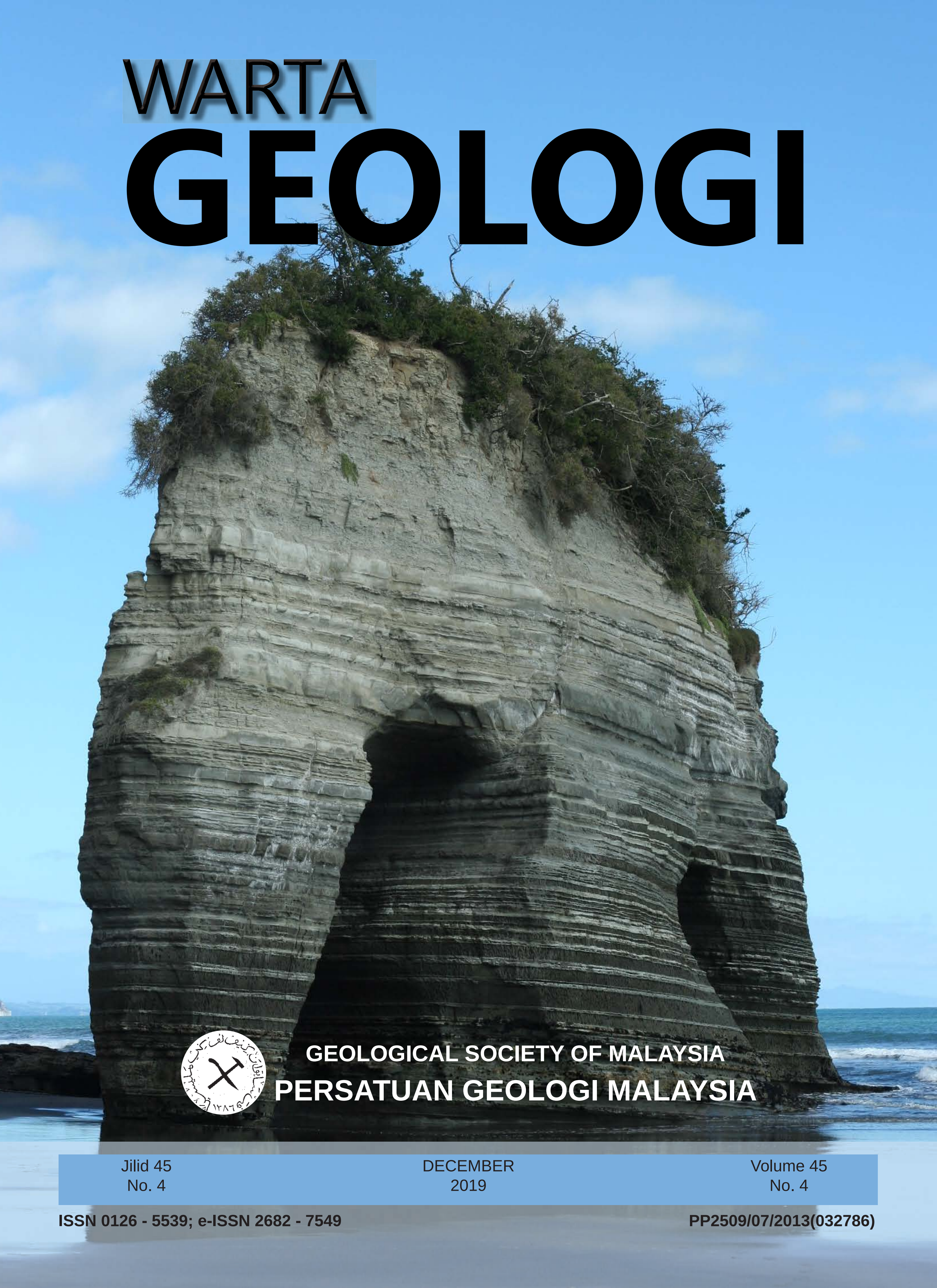

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Cover photo: Elephant Rock - the iconic sea stack on the beach near Tongaporutu, North Taranaki Basin, on the western North Island of New Zealand. The aptly named sea stack is made up of Miocene turbidites of the Mt. Messenger formation. Photo by Mazlan Madon, taken in 2009.

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Two new important outcrops along the Pan-Borneo Highway in the Lambir Hills, Miri area, Northern Sarawak

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Abstract: Road construction work of the Pan-Borneo Highway at sections of the Lambir Hills has created a few fresh temporary outcrops. Of particular importance is an excellent outcrop of the Mid-Miocene Unconformity (MMU), which we called the "White Cliff". An equally spectacular outcrop shows Lambir sandstone offset in strike-slip against a sand wedge and the older Setap Shale, at the inferred (West) Baram Line location. The outcrop is an additional data point for the Baram Line regional strike-slip system, which has been mapped previously with some confidence on both seismic and gravity data.

Keywords: Outcrops, Miocene, MMU, Baram Line, Lambir Hills, Miri, Sarawak

INTRODUCTION

In April 2019, Dr. Kessler and Dr. Jong led a short field campaign in the surroundings of Miri, northern Sarawak, with the objective to investigate new outcrops suitable for studying Baram Delta reservoir depositional settings in relation to Baram Line (or West Baram Line) tectonics, reservoir prediction and paleoenvironmental indications.

Currently, there are many fresh outcrops exposed along the track of the Pan-Borneo Highway, and this paper addresses two new outcrops of the Mid-Miocene Unconformity (MMU), and the Baram Line.

In respect of the MMU, it has been postulated that the unconformity can be traced on seismic in many offshore areas of the South China Sea, and in such way providing a correlation tool to link sub-basins (Kessler & Jong, 2016a, 2017a). Unfortunately though, the calibration of the MMU remains spurious in mainly offshore exploration wells. The best so-far dated and analyzed onshore outcrop is located in Bukit Lambir (Lesslar & Wannier, 1998).

In regard to the Baram Line, there is a broad agreement that the lineament forms the eastern boundary of Central Luconia. However, the opinions are divided if and where there might be a continuation inland Borneo after landfall at the Pantai Bungai some 50 km to the south of Miri. The various opinions have been cited and discussed by Cullen (2014).

There was an exchange of ideas with the late Prof. Tija in 2016 (Kessler & Jong, 2016b). Fieldwork by Kessler (2009) plus seismic and gravity interpretation (Kessler & Jong, 2016c, 2017b; Jong *et al*., 2016, 2017) suggest the Baram Line is making a turn to the East, crossing Bukit Lambir, heading towards Gunung Mulu and eventually aligning with other fault systems in Sabah, separating the NW Borneo shelf and turbidite basin from the Crocker Basin. If we follow this interpretation, the Baram Line is a crustal detachment fault system which encloses areas of thinned continental crust of the South China Sea, overlain by some Oligocene but mainly Neogene sediments. Accordingly, it is important to map this lineament to our best endeavors.

By April 2019, the Pan-Borneo Highway road works had advanced to the Lambir Hills area, successively cutting through the younger Tukau Formation, into the intermediate Lambir Formation, and the older Setap Shale (see Figures 1 and 2).

A simplified litho-stratigraphic scheme of the investigated area is shown in Figure 2 (Kessler & Jong, 2017a):

- The Pliocene Tukau Formation unconformably overlies the Lambir/Miri formations and is formed by intertidal clastics, in particular tidal channel sand deposits, which appear strongly amalgamated, and are interbedded with parallel silty layers. Individual channel beds are often characterized by "side-stepping" and asymptotic foresets, the laminae in which may consist of thin, gray claystone or of lignite (Kessler & Jong, 2015, 2016d).
- The Mid-Late Miocene Lambir and Miri formations form the crestal area of the Bukit Lambir and Miri

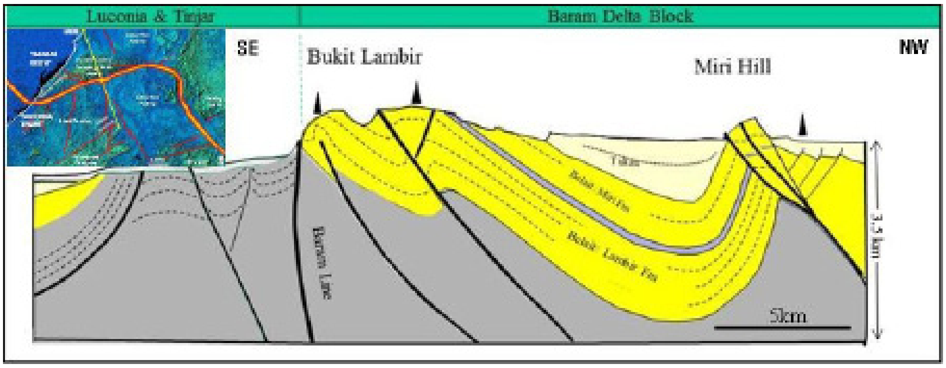


Figure 1: Tectono-stratigraphic cross-section showing folded Neogene sediments of northern Sarawak, see Figure 3 for line location. The black cones indicate the approximate positions of old exploration wells. From Kessler & Jong (2016d).

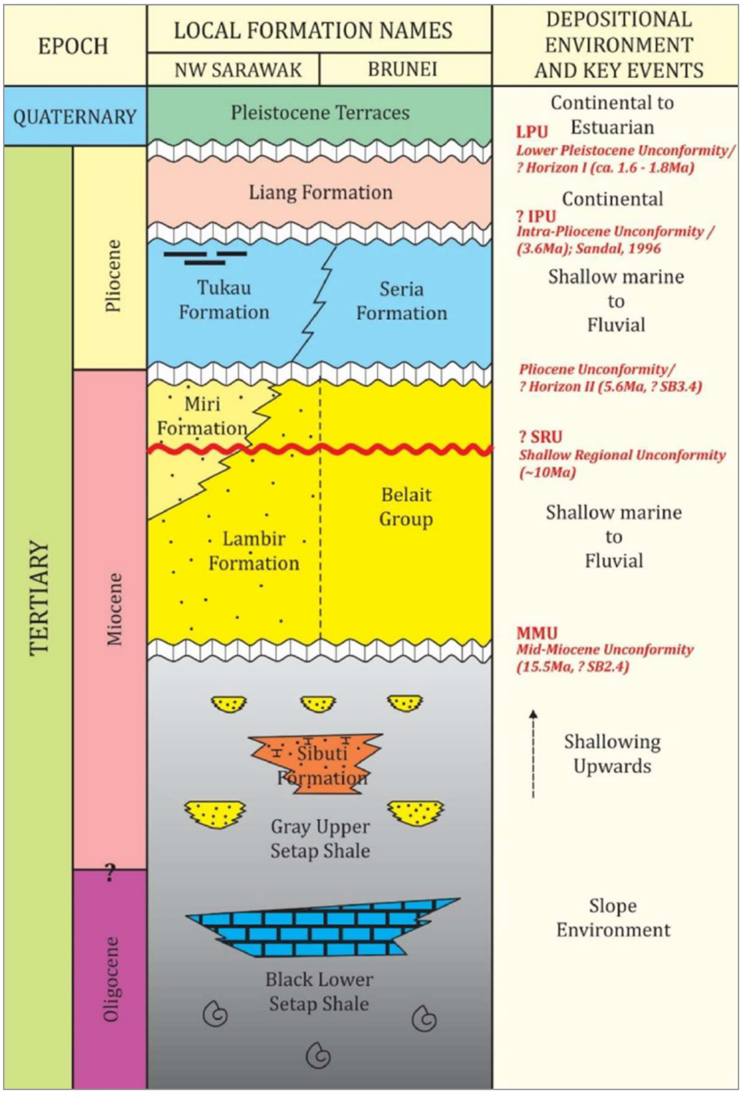


Figure 2: Simplified litho-stratigraphy of northern Sarawak. The term Miri Formation is generally used in the greater Miri area and is age-equivalent to the upper section of the Lambir Formation. Sandal (1996), however, placed the formation partially age-equivalent to the lower Tukau Formation. Likewise, the mid Early Miocene Sibuti Formation is more locally confined with the Subis Limestone Member deposited in the lower part of the Gray Upper Setap Shale (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). The observed unconformity events as annotated are established by Kessler & Jong (2017a), and modified after Kessler & Jong (2015).

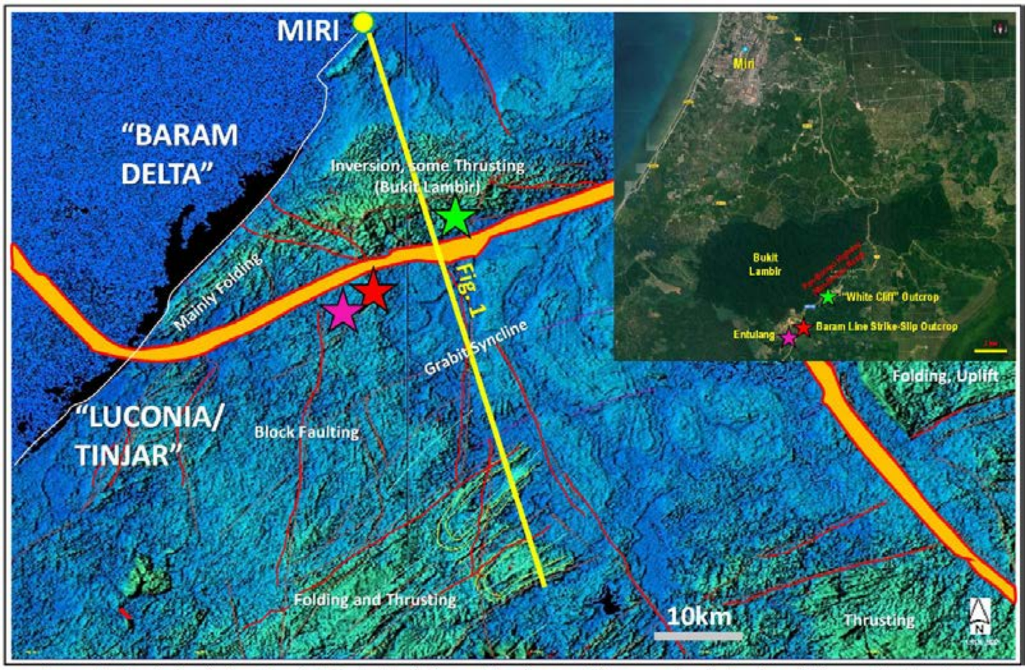
Hill (Figure 1). These formations contain about equal amounts of claystone and sandstone, the latter mainly formed by (sometimes nested) tidal channels and beach bars. Most channels are migrating and "reworked" hence are strongly amalgamated (Kessler & Jong, 2015, 2016d).

NEW OUTCROPS

The locations of the new outcrops investigated are shown in Figure 3.

The "White Cliff" outcrop (Coordinates: E 114.02648, N 4.179596)

The "White Cliff" outcrop is on the left side of the road, when approaching from Miri heading towards Bintulu, and located *ca.* 1 km after the Lambir National Park Headquarters. The outcrop is *ca.* 250 m wide (Figure 4a) and exposes a cliff section of some 8 m, the upper part of which is formed by Lambir sandstone, while the bottom part overlies the Setap Shale with a prominent unconformity, the Mid-Miocene Unconformity (see Figures



Legends: Faults (red); Syncline Axis (pale blue); Baram Line (orange fill); approximate location of Figure 1 (yellow line). Green star: approximate location of the MMU outcrop. Red star: approximate location of the fault zone currently correlated with the Baram Line track. Pink star: approximate location of the Entulang outcrop.

Figure 3: Approximate locations of the studied outcrops shown as green ("White Cliff" outcrop) and red (Baram Line strike-slip outcrop) stars in context of a regional tectonic map, and see text for exact location coordinates. The inset map shows the locations of the outcrops together with the mentioned Entulang outcrop (pink star) along the Pan-Borneo Highway (Miri-Bintulu Road). The orange Baram Line constitutes an important facies boundary, with carbonate dominate in Luconia/Tinjar area and clastics in the Baram Delta Block (Jong *et al.*, 2017; Jong & Kessler, 2019; Kessler, 2009; Kessler & Jong, 2016c).

Figure 4a: Panoramic view of the "White Cliff" outcrop. A marked unconformity, interpreted as MMU, is seen incising a silty-shaly sequence of the Setap Shale.

Figure 4b: The base of the sandstone is uneven, there is a marked relief at the unconformity as seen behind the small girl of 1.2 m in height.

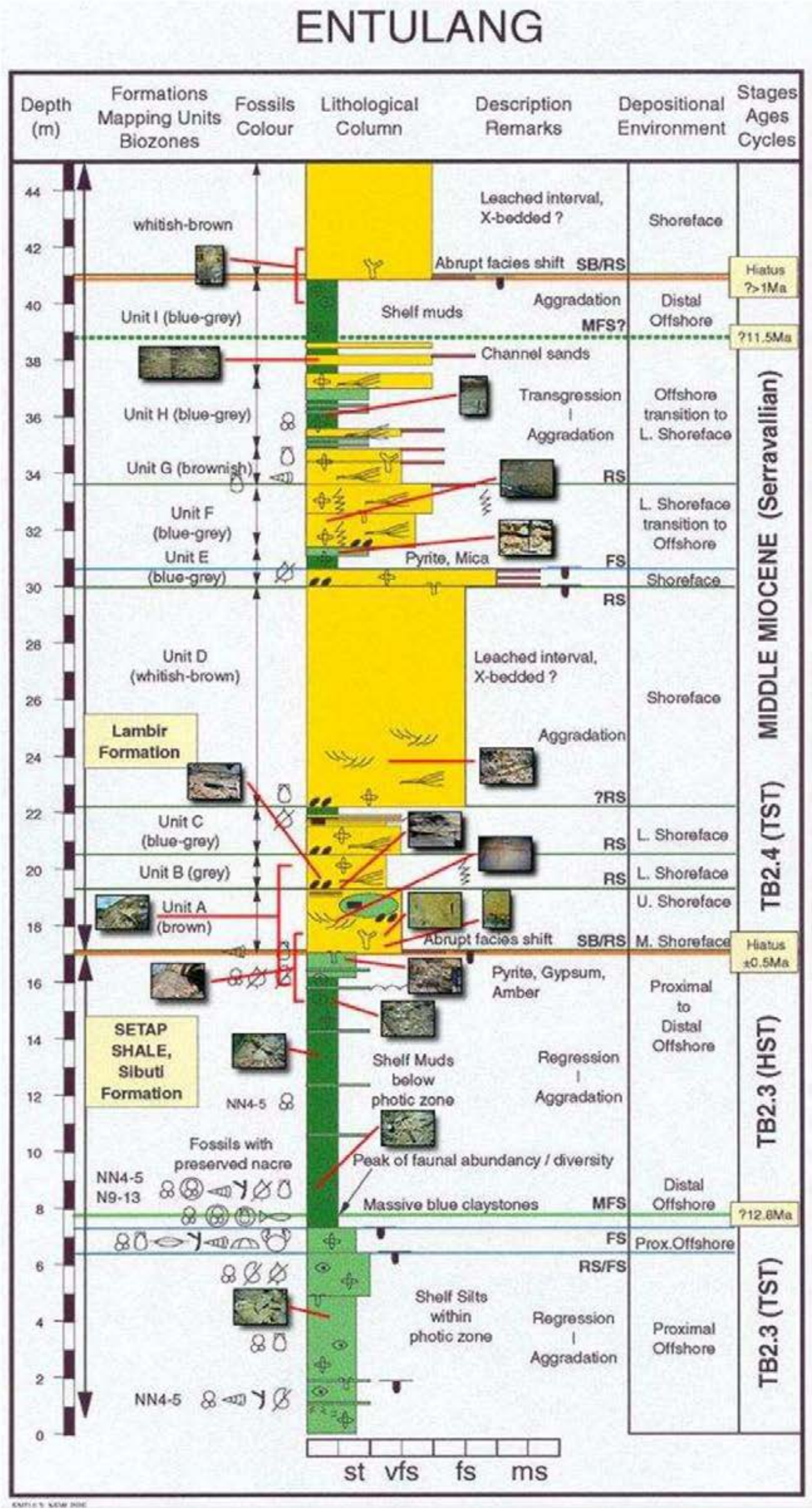


Figure 4c: Setap Shale and sand-dominated Lambir section in Entulang, Lambir Hills (from Lesslar & Wannier, 1998).

4a-e). The MMU was dated Middle Miocene by Lesslar & Wannier (1998) in the nearby Entulang outcrop (Figure 4c, see Figure 3 for location), is unevenly incised into the underlying claystone and siltstone beds (Figures 4b and 4d). The overlying Lambir sandstone beds dip at about 10° to NW and also contain clay-filled channels (Figure 4e).

Regional significance: The outcrop is outstanding because of its lateral extent. Together with additional outcrops on the same hill flank along the highway they form a combined exposure of some 500 m of the regional Mid-Miocene Unconformity not commonly seen in the older outcrops. The appearance of clay-filled channels are rare in a sand-dominated environment, which could be an analogue to subsurface "buried hills" with top and side seals provided by these clay-fill channels as a potential structural-stratigraphic trapping mechanism.

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Baram Line regional strike-slip system outcrop (Coordinates: E 114.02134, N 4.20420)

Further along the road in the direction to Bintulu, a tectonic contact between Lambir sandstone and Setap Shale can be studied. Several parallel fault zones appear to slice through the edge of the Lambir sand and offsetting it against the Setap clay (Figures 5a-c). The axis of this fault system appears to run parallel to, and possibly beneath, the highway (Miri-Bintulu Road) as shown on Figure 5a.

Figure 5a: Panoramic view of a zone of faulting near to Entulang outcrop (located on the hill side at the bottom of the photo).

Figure 4d: Detail of erosion (with a 40 cm long knife enclosed in red circle for scale).

Figure 5b: Close-up of Figure 5a showing faulting (dashed red line to the right of warning panel).

Figure 4e: The Lambir sandstone also hosts clay-filled channels. The field of view of the small channel in the middle of the photo is around 4 m wide.

Figure 5c: At this fault, we see massive, clean sandstone (left) juxtaposed against a sequence of channelized sand and siltstone, and sandstone above. A water spring seen at the bottom left marks the fault.

The history of the movements could be complex (Jong & Kessler, 2019), and a facies change is seen as a fault cutting through the Lambir sand (in the close-up pictures shown in Figures 5b and 5c). Here, we see on the right hand side channel features that are not visible in the more massive sand sheet to the left of the fault. A small spring with iron-laden deposits is seen on the fault plane.

Regional significance: There is plenty of literature about the Baram Line (e.g., Kessler, 2009; Cullen, 2014; Kessler & Jong, 2016b), but so far little or no fresh outcrop data showing the anatomy of the lineament have been published. This outcrop may be important for further studies of the lineament. For instance, tracing the Baram Line from offshore into onshore Borneo appears, at least at first glance, logical since another lineament further south, the so-called Tinjar Line, is similar in strike (but somewhat offset, by strike-slip fault?). However, the line cannot be mapped as a simple linear feature and examination of the outcrops such as this example, integrated with the available gravity, magnetics and 2D seismic in northern Sarawak area will help address the question in which direction the lineament continues onshore.

CONCLUSIONS AND FURTHER WORK

While older outcrops such as Entulang (Figure 3) may have been destroyed by the Pan-Borneo Highway construction, fortunately new ones are also created during the process. In summary, the two fresh outcrops offer an excellent opportunity for further research and academic studies. The spectacular "White Cliff" outcrop offers an unmatched location for a biostratigraphic investigation of the onshore Tukau, Lambir and Setap Shale formations. In addition, deposition environmental study ranging from shallow marine to fluvial deltaic with a regional unconformity for sea level movement can be studied also. The wide exposure of the outcrop could also serve to better constrain the magnitude of the hiatus (now set at 0.5 Ma at Entulang following the research by Lesslar and Wannier, 1998). On the second outcrop, the outcrop represents a good opportunity to investigate the tectonic implication of the strike-slip segment of onshore continuation of the Baram Line, which remains a topic of interesting debate. It is important, however, that these studies are carried out by local research institutions with applied geology program such as the Miri-based Curtin University Malaysia before they are degraded by weathering, erosion and vegetation of the unforgiving tropical climate.

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Point load strength of clastic sedimentary rocks from the Semanggol Formation, Beris Dam, Kedah Darul Aman

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Abstract: The Beris Dam is founded on a sequence of thick bedded conglomerates and pebbly to fine grained sandstones with minor mudstone mapped as the Semanggol Formation of Triassic age. The conglomerates have an average dry unit weight of 23.85 kN/m^3, and apparent porosity of 9.8%, whilst the pebbly sandstones have corresponding values of 25.35 kN/m^3, and 3.9%, respectively. Coarse, and medium, grained sandstones have similar apparent porosities of 3.8%, but dry unit weights of 25.33, and 25.36, kN/m^3. Fine grained sandstones, which are laminated, have an average dry unit weight of 25.81 kN/m^3, and apparent porosity of 2.2%.

Diametral tests on air dried core specimens (of 51.6 mm diameter) show them to fail in typical tensile splitting mode, except where inherent fracture or bedding planes are present. The fine grained sandstones split along laminae and yield a point load strength index [$Is_{(50)}$] of 2.44 MPa, whilst the relatively porous conglomerates yield an index of 5.16 MPa. Diametral tests on pebbly sandstones yield a strength index [$Is_{(50)}$] of 6.89 MPa, while those on coarse and medium grained sandstones yield indices of 8.64, and 8.83, MPa, respectively. Decreasing strength indices with increasing particle size are considered to result from the greater surface area of the coarser grains that allows preferential extension of failure crack traces along grain boundaries.

It is concluded that the point load strength of clastic rocks from the Semanggol Formation is influenced by their texture as well as inherent discontinuity planes present.

Keywords: Point load strength, Semanggol Formation, clastic rocks

INTRODUCTION

The point load strength, as described by Broch & Franklin (1972), has gained widespread acceptance as an index test for the strength classification of rock material and as a means of estimating other strength parameters as the uniaxial compressive strength (Bieniawski, 1974; ISRM, 1985; Brook, 1985). Little or no specimen preparation is needed for the test which involves the splitting of rock specimens by application of a concentrated load through a pair of spherically truncated, conical platens. The samples can be in the form of cores (diametral and axial tests), cut blocks (block test) or irregular lumps (irregular lump test).

Experience over the years has shown that there are some short-comings with the accepted practice, including the variability and scatter of test results on anisotropic rock material, the influence of core sample geometry on axial tests, and the correlation of the point load strength index with the uniaxial compressive strength (Forster, 1983). Notwithstanding these short-comings, in view of the absence of meticulous specimen preparation, and the possibility of carrying out the test both in the field and in the laboratory, the point load test is acknowledged to be generally the most convenient test for the strength classification of rock material (Brook, 1985).

The most widely known version of the test involves the diametral testing of rock cores and determination of the point load strength index [$Is_{(50)}$] which is referenced to a core diameter of 50 mm. Where cores with other diameters are tested, a size correction factor needs to be introduced, whilst both shape and size correction factors need to be introduced where specimens with shapes other than cores are tested (ISRM, 1985; Brook, 1985).

In Malaysia, point load strength indices [$Is_{(50)}$] have been reported for several rock types, including marble (Raj, 1992; 2006), Tertiary sedimentary rocks (Raj, 1995); igneous rocks (Raj, 1993; Raj & Nadzmi, 1994; Raj, 1998) and metamorphic rocks (Raj, 2004; Raj & Nadzmi, 2007). Field point load tests on irregular blocks of the Semanggol Formation have been reported by Tajul & Ismail (2003), whilst laboratory point load tests on meta-siltstone and meta-sandstone cores from the Jurong Formation in Singapore are discussed by Li & Wong (2015).

In this short note are presented the results of laboratory point load tests on borehole specimens of clastic sedimentary rocks from the Triassic Semanggol Formation at the Beris Dam in Kedah state. Variations in strength indices [$Is_{(50)}$] are discussed and conclusions reached on the factors influencing the point load strength of rocks from the Semanggol Formation.

GEOLOGICAL SETTING OF SAMPLES

The concrete-faced rockfill Beris Dam is located in the narrow valley of Sungai Beris, some 1.6 km upstream of its confluence with Sungai Muda in Sik District in Kedah state (Figure 1). The dam, which is 40 m high and about 155 m long at its crest, was completed in 2004 and used to regulate flows in the Sungai Muda drainage basin to augment water available for irrigation as well as domestic and industrial water supply and other uses (DID, 2018). The dam has a catchment area of 166 km^2; the reservoir at normal pool level covering an area of 13.7 km^2 and at maximum pool level inundating an area of 16.1 km^2 (Tajul & Ismail, 2003).

The Beris Dam and Reservoir overlie a sequence of thick conglomerates interbedded with fine to coarse and pebbly sandstones with minor mudstones that have been mapped as the Semanggol Formation of Triassic age by the Geological Survey of Malaysia (Teoh, 1992).

Conglomerates predominate at the right abutment and under the main dam, whilst at the left abutment and spillway, the conglomerates are inter-bedded with gritstone and coarse sandstone. The conglomerate, gritstone and sandstone then exposed at the foundation, abutments and spillway, were reported to be slightly to moderately weathered (Grades II - III) (Tajul & Ismail, 2003).

The matrix-supported, polymict conglomerates contain gravel to pebble-sized clasts of dark slate and mudstone, cert, quartz and other rock fragments (possibly volcano-clastics, sandstone and quartzite), whilst the matrix comprises coarse sandy to gritty materials of quartz, feldspar and rock fragments (Tajul & Ismail, 2003). The rocks were reported to be generally hard, compact and well indurated; requiring several blows of the geological hammer for the collection of samples (Tajul & Ismail, 2003).

The gritstones are transitional between the conglomerate and sandstone, and composed of fine gravel to coarse sand grains of quartz, quartzite, sandstone, chert and mudstone as well as other rock fragments. They are grey, hard, compact, and occur as inter-beds in the conglomerate and sandstone. The sandstone is generally a light grey, fine to coarse-grained, hard, compact and well indurated rock. In places, the thick sandstone beds contain shale/mudstone partings (Tajul & Ismail, 2003).

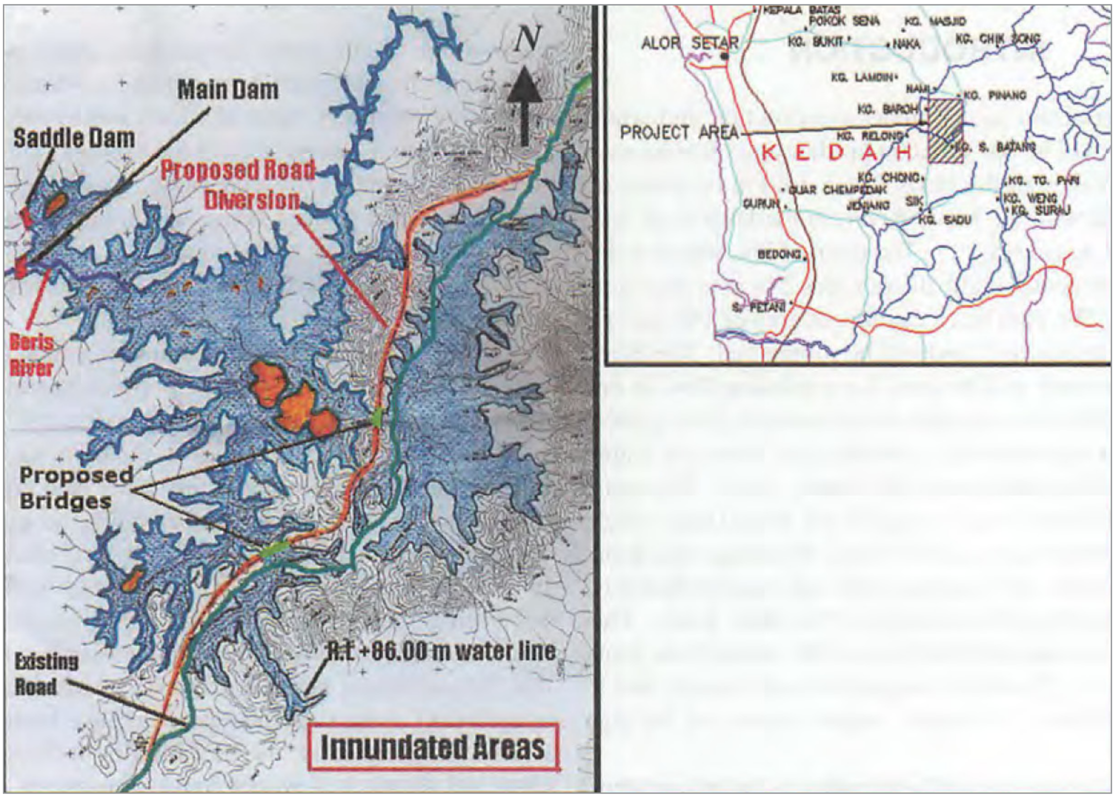

Figure 1: Location of the Beris Dam in Kedah Darul Aman. From Figure 1 in Tajul Anuar Jamaluddin & Ismail Yusoff (2003).

The bedding planes are often not clearly defined due to the thick to massive bedding. At the right abutment, however, bedding planes strike about west to west-southwest with dips of 15° to 30° towards north. At the left abutment, the bedding strikes about east-west with dips of 45° to 52° towards south. The rocks are intensely faulted and jointed with a total of 5 to 6 major joint sets having been identified (Tajul & Ismail, 2003).

Several boreholes were drilled during site investigation works for the Beris Dam and associated structures and some cores were provided to the author for study and determination of their physical properties.

METHODOLOGY

The given cores were first sawn with a diamond blade into smaller specimens and these then air-dried before unit weights, densities and apparent porosities of representative specimens determined according to the saturation and bouyancy procedure of ISRM (1979). The specific gravity of the constituent mineral grains of some specimens was also determined with a pycnometer (RRL, 1952).

The visible textural and structural features of each of the individual specimens were then described and indicated that graded bedding was present in the core samples. Thin-sections were also prepared from representative specimens of different grain sizes to identify their composition and other textural features.

The specimens were then air-dried for a week before being tested with a point load apparatus manufactured by Engineering Laboratory Equipment Limited. Diametral tests were carried out with the core specimens having a diameter of 51.6 mm which is close to the standard reference core diameter of 50 mm. Size corrections were therefore, not carried out in this study.

RESULTS

Petrography of investigated rock materials

The conglomerates and pebbly sandstones are seen in thin-section to be poorly to moderately sorted with clasts of chert, quartz and rock fragments in a finer grained matrix of similar composition. Clasts in the conglomerates are 1 to 6 mm, and the matrix some 0.1 to 0.5 mm, in size, whilst those in the pebbly sandstones are 1 to 4 mm, and the matrix some 0.13 to 0.25 mm, in size. The clasts are sub-angular to angular in shape with the rock fragments including quartz-mica schist, siltstone and sandstone. Both mono-crystalline and poly-crystalline quartz clasts are present with some grains being well rounded.

The medium and coarse grained sandstones are seen in thin-section to be well sorted with angular to sub-angular, and more rarely, rounded, grains of quartz, chert and rock fragments. In the coarse grained sandstone, the grains are some 0.15 to 1.5 mm in size with a mean value of about 0.35 mm, whist in the medium grained sandstone, the grains are 0.1 to 1.5 mm in size with a mean value of 0.25 mm. Opaque mineral grains and heavy minerals including tourmaline and zircon are sometimes seen in the thin-sections.

The fine grained sandstones are seen in thin-section to be distinctly laminated and well sorted with sub-angular to rounded grains of quartz, chert and rock fragments as well as mica flakes. The grains are some 0.06 to 0.5 mm in size with a mean value of 0.15 mm. A few heavy minerals including tourmaline and zircon are sometimes seen in the thin-sections.

Physical properties of investigated rock materials

Laboratory determined dry unit weights show variations with grain size; the conglomerates having the minimum value of 23.85 kN/m^3, and the fine gained sandstones, the maximum value of 25.81 kN/m^3 (Table 1). The pebbly sandstones have an average dry unit weight of 25.35 kN/m^3, whilst the coarse and medium grained sandstones have values of 25.33, and 25.36, kN/m^3, respectively (Table 1). There is a distinct increase in dry unit weight with decreasing grain size; a feature which may be attributed to better compaction in the finer grained sandstones. Values of dry density also show a similar variation with grain size; the conglomerates having the minimum dry density of 2,432 kg/m^3, and the fine gained sandstones, the maximum density of 2,632 kg/m^3 (Table 1).

Laboratory determined apparent porosities also reflect the variations in dry unit weights and densities; the conglomerates having the maximum value of 9.8%, and the fine grained sandstones, the minimum value of 2.2% (Table 1). The pebbly sandstones have an apparent porosity of 3.9%, whilst the coarse and medium grained sandstones have a similar value of 3.8% (Table 1). There is thus a distinct decrease in apparent porosity with decreasing grain size; a feature that again may be attributed to better compaction in the finer grained sandstones.

The specific gravity values of mineral grains in the different specimens show little variation and range between 2.62 and 2.64 (Table 1). This limited variation in values is not unexpected given the closely similar composition of the mineral grains present in the different specimens.

Loads at failure

The tested specimens all display typical tensile failure mode, splitting into two approximately equal halves (Table 2). Most of the breakage surfaces were grey and rough to the touch, though a few were marked by smooth, orange stained surfaces indicating failure along inherent fracture planes. The laminated, fine grained sandstones furthermore, split along inherent bedding planes (laminae), marked by smooth, grey breakage surfaces.

Table 1: Physical properties of core specimens from the Semanggol Formation.

Sample Number	Bulk Unit Weight (kN/m^3)	Dry Unit Weight (kN/m^3)	Apparent Porosity (%)	Bulk Density (kg/m^3)	Dry Density (kg/m^3)	Specific Gravity Grains
Conglomerate						
Cgl 1	24.76	23.77	10.1	2,525	2,423	2.64
Cgl 2	24.82	23.87	9.7	2,531	2,434	2.65
Cgl 3	24.85	23.90	9.7	2,534	2,437	2.64
Average	**24.81**	**23.85**	**9.8**	**2,530**	**2,432**	**2.64**
Pebbly Sandstone						
PSst 1	26.02	25.73	3.0	2,653	2,624	2.63
PSst 2	25.44	24.97	4.8	2,594	2,546	2.62
Average	**25.73**	**25.35**	**3.9**	**2,624**	**2,585**	**2.62**
Coarse grained Sandstone						
CSst 1	25.69	25.32	3.7	2,619	2,582	2.62
CSst 2	25.71	25.34	3.8	2,622	2,584	2.62
Average	**25.70**	**25.33**	**3.8**	**2,621**	**2,583**	**2.62**
Medium grained Sandstone						
MSst 1	25.83	25.46	3.7	2,634	2,597	2.63
MSst 2	25.64	25.26	3.9	2,615	2,576	2.62
Average	**25.74**	**25.36**	**3.8**	**2,624**	**2,586**	**2.62**
Fine grained Sandstone						
FSst 1	25.96	25.72	2.4	2,647	2,622	2.64
FSst 2	26.10	25.91	2.0	2,662	2,642	2.63
Average	**26.03**	**25.81**	**2.2**	**2,654**	**2,632**	**2.63**

The influence of inherent discontinuity planes on the loads at failure is unexpected given that the planes represent existing planes of weakness in the rock material. Results of tests where the specimens split along inherent fracture planes were thus discarded as the values are not indicative of failure through the rock material. In the case of the fine grained sandstones, however, the laminae are the over-riding control on failure through the rock material and the loads at failure are the lowest amongst the different clastic rock types (Table 2).

Apart from the influence of inherent discontinuity planes, the loads at failure are also influenced by the texture of the core specimens (Table 2). The relatively porous conglomerate thus shows loads at failure ranging from 11.0 to 16.5 kN, whilst the more dense pebbly sandstone has values between 14.0 and 21.0 kN. The coarse grained sandstone furthermore, shows loads at failure between 20.0 and 24.0 kN, and the medium grained sandstone loads at failure between 20.0 and 27.0 kN (Table 2).

DISCUSSION

Point load strength indices [Is$_{(50)}$]

The point load strength indices [Is$_{(50)}$] that have been determined are dependent upon two main factors, i.e. presence of inherent bedding planes and texture of the specimens. The influence of inherent bedding planes is seen in the fine grained sandstones where failure occurs along laminae (very fine beds <1 cm thick). The fine grained sandstone thus yields a point load index of 2.44 MPa.

The influence of bedding planes is not seen in the other tested specimens which are sampled from thick to massive beds. Li & Wong (2015) in Singapore have also pointed out that failure crack traces in point load tests on meta-siltstones and meta-sandstones of the Triassic Jurong Formation were mostly independent of bedding orientation. This independence, however, was considered to result from low-grade metamorphism which tended to "fuse" the bedding and thus offer a higher strength. The existing bedding planes therefore, no longer served as the preferential planes of weakness as experienced in many sedimentary rocks (Li & Wong, 2015).

Texture refers to the size, shape and arrangement of the constituent discrete grains or particles in a sedimentary rock and is a factor that can be expected to influence the development of the failure crack trace during point load tests. In the present tests, there can be seen an increase in the point load strength index [Is$_{(50)}$] with decreasing grain size. The conglomerates yield an index of 5.16 MPa, whilst the pebbly sandstones have a value of 6.89 MPa.

Table 2: Results of diametral point load tests on core specimens from the Semanggol Formation.

Sample Number	Load at Failure (kN)	Strength Index ($Is_{(50)}$) (MPa)	Comments on Test
Conglomerate			
Cgl C	11.0	4.12	Split in 2 along irregular surface - Good
Cgl 2	14.0	5.26	Split in 2 along irregular surface - Good
Cgl B	13.5	5.07	Split in 2 along irregular surface - Good
Cgl E	16.5	6.20	Split in 2 along irregular surface - Good
Average	-	**5.16**	
Cgl 1	10.0	3.76	Split in 2 along fracture plane - Not good
Cgl A	6.00	2.25	Split in 2 along fracture plane - Not good
Cgl D	5.05	1.90	Split in 2 along fracture plane - Not good
Pebbly Sandstone			
PSst 1	14.0	5.26	Split in 2 along irregular surface - Good
PSst 2	20.0	7.51	Split in 2 along irregular surface - Good
PSst 3	21.0	7.89	Split in 2 along irregular surface - Good
Average	-	**6.89**	
PSst 4	8.0	3.00	Split in 2 along fracture plane - Not good
Coarse grained Sandstone			
CSst 1	24.0	9.01	Split in 3 along irregular surfaces - Good
CSst 2	22.0	8.26	Split in 3 along irregular surfaces - Good
CSst 3	20.0	7.51	Split in 2 along irregular surface - Good
Average	-	**8.64**	
CSst 4	15.0	5.63	Split in 2 along fracture plane - Not good
Medium grained Sandstone			
MSst 1	20.0	7.51	Split in 2 along irregular surface - Good
MSst 2	27.0	10.14	Split in 2 along irregular surface - Good
MSst 3	25.0	9.39	Split in 2 along irregular surface - Good
Average	-	**8.83**	
MSst 4	16.0	6.01	Split in 2 along fracture plane - Not good
MSst 5	11.0	4.13	Chipped - Not good
Fine grained Sandstone			
FSst 1	7.00	2.63	Split in 2 along bedding plane - Good
FSst 2	6.50	2.44	Split in 2 along bedding plane - Good
FSst 3	6.00	2.25	Split in 2 along bedding plane - Good
Average	-	**2.44**	
FSst 4	4.70	1.77	Chipped - Not good

The coarse, and medium, grained sandstones furthermore, yield strength indices of 8.64, and 8.83, MPa, respectively.

The increase in strength index with decreasing grain size is considered to result from differences in the surface areas of the constituent grains. The larger grains present in the conglomerate and pebbly sandstone have relatively greater surface areas in comparison with those of the coarse and medium grained sandstones. As the composition of the constituent grains is closely similar, the extension of failure crack traces during application of loads is thus likely to follow grain boundaries. The greater surface areas of the coarser grains will therefore, allow for preferential extension of failure crack traces along grain boundaries.

The point load strength indices [$Is_{(50)}$] of between 4.12 and 7.91 MPa (Table 2) for conglomerate and pebbly sandstone in the present tests are comparable with the corrected indices [$Is_{(50)}$] of between 2.32 and 6.43 MPa, with an average value of 3.63 MPa determined in the field on mainly conglomerates then exposed at the

Table 3: Strength classification of core specimens from the Semanggol Formation based on point load strength indices ($Is_{(50)}$).

Sample Number	Strength Index ($Is_{(50)}$) (MPa)	Strength Classification (After Bieniawski, 1974)
Conglomerate		
Cgl C	4.12	High Strength
Cgl 2	5.25	High Strength
Cgl B	5.07	High Strength
Cgl E	6.20	High Strength
Pebbly Sandstone		
PSst 1	5.26	High Strength
PSst 2	7.51	High Strength
PSst 3	7.89	High Strength
Coarse grained Sandstone		
CSst 1	9.01	Very High Strength
CSst 2	8.26	Very High Strength
CSst 3	7.51	High Strength
Medium grained Sandstone		
MSst 1	7.51	High Strength
MSst 2	10.14	Very High Strength
MSst 3	9.39	Very High Strength
Fine grained Sandstone		
FSst 1	2.63	Medium Strength
FSst 2	2.44	Medium Strength
FSst 3	2.25	Medium Strength

abutments during construction of the Beris Dam (Tajul & Yusoff, 2003). Similar tests on irregular blocks of conglomerate and sandstone then exposed at the Spillway walls furthermore, yielded corrected point load strength indices [$Is_{(50)}$] of between 1.57 and 8.71 MPa, with an average value of 4.28 MPa (Tajul & Ismail, 2003).

In Singapore, point load tests on meta-siltstones, and meta-sandstones, of the time equivalent Jurong Formation have yielded average point load strength indices [$Is_{(50)}$] of 9.38, and 12.84 MPa, respectively (Li & Wong, 2015). The strength indices [$Is_{(50)}$)] furthermore, ranged from 6.70 to 10.24 MPa in the case of the meta-siltstones and from 10.60 to 15.02 MPa in the case of the meta-sandstones. These strength indices are higher than those determined in the present study, though this is to be expected as the rocks have experienced low grade regional metamorphism.

Rock strength classification

Bieniawski (1974) considered the point load strength index [$Is_{(50)}$] to be a quick and reliable means for the strength classification of rock materials and proposed a classification based on their unconfined compressive strength (UCS) and point load strength index [$Is_{(50)}$]. In terms of this classification, the clastic rocks from the Semanggol Formation show variations with texture, the fine grained sandstones being of 'medium strength' whilst the conglomerates and pebbly sandstones are of 'high strength'. The medium and coarse grained sandstones are of 'high' to 'very high' strengths.

Rock samples from the left and right abutments of the Muda Dam during construction were reported to be slightly and moderately weathered (Grade II-III) with point load tests showing them to be "strong to very strong" rocks (Tajul & Ismail, 2003). Rock samples collected randomly from the spillway walls were also reported to be slightly and moderately weathered (Grades II - III) with point load tests indicating them to be "medium strong to very strong" rocks (Tajul & Ismail, 2003).

CONCLUSIONS

It is concluded that determination of the point load strength of clastic rocks from the Semanggol Formation is influenced by their texture as well as inherent discontinuity planes. Conglomerates with an average dry unit weight of 23.85 kN/m^3, and apparent porosity of 9.9%, are characterized by a point load strength index [$Is_{(50)}$] of 5.13 MPa. Pebbly sandstones with an average dry density of 25.35 kN/m^3, and apparent porosity of 3.9%, are characterized by a point load strength index [$Is_{(50)}$] of 6.89 MPa. Coarse, and medium, grained sandstones have similar average apparent porosities of 3.8%, but dry unit weights of 25.33, and 25.36, kN/m, and are characterized by point load strength indices [$Is_{(50)}$] of 8.64, and 8.83, MPa, respectively. Fine grained sandstones, which are laminated, with an average dry unit weight of 25.81 kN/m^3, and apparent porosity of 2.2%, split along inherent bedding planes and yield a point load strength index $Is_{(50)}$] of 2.44 MPa.

Decreasing strength indices with increasing particle size are considered to reflect the greater surface areas of the coarser grains that allow preferential extension of failure crack traces along grain boundaries.

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High potential new Quaternary fossil cave sites in Merapoh (Pahang), with new geographic records for orangutan and Asian Black Bear

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Abstract: Cave sediments exceptionally rich with numerous vertebrate dental remains have been discovered in Merapoh, Pahang. To date, a total of 611 isolated teeth have been collected, consisting of the following taxa: Hystricid, *Rhizomys* spp. (?), *Helarctos malayanus*, *Ursus thibetanus* , *Neofelis nebuloso*, Canid (?), *Sus* spp., *Cervus unicolor*, medium-sized Cervids, *Tragulus* spp., *Capricornis sumatraensis*, large-sized Bovids, Rhinocerotid, Cercopithecines and Colobines, *Pongo* sp. and possibly other higher primates. The faunal assemblage resembles those discovered in western Peninsular Malaysia that have been dated from 33-500ky (thousand years). Cave morphology shows the fissure filled with the sediments could have been part of a subterranean stream. The absence of bones may indicate that most of the fossils have gone through a long history of reworking and other taphonomic processes, and only the most resistant dental remains have been preserved.

Abstrak: Enapan gua yang kaya dengan pelbagai tinggalan gigi haiwan vertebrata telah ditemui di Merapoh, Pahang. Sehingga kini, 611 gigi individu telah dikutip, terdiri dari taxa berikut: Hystricid, *Rhizomys* spp. (?), *Helarctos malayanus*, *Ursus thibetanus* , *Neofelis nebuloso*, Canid (?), *Sus* spp., *Cervus unicolor*, Cervids bersaiz sederhana, *Tragulus* spp., *Capricornis sumatraensis*, Bovids bersaiz besar, Rhinocerotid, Cercopithecines dan Colobines, *Pongo* sp. dan kemungkinan primat yang lebih tinggi. Kumpulan fauna ini menyerupai kumpulan yang dijumpai di barat Semenanjung Malaysia yang telah ditentukan umur pada 33-500 ribu tahun. Morfologi gua menunjukkan fisur yang diisi dengan enapan mungkin adalah sebahagian dari aliran air bawah tanah. Ketiadaan tulang menunjukkan kebanyakkan fosil telah mengalami sejarah kerja semula dan proses tafonomi yang lain sehingga hanya tinggalan gigi yang paling tinggi ketahanan terpelihara.

Keywords: Cave fossils, Quaternary vertebrate, cave sediments

INTRODUCTION

Caves often act as vaults for important scientific new discoveries, particularly within the Quaternary context. Numerous Quaternary fossil teeth have been recorded from Peninsular Malaysia, most of them found in cave sediments and in alluvium, discovered mainly in association with past tin mining activities.

One of the first known Quaternary fossil collections from Peninsular Malaysia is from a tin-bearing alluvium cave sediment (possibly from Gunung Datuk, Kinta Valley in Perak) which was reported by Hooijer in 1962. An attempt to re-examine this collection was met with mixed success due to a lack of specific information on the original site and the confusion over where the whole collection was kept (Lim, 2013). Detailed studies of Quaternary vertebrate fossils have been carried out after the discovery of highly rich cave sediments in Gua Badak C (Muhammad & Yeap, 2000) and a few other sites in Batu Caves (Yasamin *et al.*, 2012) in west Peninsular Malaysia, resulting in discoveries of assemblages of faunal remains dated from 33 to 500ky old (Yasamin *et al*., 2013). Other reports mentioned Quaternary *Elephas* fossils (Lim, 2013) and Murinae (Ishlahuda *et al*., 2019). The first report of orangutan fossils (*Pongo* sp.) from 6 sites in Peninsular Malaysia (Lenggong in Perak and Batu Caves in Kuala Lumpur) has extended significantly our knowledge about the past distribution of the genus and its implication on Southeast Asian Quaternary paleoenvironment (Yasamin *et al*., 2013). Yasamin *et al*. (2013) indicated that orangutan were present in Peninsular Malaysia at around 33 to 60ky ago in Batu Caves and at least 500ky in Lenggong.

Systematic studies on Quaternary fossils found in caves within karstic landscapes have been carried out only recently. These previously reported fossil localities are mostly found on the western side of Peninsular Malaysia due to past sampling efforts which focused only on this part of the peninsula. Current research now expands its scope to include caves in the central and eastern part of the peninsular. The first report on Merapoh Quaternary vertebrate fossils described a new geographic record of the Asian Black Bear (*Ursus thibetanus*) from Gua Layang Rusa (Yasamin *et al*., 2014). This initial finding has led to more surveys at the same site.

The Merapoh cave system (Figure 1) is developed in rocks of the Merapoh Limestone, which is stratigraphically part of the Gua Musang Group (Kamal *et al*., 2016). Numerous studies in this area focused on the sedimentology of the Permo-Triassic sequence in the Gua Musang Group (Kamal *et al*., 2016) and recent finding of Early Triassic conodonts believed to be an evidence for Triassic-Permian mass extinction in Peninsular Malaysia (Nelisa *et al*., 2017; 2018). Ongoing research in Merapoh focusses on systematic studies of the Quaternary mammal fossils. The present paper highlights some of the preliminary findings from two significant cave sites, each with high potential in yielding important new discoveries.

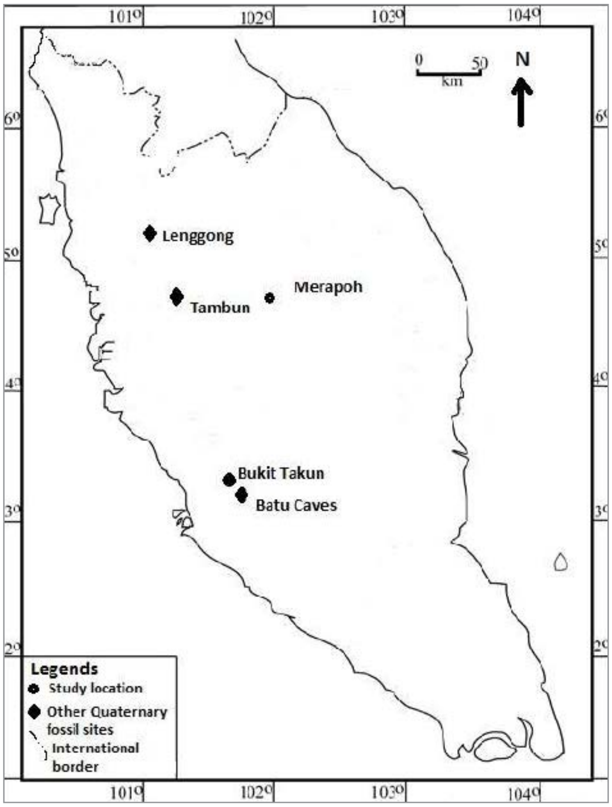

Figure 1: Location of the study area, and other reported Quaternary fossils sites such as Lenggong, Bukit Takun and Batu Caves (Yasamin *et al*., 2013; Muhammad & Yeap, 2000) and Tambun (Hooijer, 1962; Lim, 2013).

MATERIALS AND METHODS

Preliminary studies include observation of the geomorphology of the area using Google Maps in order to recognize karst hills, followed by confirmation in the field. Information about the existence and location of caves was gathered from local guides. A series of brief but detailed surveys of Gua Layang Rusa proved it to be highly productive where numerous vertebrate fossils were preserved and embedded in the cave floor. Breccia embedded on walls in another cave within the same complex, i.e. Gua Layang Mawas, was found to be fossil-bearing as well. Fossil-bearing caves are mapped manually using compass, measuring tapes and a laser range finder and drawn on graft papers. Occurrence of fossil teeth, location, depth and height of the fossiliferous sediments were noted. Other relevant geomorphological features, such as notches, collapsed limestone blocks were also added to the maps. The maps were subsequently drawn digitally using Freehand software (Figure 2).

Fossil samples were either collected from the surface of loose sediments or chiseled out from harder material. These were bagged and labelled individually. Preliminary identifications were carried out using modern zoological reference collections in the Museum of Zoology (University of Malaya). Most samples were segregated at the genus level. Observations of the sediments were carried out based on type of deposition, grain size, potential materials suitability for age determination and degree of cementation.

CAVE DESCRIPTION AND FAUNAL ASSEMBLAGES

On the surface, the limestone forms a number of small hills, typical of a mature tropical karst landscape. A total of 147 caves have been discovered. Several of the hills are located in the vicinity of the main river, Sungai Merapoh. Interpretation of Google Maps satellite imagery of Gunung Layang shows lineaments that are parallel to the current river (Figure 2).

Gua Layang Rusa forms a narrow passage trending northwest-southeast. The explored fissure is 39.5 m long and ends with a descent to another passage, which is unreachable due to a tight connection (Figure 2). Fossils are preserved in loose cave soils on the floor. The soils fill the narrow fissure with height not exceeding 1.2 m. The floor of this cave is located at about 3 m above the ground level. Parts of the soil are covered with 2 mm thick whitish, harder material believed to be coating from subsequent calcite deposition on top of the soil.

Gua Layang Mawas consists of 2 small passages, both trending north-south (Figure 2). The first chamber is about 3 m wide and the highest ceiling is 18 m. Remnants of 50-80 cm thick fossil-bearing sediments are embedded in the 1.2 m high and 13 m long notch on the east side of the cave. These sediments are composed of subangular clasts of up to 0.5 cm long, encased in fine matrix and cemented by calcite.

A total of 611 of numerous vertebrate fossil teeth have been collected from both caves (Table 1). There are roughly identified as Hystricids, *Rhizomys* spp. (?), *Helarctos malayanus*, *Ursus thibetanus* (Figure 3), *Neofelis nebuloso*, Canid (?), *Sus* spp., *Cervus unicolor*, medium-sized Cervids, *Tragulus* spp., *Capricornis sumatraensis*, large-sized Bovids, Rhinocerotid, Cercopithecines and Colobines, *Pongo* sp. (Figure 3).

DISCUSSION

Due to the mature karst landscape, the karst hills are rather small, with short cave passages. Narrow fissures and passages are often part of subterranean drainage system in karst (Audra & Palmer, 2011). In Gua Layang Rusa, based on the cave association of the nearby stream that is currently situated 3m below the cave passage, the

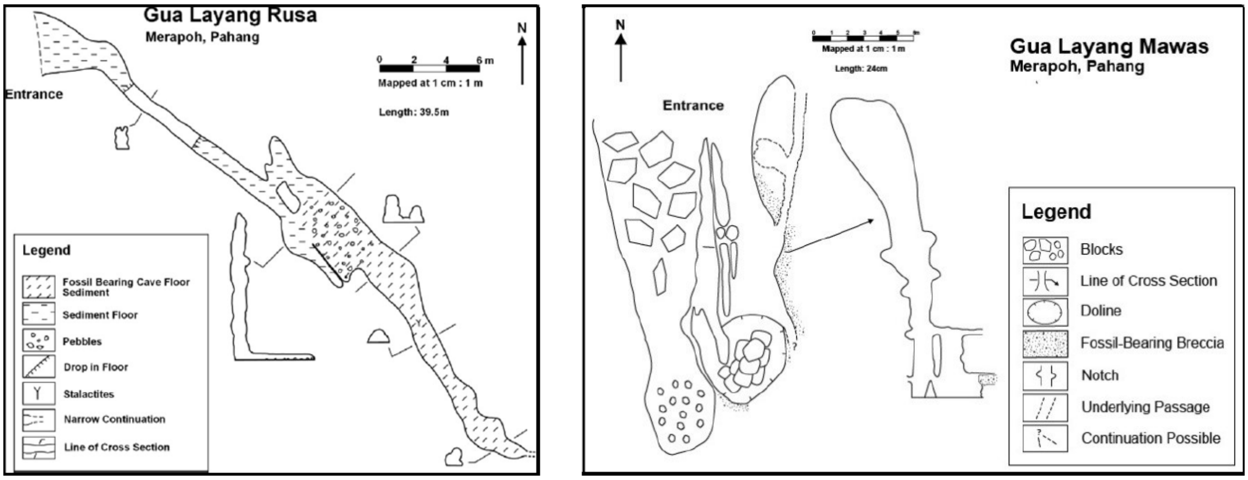

Figure 2: Maps and cross sections of Gua Layang Rusa and Gua Layang Mawas, with the locations of fossil-bearing sediments.

Table 1: Broad-group faunal composition from Layang complex and proportional breakdown of identifiable specimens. Taxon with asterisk denotes new biogeographical record for Peninsular Malaysia.

Taxon	Number of Specimens
Porcupines/ Bamboo Rats (?) Hystricids, *Rhizomys* spp. (?)	108
Bears – Malayan Sun Bear, *Asian Black Bear *Helarctos malayanus*, **Ursus thibetanus*	6
Other carnivores – Clouded Leopard, Wild Dog *Neofelis nebuloso*, Canid (?)	2
Pigs *Sus* spp.	259
Deer/ Mouse-deer/ Serow/ Wild Cattles *Cervus unicolor*, medium-sized Cervids, *Tragulus* spp., *Capricornis sumatraensis*, large-sized Bovids	158
Rhinoceroses *Dicerorhinus/ Rhinoceros*	2
Monkeys Cercopithecines and Colobines	57
***Orangutan** **Pongo* spp.	6
Undetermined	13
Total	**611**

Figure 3: Orangutan lower molar partially exposed through breccia (left) and Asiatic black bear molar (right).

sediments may have been brought into the passage when the stream level was high and flowed along the cave fissure. It is believed that the river system in caves was abandoned as the base level fell, subsequently forming the current drainage flow. Faunal dental remains are preserved in the sediments and subjected to following cave depositional process of secondary calcite deposits on top of the sediments. On the other hand, in Gua Layang Mawas, coarser material in the form of breccia may have been deposited by a flow with higher energy to fill up the passage, followed by an episode of erosion leaving the fossil-bearing breccia preserved on part of the notches in the passage.

These sites have similarities with other cave sites with vertebrate fossils, such as in Lenggong (Muhammad & Yeap, 2000; Yasamin *et al.,* 2013) and Batu Caves (Yasamin *et al*., 2013) in terms of the composition of faunal assemblages. However, Gua Badak C contains numerous bones that are associated with the fossil teeth (Muhammad & Yeap, 2000; Yasamin *et al*., 2013), while a small amount of undetermined bone fragments is present in Gua Layang Rusa, and none from Gua Layang Mawas. This may imply different degrees of reworking between these two sites.

Compared with other similar fossil-bearing Quaternary sites thus far reported from Peninsular Malaysia (Yasamin *et al.,* 2013; Figure 1), the sheer number of identifiable specimens (Table 1) collected from the Merapoh sites is noteworthy. As a whole, the Merapoh sites also yielded a sizeable proportion of non-pig artiodactyls (25.9% of total fauna) which may provide important information on the prevailing environments at the particular geological period during which the fossiliferous sediments were deposited. Given such a high productivity of the sites, it is very likely that further explorations will reveal scientifically interesting and rare representations of Southeast Asian Quaternary mammal fauna. This prediction is partially borne out by the results reported here, namely, the first discovery of orangutan fossils from any area east of the Titiwangsa Main Range within Peninsular Malaysia and additional materials of the Asian Black Bear. Since both species no longer exist in modern-day Peninsular Malaysia (Lekagul & McNeely, 1977; Payne & Francis, 1985; Francis, 2008), the recovery of their fossils from caves in Merapoh has greatly enriched our understanding of their palaeobiogeography. The full potential of the Merapoh sites in yielding meaningful scientific data hinges on effective protection of the caves and continuous financial assistance to support long term multidisciplinary study of the sites.

CONCLUSION

Systematic studies on Quaternary mammal fossils are relatively new in Peninsular Malaysia. Ongoing studies have yielded new biogeographical records of *Pongo spp*. and *Ursus thibetanus*. A short-termed but extensive survey in the Layang complex in Merapoh has proven that these high potential sites may provide more important findings and may answer some pertinent questions such as the evolution of mammals and their adaptation to the habitat changes in this part of Southeast Asia during the Quaternary. Planned future studies will include comprehensive and conclusive investigations on systematic excavation of the sites, various types of absolute dating techniques to facilitate the correlation of the chronology with other important Quaternary paleontology sites in Indomalayan region.

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Landslides in Penang Island, Malaysia: Insights on emerging issues and the role of geoscience

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Abstract: Inceasing demand for housing and infrastructure in Penang Island has forced development to expand into hillslope areas susceptible to geohazards such as landslides. Over the past few years landslide events have resulted in heightened concern for public safety. Development projects, many of which are of high-rise and high-density ventures, is increasingly approved on sensitive land with a history of landslide events. A field trip was conducted on 20 September 2018 involving 24 participants from various institutions to gain insights from selected development projects that are at risk of landslides. The focus was on hillslope areas at Tanjung Bungah and a road construction site at Paya Terubong. The field visit reaffirmed the importance of geoscience for land development, to identify areas susceptible to landslides and provide appropriate information for effective engineering solutions. With the advent of climate change, the country is now experiencing a rise in extreme weather phenomena, which may increase the occurrence of climate-influenced geohazards including landslides. Geoscientists have to take a more active role in reducing risks associated with geohazards, to protect communities from future disasters and ensure sustainable development.

Keywords: Landslide, geohazards, Penang, hill side development, geoscience

Abstrak: *Permintaan yang kian meningkat untuk perumahan dan infrastruktur di Pulau Pinang telah memaksa pembangunan untuk berkembang ke kawasan bukit yang mudah terdedah kepada geobencana seperti tanah runtuh. Sejak beberapa tahun kebelakangan pelbagai peristiwa tanah runtuh telah meningkatkan keprihatinan isu keselamatan awam. Projek-projek pembangunan yang kebanyakannya daripada jenis bertingkat tinggi dan berkepadatan tinggi, semakin diluluskan di tanah yang sensitif serta mempunyai sejarah kejadian tanah runtuh. Pada 20 September 2018 satu lawatan lapangan telah dijalankan melibatkan 24 peserta daripada pelbagai institusi untuk memahami isu risiko tanah runtuh di beberap projek pembangunan terpilih di Pualau Pinang. Tumpuan lawatan tersebut adalah di kawasan bukit di Tanjung Bungah dan tapak pembinaan jalan di Paya Terubong. Lawatan tersebut mengesahkan kepentingan geosains untuk pembangunan tanah, khususnya bagi mengenalpasti kawasan yang terdedah kepada tanah runtuh serta menyediakan maklumat yang sesuai untuk penyelesaian kejuruteraan yang berkesan. Dengan adanya* *perubahan iklim, negara kini mengalami peningkatan fenomena cuaca yang melampau, yang boleh meningkatkan geobencana yang dipengaruhi iklim termasuk tanah runtuh. Ahli geologi perlu mengambil peranan yang lebih aktif dalam mengurangkan risiko yang berkaitan dengan geobencana untuk melindungi masyarakat di masa depan dan memastikan pembangunan mampan.*

Kata kunci: *Tanah runtuh, geobencana, Pulau Pinang, pembangunan bukit, geosains*

INTRODUCTION

Penang Island is located off the coast in northwestern Peninsular Malaysia in the Strait of Malacca. The island comprises an area of approximately 300 km^2 (Figure 1). Despite the small area, Penang Island is home to George Town, the third largest city by population in the country (Department of Statistics Malaysia, 2010). The island has a prominently hilly topography with approximately half of the area comprising steep slopes that start from an elevation as low as 18 m (Institute of Strategic and International Studies and Penang Development Corporation, 1991). In their Structure Plan for 2020, the Penang State Government has recognized highland areas with an elevation above 76 m and slope exceeding 25^o as a sensitive environment where development needs to be restricted (JPBD Pulau Pinang, 2007). As the state continues to grow economically, the associated increase of population has led to higher demand for housing and infrastructure. This has resulted in expansion of development into areas that are susceptible to geohazards, on both low-lying coastal plains as well as on hillsides. Despite the inherent risks, land development within high land and slope areas has continued, especially for residential development, thereby increasing both the likelihood and potential consequences of landslides (Lee & Pradhan, 2006). Between the years of 2008 and 2015, the City Council of Pulau Pinang (MBPP) granted a total of 56 approvals for development on land with elevation above 76 m, many of which are high-rise and high-density projects in high risk areas with history of landslides (JMG, 2017). Within the past few years, a series of unprecedented impacts from landslides in Penang Island have resulted in increasing concern for public safety.

A field trip was organised on 20 September 2018 in conjunction with the Geological Society of Malaysia's 2018 National Geoscience Conference hosted by Universiti Sains Malaysia (USM) and the Department of Mineral and Geoscience Malaysia (JMG). A total of 24 participants from various institutions, primarily young geoscientists supported by the Malaysia Window to Cambridge (MW2C@UKM) programme administered by Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM) and the Asian Network on Climate Science and Technology (ANCST), joined the field trip. Led by Mr. Zamri Ramli of the Department of Mineral and Geoscience (JMG), the fieldtrip was hosted by MBPP to get an overview of pertinent geohazards issues in Penang Island, specifically landslides associated with development projects. In this context, landslides refer to slope failure or mass movement in both natural and disturbed terrain. The focus was on development projects on hillslope areas including the Beverly Hills residential development at Tanjung Bungah and a road construction site at Paya Terubong. The two sites served as examples of many other development projects approved on the sensitive hillslopes of Penang Island. This paper provides a brief account of previous landslides in Penang involving the two sites and highlights some physical impacts of previous incidences to stress the importance of geoscience information to improve the situation for future development.

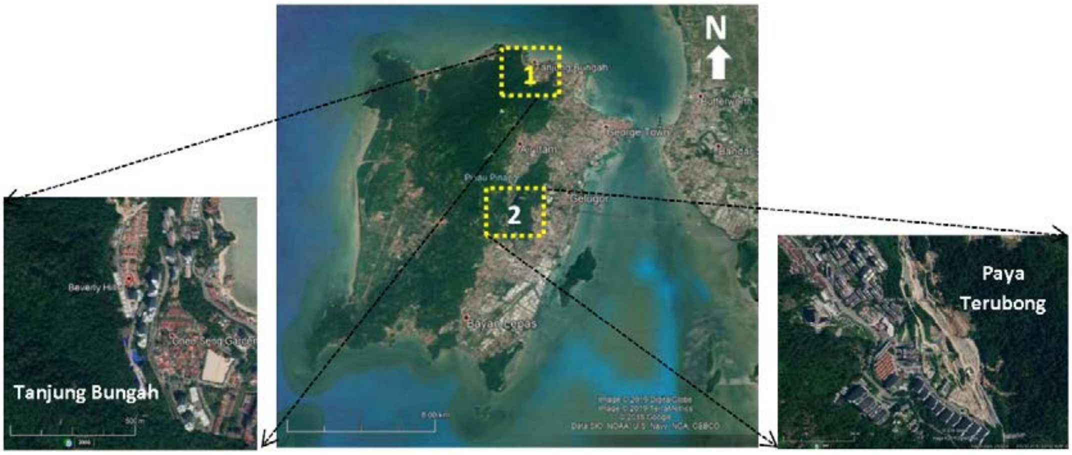

Figure 1: Penang Island - Beverly Hills in Tanjung Bungah and Bukit Kukus in Paya Terubong.

SLOPE FAILURES IN TANJUNG BUNGAH

The first site visit was to a residential project built on a hillside at Beverly Hills, Tanjung Bungah comprising 20 units of 3-storey semi-detached houses. The slope is located in close proximity to the Sg. Siru Fault and is covered by soil from weathered granite of grade V (sandy silt) to VI (clayey silt) underlain by medium-coarse grained granite-biotite bedrock (Figure 2) (JMG, 2017). The development project was approved by the City Council in 2007 and completed at the end of 2017. On 5 November 2017, while the project was still awaiting the approval for a Certificate of Completion and Compliance (CCC), the retaining wall including the road structures above it suddenly collapsed in front of the house units.

Leading up to the failure of the slope structures, the area had experienced heavy rainfall from the evening before until the next morning, during which ground movements were detected by the residents. The rainfall event, which exceeded 250 mm within 24 hours, was considered quite extreme. In the construction, the natural seasonal stream flow from the hillside was channeled to a perimeter drain constructed at the site. However during the extreme rainfall, surface runoff exceeded the capacity of the drainage system, leading to overflow that seeped through the bottom of the filled embankment (75 m long, 25 m wide and 12 m high) that supported the road platform (JMG, 2017). As the fill material for the road platform was highly permeable (sandy silt and clayey silt), this led to saturation and increased pore water pressure in the embankment and resulted in the failure of its retaining wall and rupturing of the road platform (JMG, 2017).

Geological inputs are of crucial importance in understanding slope stability and are therefore needed for safe hillside development. Prior to any slope development, geological input is required to ascertain suitability and to provide proper guideline for the Earthwork Plan Procedures that fit the sensitivity of the environment coupled with 'Good Engineering Practice' (JMG, 2017). Once a hillside development project is approved, the local authority shall appoint competent consultants to monitor the developer's adherence to the guidelines during the construction process. A Geological Terrain Map developed by the JMG shows that the Beverly Hills site is located on the boundary between land that is categorised as Class III (low suitability) and Class IV (unfavorable for development due to the extreme geotechnical constraints). In the landslide event at the Beverly Hills development

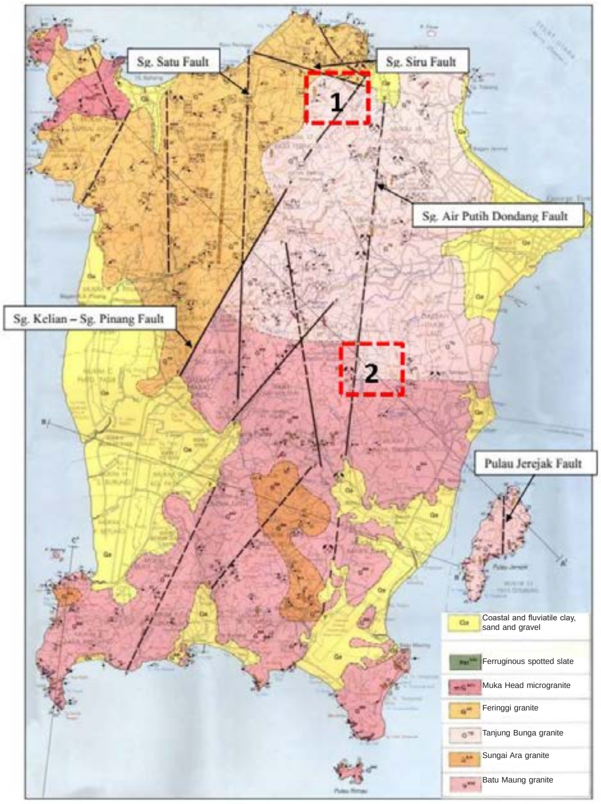

Figure 2: Geological Map of Penang Island; Site 1 (Beverly Hills) and Site 2 (Paya Terubong). [Source: JMG, 2006]

Figure 3: The front view of the collapsed retaining wall and road structures at Beverly Hills in Tanjung Bungah, Penang.

Figure 4: During the field trip, Mr. Zamli Ramli from JMG demonstrated the use of a drone for aerial site inspection of the slope condition at Beverly Hills.

site, the compliance of the earthwork conducted by the developer to existing guidelines was an issue. A historical topography map of the area revealed that the failed portion was built up on an old river channel. The design of the drainage systems reportedly did not consider worst case scenario of surface water flow during extreme rainfall events (JMG, 2017).

SLOPE FAILURES IN PAYA TERUBONG

Paya Terubong is located on the southeastern half of Penang Island. The geology forms part of the South Penang Pluton (SPP) and comprises coarse-grained and medium-grained porphyritic muscovite-biotite granite (JMG, 2006). The granite is very deeply weathered and highly variable in its geotechnical properties, with very large core stones of relatively intact granite set within highly weathered to completely weathered material. The Paya Terubong valley also marks the position of the north-south oriented Central Penang Fault Zone (Figure 2). The weathering and presence of the fault zone have both contributed to the occurrence of several landslide events in the recent past (JMG, 2006). One of the examples was on 28 November 1998, when three huge boulders (including one about the size of a double-storey house) crashed down a 30 metre high cliff, stopping just 10 m from the nearest block of residential apartments. That particular event was attributed to rock-blasting activity that was being carried out to expand the area for development. The blasting sent flying rock fragments that damaged the roof of some houses around the area, but the associated vibrations may have also triggered movement within the unstable slope. Hill cutting activity that extends above the 76 m contour, with vegetation being removed leaves steep slopes bare and exposed to direct soil erosion and gullying. In the event of a subsequent heavy rainfall, the eroded soil could turn into a mudflow that washes down to the roads and house compounds, silt up flood mitigation ponds, and increase the likelihood of flash floods downstream.

Figure 4. A view of a portion of the hillside road construction on highly unstable and steep slopes at Bukit Kukus, Paya Terubong.

A recent concern was highlighted in the area of Bukit Kukus regarding a high-density development project of four residential tower blocks of over 40 storeys, which was approved in December 2015 as well as a project for paired-road construction built directly across a steep slope, which is part of the new development in the area. In contrast to the site visit to Beverly Hills, which inspected an incident that had already occurred, the objective of the field trip to the Bukit Kukus site at Paya Terubong was to examine a development project site under construction, where there are potential future risks. The main issues discussed during the site visit were related to the risk of disturbing the stability of the slope, the adequacy of overall planning, and the extent to which the project was being developed with appropriate geoscience inputs. A month after the field trip, a landslide occurred at the Bukit Kukus construction site on 19 October 2018 claiming nine lives and injuring three others, most of whom were construction workers at the site (Bernama, 2018a). Following the incident, charges were made by the Penang Occupational Safety and Health Department against the project director for failing to ensure the safety, health and welfare at work for the employees, while the contractor was charged for failing to adhere to safe working procedures (Kaur, 2019). Similar to the case at Beverly Hills, the incident occurred following a heavy rainfall event across the state, from the afternoon two days before the event to noon the day before (Bernama, 2018b). Whilst heavy rainfall is often a key factor in triggering landslide events, along with steep slopes and inherently unstable soils, these are all conditions that occur frequently in Malaysia and need to be factored into the design of any construction work where slopes are modified or protective vegetation is removed.

THE ROLE OF GEOSCIENTISTS IN REDUCING RISK OF GEOHAZARDS

Previous landslide incidents in Penang Island have led to unnecessary loss of lives and properties, as well as environmental damage. Unless greater attention is given to recognising and dealing with the potential risks posed by geohazards such as landslides, continued development activities of a similar nature will continue to endanger the lives of the construction workers and public road users as well as compromise the safety of residents. Whilst the geohazards themselves may be seen as being part of the natural process of long-term slope development, individual slope failure events can, to a greater or lesser extent, be influenced by human activities. Inappropriate land development and inadequate engineering design can disturb the fragile stability of the hillslope areas and thereby increase the likelihood of instability (JMG, 2017). The examples seen in Penang Island should therefore be a lesson to other cities in Malaysia, which are under constant pressure for land development. With the advent of climate change, the world is now experiencing a rise in extreme weather phenomena, which may increase the occurrence of climate-influenced geohazards such as landslides. In Malaysia, climate change is expected to result in a rising trend of annual mean temperature, occurrences of extreme weather events and increased rainfall variability (Tang, 2019). Furthermore, mean sea level is projected to rise until the end of the 21st century. Increasing rainfall variability and extremes may exacerbate the risks of landslides, by increasing the frequency, magnitude and spatial extent of the hazard. To continue with business as usual will only result in similar or worse consequences. Therefore, it becomes necessary to take into account climate change factors in development of areas that are suceptible to geohazards, particularly landslides in hillslope areas.

To improve the situation and protect communities from future disasters, both structural and non-structural approaches need to be adopted to reduce the risk of the geohazards. Whether coming from academic or industry background, geoscientists have important roles to play in both of the approaches by advancing and mainstreaming the understanding of local geohazards and taking more active roles in enforcing better policy and land development control guidelines for high risk areas, as well as ensuring proper implementation of stipulated guidelines. At present, slope protection and monitoring for land development in Malaysia is only formed in administrative measures through provision of guidelines, without specific law to enforce proper implementation of the guidelines throughout planning, during and after any slope development project. Active participation through stakeholders engagement is crucial (Too *et al.*, 2011). To support local authorities forming clearer and more stringent policies and guidelines for development projects in sensitive geological settings, it is necessary to utilise robust and updated knowledge on geohazards in the area and to ensure that this knowledge is translated into better practices on the ground. Whilst avoiding development on unstable hillslopes may be the only way of avoiding problems altogether, the pressure for development may be such that this is not always a practical solution. Where development is necessary, geoscientists can help the local authorities to make informed-decisions before granting permission for new projects by providing geohazards information such as landslide susceptibility maps. Such maps will provide information on the presence of potential hazards of an area. This will be a useful input for site planners and engineers in developing detailed design of mitigation measures for specific hazards. In order for such information to be practical and relevant to others from different fields, it is important for geoscientists to develop skills to communicate in ways that planners, engineers and other end-users are able to understand. Geoscientists can also provide other empirical inputs, including rainfall threshold calculations for landslides and floods, based on past events with appropriate modelling techniques, which can then be used to assist with evacuation and emergency response planning. Such inputs should also be continually updated to be in line with local changes in land use and variability of climate conditions in order for them to be as reliable as possible.

For non-structural approaches, adopting effective governance is crucial to mobilize community resilience towards landslide. Bearing the responsibility of having the technical knowledge, geoscientists have important role to play in building community resilience from landslide disasters through network governance for sustainability. Geoscientists have the power to change the game by being more assertive in conveying geohazards information to those who need to use it, including local authorities, developers, and property owners or communities. In this age of information, disseminating geohazards information to a wider audience, including members of the public, is now easily achieved, but needs to be undertaken carefully and responsibly so that people can understand and act upon the information without over-reacting. Through better knowledge, communities can be empowered and also able to cooperate and be better prepared in efforts to reduce landslide risks. By being more transparent, buyers can make informed decisions in purchasing properties in high risk areas and developers are more likely to be compelled to be more responsible in following stipulated development guidelines so that risks are reduced. Having informed buyers (communities) may also help developers as they (the communities and property buyers) will more readily appreciate the need for mitigation and maintenance works, and be willing to share in the costs involved, if they decide to buy. In terms of overall governance, collective solutions are required, whereby geoscientists are able to work in synergy with communities and the public at large and able to pass on important geohazards information without causing undue panic or stir conflicts.

Overcoming the various challenges to be faced in dealing with future development requires both innovative and collective solutions. In order to be able to make the best use of their specialist knowledge on geohazards, geoscientists need to be able to work in synergy with other professionals from various fields including engineers, economists, local planners, social scientists, among others, towards the betterment of the people and environment. Communication is key. Each of these points of contact will have different requirements in the way in which geohazard information is passed-on and utilised. Communication will be at a technical level between scientists and engineers, but very different approaches are needed to convey essential information to non-specialists who nevertheless need to understand the issues involved so that they can act upon them appropriately. These range from planners, local government officials and insurance companies through to members of the public at large.

By taking more active role, whilst recognising the need for appropriate liaison and communication, geoscientists have a lot to offer in reducing risks associated with geohazards and in protecting communities from future disasters, to ensure that development of the country will be more sustainable.

CONCLUDING REMARKS

Inceasing demand for housing and infrastructure in Penang Island has forced development to expand into hillslope areas susceptible to geohazards such as landslides. Between 2008 and 2015, the City Council of Pulau Pinang (MBPP) granted a total of 56 approvals for development projects on land with elevation above 76 m, many of which are high-rise and high-density projects, in areas with a history of landslide events. The field trip to the hillslope areas at Tanjung Bungah and a road construction site at Paya Terubong in Penang Island highlighted several critical aspects. Development projects in hillslope areas need to take into account rainfall extremes, topography, subsurface conditions, slope stability and other factors in the design of any construction work, especially where protective vegetation is removed. In addition, all development projects should be in compliance with existing guidelines, especially at the earthwork stage. The visit revealed the importance of geoscience for land development, to identify areas susceptible to landslides and provide appropriate information for effective engineering solutions.

Climate change is expected to increase rainfall variability and extremes and exacerbate the risks of landslides, by increasing the frequency, magnitude and spatial extent of the hazard. It is important to take into account climate change factors in development of areas that are suceptible to geohazards, particularly landslides in hillslope areas. This is especially critical for Penang Island and other cities in Malaysia, which are under constant pressure for land development and require expansion into sensitive hillslope areas. In this context, the specialist knowledge of geoscientists on geohazards and risk reduction should be harnessed and communicated effectively to other professionals including engineers and local planners as well as the community, among others. Geoscientists also have to take a more active role and acknowledge the need for appropriate liaison and communication. This will enable the geoscience profession to attain its full potential in reducing risks associated with geohazards, for protecting communities from future disasters and ensuring that development of the country will be more sustainable.

Figure 5: Dato' Yunus Abdul Razak from SEADPRI-UKM and Mr. Zamri Ramli from JMG presented a token of appreciation to the representative of MBPP for hosting the field trip.

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Geoscience capability development in the petroleum industry: Challenges and opportunities

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Abstract: Geoscience capability development poses some difficult challenges to the petroleum industry, and for a national oil company like PETRONAS, the ultimate challenge (and responsibility) is to develop "local" technical expertise, particularly highly skilled geoscientists. In this paper, the author shares his personal perspective on some of these challenges, which include (1) Inadequate university geoscience curriculum, which affected the "readiness" of geoscience graduates entering the job market. (2) Over-emphasis on "manual" skills (including software skills) in internal training courses while the importance self-learning and transfer of tacit knowledge is neglected. (3) Poor interaction and cooperation between the industry, academia and the public, which stifles open dissemination of geoscience information and knowledge. (4) Lack of an open data system, which is required to encourage a vibrant culture of geoscientific research. The PETRONAS-led Malaysian oil/gas industry tried to overcome these challenges by providing employees comprehensive training programmes to accelerate capability development. The national oil company also initiated the M.Sc. petroleum geoscience course at its university to enhance the capability of young geoscientists, but some of these efforts may have fallen short of the desired outcomes. There are, however, opportunities for improvements if those critical challenges are addressed in a holistic manner, involving all stakeholders (government, academia, and industry) in a collaborative way. Petroleum geoscience capability development should be treated as a national objective, not just the responsibility of PETRONAS or oil companies. In addressing the challenges, opportunities include (1) enhancing the university geoscience curriculum, and setting the minimum entry requirement to industry at M.Sc. level. (2) strengthening the students understanding of the fundamentals of the geosciences, with more emphasis of geoscience thinking in four dimensions (3 physical and 1 temporal) while, of course, not neglecting important software skills. (3) encouraging close interactions and collaborations between industry and academia through open sharing of geoscience information and knowledge. These initiatives would create a win-win situation for industry and academia by nurturing a vibrant research culture to create knowledge and new ideas for exploration and development of petroleum resources.

INTRODUCTION

After decades of exploration of the continental shelf, the petroleum-producing basins of Malaysia are rapidly approaching maturity, with diminishing volumes of resource addition. A "creaming curve" for the Malaysian basins shows the typical trend of declining incremental reserves as the basin reaches exploration maturity, with the exception of intermittent steps due to discovery of new plays (Figure 1). The long-term imminent decline could be arrested (thereby extending the basin life) by the testing and discovery of new plays in old and new basins. This requires qualified and competent geoscientists to generate new ideas and play concepts to stimulate exploration and discovery in mature basins. The survival of the domestic exploration and production business, therefore, depends upon the industry's ability to develop and sustain a highly skilled workforce.

Skill or capability development poses many challenges for the industry, and this is particularly critical for the national oil company, PETRONAS, which has a high dependence on expatriate technical workforce, including geoscientists. This problem was exacerbated by the "great crew change" – the effect of the departure of experienced workforce during the downturn in the industry during the

[1] Disclaimer: The author currently serves as advisor to the Malaysian Continental Shelf Project under the National Security Council, Prime Minister's Office. The views expressed in this paper, however, are solely of the author's, in his personal capacity, and do not necessarily reflect the views of any organizations with which he is/was affiliated.

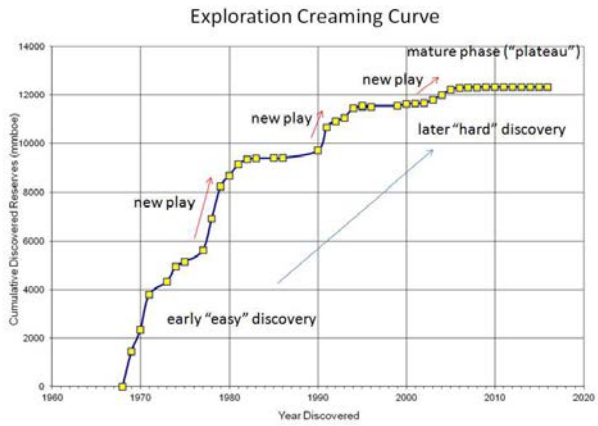

Figure 1: A basin will attain maturity, with no further reserve addition, unless a new play is found. Based on actual data from a Malaysian sedimentary basin (compiled from IHS Energy).

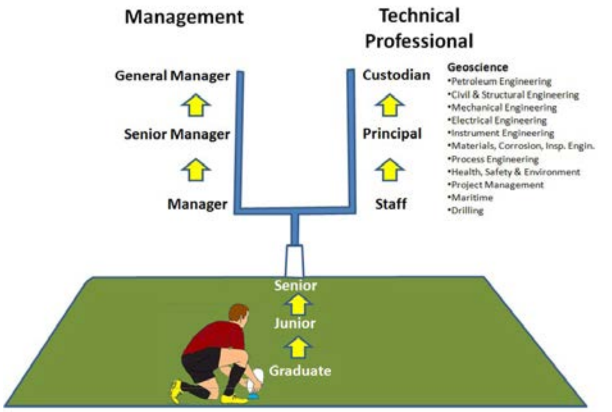

Figure 2: A dual career progression allows geoscientist to advance without necessarily having to become a manager.

1980s and 1990s. While this situation may be perceived as being "normal", there should be a concerted effort by a national oil company to "grow its own timber". But for some time, the national oil industry has been faced with not just a shortage of geoscience graduates but also the low "preparedness" or "readiness" of those graduates who, upon entry to the industry, take longer than "expected time" to develop into competent geoscience professionals. There may have been a disconnect between the expectations of the industry and the university curriculum, which could and should be addressed by stakeholders in government, academia and industry in a holistic manner.

In this paper, the author shares a personal perspective, based on his experience working for over 30 years in the Malaysian national oil company, PETRONAS. The paper discusses some of the key challenges in developing geoscience capabilities in the petroleum industry, and identifies some of the causes as well as the opportunities for remedial actions.

GEOSCIENCE "SKILL" DEVELOPMENT

In the late 1990s, PETRONAS developed internally a capability development programme whereby technical personnel were assigned to a specific "technical skill group" based on their bachelor's degree qualification (e.g., B.Sc. in Geoscience or Petroleum Engineering). The programme was regarded as a "success story" in the industry as the experience was shared with the world at industry conferences by PETRONAS representatives (Juniwati, 2012; Raiha Azni, 2013). In this scheme, a fresh graduate entering employment at the company would automatically belong to one of the technical or business skill groups, and will remain there throughout his/her career (Figure 2). In theory, switching from one skill group to another is not possible, although in practice there had been rare exceptions, e.g., people leaving technical skill groups to become managers.

The Geoscience skill group was the first to implement the skill development programme which, to this day, requires all geoscientists to undergo a common training relevant to their designated functions. A geologist, for example, would be put on a training programme that includes learning basic geology topics (which unfortunately are called "technologies", Table 1[2]) such as stratigraphy, sedimentology, geological well-log analysis, basin evolution, geochemistry, reservoir geology, laboratory techniques, and field geology (Figure 3). The intention was to provide the same basic "skills" to all geoscientists so that they can be easily assigned anywhere within the organization, i.e. highly mobile workforce. Initially, the geosciences skill groups had only two major "disciplines": geology and geophysics. After some time, it was realised that many geoscience graduates lack the most basic geoscience skill/knowledge that they should have acquired during their time at university. To rectify this problem, some fundamental skill elements were added to the programme to help fill the knowledge gaps and enhance their understanding. Most of the geology "Level 1" (or elementary) subjects were essentially "refresher" courses for the geologists but could be very important to some geophysicists. This has often resulted in the unintended effect of increasing the breadth of

[2] The use of the term "technology" in referring to a certain "skill" or "skill-set" (which in practice refers to "topics" in geosciences") and its classification into "base", "key", "pacing" and "emerging" when applied to the geosciences is fraught with difficulties. For example, is stratigraphy a "base" or "key" technology? Also, what is deemed an "emerging" technology in PETRONAS could be a common "base" technology globally.

Table 1: Inventory of basin analysis "technologies", which are essentially "topics" or sub-disciplines of geoscience, categorised according to Arthur D Little's classification of technology stages. Note that "emerging" technologies are not strictly emerging (new) globally but only internally in PETRONAS.

Base	Key	Pacing	Emerging
Sedimentary Basins & Play Analysis	Plate Tectonics and Geodynamics	Geographic Information Systems	Ground Penetrating Radar
Seismic Interpretation & Mapping	Sedimentary basin evolution	Unconventional Hydrocarbons	Fission Track Analysis
Stratigraphy & Sedimentology	Seismic and sequence stratigraphy	Chemostratigraphy	Geological CO2 Sequestration
Structural Geology	Palaeogeographic reconstruction		
Petroleum Systems Analysis	Geochemistry (Source Rock and Hydrocarbons)		
Well Log Interpretation	Petroleum Resource & Risk Assessment		
Well-site Geology	Gravity & Magnetics		
E&P Business	Seismic Attributes		
	Geopressure Analysis		
	Remote sensing methods		

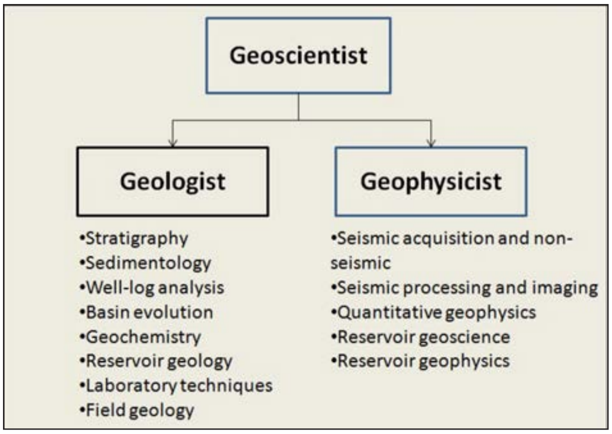

Figure 3: In the early implementation of the capability development programme, all geoscientists were categorised as either a geologist or geophysicist. The basic courses they had to go through were predetermined as shown in these lists.

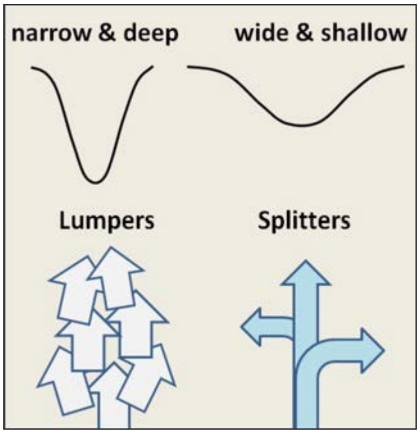

Figure 4: Designing a skill development programme often becomes a debate between the "lumpers" and "splitters", and whether a "skill" is defined as being too broad and shallow or too narrow and deep.

subjects while "watering down" the content ("shallow" or superficial treatment) (Figure 4).

The programme was modified throughout the years in line with the changing business priorities and the competing needs of the "generalists" on the one hand, and the "specialists" on the other. Yet, the poor understanding of basic concepts in geoscience remained. Often, the debate among the skill group committee members designing and overseeing the programme are the age-old argument between the "lumpers" and the "splitters" (Figure 4), and if a balance should be struck between developing to many generalists as opposed to specialists (Figure 5).

The creation of a specialist group was a necessary step in developing the institutional capability of the organisation. In 1999/2000, a dual career progression (Figure 2) was introduced to enable technical employees to

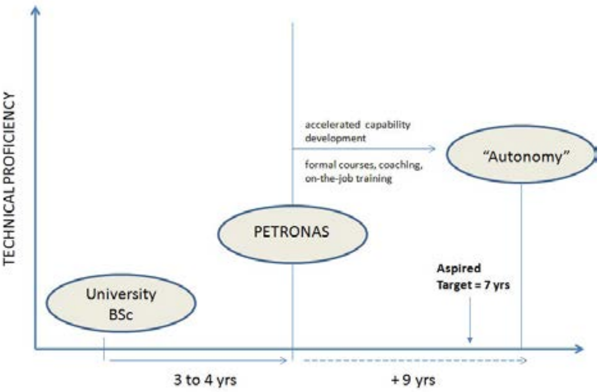

Figure 5: It was estimated that a fresh graduate takes an average of 9 years to reach time to "autonomy" (i.e. perform their duties without supervision). The accelerated capability development programme was initially designed to reduce that time to 7 years.

choose a career path along either a managerial or technical ladder, the difference being that on the technical ladder, the career progression is "competency-based" rather than "time-based". The scheme enabled technical staff, who would otherwise compete for a limited number of managerial positions, to climb the technical ladder and be promoted based on their technical competencies rather than seniority. With increasing levels of competency, senior geoscientists (generally after 7 to 10 years of experience) were therefore potentially able to progress from "staff" to "principal" to "custodian"[3] geoscientist over a period of 15 to 20 years, alongside their peers in the equivalent managerial ranks (manager, senior manager, general manager). To some extent, this scheme has helped to reduce the promotional bottleneck at the senior geoscientist level but competency assessments, whereby geoscientists are "tested" with an inventory of 20-plus "skills" by an assessor in the presence of a supervisor, can often be a daunting experience. It was also realized that it took more than 10 years for a fresh graduate geoscientist to be eligible for promotion to "staff". Thus, in 2009, a programme was introduced to accelerate the development of technical staff, i.e. to reduce the time a staff to reach a competency level that enables him/her to be able to function without supervision, the so-called "time to autonomy", from 10 to 7 years. After several cycles of assessments, it became evident that the average time to autonomy is 9 years (Figure 5). This was also reported by Juniwati (2012).

The "accelerated competency development programme", however, did not address the root cause of the problem, i.e. the "readiness" of geoscience graduates for entry into the industry. In my own experience as an assessor, many graduates lack the basic geosciences knowledge they were supposed to learn at university, making them less effective in learning the more advanced topics. Unfortunately, the training programmes put too much emphasis on workflows and software skills (e.g., computer-based seismic interpretation), creating the so-called "Nintendo geologists". By adopting a "cook-book" approach to geological analysis, important skills such as self-learning, reading, thinking and scientific analysis were neglected. Perhaps, the term "skill" or "technology" is being confused as tools and techniques which are easier to teach and learn while the more intangible "knowledge" is often ignored (Figure 6). Whereas assessing software skills maybe straight-forward (e.g. by asking for "evidence" of having user experience), assessing the level of intangible knowledge is more subjective and highly dependent on the competency of the assessor as much as on the competency of the assessee. Over time, the annual competency assessments have become what some ex-colleagues have called a "box-ticking exercise", whereby people sign up to the courses not because they want to learn something but to fulfill a human resource (HR) requirement.

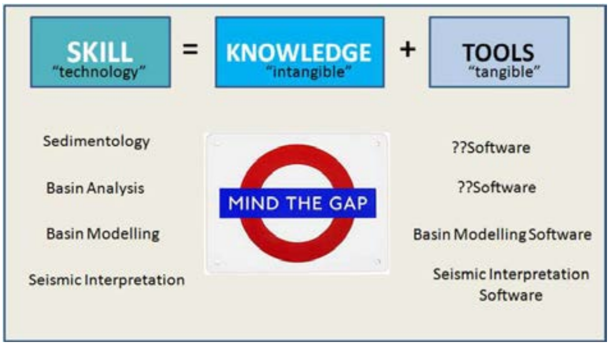

Figure 6: "Skill" is often understood to include "knowledge" and "tools" or techniques. Between skill and tools, there is a big "Knowledge Gap". While tools and techniques are tangible components (e.g. software, methodology, work processes), knowledge are intangibles which are more difficult to evaluate.

BASIN "SKILLS"

Overall, the skill development programme, and in particular, the technical professional career ladder, has managed to produce a cadre of geoscience specialists in e.g., sedimentologist, geochemist, biostratigrapher, seismic interpreter, reservoir modeller, sequence stratigrapher, and basin modeller (Figure 7). These specialist roles are

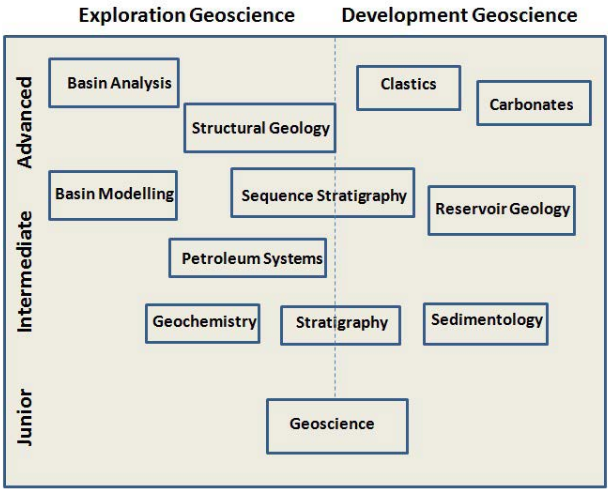

Figure 7: Geoscience specialists fall into two main categories: exploration and development. In each, there are a number of "specialisations" based on major subdisciplines.

[3] The curious usage of the term "custodian", which normally means "a person with responsibility for protecting or taking care of something or keeping something in good condition" is used for the highest-ranked technical professional in the company, equivalent in rank to a "general manager".

required for specific functions within the organization but their number is relatively small compared to the "generic" categories of geoscientists in the project or operational environments, e.g. asset teams, exploration projects. Thus, at some point in their careers, geoscientists would have to decide what path to choose: specialist or generalist (Figure 8). As it turned out, over time most geoscientists tend to opt out of the technical professional ladder altogether, thanks to the introduction of the so-called "technical manager" (Figure 9) which required passing only 50% of the technical skills inventory. In other words, the technical manager was only required to learn half of what the technical professional knew. It was no surprise that most geoscientist chose the path of least resistance, and abandoned any aspiration to be a technical professional. The technical manager scheme effectively managed to "kill" the technical professional ladder.

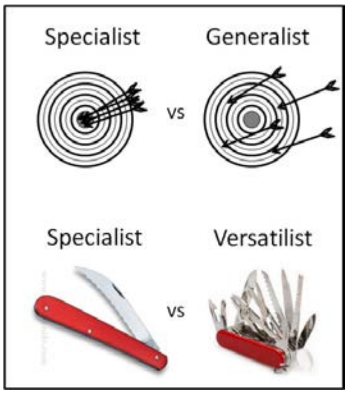

Figure 8: A geoscientist is often confronted with the dilemma: "should I be a Specialist or Generalist?". One might argue, even the Specialist is not versatile enough to handle the demands of the job. To balance between these competing traits is a major challenge.

Looking at the specialist ladder (Figure 7), by these job titles alone, it could be argued that not all specialists are equal, in the sense that the "breadth" and "depth" to which the relevant skills are treated in each area of specialization are not the same (e.g. compare sedimentologist vs reservoir modeller, or seismic interpreter vs sequence stratigrapher). Hence, geoscientists tended to opt for the "narrowest" and "shallowest" specialisation. As a result, one type of specialist failed to attract enough young aspirants, i.e. "basin" or "regional" geologist (Figure 7), whose role is to integrate the various sub-disciplines and provide the much needed 'geological' meaning to the interpretations.

Although there are textbooks and courses on basin analysis, there is no workflow or "recipe" that can be taught in a classroom. A basin geologist must, to some degree, be familiar with all the other specialised subjects, which could pose a serious problem if graduates lack the basic understanding of geoscience to begin with. If for the same salary and career opportunity, the reading list of a basin geologist (Table 1), is probably 10 times longer than, say, a seismic interpreter's, it is no surprise many geoscientists would rather "specialize" in a narrow field. Perhaps it is worth considering giving a better career incentive for basin geologists.

One could draw an analogy from the "artist vs artisan" debate. While an "artisan" is essentially a manual worker who is highly skilled at his "craft" and creates a product that is functional (e.g. seismic interpretation, or a basin model), the "artist" creates a product that is wider in both context and purpose, beyond its physical state (e.g. what the basin model means to play risk, or the implication of a seismic interpretation result to the tectonic framework). These "intangible" outcomes provide the geological story or "meaning" to an otherwise mechanical exercise of interpreting seismic or building basin models. Put in

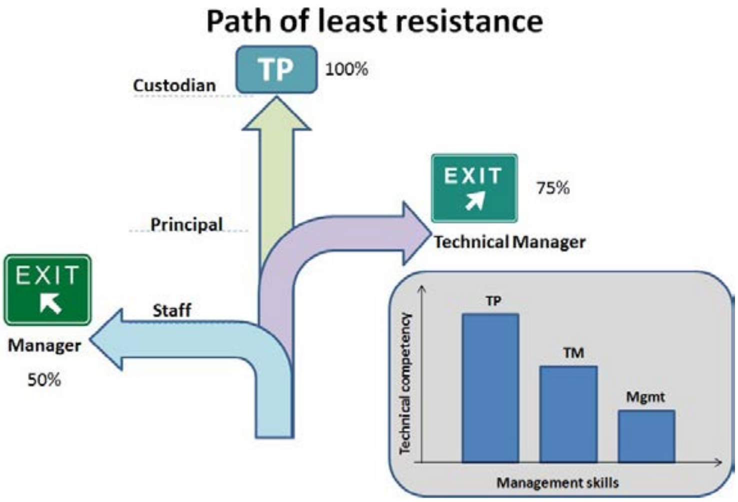

Figure 9: Path of least resistance: after finding it hard to fulfil the strict TP requirements, allowing people to exit to become managers had the unintended effect of undermining the TPCP scheme itself.

another way, there is a difference between an architect who build houses, and the highly skilled "craftsmen" hired to actually build the house (e.g., bricklayer, plumber, electrician). Certainly, a few more "architects" are needed among the many "craftsmen".

When this problem finally caught the attention of the top management, it was decided that a special programme was needed to groom a team of "basin experts". Participants were hand-picked from among the high-performers to undergo this one-year intensive programme on basin analysis, which after two years (2015-16) managed to produce about thirty potential "experts" before it was discontinued. I could envisage the lack of "basin experts" will continue for a foreseeable future if the problem is not addressed immediately

THE ROLE OF THE UNIVERSITIES

The supply of geoscience graduates is no longer a problem, as there are now many local universities (including University Malaya, Universiti Kebangsaan Malaysia, Universiti Sains Malaysia, Universiti Malaysia Sabah, Universiti Malaysia Kelantan, Universiti Malaysia Terengganu, Universiti Teknologi Petronas, Curtin University Sarawak) offering undergraduate geoscience courses. There may even be a short-term oversupply of geoscience graduates in the job market. With stiffer competition for jobs, it is important to ensure that the high standards in geoscience teaching and curriculum are achieved and maintained.

One of the root causes for the longer time to autonomy among geoscience graduates mentioned earlier is the university geoscience curriculum, which was shortened in 1996/97[4] from 4 to 3 years duration, forcing geology departments to cram as many modules as possible into a 3-year programme, often at the expense of important basic subjects. As a result, students were less grounded in the basics upon graduation. In 2007 an "inaugural" geoscience colloquium was organized to "develop action plans towards ensuring the supply of competent, qualified and intellectually ready geoscience graduates to meet industry challenges and preparedness for the global market" (Figure 10). Representatives from the Ministry of Education, the petroleum industry, and geoscience departments in local universities attended the event and agreed on key recommendations to improve geoscience education. Most importantly, it was recommended that the universities revert to the 4-year geoscience degree programme. Unfortunately, there had been no follow-up on that important resolution and the "inaugural" colloquium became the last. It is encouraging to note that

Figure 10: Inaugural geoscience colloquium 2007, a congregation of stakeholders in government, academia and industry to find ways to improve national geoscience curriculum. Will it be the last?

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4 This policy change coincided with the appointment of the new minister of education in 1995 and opening up of new private colleges and universities in the drive for Malaysia to be an 'education hub'. Unfortunately, it also coincided with the Asian Currency Crisis and a downturn in the petroleum industry.

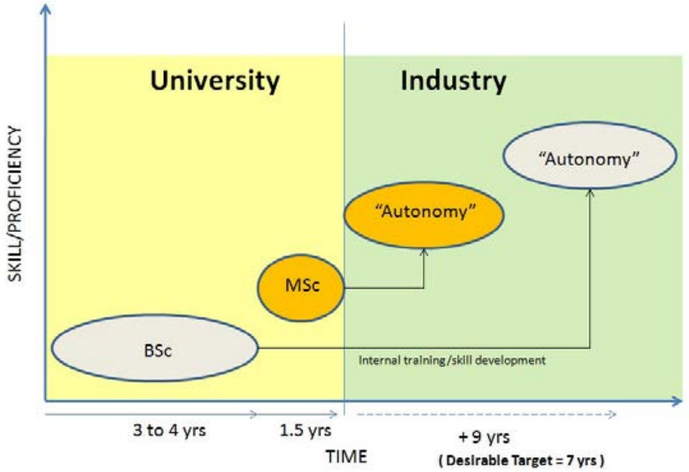

Figure 11: Encouraging students to extend their studies to MSc level would greatly reduced the time to autonomy when entering employment.

most geoscience degrees on offer now have reverted to at least 3.5 if not 4 years, but the legacy of that period is being felt to this day.

POSTGRADUATE QUALIFICATION

I have long argued that an M.Sc. degree should be made the minimum entry requirement for geoscientists in the petroleum industry in Malaysia. Besides providing some industry-related "skills" to increase "readiness" for employment, the M.Sc. course would help reduce, if not eliminate, the time and financial burden on oil companies to fill the knowledge gaps left by the universities at the BSc level (Figure 11).

Recognising the benefits of post-graduate training to geoscientists, in 2005/6 Universiti Teknologi PETRONAS (UTP) launched its M.Sc. in Petroleum Geoscience programme, with the understanding that its mother company will feed (and fund) a steady stream of junior geoscientists to undertake an intensive 18-month on-campus programme. Unfortunately, this enthusiasm did not last long, for after the successful completion of the first batch of 18 students and a change in the management in PETRONAS, business needs took priority over capability development and forced UTP to source for students and funding elsewhere. This was unfortunate because the UTP M.Sc. programme gave an opportunity for PETRONAS/UTP to set the benchmark for post-graduate entry into the industry, and at the same time reducing the period to "autonomy" and the burden of internal training by staff (Figure 11).

Similar steps were also taken by the two oldest geology departments at Universiti Malaya and Universiti Kebangsaan Malaysia which, around the same time in 2005/06, started their own M.Sc. programmes (Abdullah, 2012), thus creating a competition for graduate students who were already in short supply. Nowadays, many oil company employees themselves realize that the B.Sc. degree is inadequate and having a post-graduate training would be an advantage in their career. Many have enrolled in the M.Sc. courses as part-time students.

As the largest employer of geoscientists in the country, the national oil company could take the lead to influence the industry to require a minimum M.Sc. degree for intake into industry. The potential benefits would be immense, as it will encourage students to stay for one or two years more to pursue a Master's course or even go on to do a Ph.D., as is the normal practice in many developed countries, before seeking employment (Figure 11). However, a strong funding system for research students needs to be in place in order for this to happen. With strong financial and data support from the petroleum industry, this would encourage more geoscience research activities that will ultimately benefit the petroleum industry and the nation as a whole.

THE ROLE OF THE GEOLOGICAL SOCIETY

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

Scientific societies, such as the Geological Society of Malaysia (GSM), play an important role in bridging the knowledge gap between industry and the public (especially academia) (Figure 12). For 36 years (1977-2013), the GSM managed to fulfill that role by collaborating with PETRONAS to organize and host the industry-sponsored petroleum geoscience conference. Through this annual

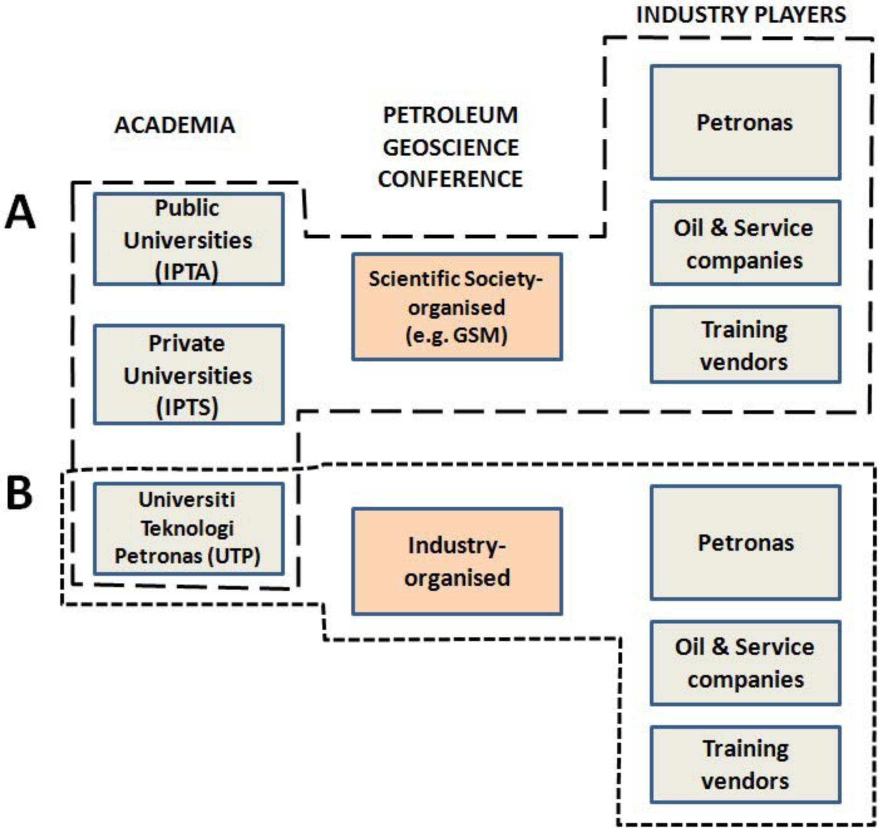

Figure 12: The Geological Society has an important role to play in bridging the knowledge gap between the Academia/Public and the Industry (A, outlined by long dashed line), which otherwise would remain closed and "elitist" (B, outlined by short dashed line). UTP has a slight advantage by being a PETRONAS-owned university.

event, geoscientific knowledge related to oil exploration is disseminated freely to the general public via its official publications, the Warta Geologi (its Newsletter) and the Bulletin. Sadly, the collaboration ended when, starting in 2015, PETRONAS decided to host a new conference series in collaboration with the European Association of Geoscientists and Engineers (EAGE). This is an unfortunate situation because EAGE, which handles the publication for this conference, provides access to the conference abstracts only to their subscribers. This means that geoscientific knowledge gained through exploration activities on the Malaysian continental shelf, under the control of the national oil company, has now been made proprietary to a foreign scientific society. Only upon GSM's request, EAGE has kindly granted GSM members complimentary access to the abstracts of the 2015 conference. As mentioned, this is not a desirable situation and requires the attention of all parties. It is hoped they will continue to give access to the abstracts from future conferences.

NEED FOR OPEN DATA AND KNOWLEDGE SHARING

Oil exploration and production data (well, seismic, production, reserves, etc.) are considered industry secrets which are strictly controlled by PETRONAS (Figure 13). Access to primary (raw) data is normally given to oil companies when reviewing exploration acreages. In addition, on a case-by-case basis, postgraduate students are able to obtain permission to use primary data in their research projects. For the most part, primary data remain confidential, but sometimes, with prior permission from PETRONAS, secondary data, which include the

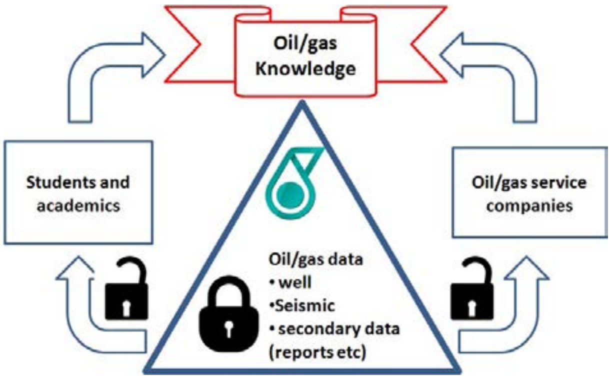

Figure 13: There is a need for open data system and knowledge sharing between the Petroleum industry and the public (principally, academia). Knowledge creates more knowledge.

interpretations of primary data, are shared publicly in technical paper presentations at local and international conferences.

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

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

CONCLUDING REMARKS

As a developing nation, Malaysia faces major challenges in developing “local” geoscience capability. Its national oil company, PETRONAS, is entrusted with this responsibility by default, as the key player in the industry. Several factors contribute to those challenges, among them: (1) Inadequate university geoscience curriculum, which affected the “readiness” of graduates entering the job market. (2) Over-emphasis in the in-house training courses on transferring “explicit knowledge” and “manual” skills (including software skills) while neglecting the importance of tacit knowledge and self-learning in geoscience education.

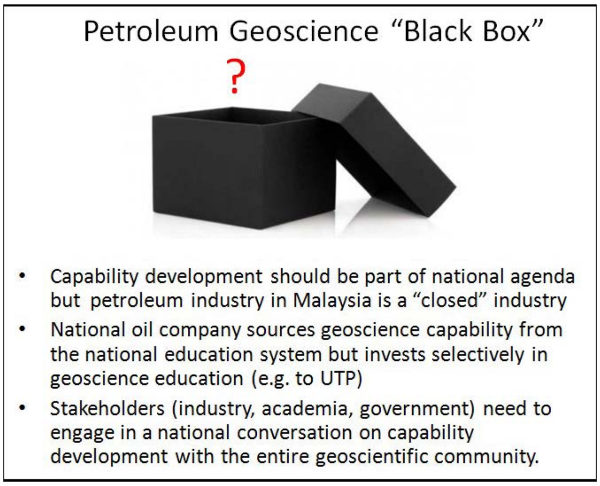

Figure 14: Petroleum geoscience capability should not be treated like a “black box”, something mysterious that is accessible only to an “elite” community.

(3) Inadequate interaction and collaboration between industry and public/academia to enable open sharing of geoscience information and knowledge. (4) Lack of open data system that can encourage a vibrant academic culture of geoscientific research and industry-academia collaborative efforts.

Developing geoscience capability in the petroleum industry should not be solely the responsibility of oil companies, but is a national objective. Petroleum geoscience should not be treated as a “black box” that is accessible only to an “elite” section of the community (Figure 14). The challenges could not be overcome without mutual cooperation between all the stakeholders in the national geoscience community (oil companies, universities, scientific societies, professional institutions, and relevant government agencies) in addressing the root causes in a holistic manner. It is hoped that this paper will trigger further discussions among stakeholders on ways to enhance geoscience capabilities, particular for the petroleum industry.

ACKNOWLEDGEMENT

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CERAMAH TEKNIK TECHNICAL TALK

Industri kuari di Malaysia

Amirruddin Rosni
Date: 9 October 2019
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Aktiviti kuari dan lombong telah lama bertapak di Malaysia. Perkembangan dari segi perundangan kuari, eksplorasi pencarian mineral, operasi harian, dan penjualan untuk produk kuari berkembang hampir setiap tahun. Bermula dari industri yang beroperasi tanpa sebarang peraturan, kini operasi kuari telah menjadi operasi yang terkawal dengan segala garis panduan yang telah ditetapkan oleh pihak berkuasa. Akibat daripada eksplorasi mineral yang tidak mencukupi, pembukaan sesebuah kuari boleh diibaratkan seperti suatu gelanggang perjudian. Oleh itu, banyak usaha pemantapan eksplorasi mineral telah diketengahkan oleh beberapa syarikat geoteknikal. Selain itu, asas kepada eksplorasi mineral dan juga operasi harian adalah pemetaan geologi kerana ilmu persempadanan dan volumetrik bergantung penuh pada ilmu pemetaan. Kuari di Semenanjung Malaysia lebih banyak bergantung kepada batuan granit untuk digunakan sebagai aggregat dalam pembinaan. Di Sabah dan Sarawak, aggregat batuan yang digunakan lebih bervariasi seperti batu pasir, batu kapur, mikro-tonalit, hornfel dan sebagainya. Ini menjadikan aplikasi ilmu geologi mengenai sifat batuan untuk operasi kuari di Sabah dan Sarawak lebih banyak berbanding di Semenanjung Malaysia. Namun, sifat mekanikal jasad batuan dan kimia batuan masih banyak yang perlu di kaji bagi memastikan kualiti produk aggregat dan keselamatan dalam kawasan operasi kuari terjaga.

CERAMAH TEKNIK TECHNICAL TALK

The Quranic perspective on geology

Hifdzi Zaim Zamri
Date: 16 October 2019
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

This presentation will deliver the topic on how Geology plays an important part in the Quran's role in delivering its message and guidance to humankind. The study of any scientific field nowadays are facing challenges to connect the field of studies towards the Quranic purpose. The aim of the presentation is to share how Allah wants us to see the world of science through the Quranic lenses that supposed to leave us in awe of Allah's words and creation. This serves as a reminder and enhance our curiosity towards the truth that Allah wants us to see as a Muslim. At the end of the presentation, participants will be guided to use a model known as 'Heaven to Earth' model that will help connect the dots between the field of science and the Quran together.

CERAMAH TEKNIK TECHNICAL TALK

Teledyne Optech Polaris Terrestrial Laser Scanner: A case study in Kundasang, Sabah

Jespal Singh Gill

Date: 23 October 2019

Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Teledyne Optech has been innovating and manufacturing LiDAR instruments, from airborne to terrestrial laser scanners, for over 40 years. In 2017, their latest terrestrial laser scanner (TLS) – called 'Polaris' – was launched which redefined the concept of TLS' efficiency and productivity at a very competitive price point. Hence, Syarikat E. J. Motiwalla took the opportunity to demonstrate the Polaris TLS at Kundasang, Sabah at the invitation of the DPP Laboratory of UTM-MJIIT. This presentation covers the Polaris TLS results from the demonstration at Kundasang, Sabah, as well as an introduction to laser scanning principles. This presentation aims to highlight some issues with TLS and how to solve them, and discuss some of the other methods of laser scanning: mobile laser scanners, handheld/ backpack laser scanners and UAV LiDAR. A hands-on demonstration of the Polaris TLS will also be available.

CERAMAH TEKNIK TECHNICAL TALK

Geosains dan industri revolusi (IR) 4

Rohayu Che Omar (Pengarah Institut Infrastruktur Tenaga, UNITEN)

Date: 6 November 2019

Venue: Makmal Geofizik, Paras 4, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Sinopsis: Revolusi industry (IR) 4 merujuk kepada satu fasa baru dalam revolusi perindustrian yang memfokuskan kepada integrasi disiplin terutama yang melibatkan 'Internet of Things - IoT' atau dengan kata lain adalah pengintegrasian pintar menggunakan rangkaian komputer dan sensor. Integrasi disiplin ini perlu bagi menggabungkan maklumat atau data yang besar dan jumlahnya banyak untuk mewujudkan ekosistem yang lebih holistik dan lebih baik untuk industri yang menumpukan pada pengurusan rantaian pembuatan, pengoperasian dan bekalan. Oleh itu bagi merealisasikan revolusi industri berlaku dalam bidang asal seperti kejuruteraan, perubatan, alam sekitar termasuk geosains, iaitu satu paradigma perubahan terhadap cara kerja atau penggunaan teknologi perlulah di ketengahkan. Proses perubahan yang akan dilakukan untuk memastikan kesesuaian dan keberkesanan teknologi terhadap penggunaan bidang asal perlu melalui satu fasa yang dikenali dengan 'Game Changing Technologies'. 'Game Changing Technologies' merupakan proses mengubah atau membuat perubahan, peralihan, penukaran atau transformasi bagi mengadaptasikan ilmu atau disiplin asal mengikut keperluan industri dan cara kerja setiap industri yang terbabit pada era IR4. Unsur atau faktor yang baru akan diperkenalkan bagi mengubah keadaan atau aktiviti yang ada dengan cara yang lebih sesuai dan keberkesanan yang lebih ketara. Oleh itu, perubahan inovasi dilihat sebagai satu laluan yang paling berkesan untuk mencari penyelesaian yang mampan kepada cabaran persekitaran dunia yang mengarahkan kepada IR4. Perubahan yang dilakukan dalam setiap inovasi perlulah diubah mengikut keperluan sesebuah industri dan menggunakan teknologi terkini sebaiknya mengguna pakai pendekatan model perniagaan industri yang terlibat. Contoh perubahan inovasi dalam geosains akan dibincangkan menerusi lingkungan teknik seperti pengurusan sisa buangan dan bahan binaan untuk sumber boleh ubah, penggunaan teknologi untuk kehidupan yang lebih mampan, pengurusan asset dan bencana alam, di mana perbincangan dan contoh dikaitkan dengan penggunaannya dalam beberapa industri di Malaysia. Metodologi yang digunakan lebih kepada pendekatan terhadap isu yang berlaku, jenis industri yang terlibat atau jenis perkhidmatan geosaintis yang diperlukan, kebolehan dan kesesuaian konsep geosains yang akan diguna pakai dan bagaimana teknologi yang akan diintegrasi boleh membantu dalam penyelesaian isu industri terbabit. Keterlibatan dan perubahan penggunaan teknologi dan idea di kalangan geosains boleh membantu dalam mengembangkan ilmu ini dan memberikan lebih peluang pekerjaan mahupun sebagai 'entrepreneur' di masa akan datang. Oleh itu perkembangan ilmu geosains itu boleh dilihat dan dihargai oleh masyarakat pada masa kini dan akan datang.

CERAMAH TEKNIK TECHNICAL TALK

Tanah runtuh pendam-lama – daripada geobahaya kepada geobencana

Tajul Anuar Jamaluddin

Date: 27 November 2019

Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Abstrak: Tanah runtuh pendam-lama yang berskala besar dan berkedudukan dalam yang tersembunyi di terrain perbukitan dan tanah tinggi tropika lembab kini telah diketahui dan dikenalpasti sebagai suatu geobahaya terrain semulajadi yang serius. Fenomena geobahaya tanah runtuh pendam berskala besar amat jarang diperkatakan di negara ini. Maklumat literatur mengenainya dalam konteks negara beriklim tropika lembab seperti di Malaysia amat terhad. Justeru, kesedaran mengenainya di kalangan pihak berkepentingan amat rendah dan ancamannya sering diabaikan. Kewujudannya pula sering terlepas pandang kerana morfologinya dikaburi oleh tindakan proses-proses eksogen (luluhawa, hakisan, pengenapan, tanah runtuh susulan) dan tutupan tumbuh-tumbuhan hutan hujan tropika yang padat dan tebal. Pengecamannya amat bergantung kepada fitur-fitur geomorfologi yang menjadi tanda pengenalan utamanya. Antaranya ialah fitur-fitur seperti kerawang, tubir utama yang curam atau cekung, kepala, lekukan di bahagian tengah dan morfologi beralun di bahagian kaki cerun, serta perlencungan pada sistem saliran semula jadi di hilir kaki cerun. Di bahagian tengah hingga atas jasad runtuhan, saliran biasanya bercabang dan berbentuk-Y ke hulu. Pengalaman mencerap dan mengkaji tanah runtuh baharu merupakan suatu aset yang amat membantu dalam penyiasatan tanah runtuh pendam-lama. Tanah runtuh pendam juga mempunyai kitaran geomorfik tersendiri, samada peringkat muda, dewasa atau tua. Biasanya semakin tua sesebuah tanah runtuh pendam, semakin sukar untuk mengecaminya. Walaupun berada pada kitaran peringkat-tua, pengaktifan semula boleh berlaku terutama apabila diganggu oleh aktiviti manusia dan tindakan cuaca yang ekstrim. Tanpa penyiasatan dan pemetaan yang terperinci, kewujudannya sering terlepas pandang kerana saiznya yang terlalu besar hingga mencapai skala ratusan hingga ribuan meter lebar dan panjang. Kini, dengan pelbagai kemudahan teknologi pengimejan terrain dan penderiaan jauh (e.g. LiDAR, IFSAR, Google Earth, dsb) proses pencerapan, pengecaman dan pemetaan tanah runtuh pendam-lama semakin mudah dan meyakinkan. Sebaik sahaja dikenalpasti, kawasan tanah runtuh pendam-lama seharusnya dielakkan daripada diganggu atau dibangunkan. Ini kerana pengalaman di Malaysia menunjukkan bahawa pembangunan infrastruktur di dalam kawasan seperti ini seringkali menimbulkan banyak masalah, daripada masalah kejuruteraan semasa hinggalah selepas pembinaan. Kerosakan dan kemusnahan yang timbul selalunya tidak dapat diselesaikan dengan mudah kerana saiz dan isipadu kegagalan yang terlalu besar dan tidak dapat diatasi dengan sebarang kaedah kejuruteraan berstruktur yang biasa. Beberapa contoh geobencana yang disajikan dalam kertas ini menjadi bukti betapa gelinciran tanah pendam-tua adalah isu geobahaya yang perlu diambil berat, kerana ia boleh berubah menjadi geobencana yang amat merugikan. Kaedah pencegahan risiko bencana yang paling baik adalah dengan mengenalpasti kewujudannya terlebih dahulu dan mengelakkan diri daripada membangun di kawasan terbabit.

Katakunci: Geobahaya tanah runtuh pendam-lama, geobencana, pencegahan risiko geobencana

CERAMAH TEKNIK TECHNICAL TALK

The hidden treasure of Sarawak petrified wood: Silicification mechanism

Askury Abd. Kadir

Date: 4 December 2019

Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Abstract: The Sarawak petrified woods occurred within the Tertiary Kayan Sandstone in the vicinity of Bungo Range which are threatening and going to be permanently destroyed by illegal exploitation activities. The uncontrolled illegal exploitation caused the geological artifacts being widely trading for antique collector, exotic items or aesthetic value without paying any fees or royalty to the government. The petrified wood, including palm and conifer trees had undergone petrification within million of years, where their original wood features replaced by silica minerals, such as opal and chalcedony. The replacement processes are unique in term of petrification, and can be translated into very high aesthetic and scientific values for geoscience communities, and cultural value for local folklore. Hence, the wood structures including their cells are retained and can be observed neither macroscopically nor microscopically. The varieties of colour and degree of preservation of the Sarawak petrified woods are attractive and have an ability to compete with other petrified wood reported around the world. The petrified wood, including palm and conifer trees had undergone petrification within million of years, where it retain original cellular wood structure and therefore can be identified by anatomical study. The silicification process taken place where all the pores and spaces, within and between cells, gradually preserving the entire tissue. Chalcedony is the most prominent silicate mineral involved in silicification. It is a fine-grained to cryptocrystalline quartz of sedimentary origins (minerals dissolved in groundwater), displaying with length-fast optical orientation, form radiating fans and spherulites from 20 to 500 microns wide under the cross-polarized transmitted light. It shows aggregate structure with traces of organic matter, iron oxides and pyrite once observed under the plane light. The silicification processes are unique and can be translated into very high aesthetic and scientific values, where the wood structures including their cells are retained and can be observed neither macroscopically nor microscopically. The relevant government agencies are greatly required for promotion and publicize our hidden treasures for our future generation. There are a lot of opportunities for geoscience community to safeguard these treasures from any humanities destruction. Nevertheless, it can be transformed into onsite research centre that attract local and international researchers. The existing infrastructure around the area can expedite a momentum for the development, viz: Borneo Height (highlands & golf tourism), Kg. Annah Rais (cultural village for Bidayuh ethnic group), Semenggok (Orang Utan Rehabilitation Centre), hot spring (under construction) and Kg Sadir (Bidayuh village).

Micro-to-meso scale heterogeneities: Implications on petroleum reservoir quality

Ekundayo Joseph Adepehin

Petroleum reservoirs are key exploration targets in conventional hydrocarbon search. The complex interaction of depositional and post-depositional factors poses difficulty in the assessment of reservoir quality in clastic sandstones. Micro-meso-scale heterogeneities constitute important modifiers of syn-depositional porosity and permeability. This presentation will showcase real time approach for characterising fluid-flow variability and controls in siliciclastic sandstones using integrated datasets based on an example from the Onshore Sarawak Basin, Borneo.

The Bulletin of the Geological Society of Malaysia received 'Jurnal Crème 2019' Award

We are pleased to inform that the Bulletin of the Geological Society of Malaysia was one of the recipients of the Jurnal Crème 2019 for SCOPUS category journal in the field of Science, Technology and Medical that was awarded by the Ministry of Education Malaysia. It is in recognition of being a highly cited journal and consequently being one of the highest ranked SCOPUS-indexed journals published in Malaysia. The award giving ceremony took place at the Zenith Putrajaya on November 5th, 2019.

We would like to express our sincere gratitude for all the support we received from the Geological Society of Malaysia council members, Advisory Board members, various contributors, especially the authors, co-authors and the reviewers. We profoundly acknowledge the Department of Higher Education (JPT), Ministry of Education Malaysia and Clarivate Analytics and Elsevier.

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Regional Geoheritage Conference 2019

The 4th Regional Geoheritage Conference 2019 was held in mystic Land of Hornbill, Sarawak at Kuching Riverside Hotel from 25 to 27 September 2019. The theme of the conference is "Celebrating Earth's Legacy Through Geoheritage". A total of 120 participants from Malaysia, Indonesia, Thailand and The Philippines attended the two days conference and one day field excursion. Geoscientist, administrators and policy makers, social scientist, entrepreneur and educationist who are involved actively in the work of establishing, promoting, conserving and enhancing geoheritage in their country were among the participants who shared their experience and knowledge. It was jointly organized by Kumpulan Warisan Geologi Malaysia (WGM), Minerals and Geoscience Department Malaysia (JMG) and UKM in collaboration with UPN Indonesia, DMR Thailand, GSM and UNESCO Global Geopark. The conference was officially launched by the Chief Minister Datuk Patinggi Abang Johari Tun Openg and the speech read by Deputy Chief Minister Datuk Amar Awang Tengah Ali Hasan. He was very optimistic that Sarawak is ready to venture into geoheritage tourism with the Sarawak Delta Geopark in its final stage. It will give benefits to the state in terms of global publicity to Sarawak as an eco-friendly state and also geotourism promotion. Hence, the proposed Sarawak Delta Geopark will be a model for regional sustainable development that can ensure a balance between conservation of heritage resources, development of tourism infrastructure, and enhancement of local socioeconomic activities.

Reported by,
Askury Abd Kadir
Vice President GSM

Deputy Chief Minister Datuk Amar Awang Tengah Ali Hasan sounding a gong for RGC 2019 launching.

Participants of the 4th Regional Geoheritage Conference at Kuching Riverside Hotel.

Field excursion to Santubong and Sarawak Cultural Village.


The organizing committee for RGC 2019.

Bengkel Penggubalan Kerangka Perundangan Perlombongan Dasar Laut 2019

(Workshop on Formulating a Legislative Framework on Seabed Mining)

On 3rd December 2019, a one-day workshop was held at Zenith Putrajaya to discuss the need for a legislative framework for seabed mining to cater for current and future needs. The workshop was organized and hosted by the Ministry of Water, Land and Natural Resources, Jabatan Mineral dan Geosains and Universiti Malaysia Terengganu, with the support of relevant government agencies and stakeholders to the offshore activities, including the Ministry of Foreign Affairs, Ministry of Fisheries, Malaysia Institute of Maritime Affairs (MIMA) and Petronas, to name a few.

After a welcoming speech by the Deputy Vice-Chancellor (Research and Innovation) of UMT, Prof Dr. Mazlan Bin Abd Ghaffar, the workshop was officiated by the Director-General of JMG, Datuk Shahar Effendi bin Abdullah Azizi.

The workshop was organized in two parts: a morning session of speeches by senior dignitaries and officers from the various stakeholder government agencies, providing their perspectives on seabed mining, deep sea mineral exploration, and the need for a strategic plan and legislation to regulate these activities in the future, followed by an afternoon session of group discussion.

The presentations were:

(Keynote) “Hala Tuju Perlombongan Dasar Laut Negara” [*Way forward for Seabed Mining in the Country*] by **Dr. Adina Kamarudin**, Ketua Pengarah Jabatan Hal-Ehwal Maritim, Kementerian Luar Negara.

“Perlombongan Dasar Laut Dalam dibawah ISA dan UNCLOS” [*Seabed Mining under International Seabed Authority (ISA) and United Nations Convention on the Law of the Sea (UNCLOS)*] by **Puan Norhasliza Mat Salleh**, Timbalan Pengarah Bahagian Keselematan dan Kedaulatan Maritim, Majlis Keselamatan Negara.

“Akta Pelantar Benua” [*Continental Shelf Act*] by **En. Mahather Smoh**, Pengarah Bahagian Penguatkuasa & Hasil Persekutuan, Jabatan Ketua Pengarah dan Galian.

Datuk Shahar Effendi Abdullah Azizi delivering his speech.

Dr Adina Kamarudin on the future of seabed mining for Malaysia.

En. Abdullah Sulaiman, Head of Marine Geology Unit, JMG, delivering his presentation on the current activities on seabed mining and the need for a legal framework.

"Keperluan Penyediaan Kerangka Perundangan Perlombongan Dasar Laut" [*The Need for Drafting a Legislative Framework for Seabed Mining*] by **En. Abdullah Sulaiman**, Ketua Unit Geologi Marin, Bahagian Perkhidmatan Teknikal, JMG.

"Peruntukan-Peruntukan di bawah Kerangka Perundangan Perlombongan Dasar Laut" [*Provisions under the Legislative Framework for Seabed Mining*] by **Prof. Dr. Wan Izatul Asma Wan Talaat**, Ketua Penyelidikan Tadbir Urus Lautan, Universiti Malaysia Terengganu.

"Seabed mining" as used in Dr Adina's keynote presentation referred to the exploration and exploitation of seabed minerals in the "High Seas", i.e. beyond the Exclusive Economic Zone (EEZ) or 200 nautical miles from the baselines (coastline) of a coastal State. Hence, the term refers to mining of deep sea minerals (principally polymetallic sulphides, manganese nodules and cobalt crusts) in areas beyond natural jurisdiction of coastal States, in what is termed "the Area". Exploration and exploitation activities in the Area comes under the governance of the International Seabed Authority (ISA), a technical body created under UNCLOS, to safeguard the efficient and sustainable use of natural resources for the benefit and "common heritage of mankind" (as touted by Ambassador Arvid Pardo in his famous speech at the United Nations in 1967). Seabed mining licences have been issued by the ISA in several "hot" areas where these minerals have been found to be in abundance (e.g. Clarion Clipperton Zone, in the East Pacific Ocean). It is thought that Malaysia, which regards itself as a "maritime nation", should prepare itself by having a legal framework for the future if and when it gets involved in seabed mineral exploration and exploitation. All the speakers at the workshop appear to hold the view that such a legislative framework is needed.

During the second part of the workshop the participants were divided into five groups to discuss whether there is a need for a new or amended bill for the purposes of regulating and monitoring seabed mining in offshore areas, both beyond the state territorial waters (3 nautical miles) and beyond national (federal) jurisdiction, i.e. beyond 200 nautical miles from the baselines or to the outer limit of the continental shelf as per article 76 of UNCLOS. Overall, the meeting participants also agreed that there is a need to have a specific legislative framework on seabed mining in both these categories of maritime spaces, and that a better option would be to draft a new bill for seabed mining and deep sea mineral exploration rather than to amend existing acts such as the Continental Shelf Act 1966 and the Mineral Development Act 1994.

The workshop is a critical first step towards having a legal framework for Malaysia to embark on seabed mining in the future.

Reported by,
Mazlan Madon

L-R: Dr Mazlan Madon, Member of the Commission on the Limits of the Continental Shelf, also GSM Immediate-Past President; Datuk Shahar Effendi Abdullah Azizi, Director-General of JMG; Dr Adina Kamarudin, Director-General of Maritime Affairs, Ministry of Foreign Affairs.

University of Malaya American Association of Petroleum Geologists Student Chapter (UM AAPG Student Chapter)

2019/2020 Session

EXECUTIVE SUMMARY REPORT I: FUNDAMENTALS OF DEEP-WATER STRATIGRAPHY & RESERVOIRS WORKSHOP

On the 10th of November 2019, the University of Malaya American Association of Petroleum Geologist (AAPG) Student Chapter organized a workshop at the Department of Geology, University of Malaya led by Dr Jon Rotzien, the President of Basin Dynamics LLC, a consulting and exploration company in Houston, Texas and a visiting professor at the University of Louisiana at Lafayette. Dr Jon was also accompanied by Mr Tan Chun Hock, a Production Geologist at Shell. The contents of the workshop consisted of the fundamentals of deep-water stratigraphy from multiple regions such as in New Zealand and the United States of America. The learning materials were taken from real data acquired by Dr Jon. The duration of the workshop lasted for seven hours (9 AM – 3:30 PM).

A total of 32 participants from the National University of Malaysia (UKM) and University of Malaya students from first year until fourth years participated in the interactive workshop. This workshp consisted of three sessions with each session having different activities. For the first session, the speakers started off the workshop by introducing some fundamentals of deep-water stratigraphy and the basics of sedimentology from certain regions such as North America, Europe and Asia Pacific. Some of the specific locations that was focused on by Dr Jon is the Mount Messenger Formation, Taranaki Basin in New Zealand.

The main principles that were also integrated in the workshop were geochemistry, petrography and geophysics. Although knowledge on stratigraphy is important to determine and interpret deep-water environment, the combined principles are also crucial. For example, thin sections were provided for students to observe by using the microscope and geochemical data obtained is important to determine the lithology of the studied region. From geochemical data, we can also determine the age of the lithology. In the workshop, Dr Jon also provided a seismic data with a length of almost three meters (size of one lab table). From this seismic data, he showed the participants the importance of it by determining the velocity and thickness of the deep-marine environment. Two other sessions were allocated for workshop exercises given by our speakers. Participants were required to observe and determine sediment structures and the lithologies in multiple images of sediment cores. Some of the sediment cores images were from California and Texas. As for the third session, we had to make relations between onshore and offshore well-logs interpretations of the same location in a marine environment in New Zealand. The participants also had to determine the unconformities and erosional surfaces in the images of the outcrop given.

From this workshop, participants gained a lot such as exposure to real-life case studies especially from outside of Malaysia and we learnt more on the importance of each principles towards interpreting deep-marine environment. The workshop ended with a gift-giving ceremony by the project director and a group photo of the speakers, participants

Group photo of the Project Director (Far Left), Speakers; Mr Tan Chun Hock (Left) and Dr Jon Rotzien (Middle), President of AAPG UM SC (Right) and Vice-President of AAPG UM SC (Far Right) with the workshop participants and committees of AAPG UM SC.

and the AAPG UM SC committees. Overall, the workshop was a success and the participants enjoyed their time in the Fundamentals of Deep-Water Stratigraphy and Reservoirs Workshop.

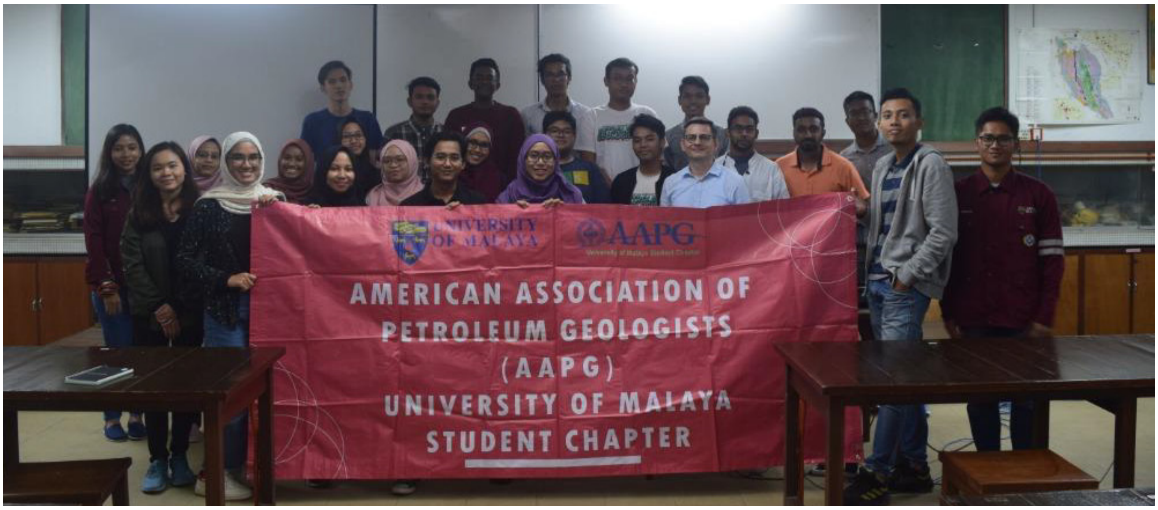
Prepared by,
Nur Azyani Binti Mursidi,
Project Director,
Fundamentals of Deep-Water Stratigraphy and Reservoirs Workshop, UMSC AAPG

EXECUTIVE SUMMARY REPORT II:
3D FACIES MODELING TALK

On the 23rd of November 2019, the University of Malaya American Association of Petroleum Geologist (AAPG) Student Chapter managed a talk namely "3D Facies Modeling" by Mr Jairo Plata. Our speaker is a highly rated geologist that has worked on multiple projects in Colombia, Venezuela, Brazil, Cuba, Malaysia and many more. He also has a master's degree in Petroleum Engineering from Universidad Industrial de Santander, Colombia and is the Principle Reservoir Geologist at Petronas since 2008. We wanted to provide a platform where students and fresh graduates could learn a thing or two on how to visualize the depositional environment and the data that could be collected from it. Facies modeling is the act of modeling a reservoir using knowledge of the facies that make up the reservoir and the depositional environments that the facies represent. The depositional characteristics will suggest rules concerning the geometries of the facies and the possible relationships between facies, especially where the facies have been related to each other within a stratigraphic sequence or a cyclothems. Facies modeling is often an important component of geostatistical reservoir characterization and facilitates construction of superior reservoir models for complex reservoirs.

The talk was held at the Makmal Paleontologi dan Stratigrafi (MPS) of University of Malaya. The committee members of AAPG UMSC arrived at the venue at 9.00 am to set up the seats for participants. At 9.30 am, the speaker arrived and we helped to set up the projector and equipment for him. Once the registration for participants has been completed, the talk began at 10.00 am sharp. The talk is divided into two segments, one is before the refreshment break at 11.30 am and the other is after the break. The segment before the break is focused more on theoretical aspects of facies modeling whereas the segment after the break is more towards the statistical side of facies modeling. Overall, the event is considered a success as the participants managed to grasp the concept of 3D facies modeling and its procedure as well as why it is vital.

Prepared by,
Muhammad Qayyum Bin Suhaimi
Project Director,
3D Facies Modeling, UMSC AAPG



Group photo of the UMSC AAPG Participants with Mr. Jairo Plata.

Annual Report of the Society for Engineering Geology and Rock Mechanics Malaysia (SEGRM) for 2018/19

(IAEG AND ISRM MALAYSIA NATIONAL GROUP)

1.0 INTRODUCTION

The Society for Engineering Geology and Rock Mechanics Malaysia (SEGRM) is affiliated with the respective parent organisation: International Association for Engineering Geology and the Environments (IAEG) and International Society for Rock Mechanics and Rock Engineering (ISRM). It was incorporated on 16th August 2016 after the IAEG Malaysia National Group and ISRM Malaysia National Group decided to have one common platform for both organisations. SEGRM is a non-profit scientific association supported by membership fees and grants/sponsors/donations that would help fund its academic and professional activities.

The main aim of the society is to contribute to the academic and technological advancement through research and international cooperation among the scholars and practitioners in the field of engineering geology, environmental geology, rock mechanics and rock engineering.

2.0 MEMBERSHIP

Members of SEGRM will automatically be members of IAEG and ISRM. The membership stands as follow:

Years	SEGRM	ISRM	IAEG with Bulletin	IAEG without Bulletin
2016	27	27	5	22
2017	46	46	5	41
2018	37	37	5	32
2019	32	32	3	29

3.0 ACTIVITIES

3.1 13th IAEG Congress

Participants from Malaysia attended the 13th IAEG Congress in San Francisco, USA, from 15th to 23th September 2018. The event was co-organised by the Association of Environmental and Engineering Geologists, USA.

3.2 10th Asian Rock Mechanics Symposium

Participants from Malaysia attended the 10th Asian Rock Mechanics Symposium in Singapore from 29th October to 3rd November 2018. The event was co-organised by the Society for Rock Mechanics and Engineering Geology Singapore (SRMEG).

3.3 3rd Annual General Meeting 2019

The 3rd Annual General Meeting (AGM) of SEGRM was held on 21st March 2019 at the Universiti Tenaga Nasional Malaysia (UNITEN). A half-day seminar was also conducted in conjuction with the AGM, with 4 presentations delivered as follows:

- Virtual Geohazards Monitoring and Assets Management System by Assoc Prof. Dr. Rohayu Che Omar, UNITEN.
- New Technology for Slope and Mass Deformation Monitoring System by Klaus M. Heil, Director, See Now Consulting Sdn Bhd.
- Laboratory Test on Rock Sample: Standard and Recommended Testing Procedure by Assoc Prof. Mohd For Mohd Amin, Universiti Teknologi Malaysia (UTM).
- Geomechanical Aspects of Tunnelling in Malaysia by Dr. Boon Chia Weng, MMC Gamuda KVMRT

The committee members remain unchanged as no election was held this year.

3.4 Short Course on Tunnel Engineering and Project Management

A short course was conducted jointly by Universiti Teknologi Mara (UiTM) Malaysia and SEGRM on 5th and 6th November 2018 at the Faculty of Civil Engineering, UiTM. The speakers for the short course were as follows:

- Prof. Dr Wulf Schubert, Graz University of Technology, Austria
- Prof. Dr Kurt Klima, Graz University of Technology, Austria
- Prof. Dr Gye-Chun Cho, Korea Advanced Institute of Science and Technology, South Korea
- Prof. Dr Zainab Mohamed, University of Technology MARA
- Ahmad Kailani Muhammad, MMC Corporation Bhd

3.5 Science and Technology for Disaster Risk Reduction (STDRR) Week 2019

SEGRM, together with Universiti Teknologi Malaysia (UTM) and several other organisations, conducted a week-long event on Disaster Risk Reduction from 24th February to 3rd March 2019 in Kundasang, Sabah, East Malaysia. The theme of this event is ‘Advancing Science and Technology for Disaster Risk Reduction’. This event aimed to provide an insight into modern and advanced geospatial technology for mapping, analysis and assessing multi-geohazards and disaster risk in a complex environment. There were 5 sub-events organised within this week-long event namely:

- Workshop and Forum on Geospatial Technology for Disaster Risk Mapping and Assessment (GEORISK2019), 25th - 27th February 2019.
- Expedition to Mount Kinabalu, 27th - 28th February 2019.
- Technological Showcase, Business and Industrial Networking, 28th February 2019.
- Workshop and Field Practice for Landslide Assessment (WFPLA2019), 28th February - 2nd March 2019.
- Post Mount Kinabalu Expedition 2019 and Workshop for Future Geohazards Research 2020-2030, 2nd March 2019.

3.6 Special Commemorative Lecture by Prof. Dr Masahiro Chigira

The event was conducted jointly with UTM and several other organisations on 6th March 2019 to commemorate Prof. Dr Chigira for his 38-years of service and upcoming retirement after long contribution to the society. He has been involved significantly in professional development, capacity building, research and innovation in Malaysia.

3.7 International Short Course Series: Rock Slope Engineering

The International Short Course Series was conducted from 21st to 23rd August 2019. The course was on Rock Slope Engineering. The course consisted of 2-days in the classroom and 1-day field work. The course was delivered by 2 geotechnical engineers and 2 engineering geologists who have experiences with data collection, analysis and design of rock slope, as follows:

- Assoc Prof. Dr Tajul Anuar Jamaludin, Universiti Kebangsaan Malaysia (UKM)
- Assoc Prof. Dr Mohd Ashraf Mohd Ismail, Universiti Sains Malaysia (USM) who is the authorised representative of Rocscience (a rock engineering software developer) for Malaysia
- Ir Dr Rini Asnida Abdullah, Universiti Teknologi Malaysia (UTM)
- Abd Rasid Jaapar, Geomapping Technology Sdn Bhd

Malaysian representatives at the 13th IAEG Congress in San Francisco, USA.

Prof. Kurt Klima of Graz University of Technology, Austria delivering his lecture on Tunnel Engineering and Project Management at UiTM.

ISRM Asian Group meeting, 10th Asian Rock Mechanics Symposium, Singapore.

4.0 PUBLICATIONS

The Inaugural SEGRM Symposium on Geo-Engineering managed to gather 22 full technical papers for presentation. Fourteen (14) of the papers have been accepted for publication in the Bulletin of the Geological Society of Malaysia while the remaining have been published in Warta Geologi.

5.0 FUTURE PLANNING

SEGRM is committed to organise more events in the future including but not limited to the following:

- Symposium on Geo-engineering in Tropical Region to be organised biannually (the second one will be in 2020) and it is hoped that the Symposium can be organised with collaboration from the IAEG and ISRM National Groups for Indonesia.
- International Short Courses on Engineering Geology and Rock Engineering to be conducted regularly by eminent lecturers from all over the world.
- A bid to host the 14th Asian Regional Conference of IAEG in 2023 jointly with IAEG Indonesian National Group.
- A bid to host the ISRM 14th Asian Rock Mechanics Symposium in 2026.

Prepared by,
Abd Rasid Jaapar
Secretary, IAEG National Group for Malaysia
Treasurer, SEGRM

Part of the SEGRM Council members who attended the Science and Technology for Disaster Risk Reduction (STDRR) Week in Kundasang, Sabah.


STDRR participants on Mount Kinabalu - Dr Khamarrul, Prof. Chigira, Dr Ferdaus and Abd Rasid. Not in photo are Dr Goh, Dato Yunus and Bailon.


Participants of the short course on Rock Slope Engineering.


Briefing session before Terrestrial Laser Scanner (TLS) survey exercise during the short course on Rock Slope Engineering.

UPCOMING EVENTS

January 30 - February 2, 2020: "Investigating pre-Tertiary Play", a field trip to Langkawi, Kedah, Malaysia. For details, contach Fendi Yusuf, +60 193478522, email address: fendiyusuf@gmail.com.

February 25-26, 2020: Cost-Effective Artificial Lift Strategies Permian Basin Congress 2020; Texas, U.S.A. For information, visit: https://www.american-business-conferences.com/contact.

February 25-27, 2020: 1st AAPG/EAGE PNG Petroleum Geoscience Conference & Exhibition; Port Moresby, Papua New Guinea. For information, contact AAPG Asia Pacific Programs Manager Adrienne Pereira, email address: apereira@aapg.org.

March 2-8, 2020: GEOEXPO International Geological Congress (36th); Delhi, India. Visit: https://www.36igc.org/science-program for more details.

March 3-5, 2020: APPEX Global 2020; London, England. Visit https://appex.aapg.org/2020 to find out more about the event.

March 16-19, 2020: 14th Middle East Geosciences Conference and Exhibition; Bahrain. To find out more, visit website https://geo-expo.com/conference/.

March 17-18, 2020: 10th IGRSM International Conference and Exhibition on Geospatial and Remote Sensing; Putrajaya, Malaysia. Details at www.IGRSM.org/IGRSM2020.

March 26-27, 2020: Advance Technology Offshore Site Investigation Conference and Exhibition, Kuala Lumpur, Malaysia. Visit: http://atosice.opsbevents.com/ for further details.

May 12-14, 2020: AAPG/EAGE Fifth Myanmar Oil & Gas Conference; Yangon, Myanmar. Visit website at https://www.aapg.org/global/asiapacific/events for more information.

June 7-10, 2020: AAPG 2020 Annual Convention and Exhibition (ACE); Houston, Texas. Contact Terri Duncan (Technical Programs Coordinator) at tel.: +1 918 560 2641 with questions or for additional information.

June 8-11, 2020: EAGE Annual Conference; Amsterdam, the Netherlands. To learn more about the event, visit https://eage.eventsair.com/eageannual2020/.

June 15-18, 2020: Asian Current Research on Fluid Inclusions 8th Biennial ACROFI Conference; Queensland, Australia. For inquiries about the conference, please contact the EGRU Conference Committee - Jan Huizenga: Jan.Huizenga@jcu.edu.au; Yanbo Cheng - Yanbo.Cheng1@jcu.edu.au.

July 15-16, 2020: International Conference on Earth Sciences and Environment (ICEMEN 2020), Langkawi Island, Kedah, Malaysia. For more details on the conference, please visit: http://www.icemen2020.com.

July 20-22, 2020: Unconventional Resources Technology Conference (URTeC), Austin, Texas, U.S.A. Email to: urtec@urtec.org to acquire more details about the event.

September 1-4, 2020: National Geoscience Conference, Bangi, Selangor, Malaysia. For further information, please visit https://www.igm.org.my/component/rseventspro/event/78-33rd-national-geoscience-conference-and-exhibition.

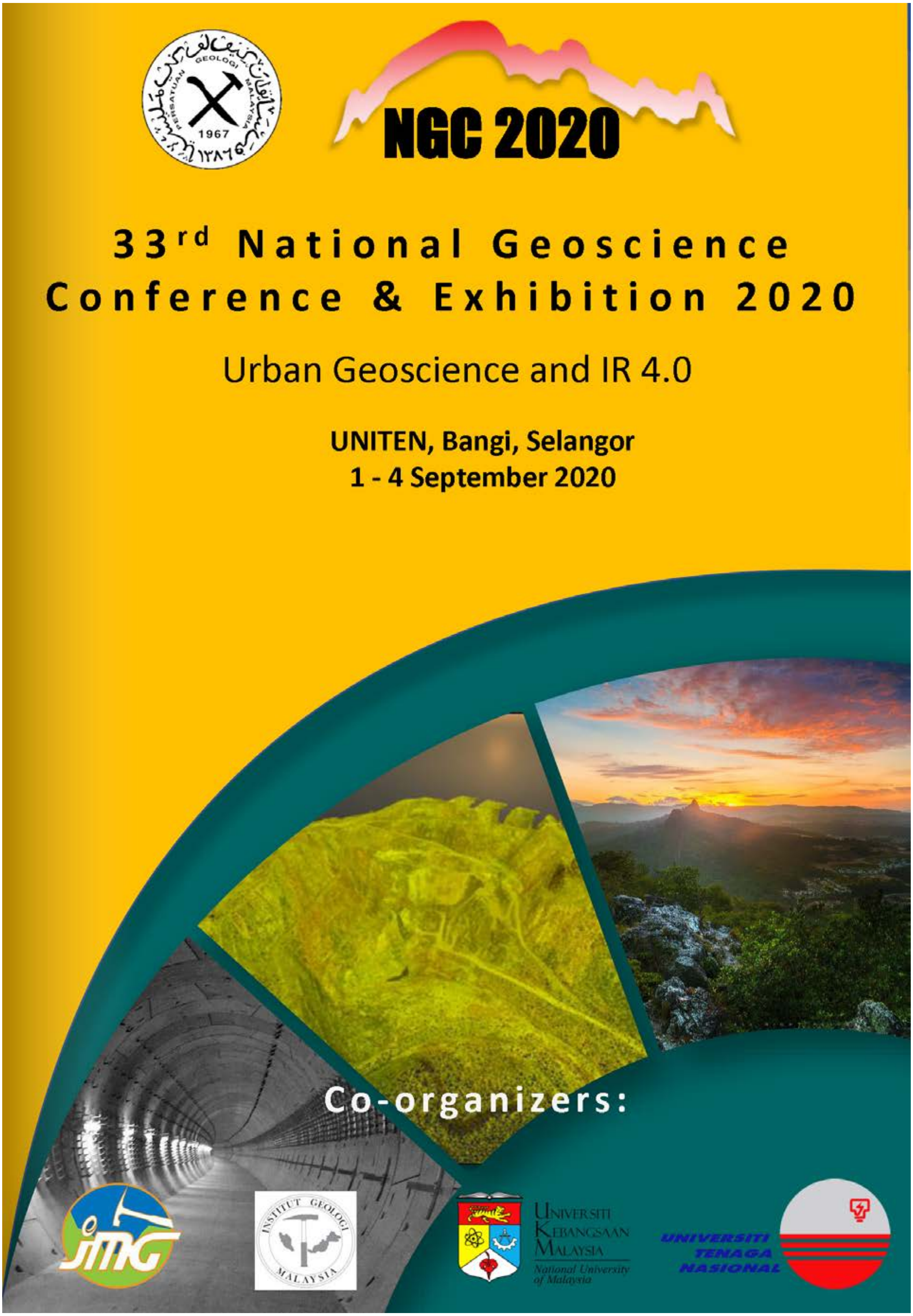
September 23-24, 2020: AAPG/EPF Energy Opportunities; Mexico City. Further details can be obtained at https://energyopportunities.info/2020/.

September 28-October 1, 2020: AAPG 2020 International Conference & Exhibition; Madrid, Spain. To receive more information regarding the event, visit https://madrid2020.iceevent.org/ for online registration.

October 11-16, 2020: SEG2020 International Exhibition and 90th Annual Meeting, Houston, Texas, USA. Further details at https://seg.org/AM/2020/.

November 5-7, 2020: AAPG/EAGE Geosciences Technology Workshop - High CO_2, High Contaminant Challenging Fields, and Alternative Energy, Ipoh, Perak, Malaysia. For details, please contact: Adrienne Pereira, AAPG Asia Pacific: apereira@aapg.org; Gerard Wieggerink, EAGE Asia Pacific: gw@eage.org.

December 1-2, 2020: Regional Congress on Geology, Minerals and Energy Resources of Southeast Asia (GEOSEA XVI). Taguig, the Philippines. For more details, visit www.geosea2020.weebly.com or send an email to gsp.geosea2020@gmail.com.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Urban Geoscience and IR 4.0
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Co-organizers:
INSTITUT GEOLOGI MALAYSIA
UNIVERSITI KEBANGSAAN MALAYSIA
National University of Malaysia
UNIVERSITI TENAGA NASIONAL

Important Dates

15 Mar 2020: Closing for submission of abstracts
15 May 2020: Final acceptance of abstracts
15 July 2020: Last day of payment for speakers

1 – 2 Sep 2020: NGC2020 (oral, poster and exhibition)
2 Sep 2020: Geoscience Awards Night and Gala Dinner
3 - 4 Sep 2020: Field excursions, Post-conference workshops & short courses

Special Events

- Geoscience Awards Night and Gala Dinner
- Inaugural Annual Prof H D Tjia Memorial Lecture

Topics:

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- Environmental and Engineering Geology
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- Geohazards, Disaster Risks Reduction & Climate Change Adaptation
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Stratigraphic Lexicon of Malaysia (2004). By Lee Chai Peng, Mohd. Shafeea Leman, Kamaludin Hassan, Bahari Md. Nasib & Roshidah Karim. 162 p. Price: RM30.00.

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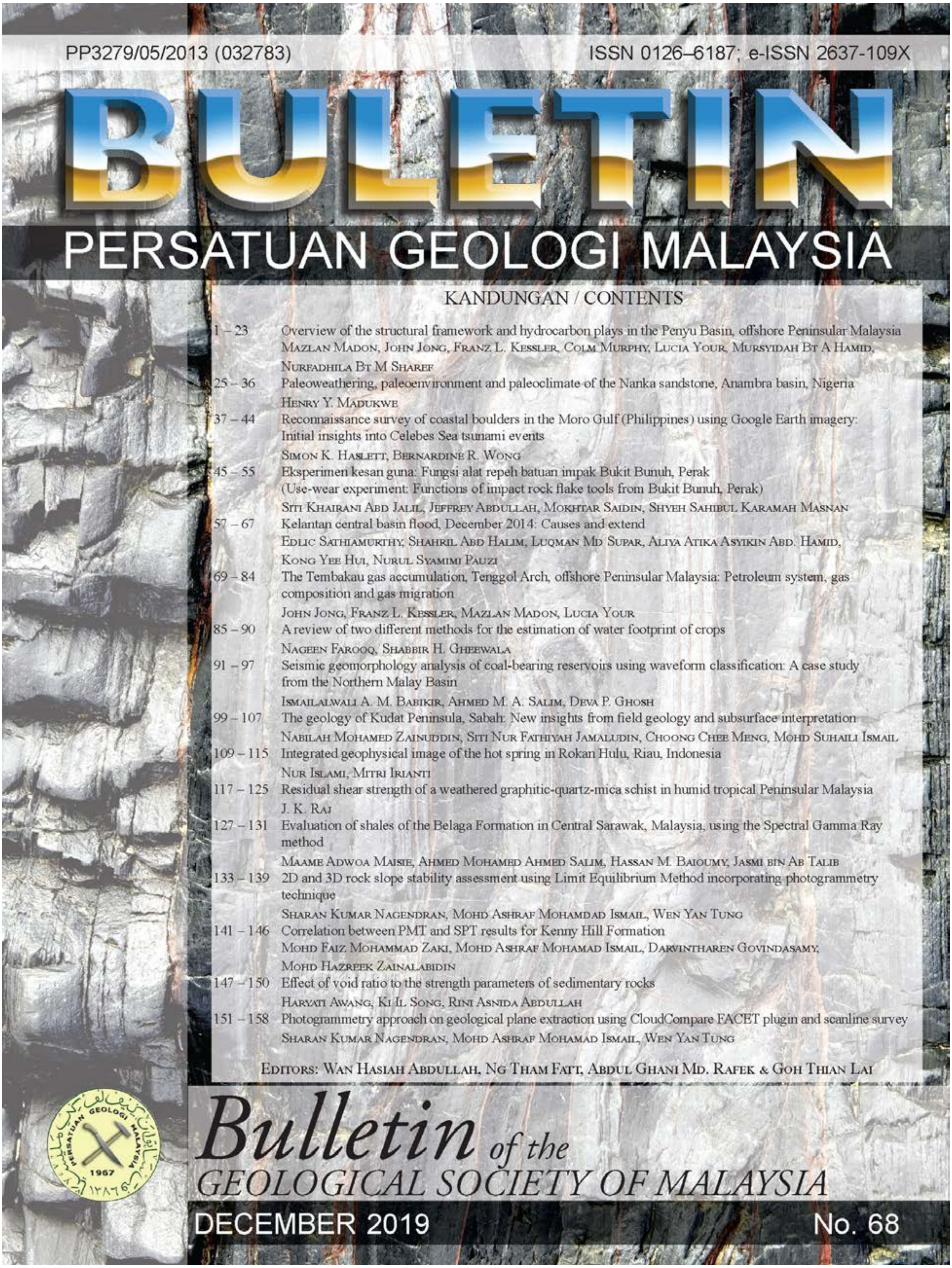

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BULETIN PERSATUAN GEOLOGI MALAYSIA

KANDUNGAN / CONTENTS

Editors: Wan Hasiah Abdullah, Ng Tham Fatt, Abdul Ghani Md. Rafek & Goh Thian Lai

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Manuscript

The paper can be written in Bahasa Malaysia (Malay) or English. For English papers, use either British or American spelling but not a combination of both. The paper should be checked thoroughly for spelling and grammar. The manuscript must be printed at 1.5 spacing in a single column on one side of A4 paper. All pages should be numbered. Length of paper should be between 3,000 and 6,000 words for the *Bulletin* and between 2,000 and 3000 words for *Warta Geologi*, excluding tables and illustrations. Metric units should be used and all non-standard symbols, abbreviations and acronyms must be defined.

Title

Title must be informative and reflects the content of the paper. Title in Malay should include an English translation. It should be concise (less than 20 words). Avoid using abbreviation in the title.

Author's Address

Addresses of all authors must be provided. The addresses should be sufficient for correspondence. Please include email address, telephone and fax of the corresponding author.

Abstract

Abstract in both Malay and English, each in one paragraph and should not exceed 300 words. It should clearly identify the subject matter, results obtained, interpretations discussed and conclusions reached.

Keywords

Please include 3 to 8 keywords that best describe the content of the paper.

References

In the text, references should be cited by author and year and listed chronologically (e.g. Smith, 1964; Jones *et al*., 1998; Smith & Tan, 2000). For both Malay and English paper, all references must be listed in English. Title of non-English articles should be translated to English.

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Book:
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Chapter of book and Symposium volume:
Hosking, K.F.G., 1973. Primary mineral deposits. In: Gobbett, D.J. and Hutchison, C.S. (Eds.), Geology of the Malay Peninsular (West Malaysia and Singapore). Wiley-Interscience, New York, 335-390.

Article in Malay:
Lim, C.H. & Mohd. Shafeea Leman, 1994. The occurrence of Lambir Formation in Ulu Bok Syncline, North Sarawak. Geol. Soc. Malaysia Bull., 35, 1-5. (in Malay with English abstract).

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Please make sure that all illustrations are useful, necessary and of good quality. A maximum of ten (10) illustrations (photographs, graphs and diagrams) are allowed and these should be cited in the text and numbered consecutively as Figures. The papers are usually published in black-and-white but it may sometimes be possible to include colour figures at the author's expense. The scales for maps and photomicrographs should be drawn on the figure and not given as a magnification. Originals should not be greater than A4 size and annotations should be capable of being reduced down to 50 percent. The caption should be listed on a separate piece of paper. Do not insert the illustration within the text.

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Submission should be made through email as attachment files or using CD-ROM. The submission should be accompanied with a listing of all files and the software (name and version) used. The file names should reflect the content of the files (e.g. Ali_Fig1.tif).

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