of a reservoir to store targeted CO₂ quantity. This paper aims to evaluate the CO₂ sequestration efficiency in coal seam gas and depleted carbonate gas reservoirs by designed CO₂ flooding through a vertical injection well and a producing well with the case study in Indonesia. A coal seam gas reservoir located in Sumatera and a depleted carbonate gas reservoir located in Java was chosen to conduct the study. The coal seams are of sub-bituminous rank and coal matrix is fully saturated by methane. The lithology of the carbonate reservoir is dolomite with single porosity system and the reservoir fluid is lean gas condensate, wherein the main composition is methane. Adsorption trapping and solubility trapping were considered as the main sequestration mechanism in coal seam gas and depleted carbonate gas reservoirs, respectively. Using compositional simulation, supercritical state CO₂ was injected into these two gas reservoirs with the same operating conditions for 30 years of simulation. Sensitivity analysis was then conducted in order to investigate the effects of injecting parameters on the sequestration efficiency of each reservoir. The advantage and disadvantage of sequestering CO₂ for the purpose of CO₂ storage and enhanced gas recovery in these two reservoirs will be also compared and discussed.

Soil carbon assessment of selected pine forest stands in Benguet Province, Philippines  
Elenita L. Racelis¹, Diomedes A. Racelis²  
¹University of the Philippines Los Baños, College of Forestry and Natural Resources (CFNR), Training Center for Tropical Resources and Ecosystems Sustainability (TREES) College, Laguna, Philippines, 4031  
²University of the Philippines Los Baños, College of Forestry and Natural Resources Institute of Renewable Natural Resources (IRNR), College, Laguna, Philippines, 4031  

The study assessed the carbon stored in soil in selected natural, managed and poorly stocked Benguet Pine (Pinus kesiya Royle ex Gordon) forest stands. It adopted a single stratum stratified sampling. Google image and GIS were used to classify and assess the types of stand based on crown stocking density (CSD): high (2/3 CSD), medium (> 1/3 - < 2/3 CSD) and low (>1/3 CSD). Composite soil samples were collected per plot from each soil depth (0-10 cm; 10-20 cm and 20-30 cm) and replicated per elevation type (high, mid and lower elevation). Results showed a mean soil C of 93.56 Mg ha⁻¹, 91.47 Mg ha⁻¹ and 85.46 Mg ha⁻¹ for high, medium and low density stands, respectively. Expectedly, the stored soil C per stand type increases from low density
to high density stands. Further, it means that the amount of carbon stored increases as the quantity of vegetation also increases. The SOC share in the overall amount of carbon stored among carbon sinks per stand type ranges from 47-69%. The study finds relevance on the global initiatives on reducing emissions of carbon dioxide (CO\(_2\)) mostly by assessing the carbon absorbed in soils and associated vegetation. Forests play a significant role in global carbon cycle. They either served as carbon sink or source of carbon. Plants assimilate CO\(_2\) from the atmosphere through the process of photosynthesis and release it through respiration. When plant dies its stored carbon is also released to the atmosphere or to the soil where it decomposes slowly and thus increases soil carbon content. However, there is little information on the level of soil carbon stored depending on the stocking rate of Benguet Pine forest stands in the Philippines.

Estimating the carbon sequestration potential of Padcal mine reforestation project

Elenita L. Racelis\(^1\), Diomedes A. Racelis\(^2\)

\(^1\)University of the Philippines Los Baños, College of Forestry and Natural Resources (CFNR), Training Center for Tropical Resources and Ecosystems Sustainability (TREES) College, Laguna, Philippines, 4031

\(^2\)University of the Philippines Los Baños, College of Forestry and Natural Resources Institute of Renewable Natural Resources (IRNR), College, Laguna, Philippines, 4031

The study forecasted the potential of the Philex-Padcal Mine new reforestation projects to store carbon over the next six years. It has been targeted that the company will establish 100 hectares additional plantation sites yearly for a total of 600 hectares from 2015 until 2020. The projection was based on actual measurements made on the existing plantations both pure and mixed Benguet Pine plantations of the project. It measured the five carbon pools; namely: trees, understorey/herbaceous, course woody debris (CWD), roots and soils. The study adopted a single stratum stratified sampling which included a 20 m x 100 m plot for big trees with dbh> 30 cm including CWD with ≥ 5cm dbh and 0.5m length while the 5m x 40m subplot included trees with dbh 5-30 cm. The understory/ herbaceous and litter samples were collected in a 0.5m x 0.5 m subplot inside the 5m x 40 m subplot. Composite soil samples were collected at various soil depths (0-10 cm; 10-20 cm and 20-30 cm) replicated per elevation type (high, mid and lower elevation). Google image and GIS were used to classify and assess the three types of stand based on crown stocking density (CSD): high (2/3 CSD), medium (> 1/3 - < 2/3 CSD) and low (>1/3 CSD). The forest inventory determined an average biomass density of 176.83 t ha\(^{-1}\) with equivalent C and CO\(_2\) stored of 169.74 t ha\(^{-1}\) and 622.37 t ha\(^{-1}\), respectively. Its mean annual increment (MAI) at age 27 was estimated at 6.55 t ha\(^{-1}\) yr\(^{-1}\) with equivalent of 2.95 t ha\(^{-1}\) yr\(^{-1}\) C or 10.81 t ha\(^{-1}\) yr\(^{-1}\) CO\(_2\). Using the computed MAI of this study plus MAI of younger plantations from other studies of the same species, the proposed 600-ha reforestation sites to be established up to 2020 have a projected mean annual sequestration rate of 10,199.18 t CO\(_2\) yr\(^{-1}\).

Numerical modelling of CO\(_2\) injection in a homogeneous anisotropic medium: Case study of carbon capture and storage pilot project Gundih field, Indonesia

Fatkhan\(^1\), Cahli Suhendi\(^2\), David P. Sahara\(^3\), Mohammad Rachmat Sule\(^1\)

\(^1\)Seismology, Exploration and Engineering Research Group, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, Indonesia

\(^2\)Geophysical Engineering, Department of Sciences, Institut Teknologi Sumatera, Indonesia
The injected CO₂ propagates in the reservoir, according to its in-situ stress and permeability, and change pore pressure and effective stress of the reservoir. Studies have been performed on the modelling of this CO₂ injection in an effort to monitor its propagation and anticipate its potential leakage. In an anisotropic reservoir, this issue gets bigger as the propagation might concentrate. We developed a Graphical User Interface (GUI) of program code to solve this coupled Thermo-Hydro-Mechanical (THM) problem in a homogeneous anisotropic material. We used this coupled software to simulate the coupled THM process of CO₂ injection. Gundih Carbon Capture and Storage (CCS) project, if successfully run, can be regarded as the first CCS pilot project in Indonesia. The project is devoted for research and development of CCS technologies since Indonesian’s government has a plan to reduce CO₂ more than 20% by 2020. One of technologies developed to reduce CO₂ emission is by injecting CO₂ into subsurface formation. In this pilot project the CO₂ is planned to be injected within 10,000 tonnes/years. Findings of Geological and Geophysical studies conclude that Ngrayong Formation is the most possible candidate to be the storage formation. The CO₂ fluid is injected into Ngrayong formation at the depth around 800 m. At this depth, CO₂ is expected to be in supercritical condition, in which the phase depends on the hydrostatics pressure and gradient thermal. In order to have more information behaviour of reservoir rocks, we proposed to simulate injection into VTI (Vertical Transverse Isotropic) media. Rock permeability have important role in CO₂ injection and is assumed with horizontal to vertical permeability ratio is around of 5. It will affect where and how much the CO₂ flux is distributed. A 3D model of a layered formation consists of porous and permeable reservoir layer and non-porous and impermeable cap rock. The model is initialized in hydrostatic condition and stress induced by gravitational loading. In this stage, the model will be compacted before the injection. A boundary condition is set as no lateral displacement normal to side boundary and no vertical displacement normal to bottom boundary. Results show that program code developed has successfully simulate the CO₂ injection into reservoir model. Another finding is the coupled fluid-flow and geomechanical simulation improve our understanding on dynamic reservoir responses due to CO₂ fluid injection.
Session 17: Structural Geology and Tectonics
Chairpersons: Claudia Baumgartner-Mora & Afroz Ahmad Shah

ORAL PRESENTATION

Friday 17 November 2017

General geology of north eastern central Gunung Semanggol, Bukit Merah: Findings on the 2017 recent fieldwork and mapping activities

Danial Ashraff bin Mohamad Iskak¹, Md Yazid Mansor², Mohd Shaufi Sokiman³

¹Geoscience Department, Faculty of Geoscience & Petroleum Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia
²Geoscience Department, Faculty of Geoscience & Petroleum Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia
³Geoscience Department, Faculty of Geoscience & Petroleum Engineering, Universiti Teknologi PETRONAS, 32610 Bandar Seri Iskandar, Perak, Malaysia

The study area is situated on the eastern part of Gunung Semanggol which is in the vicinity if Bukit Merah where the rocks are not clearly exposed due to the thick vegetation. The main lithology observed here consists of the Permo-Triassic sandstone, interbedded sandstone and siltstone, quartzite and contact breccia known as the Semanggol Formation. A detailed geological mapping has been done in this area in order to produce a geological and cross sectional map. Geological structures found are mainly joints, bedding and veins. Features such as faults and folds were not observed during this study. For each outcrop, there are about two sets of joints mainly striking almost in the N-S and E-W direction with an average dipping angle of 56° and 77° respectively. It is interpreted that this area had suffered from an internal stress coming from the igneous tectonic. This deformation was responsible for the formation of the conjugate joints based on the calculated stress obtained from the rose diagram. The maximum principal stress is mainly coming from the NE-SW direction. From the rose diagram plotted, the shear to the right and shear to the left can be determined. This paper presents additional insights on the structural elements and deformation mechanism of the Semanggol Formation along with its relationship with the Bok Bak Fault. Due to outcrop limitation within the transect area, the speculation whether the linear ridge formation of Gunung Semanggol as a result of granite emplacement across north Peninsular Malaysia is still unclear.

Assessment of relative active tectonics in parts of Aravalli Mountain range, India: Implication of geomorphic indices, remote sensing and GIS

Syed Ahmad Ali¹, Javed Ikbal¹

¹Department of Geology, Aligarh Muslim University, Aligarh, India

Aravalli Mountain Range is an example of erosional mountains, trending NE-SW, shows numerous faults and lineaments. Udaipur area, situated in south-east part of the mountain, is considered as tectonically active. So the main objective is to study relative tectonic activity of the Ahar watershed of Udaipur, Rajasthan, India. To assess relative tectonic activity of the area, geomorphic indices such as stream-length gradient index (SL), asymmetry factor (Af), basin shape (Bs), valley-floor width to valley height ratio (Vf), mountain front sinuosity (Smf), hypsometric integral (Hi), hypsometric curve, and transverse topographic symmetry factor (T) is applied. DEM (SRTM), Google earth image and enhanced images of Landsat TM (2008) is used to extract linear features. Result of
these geomorphic indices of each sub-watersheds are used to divide area from low to high relative tectonic activity classes, expressed as relative active tectonic index (Iat) and according to lat value the sub watershed UDSW2, 3 and 4 is tectonically relatively more active than remaining part of the area. Field validation associated with evidences highlighted by using geomorphic indices as well as stream deflections and lineament analysis reveals that the Ahar watershed of Aravalli Range, particularly the north-western flank, is most affected by the tectonic activity.

Shallow-water carbonates as tectonic event markers in convergent margins: Mesozoic–Cainozoic examples from central America

Goran Andjic¹, Peter Oliver Baumgartner¹, Claudia Baumgartner-Mora¹

¹University of Lausanne, Institute of Earth Sciences, 1015 Lausanne, Switzerland

The construction of the Central American land bridge represents a long-term process that initiated in Cretaceous time. Since that time, collision/accretion, subduction and strike-slip processes operated in association with arc volcanism, building a complex geological puzzle. The present-day terrane collage consists mainly of a northern province (from Guatemala to N Nicaragua), made of Precambrian–Mesozoic continental terranes (Chortis Block s.s.), and a southern province (from S Nicaragua to Panama) made of Mesozoic–Cenozoic oceanic assemblages. The oceanic assemblages reveal the long-lived influence of the Galápagos hotspot on the geologic history of southern Central America. The latter has been shaped by the collision/subduction of seamounts, ridges and plateaus since the Late Cretaceous. In addition, the fore-, intra-, and back-arc basins overlapping these provinces recorded the tectonic evolution of the active margin. Tectonic events led to major facies changes, unconformities, deformations, and variations in the supply of arc-derived material. In these basins, the age and facies of shallow-water carbonates provide time constraints on tectonic events, which are essential in order to reconstruct the past evolution of the active margin of Central America. Here, we review tectonic processes with which shallow-water carbonates may be associated: 1) Intra-arc rifting occurred in Honduras during the Aptian–Albian leading to the deposition of the shallow-water Atima Fm. The rifting is interpreted as an extensional event following arc-arc collision. 2) Collision of oceanic plateaus occurred along the Costa Rican active margin during the Campanian and the Palaeocene. Both events coincided with shallow-water deposition (El Viejo, Barra Honda fms.) on uplifted forearc lithologies associated with volcanic arc cessation. 3) Collision of seamounts occurred along the Costa Rican active margin during the middle–late Eocene. These events coincided with the uplift of the active margin in forearc and back-arc settings, allowing deposition of various shelf deposits. 4) Strike-slip faulting affected the Sandino Forearc Basin (Nicaragua, Costa Rica) during the Oligocene. We interpret the formation of narrow anticlines as a response to oblique subduction which preceded the break-up of the Farallon Plate. The Isla Juanilla Coral Reef grew on one of these structures. 5) Intra-arc rifting occurred in Nicaragua during the Pliocene, possibly in relation to slab roll-back. The footwall of the Nicaraguan Depression was back-tilted and shallow-water carbonates (El Salto Fm.) unconformably encroached on pre-Pliocene forearc lithologies.
POSTER PRESENTATIONS

Structural geology of Miri anticline in Borneo

Stephan Ongetta², Navakanesh M. Batmanathan², Shah A. A¹

¹Department of Physical and Geological Sciences, Universiti Brunei Darussalam, Brunei
²Department of Geological Sciences University Curtin Sarawak, Malaysia

The work presented here shows structural geology of Miri anticline, which is ~NE-SW trending structure that extends for > 8km, and is located in Northwest Borneo. The topographic expression of the anticlinal structure is clearly visible on the satellite data as it rises abruptly in an otherwise flat region. The sharp topographic break that extends for most of its length suggests a strong structural control on its development and growth. This motivated us to undertake a detailed geological field investigation in the region. Thus here we demonstrate, using freely available satellite data and detailed field investigations, that Miri anticline is controlled by faulting. We have mapped a number of new faults in the region, which are both normal, and reverse. The topographic break close to the Grand Old Lady oil well cuts oblique to the anticlinal axis and we have mapped a new thrust fault that dips ~31 towards SW. The southwestern portions of the ~NE dipping fold limb preserve very steeply dipping beds, which are not observable in the northeastern portion of this limb. This suggests an asymmetrical fold geometry, which is possibly controlled by fault at depth. Thus we propose a fault-bend fold structural model for the formation, and development of Miri anticline.
Session 18: Earth Sciences in Service of the Environment
Chairperson: Eleni Zagana & Elena Ifandi

ORAL PRESENTATIONS
Thursday 16 November 2017

Forward and inverse modelling of self potential time series response for DNAPL detection in closed aquifer
Harry Mahardika¹, Neny Kurniasih¹, Muhammad Zaki¹, Aditya Fabio¹

¹Institut Teknologi Bandung, Faculty of Mathematics and Natural Sciences, Earth and Complex System Physics Research Group, Jl. Ganesha No. 10, Bandung 40132, Indonesia

Self-potential (SP) method is a passive geophysical method that measures the electric potential response of the Earth. The SP signals are generated from the bulk interaction of subsurface fluid flow inside the porous rock with its solid matrix frame via electrokinetic effect mechanism. In recent geoscience studies, SP method have been applied to detect and characterize the movement of the groundwater flows, oil and water during hydrocarbon reservoir operations, and also the intrusion of salt or ionic species for long-term toxic wastes. In this study, we would like to develop a numerical model to simulate a monitoring mechanism for dense non aqueous phase liquids (DNAPL) intrusion inside a closed aquifer system. The addition of DNAPL may cause contamination to the community’s drinking water and agriculture farms that use water from the closed aquifer. The numerical simulation consist of three parts: one is the groundwater flow and the evolution of the DNAPL, and second is the generation of SP signals that can be detected in the surface and subsurface (borehole) configuration. The groundwater and DNAPL flow is controlled by the diffusion equations, while the SP problem is governed by the electrical Poisson equation. The diffusion and the Poisson equation are solved using the finite difference scheme and applied into a 2D subsurface model. This model is adapted to represent the physical properties of the closed aquifer stream and the pollutant material going into it. The last part of the study is a-proposed inverse modelling scheme that can be done for the further analysis of the SP signal. The inverse calculation is done in a hope for the location detection of the added pollutants and also characterization of the DNAPL properties. The study will probably give alternative to the current pollutant detection method and also to create a foundation for future field application in hydrology problems.

Meteorological and hydrological drought analysis of Langat River Basin in peninsular Malaysia
Md. Munir Hayet Khan¹,², Nur Shazwani Muhammad¹, Ahmed El-Shafie², Adil Rassam Timimi³, Ahmed Ali Jabir³

¹Department of Civil & Structural Engineering, Universiti Kebangsaan Malaysia (UKM), 43600 Bangi, Selangor Darul Ehsan, Malaysia
²Department of Civil Engineering, Faculty of Engineering, University of Malaya (UM), 50603 Kuala Lumpur, Malaysia
³Faculty of Engineering & Quantity Surveying, INTI International University (INTI-IU), Persiaran Perdana BBN, Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia

Malaysia is one of the countries that has been experiencing droughts caused by warming climate. Drought is an extreme meteorological phenomenon that causes great environmental and economic damages. It is mainly classified into meteorological, hydrological and agricultural droughts. Among these classifications, assessment of hydrological...
drought has more importance in the water resources management perspective. Drought analysis & forecasting is an essential tool for effective water resource management as well as mitigation of some of the more adverse consequences of drought. This study considered the areas of Langat river basin in Peninsular Malaysia. The assessments were made with Standard Index of Annual Precipitation (SIAP) over 360 months’ time from October 1986 to September 2016 (30-years). SIAP outcome was used to develop a model based on artificial neural network (ANN) for the station A (3018107) and performance of the model was evaluated. It was found that the coefficient of determination (R²) was at 0.808 between observed and forecasted values. In this study, assessments were also made of historical hydrological droughts using Standardized Water Storage Index (SWSI). For this purpose, water level data was obtained for the Semenyih river basin that is one of the three principal tributaries of Langat River and was used for calculating SWSI. The calculated index indicates that there were severe to moderate drought during 1998 and 1999, which was an El Nino year. A neural network based (ANN) model was developed as well to forecast drought in the near future, with the results of SWSI indices. The model generated was very precise and achieved a correlation coefficient of 0.95. This proves that the created model can predict hydrologic droughts very close to the observed values. Overall, this study helps to understand the history of drought conditions of the past 30 years in the Langat river basin. It further helps to forecast drought and assist in water resource management.
Modelling adiabatic boiling of the Biliran geothermal wells using CHIM-XPT

John Paul Mendoza¹, Maria Ines Rosana Balangue-Tarriela¹, Mark H. Reed²

¹National Institute of Geological Sciences, University of the Philippines - Diliman, Quezon City (1101), Philippines
²Department of Earth Sciences, University of Oregon, Eugene, OR 97403, USA

Boiling is a very common process in geothermal wells where the primary water quickly ascends to the surface and decreases temperature due to the conversion of liquid water to steam. An assumption to this system is that there is no heat exchange between wall rock and boiling water, thus it becomes isoenthalpic. The study aims to determine the changes in the fluid composition of a particular well as it ascends to the surface and to identify which minerals would precipitate out of the solution at certain temperature conditions. This information is useful for producing geothermal fields since issues such as scaling may be predicted and can be properly addressed. Using FORTRAN Programs SOLVEQ and CHIM-XPT, adiabatic boiling was simulated for the normal enthalpy wells of Biliran geothermal field. Results of theoretical geothermometry for the wells are consistent with the reported silica geothermometers and fluid inclusion studies. Aside from the steam phase, Well BN-1 formed chlorite and calcite (up to 170°C) in the initial boiling process followed by kaolinite at lower temperatures. Well BN-2 precipitated mostly talc and calcite almost all throughout its ascent. Both of which are consistent with the alteration and scales reported in previous works.

Evaluation of land use/land cover dynamics and estimation of soil erosion: A case study in north central Ethiopia

Syed Ahmad Ali¹, Teshome Tsegaw²

¹Department of Geology, Aligarh Muslim University, Aligarh, India
²Department of Earth Sciences, Addis Ababa University, Addis Ababa, Ethiopia

In north central Ethiopia, population increase is forcing farmers to expand their land by clearing forests, bushes and scrubs for crop cultivation, construction purposes and for fuel as energy source. Therefore the study has been carried to evaluate changes in landuse/landcover dynamics and estimation of soil erosion in Gozamin catchment Amhara region Ethiopia, with emphasis given to socio-environmental impact that has occurred following the change and related causes. It is very important aspect of study so as to make sound environmental management strategies and land use planning. To this end, digital image classification of remotely sensed data i.e. Landsat images of 1972, 1986 and 1999 were carried out to produce six classes of landuse and landcover. Universal Soil Loss Equation (USLE), which considered the parameters including, Rainfall Erosivity Factor (R), Soil Erodibility Factor (K), Slope Gradient Factor(S), Slope Length Factor (L), Cover and Management Factor (C), and Conservation Practice Factor (P), is adopted to estimate soil erosion of the study area. Then, the final landuse maps and all these thematic layers are prepared in a Geographical Information System (GIS) platform, following field verification and accuracy assessment. The results indicates that, there is sharp increase in cultivated land and grazing land, while there is a sharp decrease in bare land, and bush land. The other interesting result gained from this particular study is that the forest area coverage, which was only 3258.01 hectare (1.8 %), has increased to 4488.5764 hectare (2.5 %) of the total area. Finally map of soil erosion is prepared by GIS layers over lapping method which ultimately estimated soil erosion rate of study area. The study revealed that 72607 hectare of the study area is characterized by 0-12t/ha/yr soil
erosion rate; 90471 hectare of the study area is characterized by 12-211t/ha/yr soil erosion rate, whereas 16922 hectare of the study area is characterized by greater than 211t/ha/yr soil erosion rate. When estimated for soil erosion, it was found that out of the whole catchment, 169.22 km² area lies under high soil erosion rate. The findings of this particular research suggest that land degradation expansion is major change in the area which made larger area to be unsuitable for agriculture and appear as vacant land, due to failure of crop productivity. These land use/cover changes in turn caused paramount impact upon the environment and livelihood of the people. Especially, land degradation which is intensifying itself in the area requires immediate attention like afforestation programs, terracing and other remedial solutions for the area.

The compressive strength analysis of fly ash-Tatakan kaolin geopolymer to the molarity different of NaOH

Gusti Rusydi Furqon Syahrillah¹, Muhammad Saukani¹, Muhammad Baihaqi¹, Nurul Hidayat²

¹Universitas Islam Kalimantan MAB, Faculty of Engineering, Department of Mechanical Engineering, Jalan Adhiyaksa No 2, Banjarmasin, Indonesia
²Universitas Negeri Malang, Faculty of Mathematical and Natural Science, Department of Physics, Jalan Semarang No 5, Malang, Indonesia

The study of the comprehensive strength to the combination of fly ash and kaolin has been conducted to initiate the research. Of the observation to chemical composition in fly ash and kaolin clay which was characterized by X-Ray Fluorescence (XRF), it is showed that elements contained in the fly ash (which was taken from coal combustion waste of Asam-Asam power plant) were 44.58% Si and 6.38% Al, while the kaolin (which was taken from Tatakan sub-district, South Kalimantan) contained 72.98% Si and 21.08% Al. Calcined kaolin at 750°C for 3 hours made metakaolin material so exhibit pozzolanic properties. Fly ash, metakaolin and alkali solution were mixed to produce a geopolymer material with ratio Si:Al = 4. The alkali solution used for the geopolymerization process was NaOH/Na2SiO₃ with molarity variations 2M to 5M NaOH. The curing temperature was set at 60 °C for 12 hours and the setting time is 14 to 28 days. Geopolymer samples formed were tested for compressive strength, density and porosity. The best compressive strength was the sample with 5M molarity with 28 days setting time. The compressive strength value was 91.6 MPa with density of 2.04 g/ml and porosity of 5.88%. The result of this measurement indicated that the fly ash/kaolin geopolymer has a great potential to be developed much further in a building sector.

Analyses of morphology and contaminant composition on hydrocarbon contaminated soil using Scanning Electron Microscope (SEM) images at Woncolo Artisanal mining area, central Java

Eleonora Agustine¹, Dini Fitriani¹, Wahyu Srigutomo², Ilma Danandika Dimawani¹

¹Department of Geophysics, FMIPA Universitas Padjadjaran Sumedang, Indonesia
²Department of Physics, FMIPA Institut Teknologi Bandung, Bandung Indonesia

Geophysical survey at an artisanal mining area in Wonocolo, Central Java was carried out to identify changes in properties of hydrocarbon contaminated soil. Miners in the area extract hydrocarbon traditionally without imposing a proper procedure of waste treatment. In a long term, this situation causes health and environmental issues that affect the quality of people’s health in the area and its surrounding. Soil samples were collected by coring from an area having hydrocarbon contaminated soil and from an area having uncontaminated soil.
Samples with high electrical conductivity (EC) values were extracted using strong electromagnet to obtain magnetic grains which then were then morphologically analyzed using SEM. EDX analysis was conducted also to obtain information on the elemental contents of the samples. Based on the results it is concluded that higher heavy metal contents (Fe and Ti) were found in soil sampled at the contaminated area compared with that of the original soil. The contaminated soils will have round-shaped grains indicating the characteristic of contaminated soil that differs from the morphology of natural and uncontaminated grains that have tetrahedral shape. The distribution of elements in samples also confirms the contamination of the soil. To overcome this condition, it is suggested that a waste treatment procedure using IPAL should be implemented by miners in the area.

Ecotown as an approach towards sustainable development in the Philippines

Diomedes A. Racelis¹, Elenita L. Racelis², Angela A. Limpiada³

¹University of the Philippines Los Baños, College of Forestry and Natural Resources (CFNR) Institute of Renewable Natural Resources (IRNR) College, Laguna, Philippines, 4031
²University of the Philippines Los Baños, College of Forestry and Natural Resources Training Center for Tropical Resources and Ecosystems Sustainability (TREES) College, Laguna, Philippines, 4031
³University of the Philippines Los Baños, College of Forestry and Natural Resources Makiling Center for Mountain Ecosystems (MCME) College, Laguna, Philippines, 4031

The ecotown approach was piloted in selected municipalities in the Philippines to demonstrate how climate change is mainstreamed into sustainable local government planning. The municipalities were selected based on their high level of vulnerability to climate-induced natural disasters such as flood, landslide, drought, and storm surge. An important component of the ecotown approach is the vulnerability assessment mapping phase. It was conducted in selected municipalities in Siargao Island and San Vicente, Palawan as an input to the formulation of climate change-adaptive local action plan. Vulnerability assessment was done on climate change-related events which include consists of drought, rain-induced landslide, storm surge, flood, and sea level rise. GIS-generated tables showed risk to the events to of various sectors including agricultural, education, health, and tourism. The pilot project shows how the ecotown approach promotes sustainable development in terms of environmental protection, natural resources conservation, poverty reduction and social progress. It also enhances environmental protection and natural resources conservation through the generation of accurate spatial information on the state of the environment and natural assets. The approach results in poverty reduction in terms of introducing sustainable livelihood activities with the marginalized sectors of the local communities. The approach permits climate-proofing of the various economic sectors to minimize damages and losses whenever extreme climatic events occur in the locality.

Stable isotope fractionation concepts to track in situ degradation of hexachlorocyclohexane

Langping Wu¹, Yaqing Liu¹, Ralf Trabitzsch², Holger Weiß², Ivonne Nijenhuis¹, Hans H. Richnow¹

¹Department of Isotope Biogeochemistry, Helmholtz Centre for Environmental Research-UFZ, Permoserstraße 15, 04318 Leipzig, Germany
²Department of Environmental Informatics, Helmholtz Centre for Environmental Research-UFZ, Permoserstraße 15, 04318 Leipzig, Germany

Hexachlorocyclohexanes (HCH) from the former production of Lindane has spread around the globe and HCH are found in
remote areas and accumulating in arctic food chains. The HCH are practically inert to chemical degradation under typical environmental conditions and only biodegradation processes leading to elimination of HCH in the environment. Thus it is interesting to characterise biodegradation processes directly in the environment and to link sources and sinks of HCH.

α, β, γ, δ and ε-HCHs are formed during photo-chlorination of benzene, of which α-appears as racemic mixture of 2 stereoisomers, γ-HCH is used as pesticide and other isomers are waste products mostly dumped in the vicinity to the production site. Anaerobic and aerobic microbial degradation of HCH has been shown. We studied the stable isotope fractionation HCHs in order to characterise degradation processes in the environments. Reference experiments with cultures and enzyme assays were conducted with α-HCH for obtaining carbon isotope and enantiomer fractionation factors for developing a concept to analyse processes in field studies. The correlation of enantiomer and isotope fractionation have some diagnostic potential for characterising the mechanism of chemical and biological degradation processes.

We selected Bitterfeld (Germany) and Lucknow (India) as the model site to evaluate the potential to track degradation processes in the environment. Technical HCH mixtures were produced in both areas for many years. Industrial wastes were buried in the site, eventually contaminating regional aquifers. Waste water was discharged to local rivers and the contamination was spread to agricultural soil due to storm water flooding, as well as by airborne transport of dust from production sites. Reactive transport processes governing HCH uptake from contaminated soils into plants, and HCH accumulation in food and wild animals were investigated. These processes can be characterised by enantiomer and isotope fractionation.

We will provide a brief overview on our ongoing work with respect to evaluation of the degradation processes of HCH in soils, sediments and aquifers at the scale of a landscape. Further the transformation of HCHs in food webs using compound specific isotope analysis, enantiomeric fractionation and enantiomer specific isotope analysis will be discussed.

Subsurface mapping of electrical resistivity on leachate pond in Sarimukti landfill

Dini Fitriani¹, Eleonora Agustine¹, Anggie Susilawati¹, Mia Uswatun Hasanah¹, Kartika Hajar Kirana¹, Diky Irawan S²

¹Department of Geophysics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km 21, Sumedang 45363
²Geostroom (D.I.S)

In waste disposal site with open dumpsite type, leachate is usually produced. Leachate is one of the pollutant sources for the environment since it could penetrate into subsurface. Sarimukti landfill is an open dumpsite waste disposal site. In Sarimukti landfill, leachate from four waste dumping zones is channeled into a large pond called stabilization pond for treatment before further processing. In this study, we have applied electrical resistivity method to determine the magnitude of leachate resistivity and map subsurface electrical resistivity along leachate ponds and surrounding areas in Sarimukti landfill. Subsurface mapping of resistivity could be useful to identify leachate migration. The measurements were performed with Schlumberger configuration on 8 lines over the pond and and parallel to the pond. The result shows that leachate has a very small resistivity (<1Ωm). In addition, the resistivity cross-section shows that there is leakage of the leachate around leachate stabilization ponds.
Effective utilisation rice husk to produce D-xylose in Pakistan: An alternative to its land-filling to mitigate the associated environmental hazards

Ashfaq Ahmed\textsuperscript{1,2,3}, Arshad Chughtai\textsuperscript{2}, Abdul Sattar\textsuperscript{2}, Mujahid I. Alhinai\textsuperscript{1}, Bacha Rehman\textsuperscript{4}, Muhammad S. Abu Bakar\textsuperscript{1}, Rahayu S. Sukri\textsuperscript{4}

\textsuperscript{1}Faculty of Integrated Technologies, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Brunei Darussalam
\textsuperscript{2}Institute of Chemical Engineering and Technology, University of the Punjab Lahore, Pakistan
\textsuperscript{3}Department of Chemical Engineering, COMSATS Institute of Information Technology Lahore Campus Raiwind Road Lahore, Pakistan
\textsuperscript{4}Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, Bandar Seri Begawan BE 1410, Brunei Darussalam

Pakistan is agriculture based economic country which produces huge quantity of rice husk every year causing serious problems of its storage and dumping off. Traditionally, utilisation of rice husk includes its land filling and direct combustion for energy production; consequently, causing considerable disposal and environmental problems in the country. In this study, an effort have been made to utilize rice husk biomass effectively to produce D-xylose by adopting hydrolysis process. D-xylose is valuable compound important for pharmaceutical and chemical industry. D-xylose is a type of sugar and could be used as an alternative to white sugar. It is a natural healing agent, having antifungal and antibacterial properties and is safe to use in the food stuff. Hydrolysis of rice husk was carried in acidic environment using diluted sulphuric acid solution which resulted in the conversion of all carbohydrates to their basic constituents. Different types of compounds and sugars were synthesised with the D-xylose being the compound with highest yield percentage, reported up to 36 wt%. The process parameters such as hydrolysis time, acid concentration and impregnation ratio of rice husk to acid solution were also optimised. Analyses were carried out using high performance liquid chromatography (HPLC) with Restek Pinnacle II Amino Column. Highest yield of D-xylose was achieved as 36 wt% at hydrolysis temperatures of 100 °C and optimised hydrolysis time of 3.5 hours, diluted acid concentration of 5 wt% and impregnation ratio of 1:6 between rice husk to sulphuric acid solution. Study is expected to provide a useful alternative to the traditional disposing off methods for rice husk, ultimately contributing towards the reduction of associated geological hazards in terms of environmental pollution.

Estimation of environmental flow of Brunei River for future water allocation and management

Shahriar Shams\textsuperscript{1}, Md. Abdul Matin\textsuperscript{2}, Amimul Ahsan\textsuperscript{3}, Rozeana Binti Hj. Md. Juani\textsuperscript{4}, Guo Zhenren\textsuperscript{5}

\textsuperscript{1}Civil Engineering Programme Area, Universiti Teknologi Brunei (UTB), Brunei Darussalam, Jalan Tungku Link, Gadong BE1410
\textsuperscript{2}Electrical & Electronic Engineering, Northern University Bangladesh, Sher Tower, Holding #13, Road #17, Banani C/A, Dhaka, Bangladesh
\textsuperscript{3}Dept. of Civil Engg., & Institute of Advanced Technology, University Putra Malaysia, 43400 Serdang, Malaysia
\textsuperscript{4}Civil Engineering Programme Area, Universiti Teknologi Brunei (UTB), Brunei Darussalam, Jalan Tungku Link, Gadong BE1410
\textsuperscript{5}Civil Engineering Programme Area, Universiti Teknologi Brunei (UTB), Brunei Darussalam, Jalan Tungku Link, Gadong BE1410

The concept of environmental flows and its application and enforcement is a major challenge in many developing countries. The services and benefits derived from ecosystem are worth and indispensable to sustain the livelihood of people particularly living in coastal area. Decision-makers often ignore ecosystems from water
allocation, as the supporters of ecosystems are less vocal as compared to other stakeholders. This study emphasis on establishing guidelines for maintaining the minimum amount of flow known as environmental flow of Brunei River for the sustainability of its rich ecosystem. In this study, the flow of Brunei River was simulated based on land use, climate change, potential growth of industries using Water Evaluation and Planning System, a computing tool. The study finds that the month of March and June (1.48 - 3.92 m³/s) are more vulnerable to low flow. The study recommends 2.7 m³/s as the threshold value for environmental flow for Brunei River in order to preserve its rich and diversified ecosystem. The threshold value has been selected based on 90% time exceeded stream flow. Successful enforcement and application of E-flows rely greatly on promoting awareness about the existing river conditions and the knowledge and interest of the stakeholders is vital. It is recommended that flow should be monitored every two weeks to check whether the flow is above the recommended threshold value. There should be a retention pond located upstream to augment the required flow to maintain the threshold value during dry period.
A study report on Clean Ganga Mission under Swachh Bharat Abhiyaan

Mehboob Nagarbawdi¹, Sajid Hundekar², Zaid Ahmed Shaikh³

¹Department of Physics, Poona College, Pune – 411001
²Department of Geology, Poona College, Pune – 411001
³Department of Geology, Wadia College, Pune – 411001

Mahatma Gandhi wish to see a “Clean India”. To work towards this vision of Gandhiji, Hon’ble Prime Minister Shri Narendra Modi launched the Swachh Bharat mission on October 2, 2014 and asked people from all walks of life to help in its successful implementation of this mission. The mission seeks to achieve the goal of clean India in the next 5 years. Swachh Bharat Abhiyaan is not just about cleaning surroundings but also seeking the participation of people in planting trees, creating a garbage-free environment, providing sanitation facilities all paving the way to accomplishment of the vision of “Clean India” by October 2, 2019 the 150th birth anniversary of Mahatma Gandhi, including, National Mission of Clean Ganga aims at nurturing the holy River back to life, and creating a safe and better ecosystem. River Ganga has been the source of physical and spiritual sustenance of Indian civilization for millennia. National Mission for Clean Ganga aims at nurturing the river Ganga back to life. To rejuvenate the river, National Ganga River Basin Authority (NGRBA) has started the mission clean Ganga with a changed and comprehensive approach to champion the challenges posed to Ganga through four different sectors, namely, wastewater management, solid waste management, Industrial pollution and river front development.
Session 19: Remote Sensing and Geographic Information Systems in Earth Sciences
Chairperson: Afroz Ahmad Shah

ORAL PRESENTATIONS

Thursday 16 November 2017

Landsat satellite imagery: A new informative source in the palaeontological study: Case study of Mahanadi Basin, Odisha, south eastern India

Swagata Chaudhuri¹, Ajoy K Bhaumik¹, Sarmistha Chowdhury¹

¹Department of Applied Geology, Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, India

Low-cost analysis of satellite image data Landsat 8 can be used efficiently for the ‘remote prospecting’ of a geological terrain for reconnaissance study. A systematic comparative study of LANDSAT images and representative palaeontological-geochemical analysis from three basins of India, Mangrol-Valia Lignite Mine section (21°30’52”N; 73°12’20.5”E) of Cambay Shale Formation, western India and Jigni section (33°14’45”N; 74°22’0”E) from Subathu Formation in northern India and Mahanadi Basin (20°16’ N; 80°25’E) in south eastern part of India was undertaken for landscape analysis of these successions. As these areas are distinctly lacking vegetation and other land cover (like water bodies), accuracy of received satellite image data is maximum. The present work was carried out by studying bulk rock XRD, XRF, clay mineralogy and analyzing calcareous microfossil foraminifera from samples at equivalent depth of two basins (Cambay and Subathu) to support the field evidences. Landsat 8 images of these three basins are downloaded from Earthexplorer.usgs.gov. and satellite image of Mahanadi basin is used for reconnaissance study. All these three basins are situated thousands of kilometers apart and in different tectonic settings. The LANDSAT images are made a layer stack of bands 1-7 and a spectral library is created using spectral profiles of the original subset image. Present study also intends to work out the geochemical history by studying bulk Rock XRD, XRF of forty samples from equivalent depth and analyzing clay mineral slides of two basins. A noticeable thing is observed from the band ratios that the rock strata which held the fossils like foraminiferal taxa (Rhabdammina, Pyrgo, Sigmoilopsis, Reophax, Nummulites, Assilina and Alveolina), ostracods and mammal tooth are abundant in clay minerals and mineralogically comprise kaolinite, siderite, quartz, smectite. Medium to high quartz content and other detrital elements may support increased erosional power, manifested as a quantitative increase in detrital flux for these basins. Thus remote sensing approach is successfully tested to find fossil producing region with cost and time efficiently and it becomes more prevalent in palaeontology, especially in the development of remote field areas.

Utilization of remote sensing for estimating geothermal prospective areas and power plant sites selection - a case study in Karanganyar district, central Java

Dheni Kusumarani¹, M. Satya Danuarta², Yazid Abdurrazzaq S², Ahmad Faisal Faruq³, Fadhilatul Karimah³, Dr. Agung Setianto, S.T, M.Si²

¹Department of Remote Sensing and GIS, Faculty of Geography, Universitas Gadjah Mada
²Department of Geological Engineering,
Indonesian government’s roadmap plan on energy has focused on geothermal development, as the country holds 40% of world’s geothermal resources. To maximize the use of geothermal energy, thermal power plants need to be built around some potential areas. This study intended to investigate the geothermal potential area using remote sensing technique in the region of Mt. Lawu located in Karanganyar district, Central Java. Landsat 8 OLI in thermal band is used in this study. Based on radiometric calibration, atmospheric correction, and emissivity calculation with NDVI threshold method, split window algorithm is applied to retrieve the Land Surface Temperature (LST) of the study area. The temperature anomaly found in the area indicates the discovery of heat manifestation and with the discussion of regional geology and geothermal mechanism, the geothermal areas are identified. Land Surface Temperature retrieved from the algorithm shows some hot spots existence on the southwestern area of Mount Lawu. Jabalarangan Formation shows the potential of geothermal reservoir and the regional structure of normal fault with the east-west direction shows the potential of geothermal flow path, which is the most prospective area of Lawu. Combined with physical and social data, Geographic Information System (GIS) is used as an analysis tool to define suitable area for geothermal power plant sites in the region.

Understanding hydrocarbon migration is one of the importance step in hydrocarbon exploration, since it could determine whether one exploration project would be a success or otherwise. The hydrocarbon migration modelling using geophysical method may have limitation due to data availability. Therefore, this study aims at complementing hydrocarbon migration modelling using Geographic Information System (GIS) technology (ArcGIS) assisted by hydrocarbon field analysis software PETREL to model secondary migration of hydrocarbon in the north-eastern Malay basin Malaysia. In petrel, seismic data was interpreted to produce horizon which indicated occurrence of hydrocarbon migration, then it is exported to ArcGIS for advanced processing, utilizing subsurface water flow modelling in it to model hydrocarbon modelling since it is assumed secondary migration of hydrocarbon is similar to the surface water flow concept. The difference lies in mechanisms and flow direction. While water flow direction is downward due to gravity, hydrocarbon migration on the other hand is upward because it is driven by buoyancy and capillary pressure, this scenario can be shown if the Digital Elevation Model (DEM) of the basin could be developed to simulate the profile of the Top of Group E Horizon. In the next step, this DEM was processed in ArcGIS using its 3D analysis and spatial analysis to show secondary migration of hydrocarbon in the study area. Finally, all the data were overlaid to produce a map of secondary migration of hydrocarbon in north-east Malay basin Malaysia.

Utilization of satellite imaging for mapping potency of subsurface water in karst region, Pacitan, Indonesia
Friday 18 November 2017

Ayi Syaeful Bahri¹, Diptya Mas Nugraha¹, Adib Banuboro¹, Moch. Fauzan Dwihrato¹, Nizar Dwi Riyantiyo¹, Robi Alfaq Abdillah¹

¹Institut Teknologi Sepuluh Nopember, Faculty of Civil Environmental and Earth Engineering, Department of Geophysical Engineering, Jalan Arief Rahman Hakim, Surabaya, Indonesia

Pacitan is an area located in southern part of East Java and adjacent to Central Java Province. The main problems of the area are the availability of water for daily necessities and agriculture. The lack of water availability mainly occurred in the area of east and west of Pacitan. Theoretically, karst areas actually have abundant subsurface water potency. Potency of water in the karst area is found in its subsurface rivers, which is the channel of water-filled caves. These conditions are characteristic of the complexity of Karst geohydrology, especially the Karst Region Pacitan. However, the search for subsurface flow by direct tracing is almost impossible due to the wide coverage of the region and the complex subsurface topography conditions with difficult terrain. The purpose of this study is to map subsurface rivers using satellite imaging (composite bands 4.5 and 6), landsat images and regional geology of research areas. The expected outcomes of this research are the recommendations of spatial and area arrangement and the conservation of karst areas in Pacitan.

Structural analysis of Didipio open-pit mine wall using off-the-shelf digital camera

Jan Albert Macario B. Galang¹, Carmille Marie J. Escape¹, Romer Carlo T. Gacusan¹, Lawrence T. Custodio¹, Ma. Ines Rosana D. Balangue-Tarriela¹

¹UP National Institute of Geological Sciences, Oceana Gold Philippines Exploration Corporation

Structural analysis of rocks is commonly performed to ensure operational safety of open-pit mines. However, gathering of data itself already poses problems mainly due to instability along slopes. Engineering geologists often resort to mechanical tools, but this does not decrease the risk of danger. This paper provides a solution to alleviate manual measurements along dangerous slopes by applying a low-cost digital photogrammetry technique (Structure-for-motion) by generating a digital terrain model (DTM) derived from photographs obtained with the use of commercial cameras. Rock mass characterization was executed using COLTOP 3D by extracting the orientations and measurements of major structural features. The methodology was applied to a section of mine bench in the Didipio Mines operated by OceanaGold Philippines, Inc. Results show that the average values of discontinuity measurements obtained from the generated terrain models are comparable with the average of the geotechnical measurements. Out of four major geotechnical survey readings obtained from Stage 6, two trends measured from the photogrammetry-derived digital terrain model (DTM), 72/346 and 61/112 are similar to the measurements 72/330 and 63/112 from the geotechnical data. In Stage 4, two of the three geotechnical measurements are in agreement with the DTM-derived measurements. Structural measurements: 81/208 and 70/348 obtained from the simulations shows congruence with measurements: 85/220 and 80/340 respectively, from the geotechnical data. The results obtained presents good veracity, but higher accuracy could be achieved should there be an axial photograph sequence of the pit walls taken.

Geodetic slip rates along Sumatran Fault Zone (SFZ) estimated by using GPS campaign-mode surveys

Ashar Muda Lubis¹, Iwan Hermawan², Rio Saputra¹, Emma Hill², Kerry Sieh², and Nugroho Hananto³

¹1st International Congress on EarthSciences
The Sumatran fault Zone (SGZ) system is one of the perfect examples on studies about slip partitioning to accommodate the oblique convergence along the South East Asian plate boundaries. Previous studies suggest that the SFZ accommodates the strike-slip motion where its slip rate increases from South to North. However, recent study shows that the slip rates may not vary along the GSF. Therefore, in this research, we reinvestigate the distribution of slip rate along southern part of the SFZ using SuMo (Sumatran Fault Monitoring), a dense GPS campaign network to provide a better understanding of segmentation and slip rates along the SFZ. During 2013-2017, we have installed about 10 GPS monuments from south to north of SFZ. The GPS sites are mainly selected on access to locations and based on rupture area of great historical earthquakes such as two great earthquakes occurred in Liwa in 1933 (M 7.5) and 1994 (M 7.0), at Sianok and Sumani-Suliki segments where historically the great earthquakes occurred in 1923 (Ms=7.0), 1943 (Ms=7.4), 2007 (Mw= 7.5) as well as the biggest earthquake at Angkola-Barumun segments of SFZ (M=7.7) in 1892. We have conducted several times campaign surveys on GPS stations (3-4 days of measurement for each occupation site). Field observation data were converted into RINEX file and processed using GAMIT/GLOBK software in order to obtain daily position for each GPS station. The campaign solutions were combining with IGS-GPS solutions and merged into one unique solution, which was accurately mapped into the ITRF2008. We computed long-term viscoelastic deformations at GPS sites due to recent great earthquake in Sumatra. We removed such these deformations from vector GPS deformations in order to obtain signal deformation only from the SFZ. Based simple elastic model, we estimate that the slip rates vary along the segments of the SFZ from 10-20 mm/yr. More data from future survey campaigns will help us to better slip rates along SFZ. This estimation is important for future hazard assessment, mitigation and planning purposes in the region.
Coral reefs in shallow and clear waters are easily seen in satellite images. However, coral reefs and coral communities may extend to depths beyond 30 meters. Mapping these features beyond the reach of satellite images are essential in management. Side scan sonars (SSS) which cost less than 1000 USD, can provide an acoustic image of the seafloor to depths of 40 m. Combined with spot optical images or grab samples, the side scan images can be used in mapping the seafloor. Masinloc is a municipality in the province of Zambales, Philippines that has well developed reefs in San Salvador and Magalawa Islands. Satellite images show that reefs extend ~0.5 km from the western coast of San Salvador and ~1 km from northern Magalawa. This study aims to determine the extent of these reefs using low-cost SSS. A dual-frequency SSS operating at 86/455 kHz was used to collect single-beam bathymetric data and sonar images of the seafloor. The bathymetric data was then interpolated using kriging method. The SSS images were mosaicked and classified accordingly based on the type of substrate. The survey area is gently sloping and covers 2.34 km² with a depth range of 1.5-117 m. SSS images show that the shallow reefs extend to depths up to 40 m, to a distance of ~0.5 and 0.75 km further offshore in western San Salvador and northern Magalawa, respectively. Overlaying the bathymetric data and satellite image indicate that water depth in the reef detected by the satellite images is <5 m. Thus, combining low cost SSS and satellite imagery in mapping reefs can give a better definition of the extent of the coral reef.
Session 20: Artificial Materials and Technology
Chairperson: Abul Kalam Azad

ORAL PRESENTATIONS
Thursday 16 November 2017

Fabrication and characterization of Zn doped BaCe$_{0.7}$Zr$_{0.15}$Y$_{0.15}$O$_{3-\delta}$ industrial based thin film proton conducting minerals for IT-SOFC

Ahmed Afif$^1$, Abul K. Azad$^1$, Mridula Biswas$^2$, Juliana Zaini$^1$

$^1$Universiti Brunei Darussalam, Faculty of Integrated Technologies, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam
$^2$Defiant Renewables Pvt. Ltd. Pune, India

Considering high proton conductive and chemically stable electrolyte materials is the key to develop proton conducting solid oxide fuel cells operating at intermediate temperature. Wet chemical sintering route offers the opportunity to fabricate very thin electrolyte films than traditional powder-based materials. A novel method for the preparation of a thin film proton-conducting electrolyte is presented. The present work deals with the fabrication of 5% Zn doped BaCe$_{0.7}$Zr$_{0.15}$Y$_{0.15}$O$_{3-\delta}$ (BCZY15) thin film electrolyte. Electrolyte materials were prepared by an acetate-methoxyethanol solution method and examined by multilayer (4, 6, 8 times) coating on silicon and anode (NiO-BaCe$_{0.7}$Zr$_{0.15}$Y$_{0.15}$O$_{3-\delta}$) substrate at different temperatures. A thin, dense, crack free BCZY15 electrolyte film was successfully obtained on a dense anode by spin coating. Postmortem analysis by scanning electron microscope (SEM) reveals that no crack on 6 layers coating at 1100°C. Furthermore, this work shows that, Zn doped BaCe$_{0.7}$Zr$_{0.15}$Y$_{0.15}$O$_{3-\delta}$ dense thin film could be good industrial mineral for IT-SOFC.

Synthesis and properties of YSr$_2$Co$_3$O$_8$ perovskite cathode for IT-SOFCs

Auji Afiqah Binti Mohd. Kamis$^{1,*}$, Abdalla M. Abdalla$^1$, Shahzad Hossain$^1$, Nyuk Yoong Voo$^2$ and Abul K. Azad$^1$

$^1$Faculty of Integrated Technologies, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE 1410, Brunei Darussalam
$^2$Centre for Advanced Materials and Energy Sciences, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE 1410, Brunei Darussalam

YSr$_2$Co$_3$O$_8$ perovskite structure was prepared by standard solid state reaction at 1200 °C for application in Solid Oxide Fuel Cells (SOFCs). The structural and thermal characterizations have been performed through X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA). Rietveld analysis of the XRD data shows the material crystallizes in tetragonal symmetry in the P4/mmm space group with the cell parameters: $a=3.8197(2)$ Å, $b=3.8197(2)$ Å and $c=11.4331(1)$ Å. The TG/DTA experiment was performed under constant flow of nitrogen gas which exhibits a gradual weight loss at 300 °C up to 1000 °C, in a good agreement with the literature. The SEM images of the sample showed that the sample sintered at 1200°C was porous structure and suitable to use as cathode in SOFCs. Particle size measurements showed that the particles vary from 7 to 11 micron.
POSTER PRESENTATIONS

Combined use of remote sensing data, mineralogical analyses, microstructure studies, spectroscopy and Geographic Information System for geological mapping of Antiparos island (Greece)

Konstantinos G. Nikolakopoulos¹, Paraskevi Lampropoulou¹, Dimitrios Papoulis¹, Aikaterini Ragkala¹, Panagiota P. Giannakopoulou¹, Petros Petrounias¹

¹University of Patras, School of Natural Science, Department of Geology, Rion, GR-26504 Patras, Greece

This study presents the combined use of field mapping, remote sensing data analysis, mineralogy, spectroscopy and GIS techniques for the geological mapping of Antiparos Island. Antiparos consists part of the Cyclades Blueschist Belt located in the central Aegean, where gneisses, schists and Pliocene volcanic rocks occurred. During the extended field work, a number of volcanic rock samples were collected from the South part of Antiparos. The sampling strategy was to collect samples from the primary as well as the altered rocks in specific areas previously located from the remote sensing data processing. In this study, high resolution satellite images have been carried out in order to detect, allocate and separate the different geological formations. Furthermore the existing geological map was georeferenced and all the tectonic lines and boundaries were digitized. All these features were implemented in a Mobile Mapper CE GPS using Arcpad GIS and checked in situ. The collected samples were analyzed in the laboratory using various techniques including XRD, Petrographic Microscopy, SEM and IR-Spectroscopy. The qualitative mineralogical analyses were conducted by using XRD. The study was supplemented by the petrographic observations providing a detailed characterization of rock textures. In addition, SEM study and SEM-EDS analyses of the samples were emphasized on the genetic relations of the minerals. The combination of the above mentioned laboratory analyses with the spectroscopy completed the detailed characterization of studied samples. The laboratory results revealed that specific corrections should be made in the previous geological map of Antiparos concerning the volcanic rocks especially at the south part of the island. Significant conclusion is that the rock described as volcanic in the previous map, proved to be a fossiliferous limestone which includes micritic matrix of calcite with an insignificant amount of fossils. It should be noted that, the presence of dickite, a mineral which is formed in temperatures about 200oC, shows that the rocks are hydrothermally altered. All the analogical and digital data and the results of the petrographic analysis were imported in a geodata base specially designed for geological data. After the necessary topological control and corrections the data were unified and processed in order to create the final layout at 1/25.000 scale.

Surface chemistry-microstructure-rheology of washed titania and zirconia suspensions

Pek-Ing Au¹, Yee-Kwong Leong², Wendy Pei-Qin Ng¹

¹Department of Chemical Engineering, Curtin University Malaysia
²School of Mechanical and Chemical Engineering, the University of Western Australia, Crawley 6009, Australia

Mineral ores from different deposits display different physical and chemical properties. The motivation of this study was to understand the relationship between rheology and microstructure of relatively size-monodispersed oxide suspensions particularly under the effect of changing surface chemistry. The knowledge and understanding of such inter-relationship are still limited due to a lack of definitive microstructure data. Often, the surface chemistry conditions were not specified even though it determined the type of
aggregation process and the microstructure formed. In this study, the rheological parameter, including zeta potential and yield stress, of washed ZrO$_2$ and TiO$_2$ suspensions were characterized under changing pH conditions. The mechanical strength of the oxide suspensions correlated well to the surface charge properties. A consistent maximum yield stress at pH $\sim$7 was detected for TiO$_2$ suspensions at all solid loadings, which was also the location of isoelectric point. On the other hand, ZrO$_2$ suspensions exhibited a similar yield stress-pH behaviour as TiO$_2$ but over a different pH range. The pH range for flocculation appeared to be narrower than that of TiO$_2$. The yield stress decreased with pH on either side away from the isoelectric point corresponded to the increasing surface charge density. The yield stress was also found to be dependent upon both the particle size and shape. At a given solid concentration, the finer suspensions of ZrO$_2$ produced a larger yield stress than TiO$_2$ due to the higher particle concentration, and hence a greater density of attractive interaction in the gels. The vitrified microstructures of ZrO$_2$ and TiO$_2$ suspensions under different surface chemistry conditions were captured by cryo-SEM. The network structure remained unaffected despite the changing surface chemistry. The rough surface nature of ZrO$_2$ and TiO$_2$ promoted particle interaction resulting in large, irregular shaped, and compact aggregates being formed and arranged in a manner with significant inter-aggregate porosity. Inter-aggregate void and surface roughness played an important role in strengthening the aggregate structure of relatively spherical particles in highly concentrated suspensions. The yield stress-volume fraction data of all suspensions (at all pH) obeyed a power law model with an exponent value of $\sim$3. This exponent value is related to fractal dimension $D_f$ of the gel by scaling theory. $D_f$ values of $\sim$2.3 was obtained for both washed ZrO$_2$ and TiO$_2$ suspensions.
Session 21: General Session  
Chairpersons: Owais Ahmed Malik & Mohamed Abdul Salam

ORAL PRESENTATIONS

Saturday 18 November 2017

Simple solutions to big data problems to enable deployment of analytical tools across disciplines

Stephen Tyson¹, Morteza Jami¹  
¹University of Technology Brunei Darussalam, Faculty of Engineering, Department of Petroleum and Chemical Engineering, Jalan Tungku Link, BE1410, Bandar Seri Begawan, Brunei Darussalam

Petroleum companies are increasingly looking to solutions offered by analytical tools that have been developed by companies such as Google to investigate very large amounts of diverse data in an effort to reduce expenditure since the oil price downturn that started in late 2014 and reached a low of less than $30/barrel in January 2016. Discussions with technical staff in petroleum companies and government organisations dealing with large volumes of data, particularly from unconventional reservoirs which typically have significantly higher numbers of wells than conventional fields, suggest that their experiences with ‘big data’ solution providers have been unsatisfactory due to the complexity of the heterogeneous data. These complexities include problems related to data cleaning and quality control and multiple interpretations of data. Conventional solutions, such as only looking at the sanitised data, miss important insights and manually checking old data that exists outside corporate relational databases is expensively time-consuming.

An alternative technique is proposed which is robust to dirty data and simple to deploy. It is based on the ‘crawl and index’ algorithms used by Google in its search engines and consists of a periodic search over a number of drives to identify files of interest and index the data within these. An additional step of tagging the metadata within the files is used to add the ability for files to recognise themselves and flag themselves for inclusion in future searches. This creates what is known as ‘semantic interoperability’ and it essentially turns any disk, such as the C drive on a PC, or collection of disks into an intelligent smart database. The search function then knows which files on your disk, or your organisation’s disks, contain information on for example, wells, and of these which files, .LAS, .docx, .pdf, .xlsx and so on, contain information on any particular well. The semantic interoperability then allows the user to issue queries such as; “get all the information within a 10km radius of well ‘A1’, put a copy of this in a new folder and create a basemap”. Moreover, the scanning step can optionally test each of the files for compliance and flag those files with incomplete metadata like the SEGY or LAS headers.

A set of simple tools will be presented that add semantic interoperability to disparate datasets and to provide basic querying and mapping support.

Perceptions on greening existing buildings

M Motiar Rahman¹, Zubair Abu Bakar¹, Nadhirah Jaya¹, and Nuratikah Mohamad¹  
¹Universiti Teknologi Brunei, Brunei Darussalam

Emerging trend of geosciences focuses on climate change and sustainable development, among others. Green building, on the other hand, adopts the concepts of sustainable development and focuses on reducing CO₂ emission, which is one of the major causes of climate change. Green building, is therefore, directly linked to the topics of ICES2017.
Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green buildings also offer different types of economic, social and environmental benefits, which are, again, the core proposition of sustainable development. As such, the practice of green building is globally getting increased attention day-by-day. However, it is relatively new in Brunei, and the industry participants appear not to be widely aware of this. As the concept implies, implementing green building is better suited through constructing new buildings, which requires considerable investment, especially by demolishing existing ‘non-green’ buildings. Despite the fact that existing building stocks were constructed using conventional methods and utilised older technologies; but they are in good conditions and are economically viable to be used for another 15-20 years. Demolishing those buildings is therefore argued to be wastage of resources. An alternative is to ‘greening existing buildings’, i.e. to equip the existing buildings with ‘green features’. A study was therefore undertaken to generate and/or gauge the awareness of green building in Brunei, through identifying and assessing the key benefits of greening existing buildings over constructing new ‘green buildings’. This paper presents the outcomes of a questionnaire survey of 68 responses, who are mainly clients and consultants. 15 benefits were identified, with “reduced energy / electricity consumption” topping the list, and “increase in building occupancy/usage rates” at the bottom. Clients and consultants broadly agree on the importance levels of 10 benefits, but disagree on other five benefits. For example, consultants consider the benefit “increase in building value” ranks 4, compared to rank 12 by clients. However, the outcomes are largely similar to elsewhere. On the whole, the outcomes show a general awareness of the respondents to the overall benefits of greening existing buildings. Such outcomes are expected to inspire the clients to undertake more greening projects, e.g. when they will consider retrofitting or renovation works.

Factors deterring sustainable construction

M Motiar Rahman¹, Muhd U’kasyah bin Omar¹, Nurul Atikah binti Rahim¹

¹Universiti Teknologi Brunei, Brunei Darussalam

Sustainable development (SD) provides a framework, which recognises that development to be based on efficient and environmentally responsible use of natural resources, to satisfy human needs and improve quality of life, including the use of raw construction materials, water, and energy, as well as production of waste, and emission of gases responsible for climate change. These are within the scope of earth sciences in general, and geosciences in particular, and are therefore directly related to sustainable construction (SC), as SC refers to the application of SD principles in construction. SC helps to minimise the use of raw materials, energy and water; to reduce the emission, waste and pollution to the environment; as well as to protect employees’ and occupants health and safety. For such wider and proven benefits, SC is being increasingly adopted in many countries.

However, it is relatively new in Brunei and uptake is low. A study was therefore undertaken to identify the factors, and assess their degree of importance, that deters implementing SC in Brunei. 62 factors were identified, in seven groups, related to people, cost, time, technology, market, legislations/regulations, and industry/external environment. A structured
questionnaire survey collected data on the importance levels of those 62 factors from 110 responses from Brunei construction industry participants. All the factors were found as considerably important, with highest importance index of 0.806, and lowest importance index of 0.653. With a few exceptions, the three groups of respondents (i.e. clients, consultants and contractors) consider the importance levels of individual factors largely in the same way. However, factors within ‘people’ group are seen with higher importance over other groups of factors, and those within ‘market’ group with lowest importance. On the whole, the outcomes highlighted the key areas to focus on. It is expected to help the policy makers in designing suitable strategy, and thereby help implement SC in Brunei construction.

**ANN estimation and improvement of resistance of existing earthing system using additive materials**

M. A. Salam¹, Q. M. Rahman², Fushuan Wen¹, Syeed Hasan², Md Aminul Islam³, Owais A. Malik³, G. K. Han¹

¹Dept. of Electrical and Electronic Engineering, Faculty of Engineering, Universiti Teknologi Brunei BE1410, Brunei Darussalam
²Dept. of Electrical and Computer Engineering, Western University Canada, London, ON, Canada
³Faculty of Science, University Brunei Darussalam

Maintaining a minimum value of the earthing resistance is an important task. This paper deals with the measurement and improvement of the existing earthing resistance at some selected sites using charcoal and ashes as additive materials. The measurement of the soil resistivity has been carried out using F Wenner four pole equal method. For soil resistivity measurement, Fluke 1625 Advanced Earth Tester equipment was used. The investigation in terms of soil resistivity is carried out in and around at the Sekolah Rendah, Penapar and Pasir Putih substation sites in the Tutong district of Brunei Darussalam, where, the earthing resistances with charcoal and ash are measured to be 2.03 Ohm and 0.71 Ohm, 0.57 Ohm and 10.9 Ohm, 1.9 Ohm and 5.39 Ohm respectively. The CYME GRD software is used to determine the rms errors between the measured and calculated soil resistivity and these values are found to be 1.18% and 0.13%. In addition, feed-forward back-propagation artificial neural network has been used to estimate the earthing resistances and good agreements are found between actual and predicted results in case of charcoal.
Textural characterization and evolution of a speleothem from Perama Cave, Ioannina, Greece

Alkmini Tzoumaka\textsuperscript{1}, Elena Ifandi\textsuperscript{1}, Basilios Tsikouras\textsuperscript{2}, Konstantin Hatzipanagiotou\textsuperscript{1}

\textsuperscript{1}University of Patras, Department of Geology, Section of Earth Materials, GR-265 00 Patras, Greece
\textsuperscript{2}Universiti Brunei Darussalam, Faculty of Science, Physical & Geological Sciences, Jalan Tunghku Link, Gadong BE1410, Bandar Seri Begawan, Brunei Darussalam

This research focuses on the evolution of a stalactite from the Perama Cave, Ioannina, in northwestern Greece. Microtextures were studied using polarising macroscope, whereas Secondary Electron Images (SEI) were used as a corroborate method for results evaluation. Four main phases were observed in the stalactite. These phases display columnar (C), columnar open (Co), columnar elongated (Ce), columnar microcrystalline (Cm), micritic (M), microsparitic (Ms), replacive microsparitic (Msma) and mosaic (Mc) calcite fabrics. The stalactite is dominated by Cm and Msma fabrics. Particularly, in the first phase, Ce, C, Mc and less Msma and Ms, were observed. In the second phase the presence of Msma and Ms is increased, while in the third and fourth phases the growth of large calcite crystals with predominant Cm and Msma fabrics appear. Moreover, mineral microanalyses with Electron Dispersive Spectrometer (EDS) combined with Fourier-Transform Infrared spectroscopy (FTIR), showed that this speleothem is mostly composed of pure calcite whereas minor Mg-rich calcite and scarce dolomite are present in some of the growth phases. The combined use of these procedures proved to be useful in the identification of the complicated growth mechanisms of this speleothem, as it is denoted by the large variety of fabrics identified.

Simulation on cooling and freezing simulation of sand with flowing pore water

Rangga Adiprima Sudisman\textsuperscript{1}, Masahiko Osada\textsuperscript{2}

\textsuperscript{1}Universitas Pertamina, Masahiko Osada\textsuperscript{2}
\textsuperscript{2}Saitama University

Freezing pipes are often used as heat exchangers in artificial ground freezing practices. Numerical simulations with Finite Element Method have been conducted to evaluate the reliability of the surface thermal measurement experiment of sand with flowing pore water due to a cooling and freezing pipe. Besides, simulations are also required for confirming the effect of high velocity water flow to the frozen body formation. It is conducted by combining the Brinkman equation with the heat convection and heat conduction equations for porous media. The authors used COMSOL 5.2 software to calculate the flow velocity and temperature in a two-dimensional model of the x-y plane of the surface thermal measurement experiment.

Preliminary study on the potential frost heave development in the freezing of saturated sand around a freezing pipe

Rangga Adiprima Sudisman\textsuperscript{1}, Masahiko Osada\textsuperscript{2}

\textsuperscript{1}Universitas Pertamina, Masahiko Osada\textsuperscript{2}
\textsuperscript{2}Saitama University

A preliminary experimental method that focuses on the frost heave development and freezing deformation around a vertically buried freezing pipe is conducted. Deformation may occur due to the upward fluid movement and freezing expansion of pore water. This preliminary experiment aims to evaluate the applicability of 3D laser scanning method for monitoring the spatial changes around a freezing pipe. This preliminary experiment combines freezing process, thermal measurement, and surface profile monitoring of sand specimen, while the seepage flow does not
apply. The result shows that there is a significant ice development near the surface around the pipe. However, further investigation is required to define the cause of the deformation. Besides, a comprehensive thermo-hydro-mechanical freezing experiment method is proposed based on the combination of freeze-flow experiment and the evaluation of this preliminary experiment.

Track analysis of tropical cyclones entering the Philippine land area in the period 1945–2015

Carlo Martin M. Marfori¹, Marisol P. Martinez¹, Ranzivelle Marianne L. Roxas-Villanueva¹

¹Institute of Mathematical Sciences and Physics, University of the Philippines Los Banos, 4031 Laguna, Philippines

The Philippines is one of the most exposed countries in the world to tropical cyclones (TC). Tropical cyclones cause destruction that affects a country’s economy and environment. Researches have been conducted to observe the formation and movement of a TC. These may help to improve forecasting of the TCs path and intensity which may prove beneficial in preparation and prevention of worst case scenarios in its aftermath. In this study, we use Quantum Geographic Information System to perform spatiotemporal analysis on TC tracks from 1945 to 2015. The TC tracks retrieved from Unisys Weather have a 6 hour interval between each point. The tracks were constructed by connecting the points and intersecting the resulting lines with the provincial layer of the Philippines. This intersection was able to provide attribute data used for analysis. The plots and maps show that the northern parts of the Philippines experience more tropical cyclone than the southern parts. Moreover, a higher average of tropical cyclone occurrence is present in recent years. The deviation from the average frequency of tropical cyclone was also observed in the recent years. To investigate if there are deviations in the typhoon tracks, the overlap of the land area traversed by TCs in consecutive years were measured. Results show that deviations from the path often happen during years when there is an observed increase in sea surface temperature. This may indicate that global warming or in a long time frame, climate change, may have caused the TC track deviation. Results also showed that less intensity TCs occur during seasons of La Niña. Moreover, as a result, we created hazard maps based on TC frequency and areas with high occurrence of TC in the Philippines were identified.