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Geological Society of Malaysia

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Cover photo: Secondary sulphate (melanterite, ferricopiapite, szomolnokite & coquimbite) on graphitic schist, Bukit Beruntung, Selangor by T.F. Ng.

Shape parameters of clay and quartz clasts in the Neogene Tukau and Lambir Formations, NW Sarawak

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Abstract: Located in north-western Sarawak, the occurrence of large clay clasts associated with quartz pebbles in channelized deposits is a puzzling phenomenon, since the specific mass of sand and clay is only moderately different. Clay flakes are found to be on average five times larger than quartz pebbles belonging to the same unit. The clay clasts and quartz pebbles described here belonged mainly to the Pliocene Tukau Formation, with a couple of samples taken from outcrop transitional from the Lambir to Tukau Formation. Both formations are characterized by fluvial to shallow marine conditions, and are strongly influenced by tidal, wave and longshore current interaction. The quartz pebbles are always located at the bottom of amalgamated fining-upwards channel deposits. Clay clasts/clay flakes are mostly interbedded with fine-grained sandstone layers. The flakes are mostly flat and elongated, whilst pebbles are rounded to sub-rounded. Present-day examples suggest these clay clasts were formed in low-energy intertidal areas, originating from clay layers that dried-up and were washed-off with the incoming tides, though flash-flood events might also have contributed to their creation.

Keywords: clay, pebbles, quartz, Lambir, Tukau, Neogene

INTRODUCTION

Clay clasts are a common constituent of the Neogene sand-dominated Tukau and Lambir Formations of north-western Sarawak (Figures 1 and 2), which constitute the main sedimentary facies of the 'onshore Baram Delta' (Tan *et al*., 1999; Hutchison, 2005; Kessler, 2005, 2009a,b; Kessler & Jong, 2015a; Nagarajan *et al*., 2017; Jong *et al*., in prep). A simplified litho-stratigraphy scheme of the study area is shown in Figure 3.

The Tukau Formation unconformably overlies the Lambir and is formed by intertidal clastics, in particular tidal channel deposits that appear strongly amalgamated (Figure 4), and are interbedded with silty parallel layers (Figures 4 and 5). Individual channel beds are often characterized by 'side-stepping' and asymptotic foresets, in which laminae can consist of thin, gray claystone or of lignite as shown in Figure 6.

The Mid-Late Miocene Lambir Formation forms the crestal area of the Bukit Lambir. The formation contains about equal amounts of claystone and sandstone, the latter mainly formed by (sometimes nested) tidal channels and beach bars. Most channels are 'reworked' and strongly amalgamated.

This paper focuses on the size relationship between quartz and clay clasts, and will explain this strange mix of sediment fragments in the studied formations.

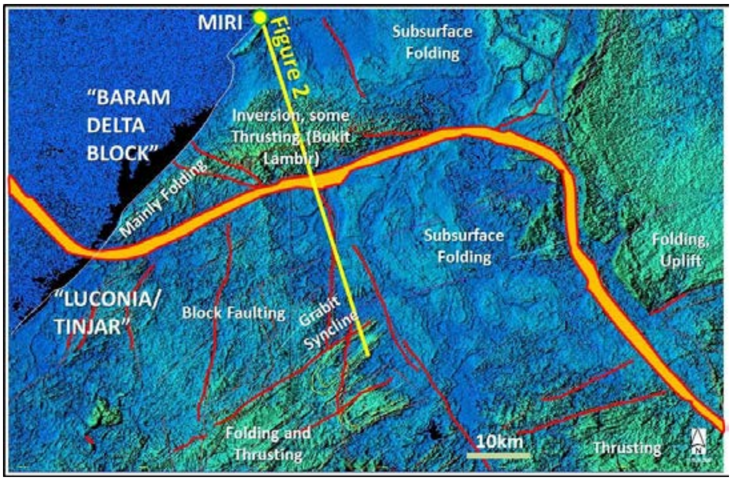

Figure 1: Regional structural elements of NW Sarawak. The orange Baram Line constitutes an important facies boundary, with carbonates dominating in Luconia/Tinjar and clastics in the Baram Delta Block. Inversion features such as Bukit Lambir and Engkabang-Karap (Jong *et al*., 2016) are seen along the lineament. From Kessler & Jong (2015a).

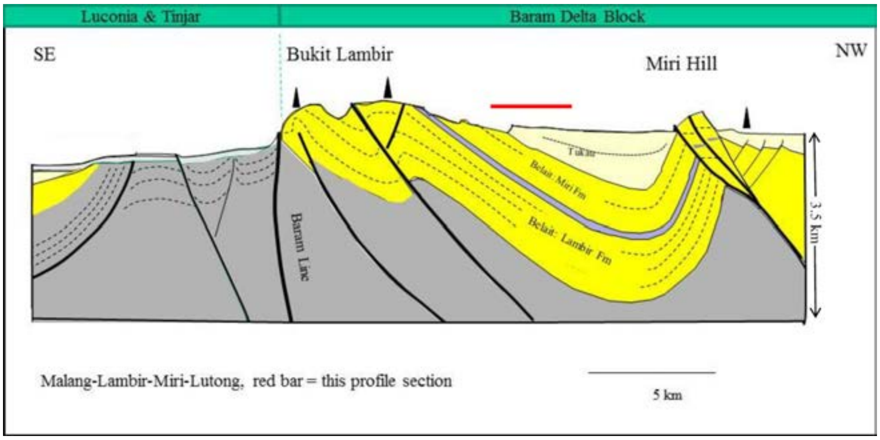

Figure 2: Tectonic/stratigraphic cross-section showing folded Neogene sediments. See Figure 1 for line location. The red bar indicates the area of outcrops.

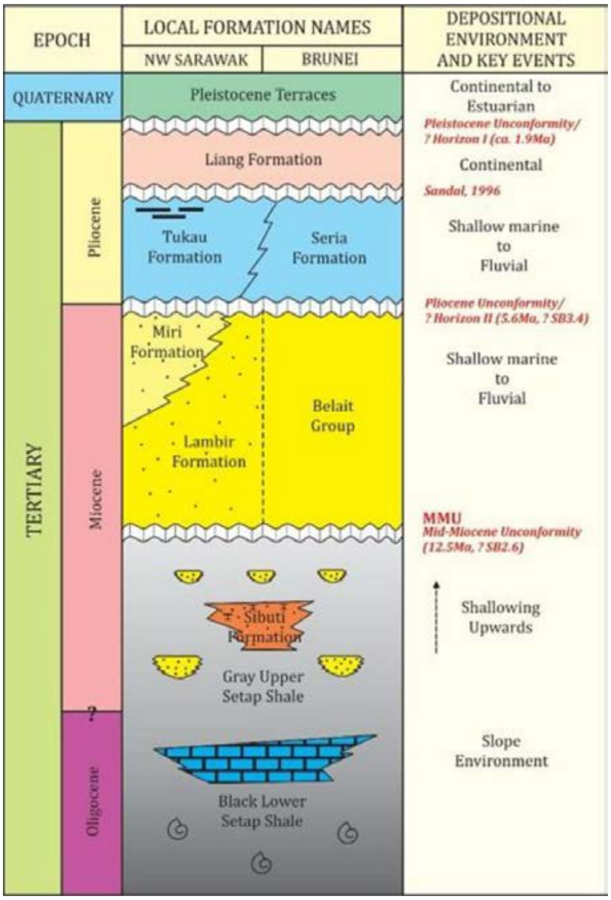

Figure 3: Simplified litho-stratigraphy scheme of the study area. The nomenclature of Miri Formation is generally used in the Greater Miri area and is age-equivalent to the upper section of the Lambir Formation, Sandal (1996) however, placed the formation partially age-equivalent to the lower Tukau Formation. Likewise, the mid Early Miocene Sibuti Formation is more locally confined with the Subis Limestone Member in the lower part of the formation located along the central anticlinorium of the Sibuti Formation (Banda & Honza, 1997). Carbonates are also widespread in the Palaeogene section, and are seen in a number of outcrops and wells (e.g., Batu Niah, Engkabang-1; Jong *et al*., 2016). Note the unconformity between Tukau/Seria and Liang Formations was not observed in this study but in Brunei has been documented by Sandal (1996). From Kessler & Jong (2015a).

Figure 4: Prograding channels and beach bar deposits in a quarry near Bakam, NW Sarawak. These sediments belong to the Tukau Formation, somewhat younger (Pliocene?) than the underlying Lambir Formation.

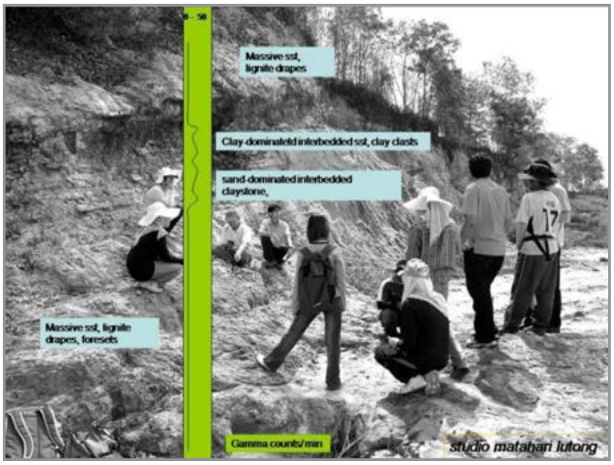

Figure 5: Gamma Ray response of a Tukau Formation channel sandstone/claystone assemblage. With students (as a scale) of the Curtin University Sarawak 3rd Year geology class, and delegates from JX Nippon. Photo taken on Saturday 12th September, 2009.

METHODOLOGY

The respective sediments (quartz pebbles, clay clasts/flakes with sands) were sampled, washed and dried. The clasts were examined and measured under the microscope. Specific mass data were obtained by determination of their volume and bulk weight. Several gamma ray measurements were carried out with a portable scintillometer on sand, clay, and clay pebble beds (Figure 5).

Occurrence and Shape of Quartz Pebbles and Clay Clasts

Within the sandy units of the studied formations, clay clasts (flakes and pebbles) are seen to have formed streaks and lenses, located within portions of outcropping sandstone beds, and mostly as deposits within amalgamated channel sediments. Measurements in several outcrops have shown grain sizes of clay clasts (both clay flakes and clay pebbles) are a magnitude larger than quartz clasts belonging to the same beds.

Tukau Formationat the Bakam Quarries, some 20 km South of Miri

Both larger-sized quartz grains (coarse sands or pebbles) and clay clasts (flakes) occur in layered and poorly sorted deposits on the bottom of sandstone channels, and may have been deposited during episodes of high water energy and turbulent flow. Quartz pebbles are sub-rounded, and are only noted in the deposits of large channels. As shown in Figures 7 to 12, clay clasts are always much larger, by an order of 5:1, than the quartz clasts occurring in the same bed. However, the specific mass balance is only 2.15 g/cm^3 for quartz pebbles, versus 1.975 g/cm^3 for clay clasts. The moderate difference observed in the specific mass data can be attributed to the complicated mix in the shape and surface area of the dried-up, and ripped-up clay flakes forming the clay clasts, which are more mobile than the sub-rounded quartz pebbles (Mike Scherer, pers. comm.).

Figure 6: A small channel from a Tukau Formation outcrop in the Luak Bay area, Miri City. Laminae within this cross-bedded and side-stepping channel are here formed by lignite. A trowel was placed in the middle as a scale.

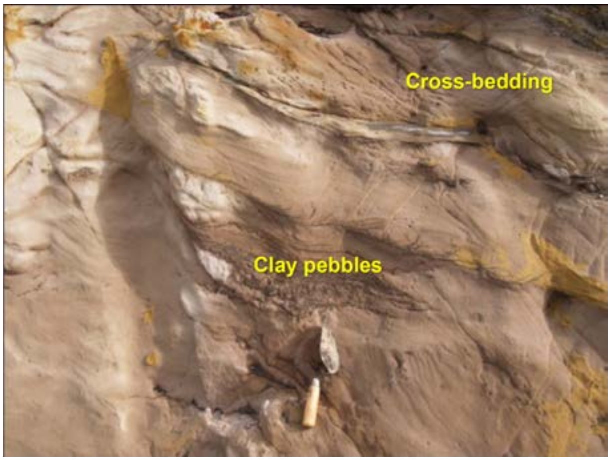

Figure 7: Lenses of clay pebbles within an amalgamated cross-bedded sandstone body, Tukau Formation, Bakam, NW Sarawak. A trowel was placed below the clay pebbles as a scale.

Figure 8: Clay clast and quartz pebble bed at the bottom of a cross-bedded sandstone unit, Tukau Formation, Bakam quarries. This bed is comprised of 60% irregularly-shaped clay clasts and 4% quartz and hard rock conglomerate. It could be a flash-flood deposit.

Figure 9: Clay flakes embedded in fine-grained sandstone (Lambir Formation, above the 'parang' knife). Note the difference in shape and size between sand particles (these are less than 0.5mm in diameter) and clay clasts (more than 20mm in diameter). There is no obvious break between the fine-grained sandstone and pebble bed, though clay clasts seem to form a lenticular-shaped body. The shown clay pebbles/flakes are likely sediments mobilized by the incoming tide. The yellow-stained area above the clay pebble bed is the result of migrating pore waters and deposition/or formation of Goethite.

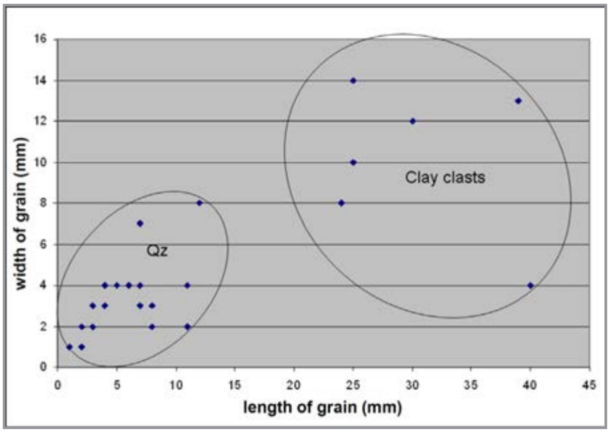

Figure 10: Comparison of quartz (Qz) and clay clasts, located in a basal conglomerate bed of large amalgamated sandstone channel deposits. This study is based on Bakam outcrop data taken from the bed shown in Figure 8.

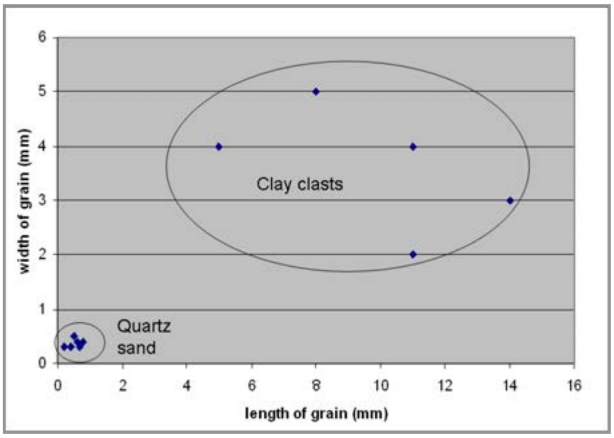

Figure 11: Comparison of quartz and clay clasts, located in a basal lamina of a stratified ripple within a large amalgamated sandstone deposit. Lambir Formation outcrop as shown in Figure 9.

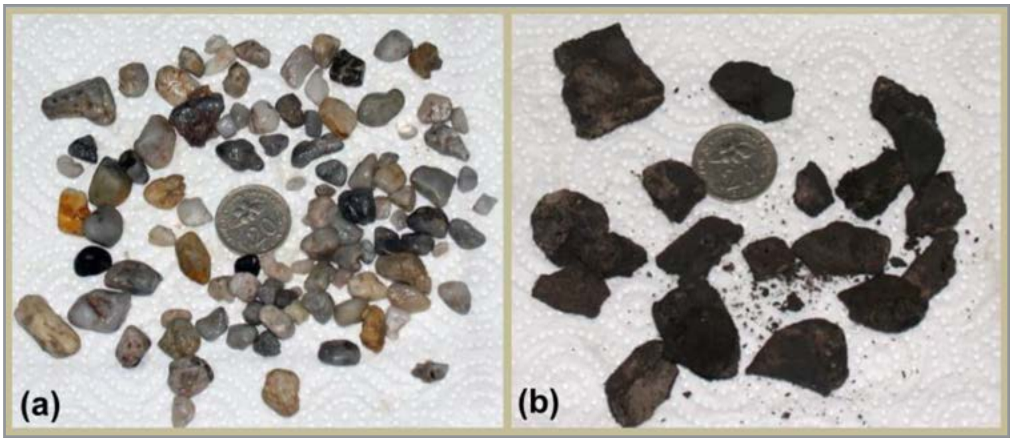

Figure 12: (a) Polymict, quartz-dominated conglomerates (a primary sediment?), and (b) Flaky clay clasts, originating from the same conglomerate bed (Tukau Formation in Bakam). Compared to the quartz clasts, the clay flakes do not show any sign of rounding, implying a short transport distance.

Transition Lambir to Tukau Formation along the Coastal (Miri-Bekenu) Road Outcrops

Clay pebbles are mostly rounded and occur in crescent-shaped layered deposits that might be remnants of tidal current deposits, within a host rock characterized by fine and laminar-bedded sand. Quartz pebbles in combination with clay clasts, such as described above, are rarely observed. Overall, we observed that quartz pebbles and clay flakes occur together in one unit mainly in the Tukau Formation outcrop of the Bakam quarries. Whilst the older Lambir Formation appears to be devoid of quartz pebble channels, and clay flakes are relative rare, and occur in conjunction with fine Swaley cross-bedded sands.

HOW AND WHERE DO CLAY FLAKES AND PEBBLES FORM?

Contemporaneous intertidal sediments South of Miri suggest that clay flakes form when thin blankets of clay dry-up at low tide, as shown in Figure 13. A couple of sunny hours is enough to dry thin clay layers as shown. Schematically, the process of clay deposition, drying and buckling, erosion and transport is shown and summarised in the sketches of Figures 14a-c.

It seems possible that the dry-up clay flakes were transported by floating over short distances at incoming tide; the clay would rehydrate quickly, and the heavier flakes would start to submerge and sink. However, the flakes might be transported further away, as long as the energy of the flow lasts. Rounding in clay pebbles, such as indicated in Figure 9, may suggest that clay pebbles are 'tumbling along' on the bottom of intertidal channels, and perhaps also along shore within the subtidal setting. It is noted that a contribution of flash-floods might also be responsible for clay clasts/flakes within some of the beds.

DISCUSSION

The origin of the large quartz pebbles as seen in the Tukau Formation remains somewhat enigmatic. Interpreted as a primary sediment, the closest areas of provenance might be at Batu Gading, 45 km to the East, and/or the Belaga Mountains, some 80 km SE of Bakam. Outcrops in these areas are formed by clastics of the Rajang Group, and also contain some hydrothermal quartz veins. Possibly, the latter served as a source of the large quartz pebbles, when the hinterland was exhumed and uplifted as from Late Miocene times onwards (Kessler & Jong, 2015b). To keep quartz pebbles as described

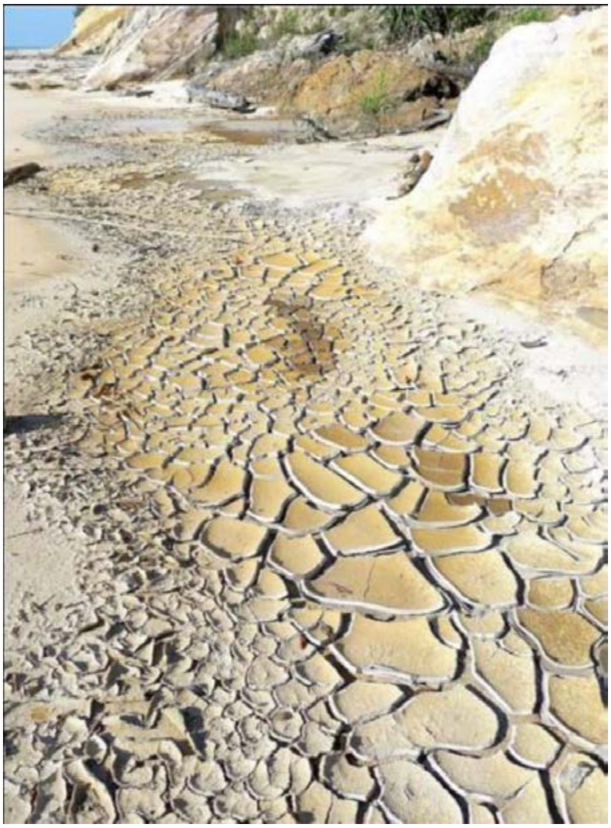

Figure 13: On the beaches South of Miri, clay layers form in puddles during high tide. During low tide, this layer dries up to form polygonal clay flakes that buckle up. The new incoming tide rips them off and moves them away.

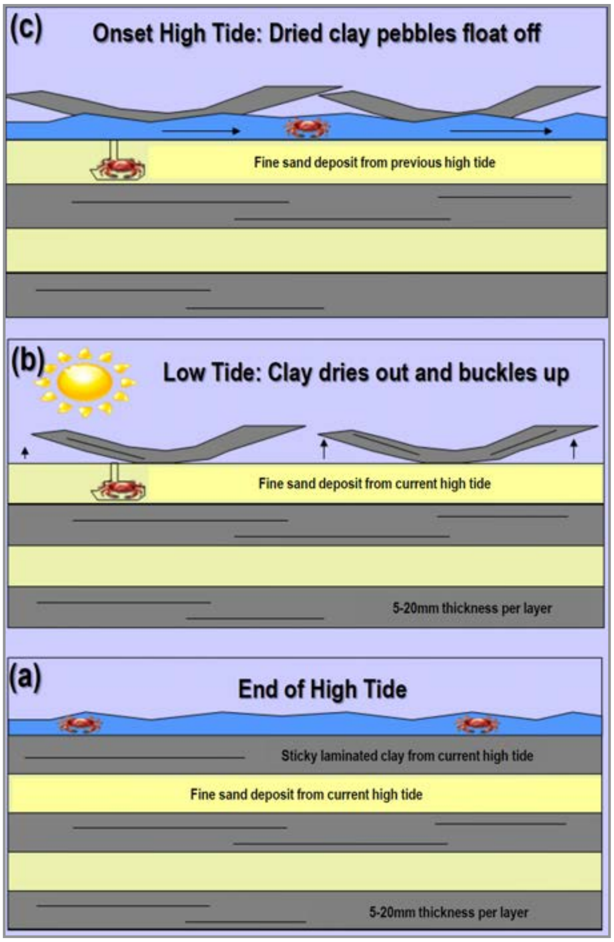

Figure 14: Schematic process of clay deposition, drying and buckling, erosion and transport. (a) during high tide, layers of sticky clay form in puddles of stagnant water, (b) as water recedes from the inter-tidal areas during low tide, the uppermost clay layer dries out quickly, and buckles up to form polygonal flakes, and (c) with water rising during high tide, the dried flakes float up and are carried away by the current.

above suspended requires a fluvial system of strong current, and probably also implies a strong relief of the hinterlands. Clay flakes, however, may have originated from near-by tidal flats, as suggested by contemporaneous sedimentation. The combined deposition of quartz pebbles and clay flakes in the described channel-bottom layers can only be explained by a sudden drop of current strength. However, the question about flow characteristics – laminar or temporarily turbulent flow/grain flow, remains.

CONCLUSIONS

In summary, both (irregularly-shaped) clay flakes and (somewhat rounded) clay pebbles are observed. Flakes seem to be the less mature sediment, suggesting a very short distance between erosion and re-deposition. The mostly smaller clay pebbles are predominantly sub-rounded, which is suggestive of more extensive transport. Quartz pebbles are only found at the bottom of channels within the Tukau Formation, and are inferred to be a primary sediment.

ACKNOWLEDGEMENTS

We thank Mr. Hajime Kusaka, GM Exploration at JX Nippon in Miri (2009-2011) for sponsoring and endorsing field studies. This study has benefited from the involvement of Third Year geology class students (2009) of Curtin University Sarawak, whom had helped in outcrop logging and descriptions. Our gratitude is also extended to Mr. Fairy Dasun for providing the drafting assistance to finalise the figures accompanied this paper. We also thank our reviewers Dr. Mike Scherer and Mr. Steve Barker for their constructive reviews that enhanced the quality of this manuscript.

REFERENCES

Banda, R.M. & Honza, E., 1997. Miocene stratigraphy of northwest Borneo Basin. Bulletin of the Geological Society of Malaysia, 40, 1-11.

Hutchison, C.S, 2005. Geology of North West Borneo: Sarawak, Brunei and Sabah. Elsevier, Amsterdam. 421 p.

Jong, J., Kessler, K.L., Noon, S. & Tan, T.Q., 2016. Structural development, depositional Model and petroleum system of Paleogene carbonate of the Engkabang-Karap Anticline, onshore Sarawak. Berita Sedimentologi, 34, 5-25.

Jong, J., Harun Alrashid bin Mohamad Idris, Barber, P., Kessler, F., Tan, T. T.Q. & Uchimura, R., in prep. Exploration History and Petroleum Systems of the Onshore Baram Delta, Northern Sarawak, Malaysia. Bulletin of the Geological Society of Malaysia.

Kessler, F.L., 2005. Comments on the evolution of the Bukit Lambir Area, Sarawak, Malaysia. Paper presented at the GSM conference, Kuala Lumpur, December 2005.

Kessler, F.L., 2009a. Channels – Size Matters. Houston Geological Society Bulletin, 51(1), 29-33.

Kessler, F.L., 2009b. Observations on sediments and deformation characteristics of the Sarawak Foreland, Borneo Island. Warta Geologi, 35(1), 1 -10.

Kessler, F.L. & Jong, J., 2015a. Northwest Sarawak: a complete geologic profile from the Lower Miocene to the Pliocene covering the Upper Setap Shale, Lambir and Tukau Formations, Warta Geologi, 41(3-4), 45-51.

Kessler, F.L. & Jong, J., 2015b. Tertiary uplift and the Miocene evolution of the NW Borneo shelf margin. Berita Sedimentologi, 33, 21-46.

Nagarajan, R., Armstrong-Altrin, J.S., Kessler, F.L. & Jong, J., 2017. Petrological and Geochemical Constraints on Provenance, Palaeoweathering, and Tectonic Setting of Clastic Sediments from the Neogene Lambir and Sibuti Formations, Northwest Borneo. In: Mazumder, R. (ed.), Sediment Provenance – Influence on Compositional Change from Source to Sink. Elsevier, Amsterdam, Netherlands, 123-153.

Sandal, T. (ed.), 1996. The geology and hydrocarbon resources of Negara Brunei Darussalam, Brunei Shell Petroleum Co. Sdn. Bhd. and Brunei Museum. 243 p.

Tan, D.N.K., Abdul Hadi b. Abdul Rahman, Azlina Anuar, Boniface Bait & Chow, K.T., 1999. West Baram Delta. In: The Petroleum Geology and Resources of Malaysia, Petroliam Nasional Berhad (PETRONAS), Kuala Lumpur, 293-341.

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Morphological description of a mud volcano caldera from deepwater Sabah – general implications for hydrocarbon exploration

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Abstract: A 500m diameter mud volcano caldera at 1100m water depth offshore Sabah, Malaysia, was investigated using unreprocessed three dimensional exploration seismic data. The seabed morphology was derived from these data and interpreted in conjunction with the sub-seabed seismic profiles. The mud volcano overlies a toe-thrust anticline and has a well-defined caldera that is being infilled by flow deposits from a cone developed on the caldera basin floor. Topographic highs in the west and south may represent former mud volcanoes on the caldera rim but a channel on the outer western flank suggests that pressure relief is occurring through outflow of heavy brines. The Sabah mud volcano has many features in common with other mud volcanoes worldwide within active petroleum provinces, and in most cases are associated with hydrocarbon seepages.

Keywords: mud volcano, seabed morphology, offshore Sabah

INTRODUCTION

The deepwater seabed of offshore Sabah, Malaysia, is locally a very active depositional environment particularly above the crests of toe-thrust anticlines. Seabed fluid plumes are commonplace and several unpublished occurrences of mud volcanism with associated calderas are documented within commercial geological reports. Mud volcanoes are common in compressional tectonic belts, within deltas and submarine slopes undergoing gravitationally driven detachment (e.g., Niger Delta: Graue, 2000) (Davies *et al*., 2007). For further reference, a summary of processes and implications for mud volcanism is provided by Mazinni (2009). Davies *et al*. (2007) summarises the "birth" of the Lusi mud volcano in East Java as the direct result of connection of a high-pressure fluid at depth with shallow sediments at a depth at which fractures can be initiated and induced by drilling activities. Van Rensbergen *et al*. (1999) described the structural evolution of shale diapirs from reactive rise to mud volcanism based on 3D seismic data in Baram Delta, offshore Brunei.

The objective of this paper is to describe the seabed morphology of one such prominent mud volcano and associated caldera together with an interpretation of its origins, current activity and implications for deepwater hydrocarbon exploration from both petrogenic and engineering viewpoints. A comparison with published data from the deepwater Niger and Nile Fans is discussed.

The data used for the geomorphological interpretation comprises solely of commercial three dimensional (3D) exploration seismic data acquired by JX Nippon Oil and Gas Exploration (Deepwater Sabah) Limited as part of a semi-regional prospect evaluation. No reprocessing of the seismic data was carried out to enhance high frequencies at the seabed. The seabed two way time pick on the seismic data was auto tracked within IHS Kingdom software, edited for data spikes and converted to depth using a velocity of approximately 1510m/s. The resulting depth data together with amplitude characteristics were exported for mapping and display within Surfer v12.8 mapping software.

REGIONAL SETTING

The mud volcano caldera lies approximately 100 kilometres north-west of the Sabah coastline (Figure 1) at a water depth of 1100m on the lower continental rise (Figure 2). It is associated with an area of disturbed seabed overlying a north-east to south-west trending toe-thrust anticline that has a positive topographic effect on the modern seabed forming a shoal or submerged ridge of approximately 150m in elevation. Seismic data indicate that the mud volcano feeder may be related to deep seated antithetic faults on the toe-thrust plane.

Large slope failure scars apparent at the seabed extend from the upper and mid continental slope and pond on the southern flank of the shoal or pass around its western margin. These features are relict and are buried by a mimicking drape up to 30m in thickness. It is estimated that the slope failures are Late Saalian (*ca.* 130ka BP) and that no significant mass transport deposition has occurred here since that time. In contrast the drape thickness on the shoal where the mud volcano caldera

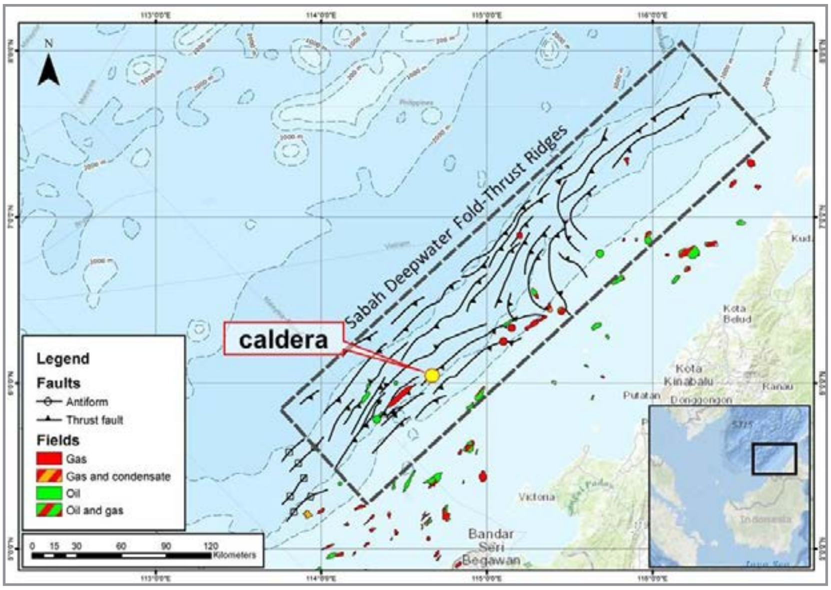

Figure 1: Location map of the Sabah mud volcano caldera, offshore Sabah deepwater area.

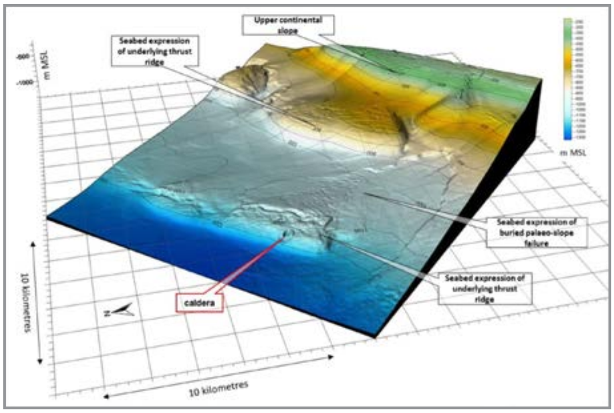

Figure 2: Three dimensional image of the seabed illustrating the geomorphological setting of the mud volcano caldera.

is present is variable and discontinuous suggesting that hemipelagic deposition has been restricted and that the area has remained active to the present day.

BATHYMETRY AND SEABED MORPHOLOGY

The mud volcano caldera is approximately circular in plan with a diameter of 500m (Figure 3a). The water depths vary between a minimum of 1085m on the caldera rim in the south to 1173m within the caldera basin in the north, with a total elevation range of 88m.The sill to the caldera depression lies at 1151m. To the west outside the caldera rim lies a sub-linear channel 4m in depth running to the north-north-west. Its significance is discussed below.

Seabed gradients are high and complex (Figure 3b). The highest gradients are present within the inner flanks of the caldera and are commonly in excess of 30°. The maximum gradients of 48° and 51° lie in the south-west and west, respectively. Such high gradients suggest that the slopes within the caldera will be unstable and have not had a long period of time to decay.

In profile the caldera is asymmetrical (Figure 4). The south-west to north-east strike profile shows a higher elevation on the south-western rim possibly as a result of rising fluid plumes on that side. In contrast in the north-east no rim is developed. The dip profile from north-north-west to south-south-east shows a well-developed rim on both the southern and northern sides with an overall dip of the base of the caldera down to the north and the presence of an elevated cone in the centre. In the north the profile passes through the caldera sill (lowest point on the rim) at 1151m water depth approximately 22m above the areally restricted flat base of the caldera basin.

The key elements of the mud volcano and caldera complex are illustrated on Figure 5 and comprise of the following:

Caldera Rim: The rim encircles the caldera depression on three sides, being absent on the eastern flank. The maximum development occurs in the south and west and may be partially related to uplift due to fluid migration from depth. The rim is breached in the north at the caldera sill (Feature D).

Inner Caldera Cone: The cone lies in the centre of the overall caldera complex but due to caldera wall slumping in the south appears offset to the southern margin of the caldera floor. The inner caldera cone is interpreted to represent the active vent today that is progressively infilling the caldera basin with mud flows. It has a maximum elevation of 15m above the caldera floor with an asymmetrical profile (Figures 4 and 8) due to preferential flow deposition to the north and east. The mud forming the flows is interpreted to have a composite origin combining sediments from deep within the toe-thrust anticline and more recent sediments remobilised by upwelling relatively warm fluids with methane gas. Clasts of firmer material particularly from depth may be entrained within the mud (Van Rensbergen *et al*., 2003; Giresse *et al*., 2010).

Inner Caldera Depression: The inner caldera depression has been largely filled by mud flows from the cone. It is restricted to the north of the caldera where

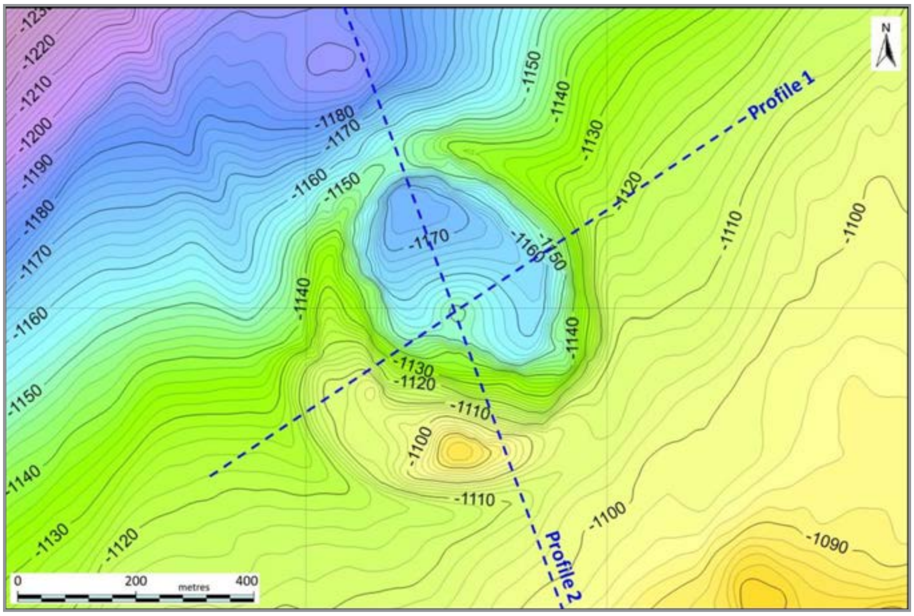

Figure 3a: Caldera bathymetry (metres MSL).

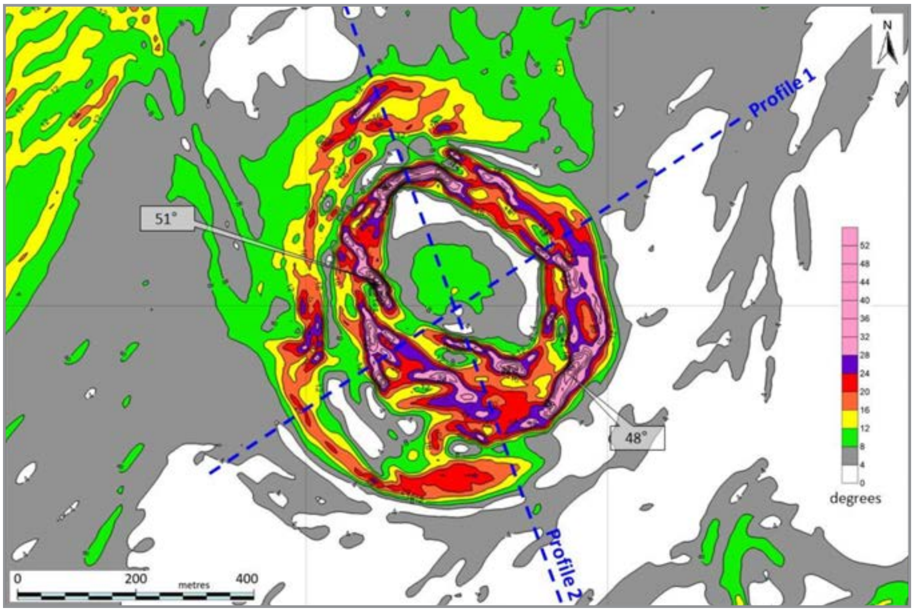

Figure 3b: Caldera seabed gradients (degrees).

it forms a small, relatively flat bottomed area at about 1173m water depth.

Caldera Sill: The lowest point on the caldera rim lies in the north and forms a sill at 1151m water depth. There is no evidence of overflow from the caldera over this sill at the present day seabed.

Southern Rim Peak: The shallowest point on the rim lies in the south at 1085m water depth overlying a deep seated plume. The morphology of the peak is suggestive of a mud volcano cone although within the limitations of the data no individual flows can be seen at the seabed. Further high resolution work is required.

Caldera Slope Failure: Very high seabed gradients resulting in seabed instability are present within the caldera bowl. A possible slump is interpreted on the inner southern flank of the caldera possibly further destabilised by upwelling fluids.

South-western Rim Peak: This peak may also represent a volcanic mud cone underlain by a migrating fluid plume but fluid escape and pressure release on its lower flanks has restricted the development of a mud volcano at this location.

Outer Rim Disturbed Seabed: A depression with possible pockmarks is present on the lower slope of the outer western rim. This is interpreted as an active fluid vent resulting from seabed breaching near the foot of the south-western rim peak mud volcano. Pressure release through fluid venting may be responsible for the limited development of the south-western peak.

Outflow Channel: A sublinear channel up to 4m in depth extends from the disturbed seabed on the outer rim (Feature H) out to deepwater to the north-north-west of the caldera complex. It is interpreted to be the product of outflow from outer rim depression, Feature H. The channel extends to a water depth of 1265m where it terminates. No deposition fan is present at the channel termination suggesting that saline fluid flow with little entrained sedimentary material is responsible.

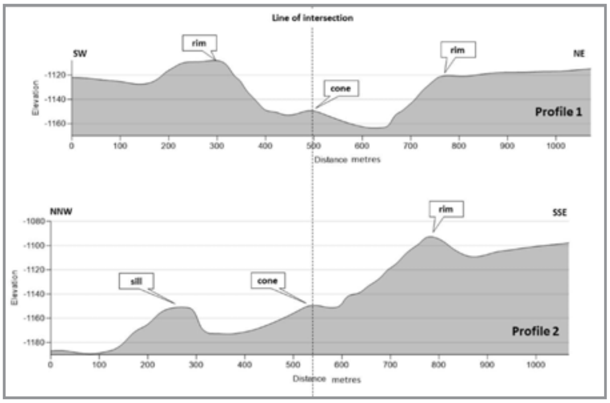

Figure 4: Caldera seabed profiles (metres MSL).

Moat: A discontinuous moat - a channelized depression is present in the south and south-west adjacent to the area of maximum topographic development. It is interpreted that the moat is a product of modern near seabed currents accelerating around the area of greatest resistance.

Northern Depression: An area of subsidence is present to the north of the caldera complex forming a shallow depression up to 5m deep and 200m in diameter. It is interpreted that this is the product of shallow sediment withdrawal due to subsurface sediment mobilisation by migrating fluids (Van Rensbergen *et al.*, 2003; Judd & Hovland, 2007).

A notably missing feature and not obviously present in this Sabah mud volcano-caldera complex is the gryphon (Figure 6), which is a steep, short cone that gives off mud that could be collapsed in this particular example due to earlier eruption events.

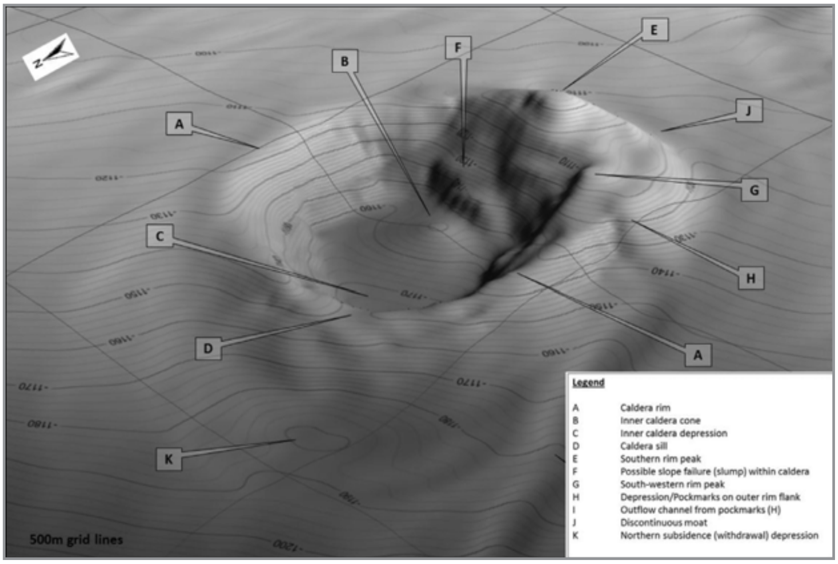

Figure 5a: Caldera geomorphological features displayed on shaded relief map with bathymetric contours.

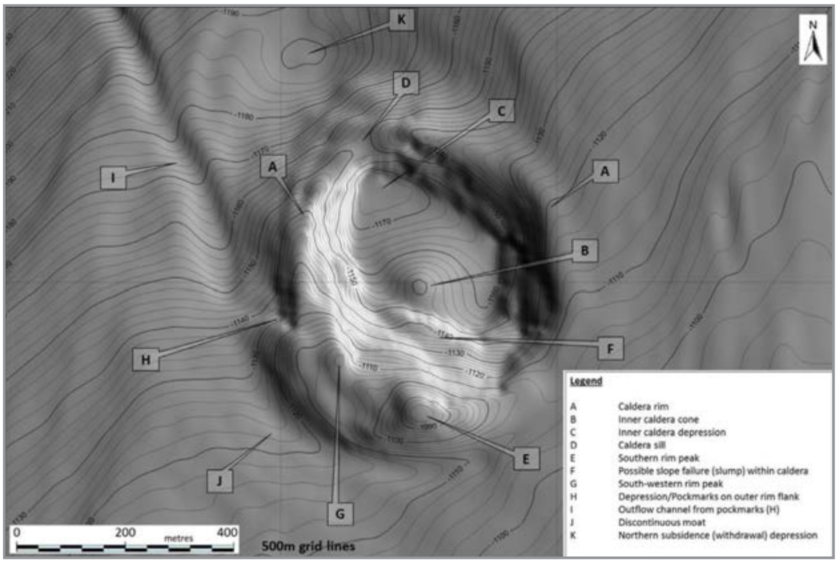

Figure 5b: Three dimensional rendering of caldera geomorphological features displayed on shaded relief map with bathymetric contours.

CALDERA AMPLITUDES AND THEIR SIGNIFICANCE

Amplitude analyses were carried on the data to further refine the interpretation. They comprised RMS, peak positive and peak negative extractions at the seabed and within a window from seabed to the base of the gas hydrate stability zone. There was very little difference between the RMS analyses and the peak positive analyses whilst the peak negative showed a relatively random distribution determined largely by the presence of free gas at the base of the gas hydrate stability zone. Only the RMS amplitudes are illustrated here.

The RMS amplitude distribution for a 32ms window centred on the seabed pick is illustrated in Figure 7 both in plan view and in three dimensions. The profiles through the caldera (Figure 8) clearly show the exceptionally high amplitudes at and near the seabed within the caldera.

The high positive and RMS amplitudes are interpreted to be due to the presence of high concentrations of gas hydrates at the seabed and within the near seabed sediments together with authigenic carbonate layers and concretions. The hydrates themselves are the product of dissolved methane gas from within the relatively warm upwelling fluids and mud crystallising when in contact with the cool (*ca.* 4°C) bottom water and near seabed sediments.

The high amplitudes are concentrated in three distinct areas:

Central caldera: High amplitudes extend from the caldera cone (B) downslope to the east and northeast before turning to the west. The amplitudes are interpreted as due to gas hydrates present within recently ejected mud flows from the cone.

Caldera slope failure: An isolated area of high amplitudes is associated with the inner caldera slope failure (F), and may identify the location of a small fluid plume. Upwelling fluids beneath the slope may be a factor in destabilising this part of the inner rim.

South-western rim peak: Anomalous high amplitudes are present to the south and east of the south-western rim peak (G). No seabed flows are resolved by the seismic data but it is possible that the high amplitudes are due to gas hydrates present within relatively recent flows that otherwise lie below the limits of seismic resolution.

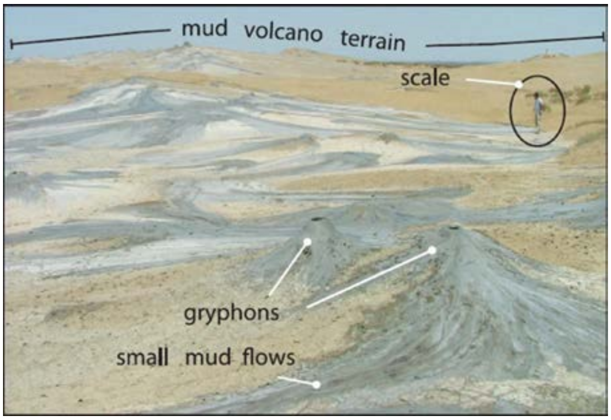

Figure 6: Photograph of mud volcano terrain from Azerbaijan comprising several gryphons from which small mud flows emanate (after Davies *et al*., 2007).

INTERPRETED ORIGIN AND DEVELOPMENT OF THE MUD VOLCANO-CALDERA COMPLEX

The mud volcano-caldera complex forms part of an extensive disturbed seabed area related to regional thrust tectonics and slope destabilisation. Asummary of the interpreted features within the caldera complex is presented on Figure 9 for this discussion. No absolute dating information is available and as a result only relative timings can be discussed.

It is interpreted that initially the mud volcano-caldera complex developed as a result of upwelling warm fluids expelled at depth during the ongoing development of the underlying toe-thrust anticline. The central depression

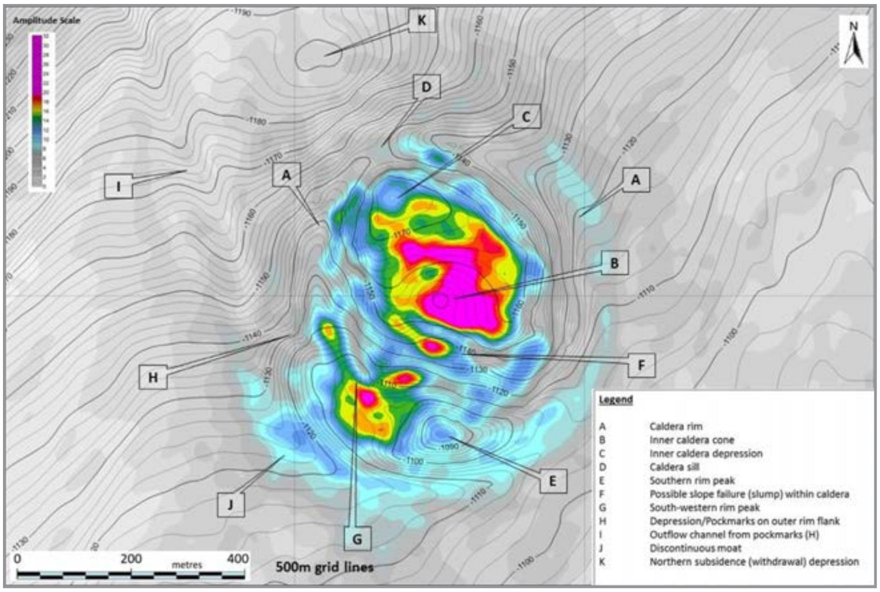

Figure 7a: RMS amplitude distribution at seabed.

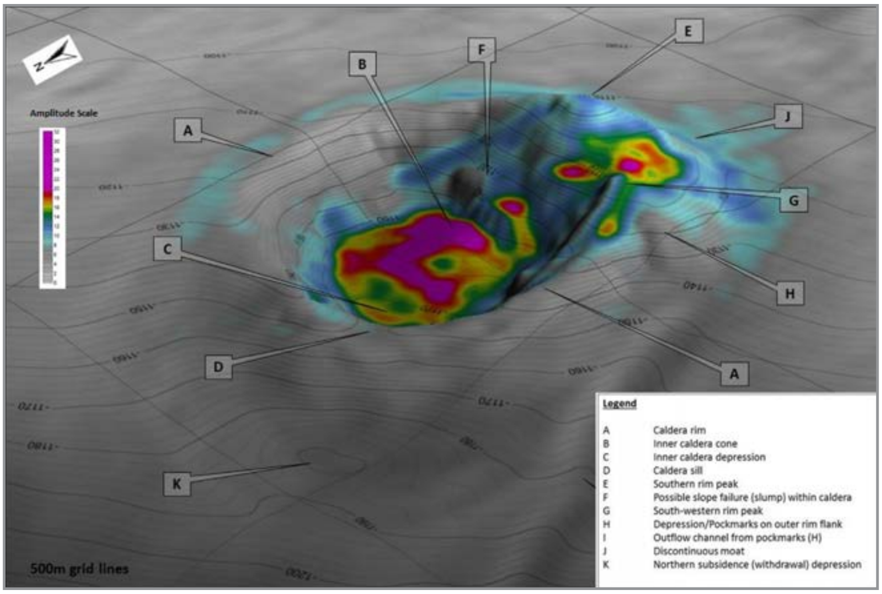

Figure 7b: Three dimensional rendering of RMS amplitude distribution at seabed.

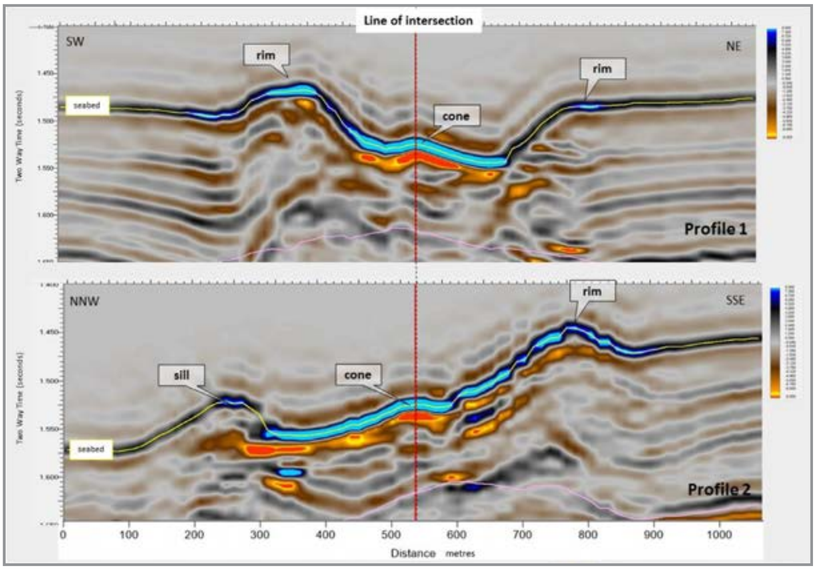

Figure 8: Seismic profiles through the caldera illustrating amplitude variations (see Figure 4 for equivalent sections to the bathymetric profiles).

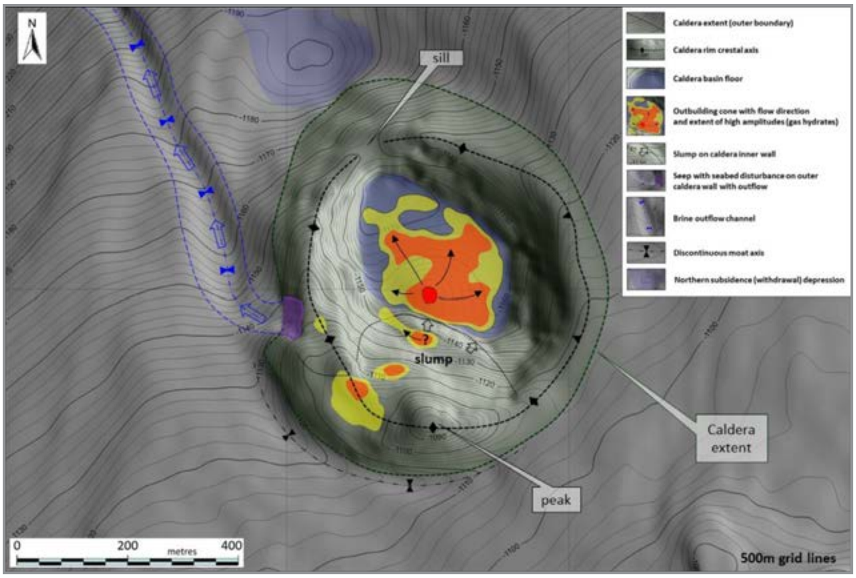

Figure 9: Interpretation Synopsis overlain on seabed shaded relief with bathymetric contours.

and inner flanks of the caldera were likely formed by subsidence of the central area above the plume due to sediment expulsion and deposition on the rim by mud volcanoes primarily in the south and west. The seismic evidence suggests that the present day caldera is just the modern expression of a series of stacked calderas and mud volcanoes located above a preferential fluid flow path. However, the data resolution is poor and further work is required.

At the present day a new mud volcano is building within the floor of the caldera creating a cone with flows largely to the north and east. High amplitudes suggest that the original mud flows had a high (methane) gas content that is now represented by gas hydrates. The mud flows may also contain clasts from depth.

Mud volcano activity in the west and south is interpreted to be limited at the present day. This may be due to pressure release on the western outer rim of the caldera through escaping fluids. The presence of disturbed seabed and in particular the seabed channel without a depositional fan at its termination suggest that the escaping fluids are heavy brines with little entrained sediment.

ANALOGUES FROM OTHER DEEPWATER AREAS AND IMPLICATIONS FOR HYDROCARBON EXPLORATION

Mud volcanoes are often linked with places where petroleum gathers. As hydrocarbon exploration has expanded into ever deeper water, mud volcanoes have been discovered in a variety of passive and active tectonic settings. Deepwater mud volcanoes occur throughout the world in petrogenic provinces where they are largely the product of the expulsion of light hydrocarbons, primarily methane, in conjuncution with warm bouyant fluids. Their identification is important particularly in frontier areas as they may be indicators of active petroleum systems with hydrocarbon seepages (e.g., Etiope, 2009; Jong *et al*., 2014 & 2016).

In Jong *et al*. (2014), it was mentioned that a surface geochemical sampling study was conduted in the study area with a couple of samples taken from within the caldera. Outcomes of geochemical analyses including $C10^+$ gas chromatogram and biomarker investigations indicated the occurrence of hydrocarbon seepages with the presence of thermogenic hydrocarbon generation associated with this particular mud volcano caldera, suggesting leakage of hydrocarbons *via* vertical feeder faults from deeper reservoirs to seabed (Figure 10). Jong *et al*. (2016) described the origin of an onshore analogue of a mud volcano-caldera complex at the Engkabang-Karap Anticline attributed to the presence of overpressured and semi-liquid mobile shale located in an area of compressive tectonism with strike-slip faulting, and thrusting. The volcano's complex fault-segmented vent can be observed reaching *ca*. 1250m into the subsurface rooted in a prominent strike-slip system facilitating petroleum gas migration (Figure 11).

Together with the identification of gas chimney and pockmark formation (e.g., Cathles *et al*., 2010; Figure 12) for indications of an effective hydrocarbon charge system, mud volcanoes also represent significant geohazards to exploration and development and should be avoided. The primary geohazards are:

- Unstable seabed prone to faulting and movement.
- Steep gradients that are both unstable and can create pipeline spanning.
- Brine flows eroding the seabed around infrastructure.
- Mud flows that can disrupt and bury seabed infrastructure.
- Weak near seabed sediments that can result in self burial of infrastructure.
- Gas hydrate formation particularly over time that can impair or damage the integrity of well heads, blow out preventers and pipelines.
- Authigenic carbonates forming unexpected, discontinuous and brittle hard grounds.
- Evidence for shallow overpressures and anomalously elevated temperatures with the potential for weak, fluidised mud levels that could flow into a well.

Mud volcanoes may also introduce hydrocarbons to the seabed and shallow seabed sediments resulting in high biological activity (e.g., Jong *et al*., 2014).

The mud volcanoes in offshore Sabah occur within a region of active thrusting and are likely driven by deep overpressures and expulsion of fluids along plains of weakness (e.g., Nguyen *et al*, 2016). Two examples from other deepwater regions are compared and discussed below; the compressional thrust belt at the toe of the deepwater Niger Delta and Western Nile Fan.

Deepwater Niger Delta

The Niger Delta lies offshore West Africa and has developed by progradation across the continental shelf and oceanic crust since the Early Eocene (Corredor *et al*., 2005; Cobbold *et al*., 2009; Bellingham *et al*., 2014). Compressional thrust belts are present at the toe of the slope with detachment on the shale of the Akata Formation. Active mud volcanoes are associated with the compressional thrusts (Figure 13).

Three dimensional seismic imaging of the seabed geomorphology of a ridge with the deepwater Niger Delta thrust belt (Thompson, 2008) reveals extensive slope instability and failure on the downslope side accompanied by evidence of active fluid migration in the form of a mud volcano (Figure 14, upper panel). Mud flows from the volcano spill across the toe of the ridge into the deep basin.

A comparison of the Niger seabed morphology with the deepwater Sabah fold-thrust ridges (Figure 1) discussed here shows many similarities. The outer flank of the Sabah ridge is disturbed by slope instability with slumping down into deeper water. The mud volcano is also present within the area of instability and shows a well-developed caldera. However, the Sabah mud volcano

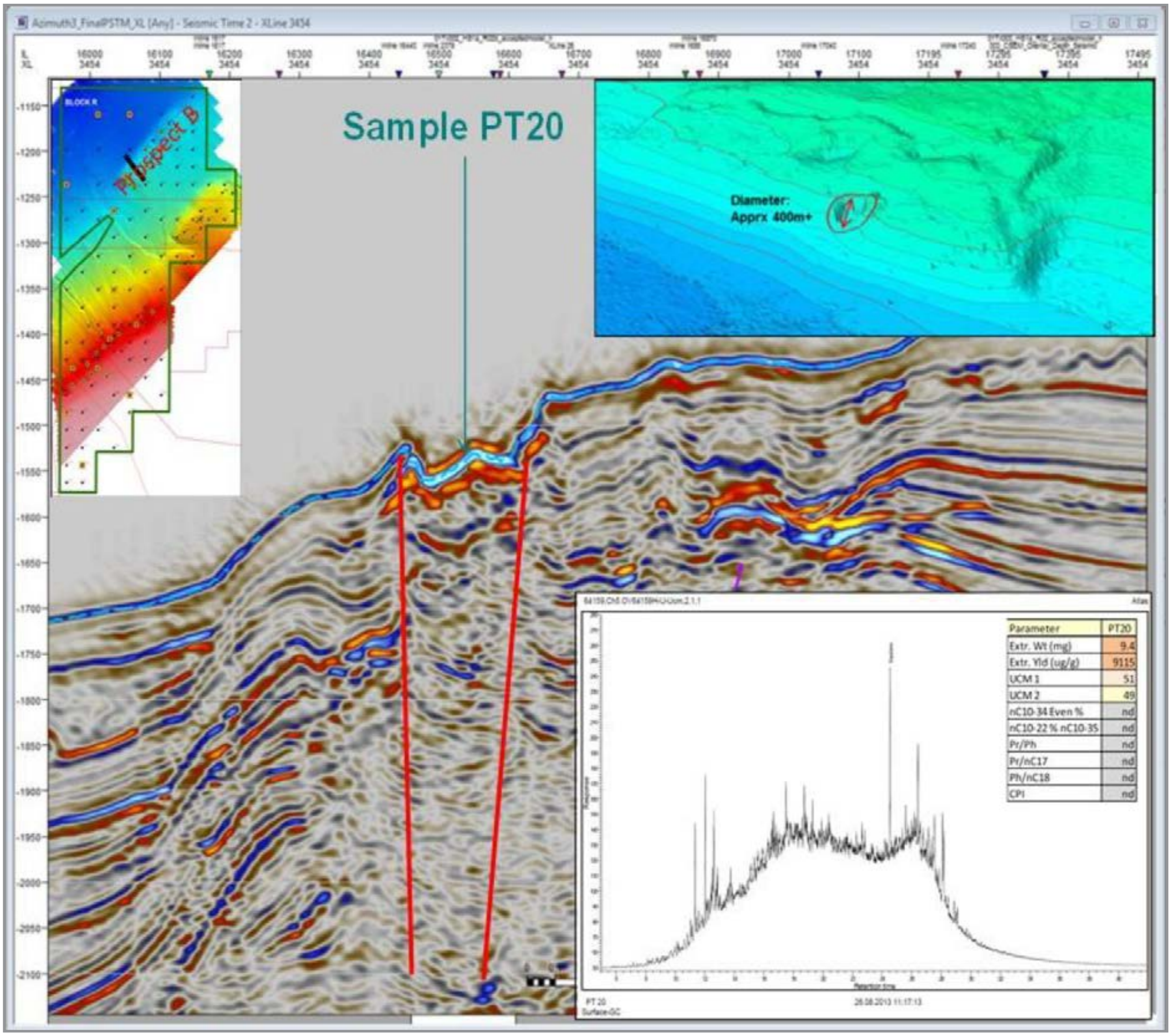

Figure 10: Sample PT20 taken within the studied mud volcano and caldera complex, which shows a strongly biodegraded oil-prone anomaly in its $C10^{+}$ GC signature, having dominant unresolved complex mixtures (UCM) and a lack of n-alkanes (bottom right insert). Note also the common occurrence and association of shallow faulting with pockmark features. From Jong *et al*. (2014).

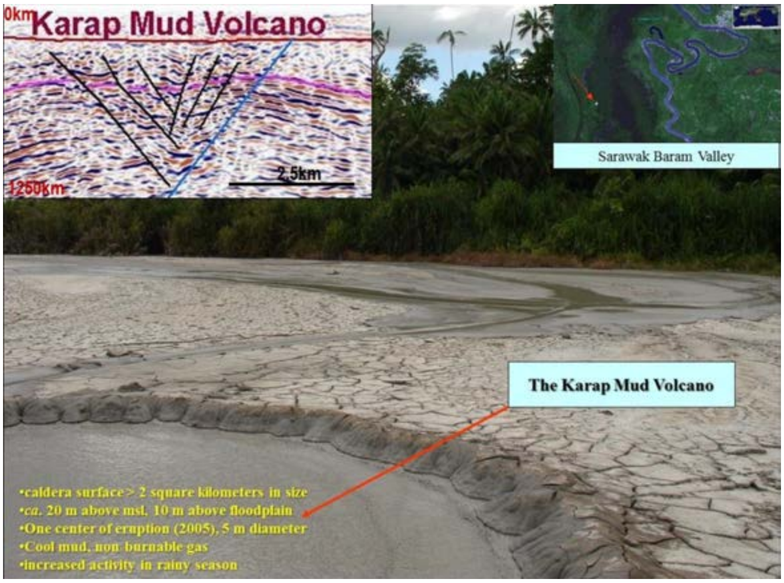

Figure 11: View on the central caldera perimeter of the Karap mud volcano. Inset on top left shows the subsurface seismic feature of the volcano complex with significant crestal faulting, which facilitates gas migration and top right inset shows the Google satellite image with the small white dot representing the location and size of the complex (after Jong *et al*., 2016).

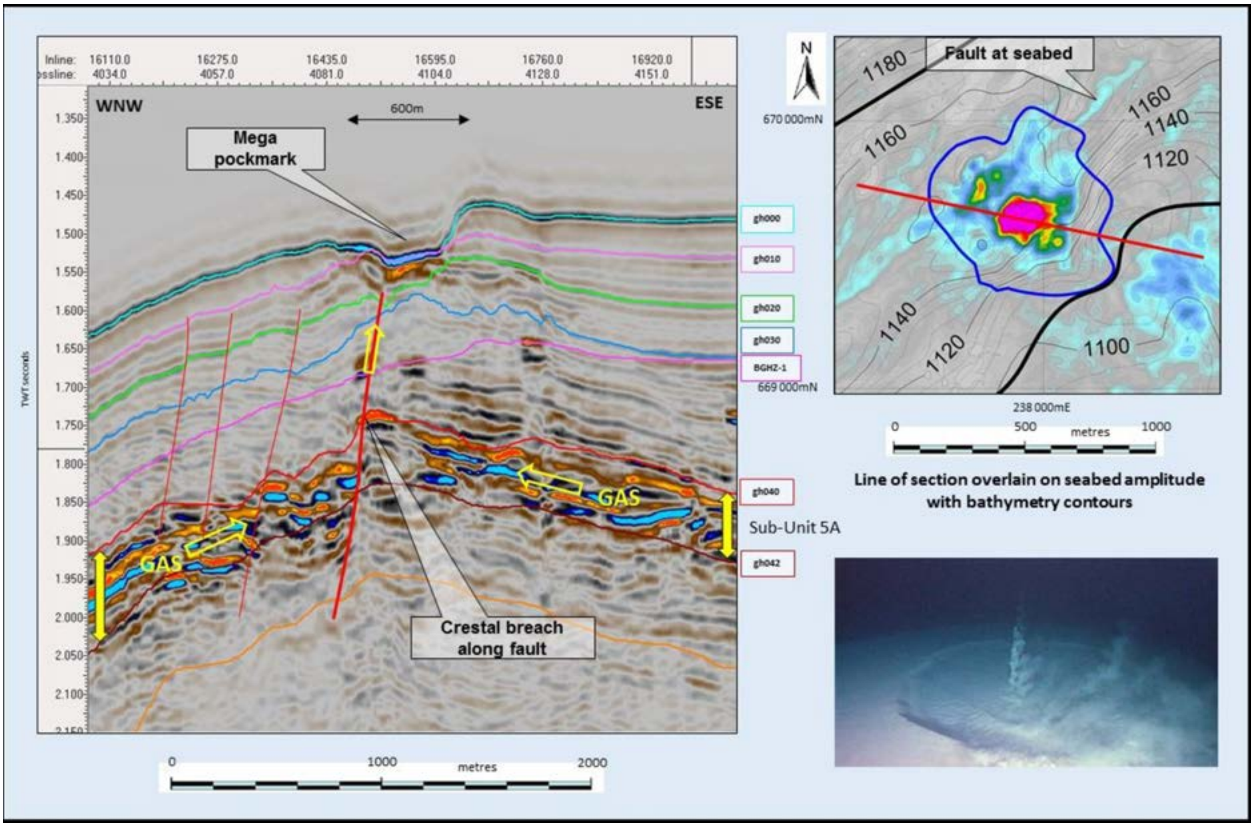

Figure 12: A seismic expression of a mega pockmark located to the north-east of the Sabah mud volcano caldera. The gas accumulation is interpreted to vent to the seabed pockmark location *via* the feeder fault. Top right: seabed amplitudes of the mega pockmark, Bottom right: a seabed image of upwelling fluid and gas escape with pockmark from Garden Banks, USA.

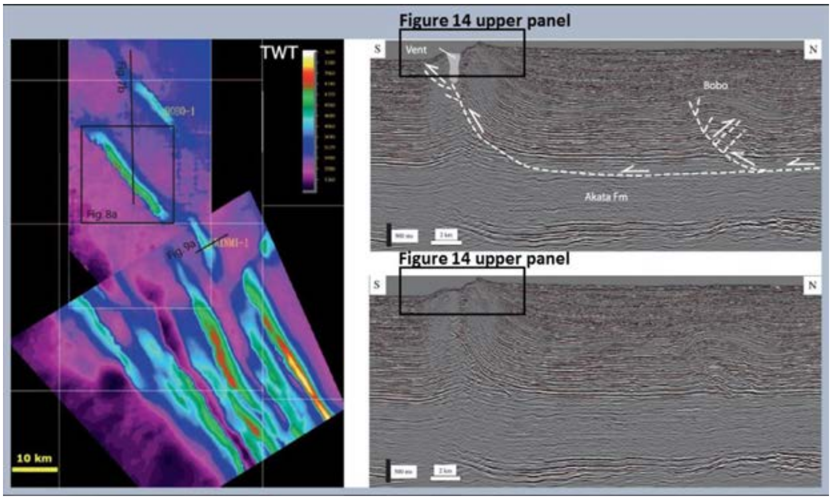

Figure 13: Lower Niger Fan mud volcano related to deep thrust belt (after Cobbold *et al*., 2009, Figure 7).

does not display multiple mud flows into deep water but a well-defined channel originating from the outer flank of the caldera rim that may act as a pressure relief restricting caldera flow activity.

The subsurface comparison between the two calderas is illustrated in Figure 15. The Niger example is approximately twice the dimensions of the Sabah example discussed here, but yet both show many similarities. Both are asymmetric in relation to the regional slope. The upslope caldera rim from the deepwater Niger example clearly shows the elevation is due to upthrusting and also displays a well-developed piggyback basin. This is not imaged on the Sabah example where general disturbance by upwelling is more prevalent. The caldera in the Niger example has a central domed basin due to mud expulsion with a clear feeder pipe, while in the Sabah example the expulsion cone is offset to the south possible due to caldera wall slope failure and the pipe is poorly imaged. It is of note that the scale of the Niger mud volcano is comparable to others found in deepwater offshore Sabah, and the current mud volcano-caldera complex under discussion is a relatively small example.

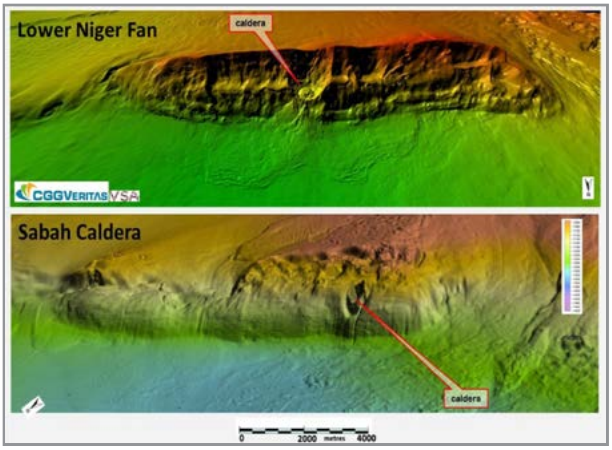

Figure 14: Geomorphological comparison between Lower Niger Fan (upper panel, after Thompson, 2008) and Sabah mud volcano calderas (lower panel).

Western Nile Delta

Extensive areas of mud volcanism are present on the deepwater fan of the western Nile Delta, Egypt (Loncke & Mascle, 2004) associated with active brine seepage (Huguen *et al*., 2005). The mud volcanoes have been extensively researched in high resolution including deep sea submersible dives and sampling (Foucher *et al*., 2005; Deville *et al*., 2007; Dupré *et al*., 2014). Although the driving mechanism is different, it is of note that the mud volcanoes contain clasts of material derived from depth. Similar clasts may be present within the Sabah mud flow deposits and detailed investigation could provide both samples of the deeper deposits and the origins of the overpressures. Often the source rock for the mud daiapirsm and by extension mud volcanism is the same as the petroleum source rock (Ware & Ichram, 1997), and sampling from the mud flows could provide an insight into the nature of the petroleum reservoirs.

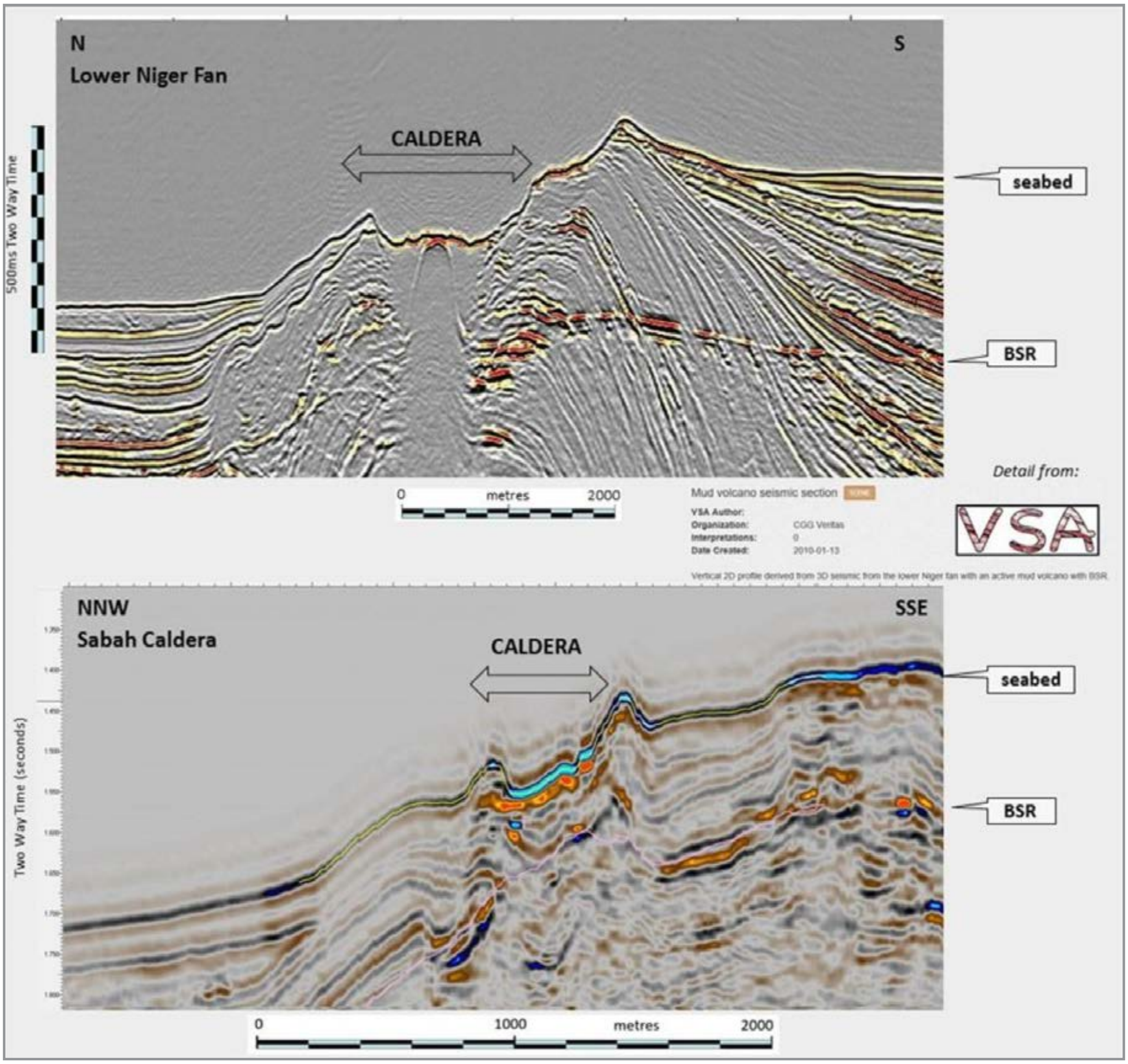

Figure 15: Detail geomorphological comparison between Lower Niger Fan and Sabah mud volcano calderas (CGGVeritas detail from the Virtual Seismic Atlas)

CONCLUSIONS

The discussed deepwater Sabah mud volcano lies within an area of seabed disturbance associated with active fluid and gas migration above a toe-thrust anticline. The mud volcano is also interpreted to be active with venting occurring within the central caldera. Activity on the caldera rim may be limited due to pressure relief from a vent-channel pair on the western flank. The mud volcano-caldera complex is comparable to others in petrogenic provinces worldwide and may also be indicative of an active petroleum system. However, this observation requires further comparison with other known and existing mud volcano-caldera complexes in deepwater Sabah to fully establish the connection between the seabed features of mud volcanoes, pockmarks and hydrocarbon seepages with the subsurface petroleum systems. We hope to expand on this study to cover the wider deepwater Sabah area in the future when other examples are made available for further evaluation.

ACKNOWLEDGEMENTS

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REFERENCES

Anonymous, 2010. CGGVeritas VERNG02 Seabed Mud Volcano Seismic Section. Virtual Seismic Atlas Table.

Bellingham, P., Connors, C., Haworth, R., Radovich, B. & Danforth, A., 2014. The Deepwater Niger Delta: An Underexplored World-Class Petroleum Province. GEOExPro, October 2014, 54-56.

Cathles, L.M., Zheng Su & Duofu Chen, 2010. The Physics of Gas Chimney and Pockmark Formation, with Implications for Assessment of Seafloor Hazards and Gas Sequestration. Marine and Petroleum Geology, 27, 82-91.

Cobbold, P.R., Clarke, B.J. & Løseth, H., 2009. Structural Consequences of Fluid Overpressure and Seepage Forces in the Outer Thrust Belt of the Niger Delta. Petroleum Geoscience, 15, 3-15.

Corredor, F., Shaw, J.H. & Bilotti, F., 2005. Structural Styles in the Deepwater Fold and Thrust Belts of the Niger Delta. American Association of Petroleum Geologists Bulletin, 89(6), 753-780.

Davies, R. J., Swarbrick, R.E., Evans, R.J. & Huuse, M., 2007. Birth of a Mud Volcano: East Java, 29 May 2006. GSA Today, 17, Issue 2, 4-9.

Deville, E., Prinzhofer, A., Foucher, J-P., Mascle, J. & Caprais, J-C., 2007. Mud Volcanoes from the Nile Delta (Deep Offshore Egypt): Nature and Origin of Fluids. AAPG European Regional Conference, Athens, Greece, 2007.

Dupré, S., Mascle, J., Foucher, J-P, Harmegnies, F, Woodside, J. & Pierre, C., 2014. Warm Brine Lakes in Craters of Active Mud Volcanoes, Menes Caldera off NW Egypt: Evidence for Deep-rooted Thermogenic Processes. Geo-Marine Letters, 34(2), 153-168.

Etiope, G., 2009. A Global Dataset of Onshore Gas and Oil Seeps: A New Tool for Hydrocarbon Exploration. Oil and Gas Business. http://www.ogbus.ru/eng.

Foucher, J.-P., Woodside, J., Pinheiro, L.M., Huguen, C., Mascle, J. & MEDIFLUX and MVSEIS scientists, 2005. Fluid Seepage on Continental Margins: Recent Results from the Nile Deep-Sea Fan and the Gulf of Cadiz Continental Slope. Geophysical Research Abstracts, 7: 7880.

Giresse, P., Loncke, L., Huguen, C. & Mascle, J., 2010. Nature and Origin of Sedimentary Clasts Associated with Mud Volcanoes in the Nile Deep-sea Fan. Relationships with Fluid Venting. Sedimentary Geology, 228 (3-4), 229-245.

Graue, K., 2000. Mud Volcanoes in Deepwater Nigeria. Marine and Petroleum Geology, 17(8), 959-974.

Huguen, C., Foucher, J.P., Mascle, J., Ondreas, H., Thouement, M., Loncke, M. & the NAUTINIL Scientific Party., 2005. Active Brine Seepage on the Nile Deep Sea Fan: "in situ" Dive Observations on Mud Mounds in Menes Caldera (NAUTINIL Cruise, 2003). Geophysical Research Abstracts, Vol. 7, 07332.

Jong, J., Nuraini, D. A. & Khamis, M. A., 2014. Basin Modeling Study of Deepwater Block R (DWR) Offshore Sabah and Its Correlation with Surface Geochemical Analyses. International Petroleum Technology Conference 2014, Kuala Lumpur, 3986-3996.

Jong, J, Kessler, F.L., Noon, S. & Tran, Q.T., 2016. Structural Development, Depositional Model and Petroleum System of Palaeogene Carbonate of the Engkabang-Karap Anticline, Onshore Sarawak. Berita Sedimentologi, 34, 5-25.

Judd, A.G. & Hovland, M., 2007. Seabed Fluid Flow: The Impact on Geology, Biology and the Marine Environment. Cambridge University Press.

Loncke, L., Mascle, J. & Fanil Scientific Parties, 2004. Mud Volcanoes, Gas Chimneys, Pockmarks and Mounds in the Nile Deep-sea Fan (Eastern Mediterranean): Geophysical Evidences. Marine and Petroleum Geology, 21, 669–689.

Mazzini, A., (ed), 2009. Mud volcanism: Processes and implications. Marine and Petroleum Geology, 26, 1677-1680.

Nguyen, B., Jong, J., Takahashi, Y. & Wada, N., 2016. The Role of Mobile Shale in Forming Fold Belt Anticlines and Hydrocarbon Accumulations in Sabah Basin, Malaysia. 35th International Geological Congress, Cape Town, South Africa, August 2016.

Thompson, S., 2008. CGGVeritas VERNG02 Seabed Mud Volcano. Virtual Seismic Atlas. http://www.seismicatleas.org.

Van Rensbergen, P., Morley, C.K., Ang, D.W., Hoan, T.Q. & Lam, T., 1999. Structural Evolution of Shale Diapirs from Reactive Rise to Mud Volcanism: 3D Seismic Data from the Baram Delta, Offshore Brunei Darussalam. Journal of the Geological Society, London, 156, 613-650.

Van Rensbergen, P., Hillis, R.R., Maltman, A.J. & Morley, C.K. (eds), 2003. Subsurface Sediment Mobilization. Geological Society of London Special Publications, 216.

Ware, P. & Ichram L.A., 1997. The role of Mud Volcanoes in Petroleum Systems: Examples from Timor, the South Caspian and the Caribbean. Proceedings of an International Conference on Petroleum Systems of SE Asia and Australasia, 955-970.

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The effects of porestructure on sonic velocity in carbonates: examples from Gunung Rapat Limestone, Ipoh

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Abstract: Correlation between rock physical properties (eg: porosity, permeability and sonic velocity) are not easy to be established. The correlation trends are governed by the pore type, size, and geometry. The preliminary results show a large scattering distributing in the correlations. The scattered correlations are due to the different types of microporosity, pore geometry and micrite microtextures of the carbonate rocks.

Keywords: rock physics, carbonate, dolomite, micropores, sonic velocity, Gunung Rapat limestone

INTRODUCTION

It is estimated that more than 60% of the world's oil and 40% of the world's gas reserves are held in carbonate reservoirs. Carbonate is predominantly composed of calcite of organic, chemical or detrital origin (Blyth & Freitas, 2010). Carbonate rocks are also heterogeneous than clastic rocksand thus may contain different types of porosity (Pourmohammadi *et al.*, 2007). In the carbonate formations, the determination of the type and value of both primary and secondary porosity has a significance influence in giving the correct prediction of permeability and evaluation of hydrocarbon reserves (Kazatchenko *et al.*, 2003).

Correlations between porosity and other rock properties of carbonates are not easy to be established. The heterogeneity of the pore types and grains create a large scatter in the relationship. Many studies have shown that sonic velocity and permeability of the carbonate depends not only on porosity distribution, but the pore geometry as well (Anselmetti & Eberli, 1993). Though numerous studies have been done on rock properties of Gunung Rapat carbonates (Figure 1), but quantifying the correlations between these rock properties (eg: sonic velocity to permeability) are still ambiguous (Habibur, 2011; Baechle *et al.*, 2006). Thus, this paper will establish the correlations of porosity and other rock propertiesand determine the elements affecting the variations (diagenetic alterations).

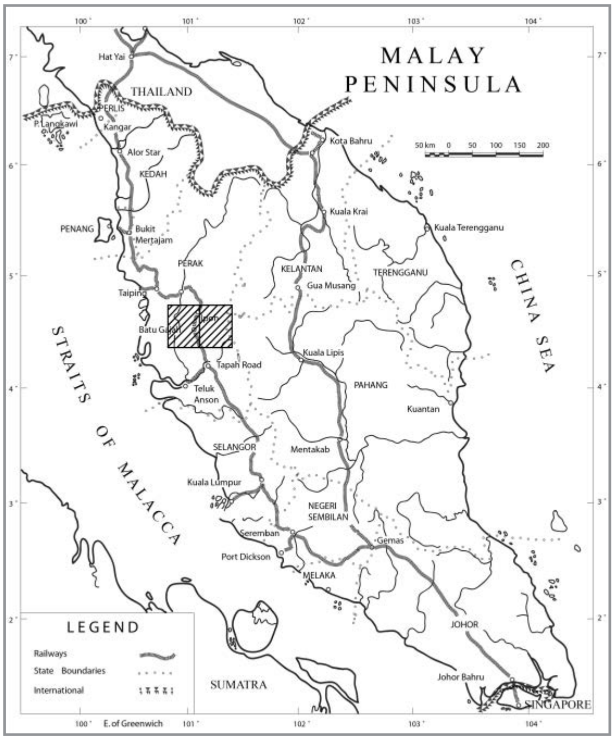

Figure 1: Location of Gunung Rapat in Peninsula Malaysia (modified from Memoir of the Geological Survey of West Malaysia, 1967).

AIMS

The objectives of this paper are: -

- To establish correlations between rock physical properties (eg: porosity and permeability), sonic velocity and sedimentological/ diagenetic characteristic of carbonates from Gunung Rapat, Ipoh.
- To investigate the inverse yet scattered relationship between porosity and sonic velocity of the carbonates.
- To study the relationship between sonic velocity and permeability of the carbonates.
- To confirm the direct trend in the correlation of porosity and permeability, and,
- To investigate the factors affecting the amount porosity in the carbonates (eg: dolomitization, grains size and distribution).

METHODOLOGY

This paper will present the analyses done on 20 core samples from Gunung Rapat, Ipoh. The cores are 1 inch in diameter and 1.5 inch long. Amongst the analyses done are the sonic velocity, porosity and permeability (through Helium Porosimeter and Mercury Porosimeter Pascal 140 & 240), XRD (X-Ray Diffraction) and SEM (Scanning Electron Microscope). Klikenberg correction method is applied to correct the gas slippage effect. The pore spaces for the samples are tight. Thus, helium and mercury are injected for the porosimeter for maximum coverage of the pores.

The classification of porosity uses the scheme proposed by Eberli (2003). Based on this Eberli (2003), there are five categories of porosity – interparticle and intercrystalline, microporosity, moldic, intraframe and low porosity carbonates. This paper does not apply the classification scheme by Choquette & Pray (1970) because the porosity of the samples is minute and not visible through polarized microscope. In this study, 20 thin sections were also prepared. The thin sections images were taken with Olympus BX 51 microscope and analyzed using Digital Image Analysis (DIA) software. Dunham's classification (1962) of carbonate rocks is used for identification through thin sections. The classification of microporosity is defined by Habibur's Scheme (2011) – very fine micropores (0.1 – 2 μm), fine micropores (2 – 4 μm), medium micropores (4 – 6 μm) and coarse micropores (6 – 10 μm).

RESULTS AND INTERPRETATION

Sonic Velocity – Porosity – Permeability

The P-wave velocity obtained ranges from 4964 m/s to 6818 m/s and the S-wave velocity ranges from 2014 m/s to 4258 m/s (Figure 2). The porosity ranges from 1.6% - 6.1% (Figure 2) while permeability ranges from 0.000135 mD (miliDarcy) to 0.610234 mD. Scattering and wide trend are obtained from the established porosity and sonic velocity (P-wave and S-wave velocity) graphs. The correlations of porosity-Pwave velocity and porosity-S-wave velocity showan inverse relationship where the amount or percentage of the porosity increases as sonic velocity decreases. This inverse trend is predictable from the amount and distribution of the pore space (Blaechle *et al.*, 2004). Theoretically, more pore space will produce a lower reading in sonic velocity. The large scattering trend in correlation is due to the heterogeneity of the pore type, pore shape and geometry (Figure 2) (Eberli *et al.*, 2003).

These scattering trends are also reported in Eberli *et al.* (2003) and Wang *et al.* (1991). It is also suggested that other than the amount of porosity, the other intrinsic properties of the rocks (eg: pore geometry and mineral composition) also affect the sonic velocity values (Wang *et al.*, 2004).The characteristics of carbonate sediments that are prone to rapid and pervasive diagenetic alterations (eg: continuous cementation and dissolution processes) change the mineralogy and pore structure of the rocks. These modifications affect the sonic velocity of the rocks, thus resulting in a dynamic relationship between porosity and sonic velocity (Blaechle *et al.*, 2008). In order to have a better correlation, the classification between macroporosity and microporosity is needed (Habibur *et al.*, 2011). Microporosity fraction shows a clear inverse trend, velocity decreases with an increase in microporosity (Figure 2A & 2B).

Table 1: The relative contribution of different pore types of micrite microtextures on fluid flow.

Microtexture	Micropores	Fluid Flow
Subrounded Micrites	Very fine, fine, medium	Poor – Moderate
Microrhombic & Polyhedral Micrites	Fine, medium, coarse	Poor – Moderate
Compact Anhedral Micrites	Very fine	Very poor

Scanning Electron Microscope (SEM)

The microporosity in carbonate rocks is affected by microtextures of micrite and not the type of micropores (Figure 3). In standard cases, fine micropores will be low in porosity. However, in this paper, fine micropores can have either low or good porosity depending on their occurrence in certain types of micrite microtexture (Sample B and C in Figure 3). High porosity rock could have faster and higher sonic velocity value due to high amount of fine micropores (Sample B in Figure 3). The micropores are too discrete to act as a porous medium. Thus, samples with high microporosity will also have high sonic velocity value.

Permeability of the carbonate rocks is also governed by the occurrence and distribution of micrite microtextures. The micropores that occur in microrhombic and polyhedral micrites tend to have better connectivity (Sample F and H in Figure 3). Occasionally, these micrites contain lower amount of microporosity due to the textural arrangements and have good inter-connectivity between the micropores (Table 1).

CONCLUSION

A general inverse trend in the correlation of porosity-sonic velocity is deduced from the scatted distribution of the graphs. The sonic velocity of the carbonate not only influenced by the amount of porosity, but also by the crystallometry and morphometry of the micrite microtextures. The correlation of porosity-permeability has a normal direct trend. Crystallometry and morphometry of micrite microtextures govern the trend of this correlation. This shows that the shape of the micropores (tortuosity and edginess) of the pore are more important in affecting the acoustic behavior of carbonates. The microporosity could be predicted through sonic reading.

REFERENCE

Anselmetti., F.S. & Eberli, G. P., 1993. Controls on Sonic Velocity in Carbonates. Basel: PAGEOPH Vol 141, No: 2/3/4.

Baechele, G.T., Eberli, G. P., Boyd, A., DeGrange, J., M. & Al-Kharusi, L., 2008. Oolmoldic Carbonates: Pore Structure and Fluid Effects on Sonic Velocity. Las Vegas: SEG Annual Meeting.

Baechle., G.T., Weger, R., Eberli., G P. & Colpaert, A., 2006. Pore Size and Pore Type Effects on Velocity – Implicaiton for

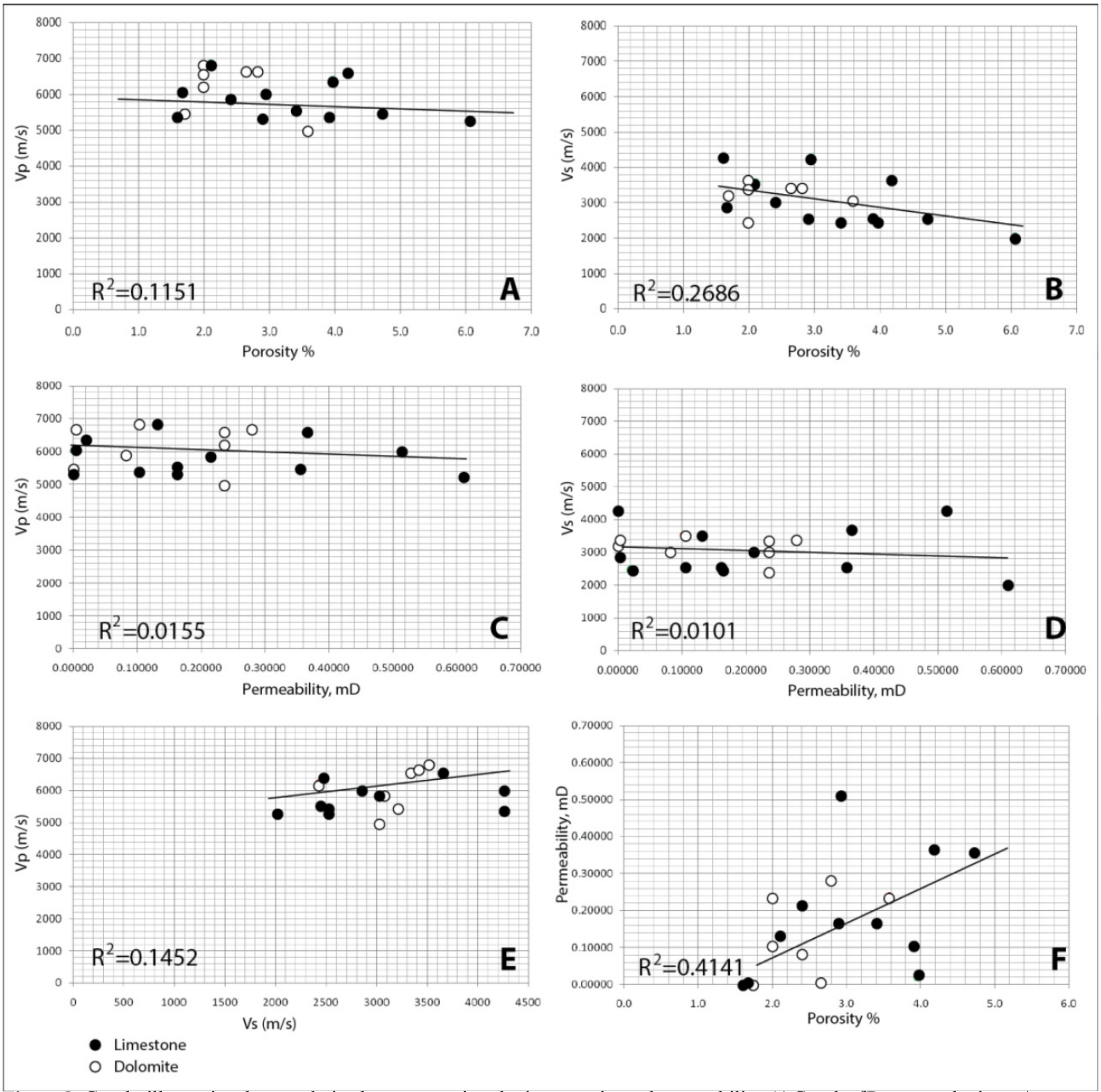

Figure 2: Graphs illustrating the correlation between sonic velocity, porosity and permeability. A) Graph of P-wave velocity, m/s, versus porosity, %, with a correlation factor, R^2, of 0.1151. B) Graph of S-wave velocity, m/s, versus porosity, %, with a correlation factor, R^2, of 0.2686. C) Graph of P-wave velocity, m/s, versus permeability, mD, with a correlation factor, R^2, of 0.0155. D) Graph of S-wave velocity, m/s, versus permeability, mD, with a correlation factor, R^2, of 0.0101. E) Graph of P-wave velocity, m/s, versus S-wave velocity, m/s, with a correlation factor, R^2, of 0.1452. F) Graph of permeability, mD, versus porosity, %, with a correlation factor, R^2, of 0.4141.

Carbonate Rock Physic Models. Berge, Norway: Workshop "Sound of Geology".

Baechle., G.T., Weger, R., Eberli., G.P. & Massaferro, J.L., 2004. The role of Macroporosity and Microporosity in Constraining Uncertainties and in relating Velocity to Permeability in Carbonate Rocks, Denver, Colorado: SEG International Exposition and 74th Annual Meeting.

Blyth, F.G.H., & Freitas D.M. H., 2010. A Geology for Engineers. 7th Edition, Great Britain, Butterworth Heinemann.

Choquette, P. W., & Pray, L. C., 1970. Geologic Nomemclature and Classification of Porosity in Sedimentary Carbonates. AAPG Bulletin, v. 54, no. 2, p.250.

Eberli, G.P., Baechle, G.T., Anselmetti, F.S. & Incze, M.L., 2003. Factors Controlling Elastic Properties in Carbonate Sediments and Rocks. D. Clark Edition. The Leading Edge, Society of Exploration Geophysicists.

Eberli, G.P., Baechle, G.T., Weger, R. & Massaferro, J.L., 2004. Quantitative Discrimination of Effective Porosity using Digital Image Analysis: Implications for Porosity-Permeability Transforms. Paris: 66th EAGE Conference.

Habibur, R., Pierson, B.J. & Wan Ismail, W.Y., 2011. Quantification of Microporosity and its Effects on Permeability and Sonic Velocity in Miocene Carbonate Reservoirs. Offshore Sarawak, Malaysia. Universiti Teknologi PETRONAS, Kuala Lumpur: Seacarl.

Habibur, R., Pierson, B.J. & Wan Ismail, W.Y., 2011. A New Approach to Classify Microporosity in Miocene Carbonate Reservoirs of Offshore Sarawak, Malaysia. Richardson,

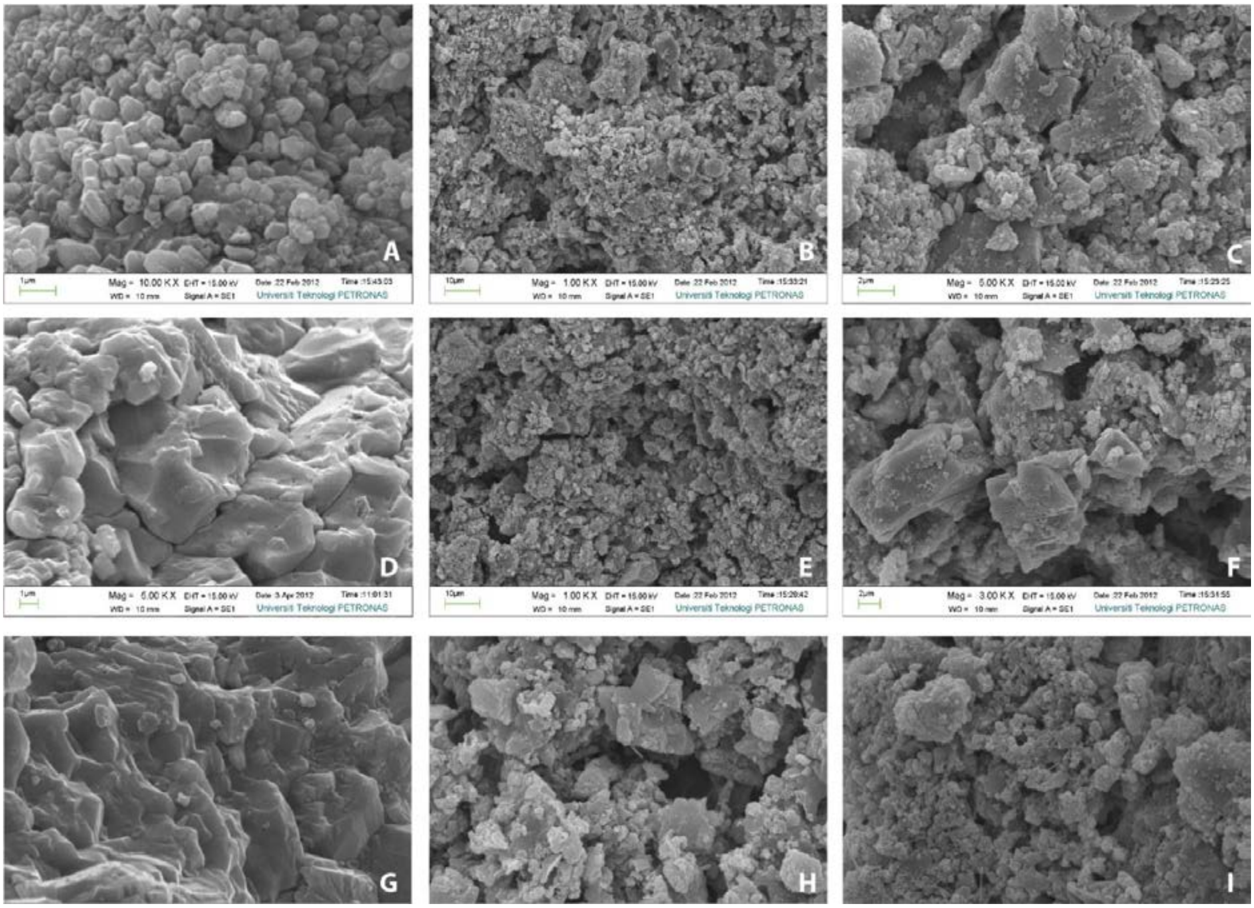

Figure 3: SEM images on sample 15, 16, 18, 6, 4, 8, 5, 9 and 14. A) Sample 15 - Grainstone - Very fine micropores with low porosity and poor interconnection in subrounded micrites. B) Sample 16 - Packestone - micropores with good porosity and moderate interconnection in subrounded micrites. C) Sample 18 - Grainstone - Fine micropores with low porosity and poor interconnection in microrhombic and polyhedral micrites. D) Sample 6 - Crystalline dolomite - Very fine micropores with low porosity and very poor interconnection in compact anhedral micrites. E) Sample 4 - Packestone - Medium micropores with low porosity and poor interconnection in subrounded micrites. F) Sample 8 - Grainstone - Medium micropores with low porosity but moderate interconnection in microrhombic polyhedral micrites. G) Sample 5 - Crystalline dolomite - Very fine micropores with low porosity and poor interconnection in compact anhedral micrites. H) Sample 9 - Packestone - Coarse micropores with good porosity and moderate interconnection in microrhombic and polydegral micrites. I) Sample 14 - Crystalline dolomite - Very fine micropores with good porosity but poor interconnection in subrounded micrites.

Texas: IPTC 14583.

Habibur, R., Pierson, B.J. & Wan Ismail, W.Y., 2011. Classification of Microporosity in Carbonates Examples from Miocene Carbonate Reservoirs of Central Luconia, Offshore Sarawak, Malaysia. Richardson, Texas: IPTC 14583.

Kazatchenko, E., Markov, M.& Moutsavov, A., 2003. Determination of Primary and Secondary Porosity in Carbonate Formations Using Acoustic Data. Richardson, Texas: SPE 84209.

Pourmohammadi, S., Hetland, S., Spildo., K. & Skauge, A., 2007. Fluid Flow Properties of Different Carbonate Classes. Richardson, Texas: SPE 111433.

Wang, Z., Hirsche, W.K. & Sedgwick, G., 1991. Seismic Velocites in Carbonate Rocks. Journal of Canadian Petroleum Technology.

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The West Baram Line in the southern South China Sea: a discussion with late Prof. H.D. Tjia on its possible onshore continuation and nomenclature

Franz L. Kessler[1] & John Jong[2]

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[2]JX Nippon Oil and Gas Exploration (Deepwater Sabah) Limited

Introduction

It is in the nature of strike/slip lineaments that they cannot be stopped abruptly, but instead must further continue, leading to a zone of extension which is less common, or more commonly resulted in a zone of compression such as the Late Miocene collision front in NW Sarawak. The West Baram Line (WBL), as seen in the Sarawakian waters in the South China Sea is arguably a regional strike/slip system, and can be mapped with some confidence on both seismic and gravity data. For a couple of hundreds of kilometres it can be traced in the offshore forming a tectonic boundary between the Central Luconia Province and West Baram Delta, with a strike of some 300 deg in NW/SE direction (Figure 1).

Already early petroleum geologists such as James (1984, Figure 1) indicated that the dip of the lineament changed from area to area. Some workers like Baillie *et al*. (2004) suggest a possible linkage of WBL in the NW to the Sankulirang Fault systems in the south-eastern Borneo through the so-called 'trans-Borneo tectonic freeways'. Prolongating the WBL from offshore into onshore Borneo therefore appears, at least at first glance, logical since another lineament further south, the so-called Tinjar Line, is similar in strike. At second glance, however, the line cannot be mapped as a linear feature shown in Figure 1, given there are neither surface indications (Kessler, 2006 & 2009), nor conclusive indications based on limited seismic data available during the early days.

This brings us to the question in which direction the WBL continues onshore. Cullen (2014) summarized a number of options presented by various authors including a model that suggest the Tinjar Line is a possible onshore extension of WBL, which remains a subject of wide speculation. Nonetheless, in recent years with the acquisition of new gravity, magnetics and 2D seismic in northern Sarawak by JX Nippon, we have managed to unravel a clearer subsurface continuation of the WBL onshore (e.g., Kessler & Jong, 2016; Jong *et al.*, 2016; Figures 2-3).

Discussion

Recently, the strike of the line, as well as questions of semantics, were topics of a discussion between us and the late Prof. H.D. Tjia, an eminent geoscientist who have contributed so much to the geology of both Indonesia and Malaysia, and to whom we dedicate this article to. Summarised below is the unedited correspondence and discussion we had with the late Prof. H.D. Tjia on these topics, starting with an initial email received by the corresponding author of the article 'Structural Development, Deposition Model and Petroleum System of Paleogene Carbonate of the Engkabang-Karap Anticline, Onshore Sarawak' by Jong *et al*. (2016) published in Berita Sedimentologi, Vol. 34, p. 5-25:

"Dear Dr. Jong,

On Figure 2 of your joint article on the Engkabang area shows a 'West Baram Line' striking sub parallel to the current Sarawak shore line (see Figure 4). Its caption refers to a 'Baram Line'. The WEST BARAM LINE is an established tectonic expression striking NNW approximately from Tanjung Bungai (Bekenu area) far into the offshore of the Sarawak basin. We may still bicker about its significance, however, your joint article does a disservice by introducing another 'West Baram Line'. That particular line of figure 2 needs another name. A Badas Syncline runs parallel to it. The Lambir structure strikes likewise.

I believe a correction will be necessary.

Regards,
H.D. Tjia"

A reply dated the same day was given by Dr. F.L.Kessler:

"Dear Professor Dr. Tjia,

Dr. Jong was kind to forward me your question regarding West Baram Line (WBL) and its course onshore. As you rightfully say, there is a lot of bickering about it. Firstly, the West Baram Line and the Baram Line as quoted by a few authors are one and the same, so I believe. In respect of the course of this lineament, let me explain a little more. During my years in Shell and later in Curtin University Sarawak I was very keen to find an answer to the question whereto the WBL was heading in the onshore area. I spent several weekends myself and later with students mapping folds, using also older data such as Liechti et al., 1960.

1) The first important finding was, that there is an area with weak or no folding at all a few km inland from the Bungai Beach (Pantai Bungai). Hence, a straight line from

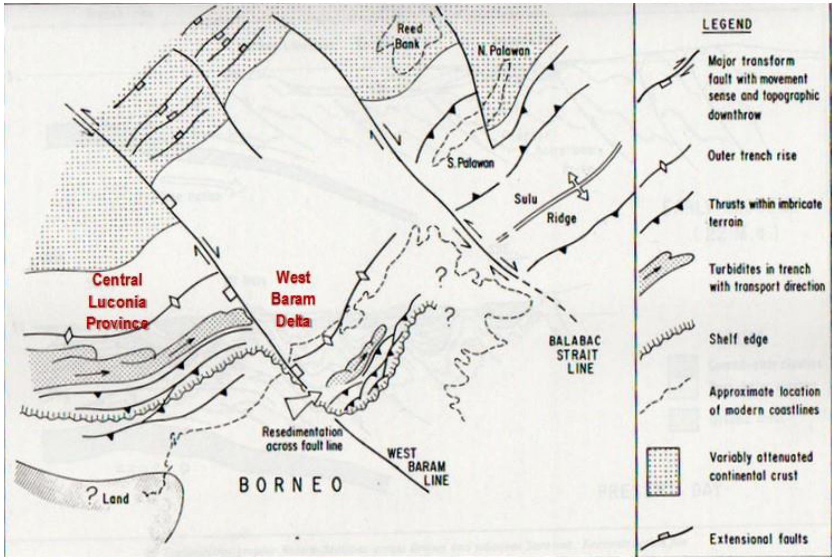

Figure 1: Tectonostratigraphic map for NW Borneo in Oligocene time illustrating the hypothesis of the West Baram Line as an active transform fault (after James, 1984).

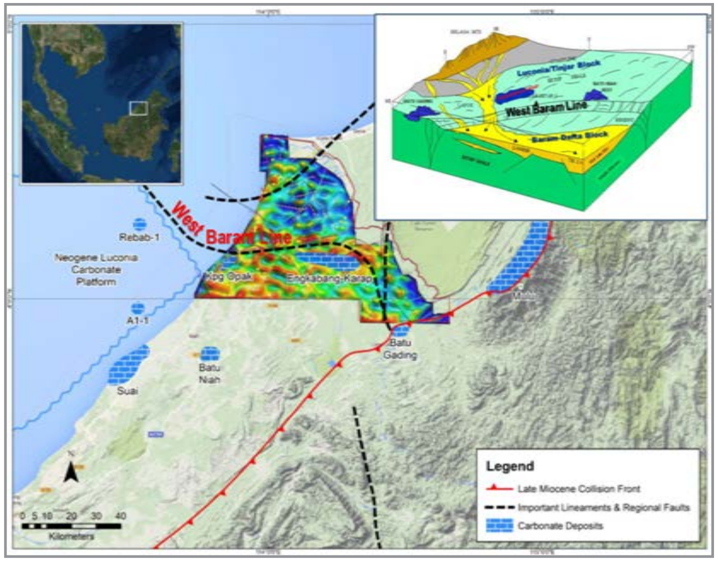

Figure 2: The interpretation for an 'S-shape' onshore continuation of the West Baram Line based on gravity data acquired by JX Nippon. The WBL as annotated subdivides the stable Tinjar/Luconia Block from the subsiding Baram Delta to the north as illustrated in the inset block diagram (after Kessler & Jong, 2016).

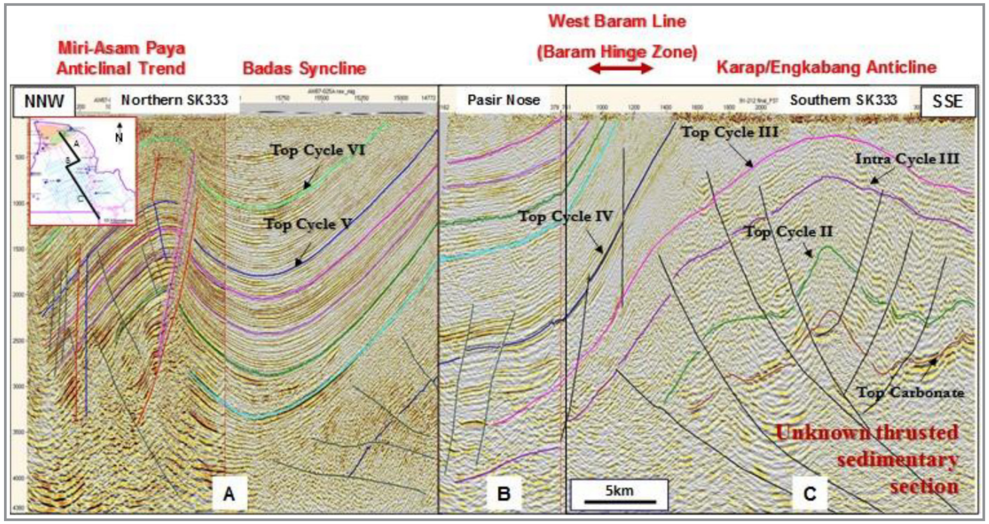

Figure 3: A NNW-SSE seismic correlation of onshore Baram Delta in northern Sarawak and interpreted sequences. Onshore, the West Baram Line (or Baram Line) is marked by a hinge zone that separates the stable and uplifted Karap/Engkabang Anticline of the Tinjar/Luconia Block from the subsiding Baram Delta. Overall the area has been affected by various episodes of deformation events starting from Late Oligocene to Mid Miocene wrench movement and related folding, to the Mid Pliocene uplift and compressional folding (after Kessler & Jong, in prep.).

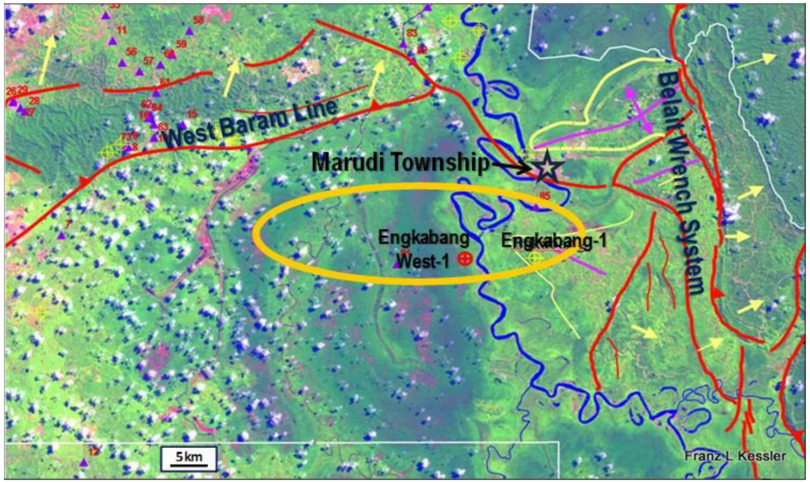

Figure 4: The mentioned 'Figure 2' in Jong *et al.* (2016) with the annotation of West Baram Line. The tectonic overview map of the Greater Engkabang-Karap area (enclosed in yellow oval) near Marudi shows converging regional structural lineaments of Baram Line and Belait Wrench system.

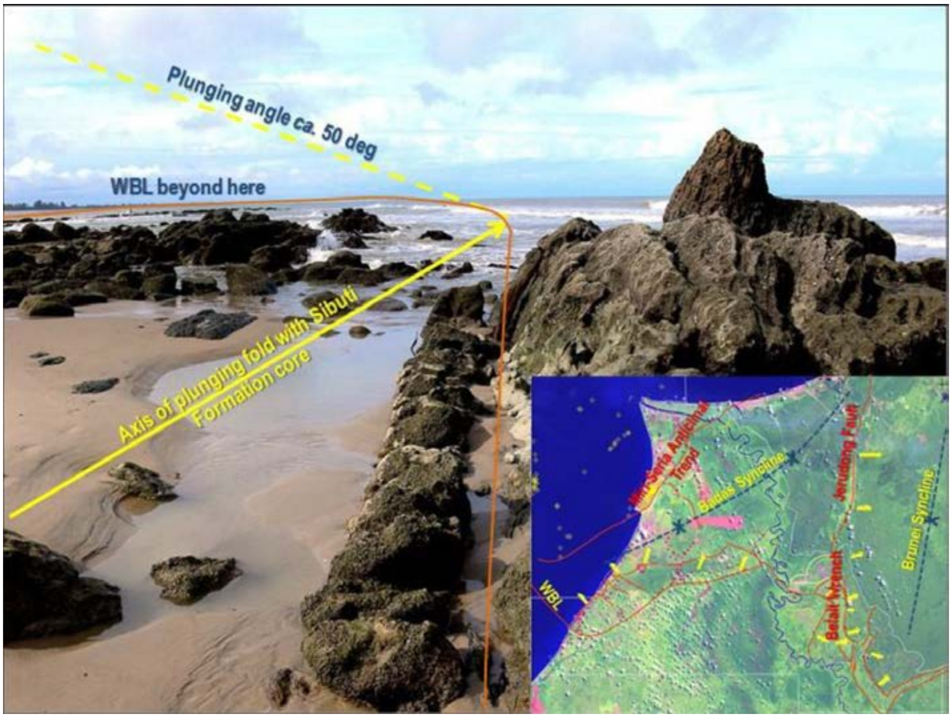

Figure 5: Plunging fold at Pantai Bungai. Inset regional tectonic map shows pattern of faults and lineaments in red, syncline axis in blue dashed-line, yellow arrows show direction of dip into clastic depocentres. The big Brunei Syncline on the left was over-thrusting the Baram Block, with the overthrust being the Jerudong Fault.

Pantai Bungai inland won't work, since neither folding nor faulting can be identified. I mapped the area as well as possible, and gave a talk in 2006 at the Geosea. To confirm the 'best candidate' for the WBL, I followed the southern limit of the Lambir inversion feature by criss-crossing the suspected course of line on my motorbike. Heading inland I saw folded clastics of the Lambir to my left, and flat-lying to mildly folded Setap Shale to my right. My latest thinking is that the WBL might splits in two branches around the Bukit Lambir inversion block, and the latter may hence be a pop-up structure between the two branches. The northern branch can be seen in 2-3 outcrops along the coastal road between Tusan and Kpg Beraya.

2) *2009 saw the acquisition of gravity, magnetics and seismic. Particularly on gravity one can distinguish clastic-dominated areas belonging to the greater Baram Delta and a block to the SW, (I call Luconia/Tinjar) with many carbonate area signatures. Seismic in the area of Bukit Engkabang also shows a clastic Baram depocentre to the NE and a very tectonized platform edge to the SW. This fits well with my fieldwork findings.*

Accordingly, we believe evidence for the S-shaped course of the line is rather solid, but there remain questions in which direction it continues from the Long Lama area. I do not have good data on this, so I have to speculate. The perhaps most likely continuation might run towards Batu Gading, then Mulu, and from there via Klias to Northern Sabah, were there is again plenty of evidence on seismic for a tectonic suture. Should this rather speculative interpretation turn out to be correct in the light of future data, then it would mean that the lineament might be the boundary which divides areas of clastic depocentres (on strongly attenuated crust) from carbonate-dominated platform areas (on less attenuated crust). Some of the course in the Borneo hinterlands may be masked by the Rajang metamorphics, which seem to overthrust the foreland.

Respectfully and kind regards,
F.L Kessler"

Immediate follow-up reply by Prof. H.D.Tjia:
"Dear Dr Kessler,

Thank you for the explanation. I am not disputing your interpretation as such as I consider that an interpretation and I am not that familiar with the new subsurface onshore data that you refer to. My main unease is about the name of using WBL that by virtue of its linearity and length most probably has had significant strike-slip displacement component and extending that name to an interpreted segment of different trend and (interpreted) reverse displacement. Should not the entire interpreted structure be named something like "West Baram Line – XXX structure" and not just West Baram Line or Baram Line? It is not a matter of semantics, and a new or combined designation of the structure would avoid unnecessary confusion and alert the reader of the different kinematics of the two segments.

Thank you again for your time and explanation.

Sincerely,
H.D. Tjia"

Subsequent correspondence by Dr. John Jong, Apr 5, 2016:

"Thanks Franz for the response to Dr. Tjia. I believe the seismic data acquired by JX Nippon in 2009/2010, in

conjunction with the gravity data will help in someway to detail the onshore continuation of the WBL. There will be some regional sections, in both strike and dip direction interpreted by Dr. Peter Barber for us that will be included in our onshore Baram Delta publication for GSM 50. It's now a joint paper with MPM. John"

Final reply/clarification by Dr F.L. Kessler, Apr 5, 2016:

"Dear Prof. Dr. Tjia,

Thanks for your quick reply and I just forwarded it to Dr. Jong for his views on this. Your concern is fully understood, and let us perhaps look for an appropriate solution together with Dr. Jong.

I believe there are again 2 aspects to the problem:

1. The question of the contiguity of the WBL offshore portion with any lineament onshore.

2. Clarity of concept and appropriate wording.

On the question of contiguity, let me first talk about the WBL in the offshore. I investigated in 2007 the course of the line on Shell 2D seismic data, and what I can say is that picking the line is far from obvious - the best description that comes to my mind is a combination of the Central Luconia platform escarpment (high shoulder West), this being mostly the one which is picked in publications, and a low angle detachment plane (low, East, Baram Delta Block), hardly imaged on seismic. The axes of structures (highs and lows) as well as regional faults are bent in the vicinity of the WBL, suggesting strike/slip.

In the onshore, the Baram Delta block is morphologically higher than the Luconia flank, and formed by a plunging anticline of Upper Setap claystone and Lambir sandstone. The anticline plunges into the WBL with an estimated angle of some 50 deg. (see Figure 5). I believe the onshore feature is contiguous with the offshore WBL, and divide Luconia/Tinjar from the Baram Block, yet geodynamics might be different.

On the question of clarity of concept, it might indeed be preferably if a different name might be chosen for the onshore segment. However, if we rename it and some authors continue to put straight WBL extension lines through tectonically undisturbed terrain, we have achieved the contrary of our intentions, and the effect may be counterproductive. a bit of a dilemma I guess.

Respectfully and kind regards,
Franz L Kessler"

Summary

Having mapped onshore outcrops and interpreted the latest subsurface seismic and gravity data, we used the terms Baram Line and West Baram Line (mostly for offshore extension) interchangeably. Following this communication, it was with great sadness that we found out Prof. Dr. H.D. Tjia untimely passing on June 9, 2016, a devastating loss of a distinguished scholar in Malaysian/SE Asian geology. It was an honour and we greatly appreciated the discussion we had with the dedicated geologist. A manuscript entitled 'Exploration History and Petroleum Systems of the Onshore Baram Delta, Northern Sarawak, Malaysia', by Jong *et al.* (in prep.) is currently being prepared to further illustrate the subsurface expression of the WBL (or Baram Line) in onshore northern Sarawak area, which has been accepted for publication in the Golden Jubilee edition (GSM 50) of the Bulletin of the Geological Society of Malaysia. The special volume is planned to be published in early 2017.

References

Baillie, P., Darman, H. & Fraser, T. H., 2004. Deformation of Cenozoic Basins of Borneo and West Sulawesi: Proceedings Deepwater and Frontier Exploration in Asia and Australasia Symposium, Jakarta.

Cullen, A.B., 2014. Nature and significance of the West Baram and Tinjar Lines, NW Borneo. Marine and Petroleum Geology, 51, 197-209.

James, D.M.D. (Ed), 1984. The Geology and Hydrocarbon Resources of Negara Brunei Darussalam, Brunei Shell Petroleum and Brunei Museum. 169 p.

Jong, J., Kessler, F., Noon, S. & Tan, T. T.Q., 2016. Structural Development, Deposition Model and Petroleum System of Paleogene Carbonate of the Engkabang-Karap Anticline, Onshore Sarawak. Berita Sedimentologi, 34, 5-25.

Jong, J., Harun Alrashid bin Mohamad Idris, Barber, P. Kessler, F., Tan, T.T.Q. & Uchimura, R., in prep. Exploration History and Petroleum Systems of the Onshore Baram Delta, Northern Sarawak, Malaysia. Bulletin of the Geological Society of Malaysia.

Kessler, F.L., 2006. Observations on Subtle Deformation in the Folded Foreland, Sarawak, Borneo. Paper presented at the Geo Asia Conference, Kuala Lumpur, June 2006.

Kessler, F.L., 2009. The Baram Line in Sarawak: Comments on its Anatomy, History and Implications for Potential Non-Conventional Gas Deposits. Warta Geologi, 35(3), 105-110.

Kessler, F.L. & Jong, J., 2016. Paleogeography and Carbonate Facies Evolution in NW Sarawak from the Late Eocene to the Middle Miocene. Warta Geologi, 42(1-2), 1-9.

Kessler, F.L. & Jong, J., in prep. Carbonate banks and shoals on the northern shore of Palaeogene and Early Neogene Borneo: Observations and implications on stratigraphy and tectonic evolution. Bulletin of the Geological Society of Malaysia.

Liechti, P., Roe, F. W. & Haile, N. S., 1960. The Geology of Sarawak, Brunei and the western part of North Borneo. British Territories of Borneo, Geological Survey Department, Bulletin (Two volumes), 3. 360 p.

NATIONAL GEOSCIENCE CONFERENCE 2016 (NGC 2016)

14 November - Lebih 120 peserta hadir dalam National Geoscience Conference (NGC 2016) bagi berkongsi pengetahuan dan kepakaran tentang penggunaan teknologi yang dapat membantu meningkatkan kualiti hidup melalui penggunaan dan pengurusan sumber alam seperti batuan, tanah, sumber mineral, petroleum dan air bawah tanah.

Penggunaan teknologi dalam geosains telah terbukti menjana penyelesaian yang kreatif dan inovatif dalam menangani isu-isu semasa alam sekitar. Melalui pendekatan ini penemuan baru yang praktikal boleh membantu meluaskan pengetahuan dan teknologi baru untuk digunakan bagi masa depan yang lebih bermakna.

Persidangan dianjurkan oleh Persatuan Geologi Malaysia (GSM) dengan kerjasama Universiti Malaysia Pahang di bawah Fakulti Teknologi Kejuruteraan dan Jabatan Mineral & Geosains Malaysia yang berlangsung di MS Garden Hotel Kuantan.

Hadir dalam program adalah Naib Canselor UMP, Profesor Dr. Daing Nasir Ibrahim, Ketua Pengarah Jabatan Mineral Geosains Malaysia, Haji Sallehhuddin Mior Jadid, Dekan Fakulti Teknologi Kejuruteraan (FTK), Profesor Dato' Dr. Zularisam Ab. Wahid, Timbalan Presiden GSM, Abdul Rasid Jaapar dan pengerusi persidangan NGC, Dr. Mohd Fakhrurrazi Ishak.

Menurut Profesor Dr. Daing Nasir, persidangan ini merupakan platform yang sesuai melibatkan pertemuan intelektual dalam menangani isu-isu alam sekitar semasa, terutamanya yang berkaitan dengan kajian geosaintifik, penyelidikan dan pelaksanaan.

Bertemakan "Geosains dan Alam Sekitar Teknologi Masa Depan yang Lebih Baik", ianya berkongsi kepakaran dalam menangani kebimbangan dengan isu-isu berkaitan dengan kelestarian bumi dan kesan pembangunan fizikal secara semulajadi ekosistem.

"Oleh itu, usaha yang serius diperlukan di peringkat antarabangsa negara yang dapat memberi pengetahuan yang diperlukan untuk memahami hubungan antara perubahan persekitaran global dan kesejahteraan manusia dan pembangunan," katanya.

Malahan, ianya memberi tumpuan pengetahuan keseluruhan mengenai perubahan alam sekitar dan masalah yang paling mendesak pembangunan manusia iaitu menyediakan makanan yang selamat dan mencukupi, air, tenaga, kesihatan, penempatan dan perkhidmatan ekosistem yang lain untuk kestabilan sistem bumi.

Antara yang akan dibincangkan termasuklah pandangan dan inovasi dalam bumi asas, sains biologi dan sosial yang paling penting kepada asas alam sekitar pembangunan mampan dan implikasi global perubahan alam sekitar, perubahan iklim termasuk, untuk makanan, air, kesihatan, penempatan manusia, biodiversiti dan ekosistem.

Begitu juga dengan pengurusan ekosistem dan risiko bencana penilaian mengurangkan impak dan mengenai bidang bidang utama berkaitan dalam disiplin geosains, geokimia, hidrogeologi dan geologi kejuruteraan.

Profesor Dato' Dr. Daing Nasir Ibrahim berkata, dalam fasa menjana kegemilangan, UMP mengorak langkah mengembangkan potensinya dengan memperkenalkan beberapa inisiatif terhadap pendidikan Latihan Teknikal dan Vokasional (TVET) bagi menyokong usaha kerajaan terhadap ekosistem TVET nasional secara berkualiti dan berinovasi.

Hadir membentangkan kertas kerja ialah Profesor Emiritus Prof. Dato' Dr. Ibrahim Komo dari Universiti Kebangsaan Malaysia (UKM) bertajuk `Integrated Approach of Pollution Characteristic and Health Risk Assesment of Mineral Bauxite Exploitatation'. Turut berkongsi kepakaran, Profesor Madya Dr. Tajul Anuar Jamaluddin dan seramai 96 peserta telah membentangkan kertas kerja pada persidangan kali ini.

Dr. Mohd Fakhrurazzi Ishak
Pengerusi Persidangan NGC 2016

NATIONAL GEOSCIENCE CONFERENCE 2016 (NGC 2016)

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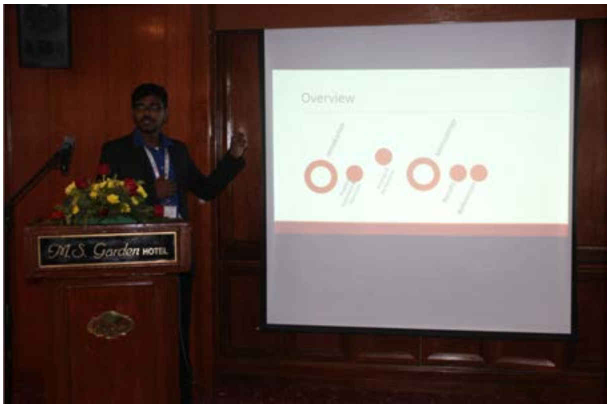

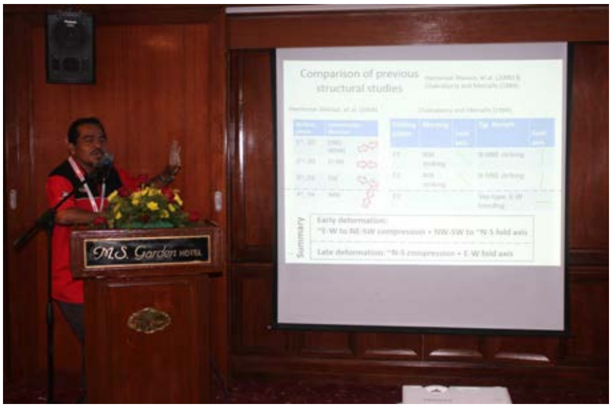

CERAMAH TEKNIK TECHNICAL TALK

Fossil sharks from Thailand: Stratigraphical and palaeobiogeographical implications

Dr. Gilles Curry (Professor in Vertebrate Palaentology, University Claude Bernard Lyon 1, France)
Date: 21 July 2016
Venue: Department of Geology, University of Malaya

Dr. Cuny studied in Paris (PhD degree from Université Pierre et Marie Curie (Paris VI)). He has previously worked/taught at the Natural History Museum of Denmark (Copenhagen) for some 12 years; currently he is the Professor at Université Claude Bernard Lyon 1 - Laboratoire de géologie de Lyon, terre, planètesetenvironnement. He has collaborated closely with dinosaur and non-dinosaur research groups of Mahasarakham University (Thailand); now he is collaborating with us in Malaysia. He is a renowned researcher in the palaeontology of fossil sharks.

Dr. Cuny presented a quick introduction to fossil shark teeth and how to collect them. An overview of the Palaeozoic and Mesozoic shark fossil record from Thailand was discussed, with an emphasis of the Lower Cretaceous. The talk also covered on two aspects of the geological use of these fossils: Their capacity to correlate terrestrial formations and their helpfulness in better understanding palaeobiogeographic patterns.

The Proto-South China Sea: Where was it and where is it?

Professor Robert Hall (SE Asia Research Group, Department of Earth Sciences, Royal Holloway, University of London)
Date: 16 November 2016
Venue: Department of Geology, University of Malaya

The talk by Professor Dr. Robert Hall was held at the Mineralogy and Petrology Lab of the Department of Geology, UM. The lab was packed by more that 100 participants from the industry and academics, as well as students from local universities. There was a lively discussion session following the presentation.

Abstract: The term Proto-South China Sea was originally introduced to describe oceanic crust that formerly occupied the region north of Borneo where the modern South China Sea is situated. This oceanic crust was inferred to have been Mesozoic, and to have been eliminated by subduction beneath Borneo, from Sarawak to Sabah. Subduction was interpreted to have begun in Early Cenozoic and terminated in the Miocene. Later, the term was used for inferred oceanic crust, now disappeared, of quite different age, notably that interpreted to have been subducted during the Late Cretaceous below Sarawak. More recently, some authors have considered that southeast-directed subduction beneath Sabah continued until much later in the Neogene than originally proposed, based on the supposition that the NW Borneo Trough and Palawan Trough are, or were recently, sites of subduction. Others have challenged the existence of the Proto-South China Sea, or suggested it was much smaller than envisaged when the term was introduced.
There is good evidence for subduction between the Eocene and Early Miocene below Sabah, and the western limit of subduction was the West Baram Line. The subducted slab can be imaged in the lower mantle using P-wave tomography. There was no subduction between the Eocene and Early Miocene beneath Sarawak, SW of the West Baram Line, where there was terrestrial to marginal marine deposition. The present-day NW Borneo Trough and Palawan Trough are not subduction trenches and these relatively shallow features have different origins. It is suggested that the term Proto-South China Sea should be used only for the slab subducted beneath Sabah and Cagayan between the Eocene and Early Miocene. Oceanic crust subducted during earlier episodes of subduction in other areas should be named differently. Paleo-Pacific Ocean is a better term for lithosphere subducted under Borneo in the Cretaceous and earlier in the Mesozoic.

CERAMAH TEKNIK TECHNICAL TALK

Discovering hydrocarbon: The role of stratigraphy

Shamsudin Bin Jirin (PETRONAS)
Date: 12 October 2016
Venue: Bilik Mesyuarat Program Geologi, Bangunan Geologi,
Universiti Kebangsaan Malaysia

Pada 12 Oktober 2016 bersamaan dengan hari Rabu yang lalu, satu ceramah teknik bertajuk *Discovering Hydrocarbon: The Role Of Stratigraphy* telah diberikan oleh penceramah daripada Syarikat Petroliam Nasional Berhad (PETRONAS). Bekerja dalam sektor eksplorasi minyak dan gas, Encik Shamsudin Bin Jirin sebagai penceramah merupakan alumni Geologi di Universiti Kebangsaan Malaysia. Ceramah yang dijalankan pada pukul 11 pagi hingga pukul 1 petang di Bilik Mesyuarat, Bangunan Geologi UKM ini telah dihadiri oleh kira-kira 120 orang termasuklah pelajar, pensyarah dan kakitangan bukan mengajar.

Tajuk ceramah yang diberikan ternyata menarik minat pelajar. Sepanjang ceramah berlangsung, pelajar memberikan penumpuan yang baik serta mengajukan banyak soalan yang bernas kepada penceramah. Sebagai kesimpulannya, ceramah ini berjaya mencapai objektifnya yang utama iaitu memberikan pendedahan awal kepada pelajar tentang industri minyak dan gas negara.

Jhstolistikha Percy Dos
Exco Akademik, Kelab Geologi UKM

Abstract: Hydrocarbon exploration remains very challenging and yet exciting tasks for many explorationists. The challenges are further escalated with the increasing geological complexity in the remaining hydrocarbon potential areas yet to be discovered. Most of significantly commercial big hydrocarbon accumulations especially in hydrocarbon prolific areas have been discovered, thus leaving remaining smaller accumulations stranded within a geologically complex, frontier and high risk areas to be explored. Owing to these complexities a proper geological assessment is critically required for further exploration efforts. Typically the assessment covers various geological aspect of basin evolution, prediction of temporal and spatial depositional facies development, petroleum system components, recognition of basin prospective corners and upside potentials before drillable hydrocarbon prospects is identified. One of the key integral component is stratigraphy which plays an important role across all the petroleum system components. In this sharing various aspect of stratigraphy and its role in supporting the discovery of hydrocarbon are discussed. Some examples focussing on its application from several geological setting and geographic areas are also presented for further illustration.

CERAMAH TEKNIK TECHNICAL TALK

Diamond - from gemmology to geology

Mr. Tay Thye Sun (Far East Gem Lab, Singapore)
Date: 11th November 2016
Venue: JMG Sarawak Office, Kenyalang Park, Kuching, Sarawak

A recorded close to 40 attendance from the fraternity of geologists and non-geologists alike from Kuching, Sarawak were given a rare treat by Mr. Tay Thye Sun's enthralling, very informative 2-hour technical talk on "Diamond - from Gemmology to Geology" at JMG Sarawak Office, Kenyalang Park, Kuching, Sarawak on 11th November 2016.

Mr. Tay began the talk by introducing the history of diamond that was first found in India around 2000 BC and how it has become valuable and associated with power and social status. He went on to explain the natural diamonds verses imitations and synthetic diamonds. He dealt at length on Kalimantan diamond: explaining the history of diamond mining, its occurrence and geology of the associated areas, its production, its characteristics and a number of past studies carried out on Kalimantan diamond. He ended the talk by emphasizing that more studies is needed to know the diamond crystals structure and its formation, in order to complete the story of Kalimantan deposits.

Ling Nan Ley
Secretary,
Institute of Geology Malaysia

Photo credit: Yong Mei Ling,
JMG Sarawak

CERAMAH TEKNIK TECHNICAL TALK

Creep response in shear of clayey geo-materials under saturated and unsaturated conditions

Nor Shahidah Mohd Nazer (Universiti Kebangsaan Malaysia)
Date: 16 November 2016
Venue: Bilik Mesyuarat Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Nor Shahidah is a lecturer at the Geology Programme, Universiti Kebangsaan Malaysia. She just received her PhD from The University of Strathclyde, Glasgow United Kingdom. Her specialization is in soil mechanics. The presentation is a part of her PhD research.

Abstract: Creep imposed many problems in landslides mitigation and remediation work as it causes slope to move at very slow rate and being hardly identified. Plane failure located along saturated soil layers is directly affected by the changes in positive pore water pressure in which they were greatly impact by the changes in its surrounding hydrology. The rise and fall of water table gives an adverse effect to the soil shear strength and this could lead to the onset of failure. To see how creep is affecting the deformability of landslides, we are looking from its kinematics point of view on how likely the presence of creep in shear could potentially trigger the movement of landslides and what are the contributing factors behind it. Several creep and relaxation test has been carried out on saturated and unsaturated clay samples by means of direct shear box. Each creep and relaxation test was performed by either measuring the evolution of movements in horizontal displacement or decay in shear stress. An attempt to visualize their response at qualitative level were made by selecting various analogue models from the combinations of spring and dashpot. These two components which exhibit elastic and viscous characteristics was a great medium to obtain good conceptual understanding of viscosity effects in soils from their simple mechanical response. Finally, we aimed to define creep and relaxation from only a single mechanical model by which the model must be coordinated to justify both responses of creep and relaxation with existing experimental parameters.

CERAMAH TEKNIK TECHNICAL TALK

Outcrops and geological pictures around the world

Ms. Farah Fazulah
Date: 30 November 2016
Venue: Bilik Mesyuarat Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Ms Farah Fazulah is Geology-UKM alumni. She is now working with Sarawak Shell Berhad (SSB) and Sabah Shell Petroleum Company (SSPC). The sharing is about geomorphology and landscapes from all over the world.

Abstract: Slide shows showing outcrops and geological events around the world that is gathered during my personal travelling, including USA national parks, UK, Australia and also Europe. This exposure is to show different rock types and weathering that govern the shape and colour at present day. Ideally this session is to provide exposure of outcrop in different climate setting, and hopefully it will encourage the student to also explore the world in future.

Your personal branding using Career Passport and NrgEdge

Mr. Mohd Anas Asalem
Date: 30 November 2016
Venue: Bilik Mesyuarat Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Anas started his career journey with NrgEdge because he believes this great platform have an enormous potential to grow in near future. During his study in Universiti Teknologi Malaysia (UTM), he has an excellent academic performance as well as a set of soft-skills such as leadership, teamwork, project management and communication skills which makes him an outstanding person.

Terrestrial Lidar sharing session

Ms. Lim Chin Hooi
Date: 14 December 2016
Venue: Bilik Mesyuarat Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Ms. Lim is Sales & Support Manager at GPS Lands (M) Sdn. Bhd. She has lots of experience in mapping using Lidar technology instruments. During the talk, she introduced the LIDAR instrument and share what Terresterial Lidar is all about. We had an opportunity to learn how to operate and analyze the data using the specific software.

CERAMAH TEKNIK TECHNICAL TALK

The use of geophysical principles in the detection & characterization of solution channels, voids in limestone formation & rock slope discontinuity survey

Ir. Liew Shaw Shong (G&P)
Date: 21 December 2016
Venue: Department of Geology, University of Malaya

The above talk was presented by Ir. Liew Shaw Shong (G&P) on 21st Dec. 2016 at the Dept. of Geology, Univ. Malaya. An abstract of the talk is attached below. As usual, there was a lively discussion following the talk.

We thank Ir. Liew for his support and contribution to the Society's activities.

Tan Boon Kong
Chairman,
W/G on Engineering Geology, Hydrogeology & Environmental Geology

Abstract: This lecture will cover a forensic investigation involving hydraulic failure at a quarry site with occurrence of sinkholes in river banks and washout of cavity infill to a lower rock face in a limestone formation. The content will cover the planning, execution and interpretation of survey data from 2D resistivity survey with objective to detect high moisture zone implying fractured or jointed rock mass and cavity features with either infill or empty in a limestone quarry face. The interpreted results with respect to their geophysical properties will be compared and validated with the observation of wet spots on the rock mass, cavities and boreholes implying the existence of such features. The resistivity survey also helps to reveal the connectivity of the sinkhole occurrence in the nearby river banks with well developed solution channels to the emerging river water from the quarry bench surface.

In addition to the hydraulic investigation, the stability assessment of a jointed rock mass slope using the ground borne terrestrial Light Detection and Ranging (LiDAR) technique will be presented to demonstrate the efficiency of discontinuity survey on jointed rock slope. The intention of this lecture is also aimed to illustrate how the engineering professional shall make effort in applying and adopting new technology available with good fundamental understanding of the operational principles for the challenging engineering applications. This involves convincing the project client to move forward from traditional surveying and investigation techniques with these new high quality and efficient geophysical methods.

Organizing Committee

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Prof Dr Joy Jacqueline Pereira (Disaster Risk & Climate Change)
Prof. Dr. Che Aziz Ali (Geotourism & Geoheritage)
Prof. Dr. Azman Bin Abd Ghani (Regional Geology)

For more information and details,
visit our website at:

www.ngc2017.com

Contact us at:

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Phone: +(603)-7957-7036
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NGC 2017 NATIONAL GEOSCIENCE CONFERENCE

2nd Circular: Call for Papers

Hotel Istana
Kuala Lumpur
9 – 10 October 2017

In conjunction with the
Geological Society of Malaysia
50th Anniversary

Invitation

The Geological Society of Malaysia (GSM) proudly presents the National Geoscience Conference (NGC) 2017. The Society invites the international geoscientists community to join the event and engage in the knowledge sharing session in Kuala Lumpur on 9th – 10th October 2017.

The main theme for this 30th NGC edition is "Geoscience for a Sustainable Future". As the economy is driving into a continuous uncertainty, geoscientists have to adapt to ensure sustainability in the geological field. In conjunction with the 50th anniversary of GSM, the conference will also look from past experiences to prepare for the future of fellow geoscientists and the direction of geoscience in general.

Themes

Main Theme

Geoscience for a Sustainable Future

Limited natural resources and increasing concerns on the environment has forced geoscientists to venture into multiple fields to cater to the ever changing needs. While several traditional geoscience sectors are currently experiencing a slump, new arising opportunities are waiting to be capitalized and ensuring the sustainability.

Sub Themes

- Engineering Geology and Rock Mechanics
- Petroleum Geology
- Mineral Resources
- Regional Geology
- Professionalism, Ethics and Education in Geosciences
- Disaster Risk Reduction and Climate Change Adaptation
- Geoheritage, Geoparks and Geotourism

GSM 50th Anniversary

The society was founded in 1967 with the aim of promoting the advancement of the earth sciences in Malaysia and the Southeast Asian (S.E.A) region. Currently, it has a membership of more than 600 earth scientists worldwide of various disciplines and expertise.

Sponsorship and Exhibition

Sponsorship Packages

Platinum – RM30,000 Logo on opening screen and goodies, advertisement (colour) on front/back page of event magazine, 5 admission tickets and 5 tickets for student sponsorship & 1 slot of talk	
Diamond - RM20,000 Logo on opening screen and goodies, advertisement (colour), 4 admission tickets and 2 tickets for student sponsorship & 1 slot of talk	**Gold - RM10,000** Logo on opening screen and goodies, advertisement (black and white), 3 admission tickets and 1 tickets for student sponsorship & 1 slot of talk
Silver - RM5,000 Logo on opening screen, advertisement (black and white), 2 admission tickets & 1 slot of talk	**Bronze – RM2,000** Logo on opening screen, 1/2 page of advertisement (black and white) & 1 admission ticket

Exhibition: The price for 3m × 3m booth is RM 3,000.

Registration

Categories	Fees
GSM Members	RM 550
Non – GSM Members	RM 750
Student GSM Members	RM 350
Student Non – GSM Members	RM 550
Student Daily Pass	RM 200
Late Registration	RM 1000

Entitlements
All participants are entitled for tea breaks and lunch meals except for student daily pass

Payment: Please bank the money into our account:
Geological Society of Malaysia
Standard Chartered Bank
794 105402263

Please mail the bank in slip to us for verification.

Venue & Accommodations

Venue
Hotel Istana Kuala Lumpur
Located at the heart of Kuala Lumpur, Hotel Istana offers a strategic place in the middle of the bustling area of Bukit Bintang. The venue offers exquisite bedrooms at affordable price

Nearby Hotels

Parkroyal Kuala Lumpur

Hotel Grand Millennium

Hotel Metro 360

Important Dates

Submission of Extended Abstract: 30th June 2017
Acceptance of Extended Abstract: 1st August 2017
Early registration deadline: 15th September 2017

Registration deadline is on 15th September2017. Registration after that date will be considered as late registration

Kindly submit the full papers once the acceptance notice is issued

Programme Tentative

Date	8th Oct	9th Oct	10th Oct	11th Oct	12th Oct
Morning	Golf/Short Courses	Keynote Speech	Technical Sessions 3&4	Field Trip	Field Trip
Afternoon		Technical Sessions 1&2	Technical Sessions 5&6		

*Golf, Short Courses and Field Trips are charged separately. Tea breaks and lunch are provided to all participants

Publications

Full papers from the presentations at the conference will be published in the Bulletin of the Society. All presenters are required to submit the full papers once the acceptance notice is issued.

Keynote Lectures

Prof. Dr. John Kuna Raj

Tentative Title: Historical Perspective of GSM

After 50 years of its establishment, the Geological Society of Malaysia has experienced numerous ups and downs, from the days of bustling tin mining to recent decline in oil and gas industry. The history of GSM in turn provides a valuable experience to prepare for the future of geological field in Malaysia.

Prof. Emeritus Dato Dr Ibrahim Komoo

Tentative Title: Challenges and Future Prospects for Geoscientists

Modern challenges including depleting mineral resources and increasing concerns about the climate change has forced geoscientists to venture out of the traditional geological job scope to cater the ever changing environment. Geoscientists must adapt to these challenges and open new opportunities to ensure the relevance of geological field in driving the economy.

Short Courses

Geohazards and Disaster Risk Reduction	Mineral Resources
Petroleum Geology	Engineering Geology and Professional Practices

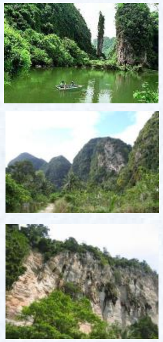
* All short courses will be charged separately. The short courses will be held at Hotel Istana, Kuala Lumpur

Field Trip

Tambun, Ipoh, Perak

Geoheritage

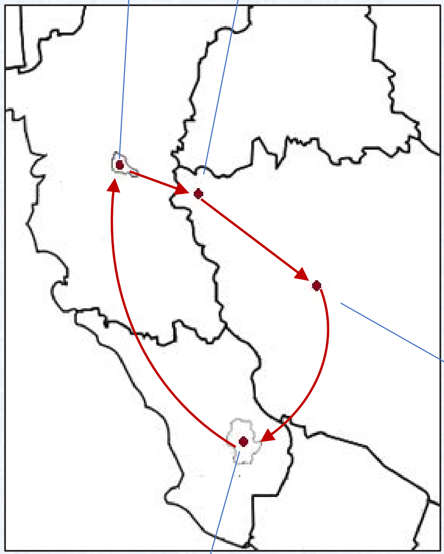
The karst area of Kinta offers scenic view but geohazards persists in terms of rock fall



Cameron Highlands, Pahang

Geohazards

Rapid development with lack of planning often results in disaster such as flash floods and landslides (Gunung Pass area)



Kuala Lumpur

Start and Finish Point

The bustling city of Kuala Lumpur where the conference will be held also serve as the starting and finishing point for the field trip.

Penjom Mine, Pahang

Mineral Resources

The Penjom mine is among the biggest gold mine in Malaysia, situated along the gold belt east to the Main Range

*The field trip contains two packages; the first one is to visit every locality shown on the map above. The second package is to stay at Cameron Highland on the second day for a short course on geohazards but will not visit the Penjom Mine.

NEW MEMBERSHIP

Full Member

1. Abdullah Syamsul
2. Elvaene James
3. Fakhruddin Afif Fauzi
4. Koen Vogel
5. Mohd Shafik Mohd Noh
6. Numair Ahmed Siddiqui
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Dear Members

Please update your contact details by sending your email address, telephone no. and fax no. to : geologicalsociety@gmail.com

International Geomapping Competition 2016

21 - 7 Oktober 2016, Universitas Gadjah Mada, Indonesia

International Geomapping Competition 2016 adalah sebuah pertandingan anjuran Himpunan Mahasiswa Teknik Geologi Universitas Gadjah Mada (UGM), Indonesia yang bertemakan “Discover beyond the Earth”. Pertandingan ini diadakan bersempena dengan program *Geoweek* UGM yang berlangsung selama seminggu bermula dari 1 Oktober 2016 sehingga 7 Oktober 2016. Pertandingan ini disertai oleh 14 buah universiti dari tiga buah negara di rantau Asia Tenggara iaitu Universiti Mahidol, Universiti Chulalongkorn, Universiti Chiang Mai (Thailand), Universiti Kebangsaan Malaysia dan Universiti Malaysia Kelantan (Malaysia) dan Universitas Gadjah Mada, Institut Teknologi Bandung, Universitas Dipernogoro, Universitas Trisakti, Universitas Padjajaran, Universitas Jendral Soedirman, Universitas Pembangunan Nasional, Universitas Sriwijaya dan Institut Sains dan Teknologi AKPRIND (Indonesia). Universiti Kebangsaan Malaysia telah diwakili oleh tiga orang pelajar prasiswazah iaitu Saudara Khairul Ikhwan Abd Rahim, saudari Afiqah Azhar dan saudara Ahmad Kamil Ahmad Nadzri yang masing-masing merupakan pelajar tahun akhir Program Geologi. Pertandingan dimulakan dengan acara perasmian pada 1 Oktober 2016 dengan sedikit kuliah mengenai geologi kawasan di Gunung Kulon Progo dan Gunung Serayu Selatan oleh Encik Wartono Rahardjo (Senior Lecture, Retired). Setiap kumpulan mendapat kavling berkeluasan 2x2 km persegi hasil daripadacabutan undian yang telah dilakukan.

Kerja lapangan bermula pada 2 Oktober 2016 sehingga 4 Oktober 2016 dan setiap kumpulan menginap di tujuh buah *Base Camp* yang terletak berdekatan dengan kavling masing-masing selama tempoh kerja lapangan berlangsung. Setiap kumpulan hanya diberi masa dari jam 7 pagi sehingga 4 petang serta 7 pagi hingga 3 petang pada hari terakhir untuk menyelesaikan kerja lapangan di kavling masing-masing. Kerja lapangan dilakukan dengan menggunakan kaedah rintisan jalan raya, rintisan sungai dan rentas hutan. Sebanyak 102 lokaliti dapat dicerap disekitar kavling tersebut dan batuan yang dijumpai ialah dari jenis volkanoklastik iaitu breksia andesit, andesit, tuf, lapilli tuf, aliran lava dan batuan karbonat iaitu batu kapur dan marmar.

Setelah selesai merekod maklumat di lapangan, semua peserta diberi ruang dan masa selama dua hari untuk berbincang dan mempersiap bahan untuk sesi pembentangan. Sesi pembentangan dilakukan pada tarikh 6 Oktober 2016 yang mana merupakan malam penutup bagi pertandingan ini. Setiap peserta dikehendaki membentang hasil pemetaan masing-masing melalui poster dan diikuti dengan pembentangan slaid yang dinilai oleh tiga orang juri. Universitas Gadjah Mada telah dinobatkan sebagai pemenang tempat pertama pertandingan diikuti oleh Institusi Teknologi Bandung ditempat kedua serta Universitas Trisakti di tempat ke tiga.

Pengalaman menyertai pertandingan ini sedikit sebanyak telah memberi gambaran kepada kami tentang geologi di negara lain selain dari Malaysia. Kami juga dapat belajar bagaimana teknik dan cara bekerja para geologis serta dapat bertukar-tukar pendapat dan pandangan dengan para peserta lain. Pengalaman berharga ini pasti tidak akan dilupakan.

Khairul Ikhwan Abd. Rahim, Afiqah Azhar & Ahmad Kamil Ahmad Nadzri
Program Geologi, Pusat Pengajian Sains Sekitaran & Sumber Alam, Fakulti Sains & Teknologi,
Universiti Kebangsaan Malaysia

Oil & Gas Forum: Reality in the oil and gas industry and the future that lies ahead

30 November 2016, Department of Geology, University of Malaya

On the 30th of November 2016, an oil and gas forum was organized by the standing committees of the University of Malaya American Association of Petroleum Geologists Student Chapter at the Department of Geology, University of Malaya. The forum entitled "Reality in the Oil and Gas Industry and The Future That Lies Ahead" was attended by approximately 60 students & lecturers from various backgrounds. The panels invited to share their knowledge and views regarding the theme were as follows:

Mr. Robert C. Shoup (Clastic Reservoir Systems Pte. Ltd.)
Mr. Fariq Shazanee (NEXC PETRONAS)
Mr. Daniel Lynd Rogers (NEXC PETRONAS)

The forum session started at around 2 P.M. and wrapped up at around 4 .30 P.M. Throughout the forum session, the issues discussed include the sentiments and reasons behind the oil price downturn, concerns regarding the unstable job opportunities and prospects, as well as technical-related subjects like the sustainability of oil reserves for future demands and impacts of renewable energy on the oil and gas industry. The panels also shared their opinion on how students and fresh graduates can improve their competency in adapting to the current downturn of the industry and what are expected of the fresh graduates once they enter the work field. Afterwards, a rather fruitful questions and answers session concluded the forum session, followed by a refreshment session for the panels and participants.

The participants gave positive feedbacks, saying that they gained a lot of knowledge and insights from the forum session. We hope that this kind of event will be held more in the future with different topics that are related to students as we can get fresh opinions from different perspectives.

Nur Ain Binti Arbain
External Secretary
University of Malaya AAPG Student Chapter
Kuala Lumpur

UPCOMING EVENTS

February 20-21, 2017: Effective Tender Preparation and Evaluation (Oil & Gas) Course, Kuala Lumpur, Malaysia. email: register@gnaritasgroup.com

February 22-24, 2017: Exciting Evolution: Myanmar's Petroleum Systems, Plays & Field Developments, Yangon, Myanmar. email: apereira@aapg.org

March 8-10, 2017: Sustainable Energy & Technology ASIA (SETA) 2017. Bangkok, Thailand. email: secretariat@seta.asia, tel. no.: +6688 2422929

March 12-15, 2017: Geotechnical Frontiers 2017. Orlando, Florida, USA. http://geosyntheticsconference.com/

March 14-16, 2017: Influence of volcanism & associated magmatic processes on petroleum systems, Oamaru, New Zealand. email: apereira@aapg.org

March 15-17, 2017: First ASRO Geological Congress, El Jadida, Morocco. email: info@asrongo.org; website: http://asrongo.org/conference/asro-geological-congress/irst-asro-geological-congress/

April 2-5, 2017: Annual Convention & Exhibition (ACE 2017) by American Association of Petroleum Geologist (AAPG), Houstan, Texas, USA. Register: online at ACE.AAPG.org; tel. no.: +1 781 821 6732

April 4-7, 2017: International Conference on Sustainable Soil Management, Bintulu, Sarawak, Malaysia. Visit website: www.mss.com.my/soils2017

April 5-7, 2017: The Energy & Materials Research Conference 2017, Lisbon, Portugal. email: conference@emr2017.org; web: emr2017.org

April 26-28, 2017: Seapex Exploration Conference (SEC) 2017, Singapore. Visit website: www.seapexconf.org for further details.

May 7-9, 2017: 19th Asia Oil & Gas Conference (AOGC2017), Kuala Lumpur, Malaysia. email: aogc@icep.com.my; website: www.aogc.com.my

May 29 - June 2, 2017: 4th World Landslide Forum. International Consortium on Landslides. Ljubljana, Slovenia. http://www.wlf4.org/

June 4 - 7, 2017: FUTORES II International Conference. Future Understanding of Tectonics, Ores, Resources, Environment and Sustainability. Townsville, Queensland, Australia. Hosted by Economic Geology Research Centre and James Cook Universit. https://www.jcu.edu.au/futores

June 4 - 8, 2017 : 3rd North American Symposium on Landslides (NASL). Roanoke, Virginia, USA

June 26 - 28, 2017: Characterizing regional groundwater flow systems: Insight from practical applications and theoretical development. Calgary, Alberta, Canada. http://regionalgwflow.iah.org/activities/calgary-symposium-2017

July 5-7, 2017: Engineering Geology 50 Conference, Portsmouth, U.K.. Organised by the University of Portsmouth. Further details at: www.port.ac.uk/engineering-geology-50-conference/

July 11 - 13, 2017: Australasian Groundwater Conference 2017. Sydney, Australia. email: w.timms@unsw.edu.au

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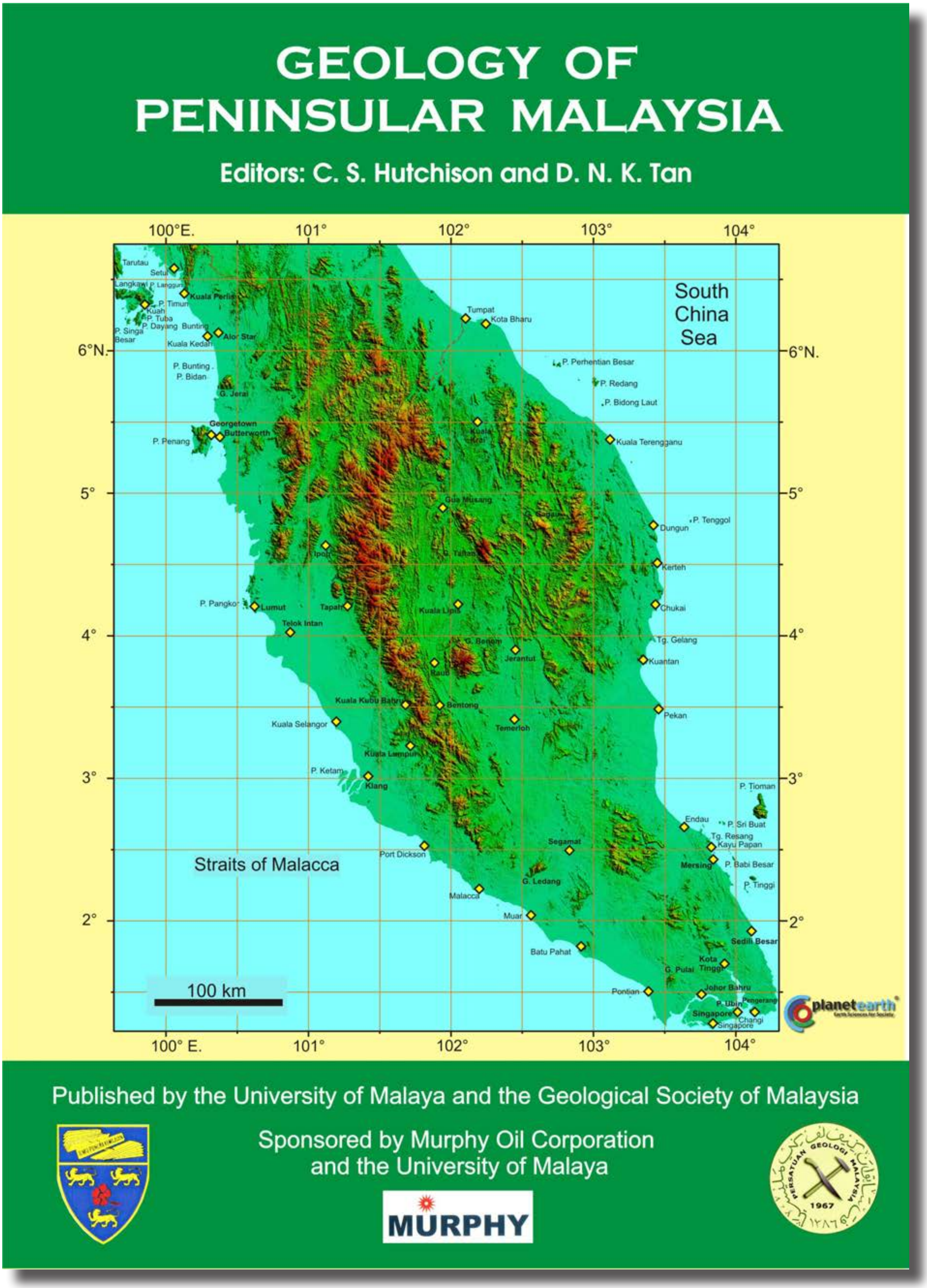

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