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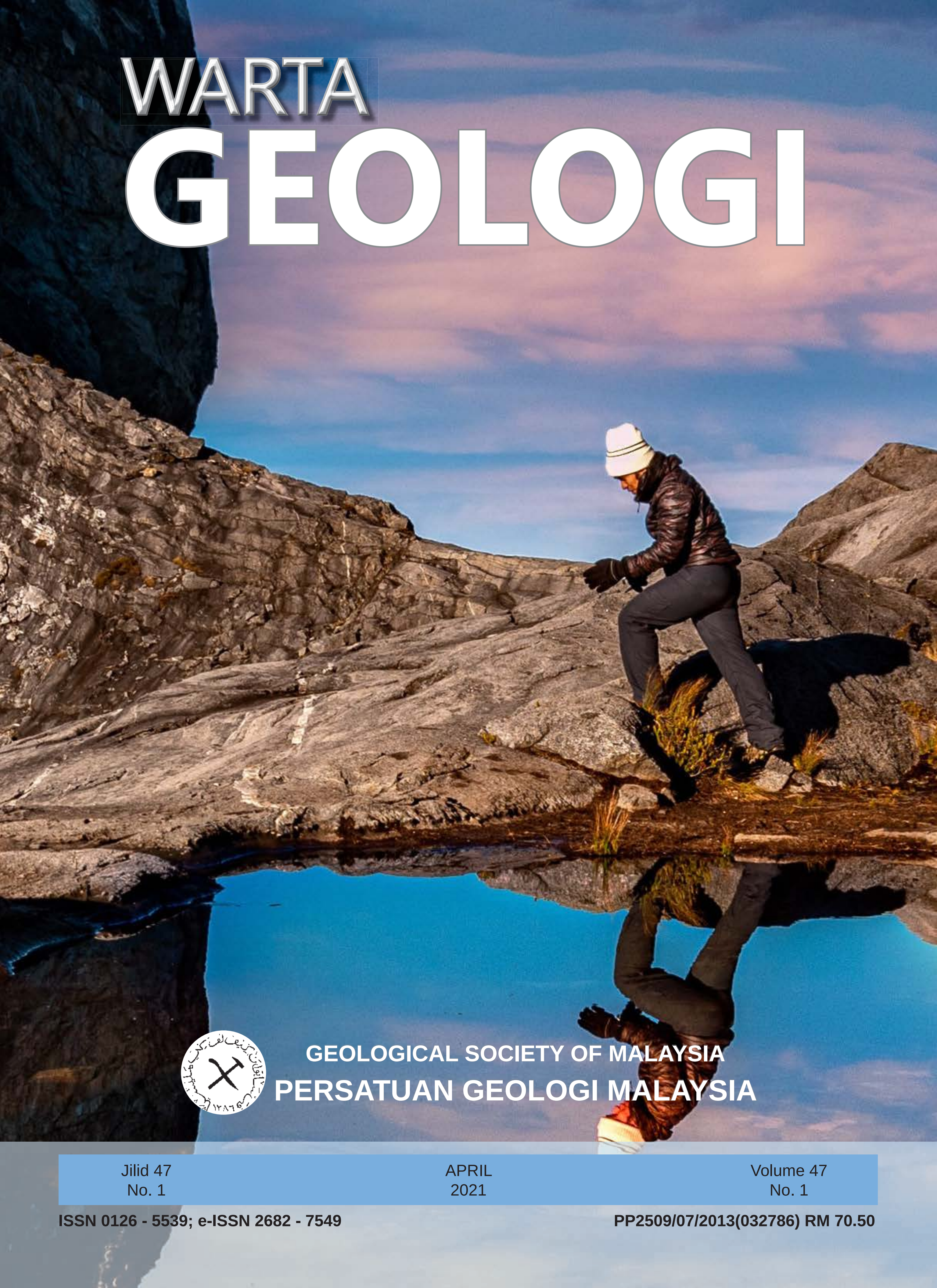

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Cover photo: Peak of Gunung Kinabalu, Sabah, Malaysia: The beautiful reflection of Kinabalu rock formation during sunrise. This photograph, taken by Yusuf Madi, is the winner of GSM National Geology Photography Competition 2020/2021

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Ultrasonic pulse velocities and dynamic elastic constants of sandstones from the Semanggol Formation, Beris Dam, Kedah Darul Aman

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Abstract: The main 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. Ultrasonic pulse measurements show velocities of compressional and shear waves through the sandstones to increase with decreasing grain size; the pebbly sandstone with velocities of 2.210, and 5.171, km/s, and the coarse grained sandstone with velocities of 2.477, and 5.612, km/s, respectively. The medium grained sandstones have compressional and shear wave velocities of 2.457, and 5.793, km/s and the fine grained sandstones, velocities of 2.572, and 5.867 km/s, respectively. Dynamic elastic constants computed from the ultrasonic velocities also increase in values with decreasing grain size; Poisson's ratio varying from 0.36 to 0.39, the modulus of elasticity from 35.076 to 48.210 GPa, the bulk modulus from 52.260 to 67.362 GPa and the modulus of rigidity from 12.637 to 17.468 GPa. Increasing velocities and elastic constants with decreasing grain size are considered to result from a denser arrangement of constituent grains as shown by increasing dry unit weights. Comparison with the results of an unconfined compression test on a fine grained sandstone indicate that the ultrasonic elastic constants are good approximations of static elastic constants.

Keywords: Ultrasonic pulse velocities, elastic constants, Semanggol Formation

INTRODUCTION

Properties of rock material are usually only considered from the point of view of their reaction to static stresses, i.e. the stresses to which a structure in rock would normally be subjected. However, during the construction phase of engineering projects, and possibly later if earthquakes or nuclear explosions are considered, a rock material may be subject to transient dynamic loading from the action of explosives, often exceeding by many orders of magnitude any static stress to which it may be subjected (Farmer, 1968). The way in which a rock material may accept or reject these dynamic stresses is of direct importance to the design of structures and towards this end, a knowledge of its dynamic elastic constants is extremely useful (Farmer, 1968).

Various methods are available for determination of the dynamic elastic constants of rock material; the most common laboratory method involving their calculation from measurements of the propagation velocities of compressional and shear waves (ASTM, 1976). Such a calculation procedure is possible in view of the fact that the existence and velocity of all body waves in an elastic medium is a function of its density and elasticity (Obert & Duvall, 1976). Where pulse frequencies above the audible range are used in determination of the velocities, the calculated constants are termed ultrasonic elastic constants (ASTM, 1976; AIT, 1981). It is to be noted that these ultrasonic constants, and wave velocities often do not agree with those determined by static laboratory, or *in situ* methods (ASTM, 1976). The ultrasonic method, however, has the advantage that it is a non-destructive technique and allows for preliminary prediction of the elastic properties of rock material.

A number of studies involving the ultrasonic method have been carried out in Malaysia; Raj (1996) showing compressional and shear wave velocities as well as dynamic elastic constants of igneous rocks from the Ajil area to be dependent upon inherent mineral compositions and textures. The ultrasonic method furthermore, determined a compressional wave velocity of 6.046 km/s for a porphyritic hypersthene micro-diorite from Tawau (Raj, 2004a), whilst a meta-rhyolitic tuff from the Dinding Schist was shown to be an anisotropic rock material with compressional wave velocities of 5.616, and 3.973, km/sec, parallel, and perpendicular, to foliation, respectively (Raj, 2004b).

Goh *et al*. (2016) determined the ultrasonic pulse velocities of compressional waves through some 70 granite, and 24 schist, specimens cored from samples collected at various locations in Peninsular Malaysia. Unconfined compression tests of the cores then led to proposal of two empirical relationships that were said to predict the uniaxial compressive strength from the compressional wave velocity.

Nurul Huda *et al*. (2019) determined the ultrasonic pulse velocities of compressional and shear waves through eight sandstone cores from the Kenny Hill Formation. Unconfined compression tests of the cores then allowed determination of the uniaxial compressive strengths as well as modulus of elasticity, shear modulus and bulk modulus. Regression analyses were said to yield good correlations between compressional wave velocities and static elastic constants.

In this short note, the compressional and shear wave velocities of ultrasonic pulses through sandstones from the Triassic Semanggol Formation are presented. Results of calculations of a number of dynamic elastic constants are also presented together with a discussion on the factors influencing the pulse velocities and elastic constants.

METHODOLOGY

Several boreholes were drilled during site investigation works for the main Beris Dam located in the narrow valley of Sungai Beris, some 1.6 km upstream of its confluence with Sungai Muda in Sik District in Kedah Darul Aman. A number of discontinuous rock cores from the boreholes were provided to the author for laboratory study and determination of their geotechnical properties.

One of the cores provided (borehole QR 3 at 37.50 to 38.80 m depth) was 0.7 m in length and showed graded bedding from pebbly sandstone at the base through coarse and medium grained sandstone to fine grained, laminated sandstone at the top. In order to investigate the influence of grain size on ultrasonic pulse velocities, the core was diamond sawn into several shorter specimens of differing grain size. The unit weights, densities and apparent porosities of these shorter specimens were then determined employing the saturation and buoyancy procedure of ISRM (1979). Thin-sections were prepared from representative specimens to identify their compositions and textures whilst the specific gravity of constituent mineral grains were determined with a pycnometer (GBRRL, 1952).

The tops and bottoms of the shorter cores were then finely ground before their visible textural and structural features described. The specimens were oven-dried at 105°C for 12 hours before measurement of ultrasonic pulse velocities along core lengths using an OYO Corporation Sonic Viewer (Model 5217 A). Compressional and shear wave transducers of 63 kHz, and 33 kHz, frequency were employed; the pulse rate set at 512 pps (pulses per second), a sampling range of 200 ns, and input, and output, gains of 10, and 3, respectively. For determination of the compressional wave velocities, which were carried out after measurement of the shear wave velocities, a thin film of grease was applied on the core ends to ensure good contact with the transducers.

After determination of the compressional and shear wave velocities, several dynamic elastic constants were calculated based on formulae provided in standard laboratory manuals as those of the American Society for Testing and Materials (ASTM, 1976) and the Asian Institute of Technology (AIT, 1981). It is to be noted that these formulae are based on assumption of a linear relationship between applied stress and the resulting strain; an elastic medium being one in which all strain is instantaneously and totally recoverable on removal of the applied stress (Farmer, 1968). In such a medium, the existence and velocity of all body waves is thus a function of its density (or unit weight) and elasticity; the propagation velocities of compressional, and shear, waves being related to the modulus of elasticity (E) (or Young's modulus), modulus of rigidity (G), Poisson's ratio (ν) and unit weight (or density) (Obert & Duvall, 1976).

It must be pointed out here that the formulae for calculation of the ultrasonic elastic constants have been employed in many other studies, though there are few demonstrations where these equations are truly applicable (Birch, 1966). The equations are furthermore, only valid if a material is isotropic, homogeneous and linear-elastic (Obert & Duvall, 1976). Rock material, however, is usually anisotropic, heterogeneous and behaves nonlinearly when subject to large stresses, though its behavior can be considered to be linear for sufficiently small changes in stress (Fjaer *et al*., 1992).

GEOLOGICAL SETTING OF SAMPLES

The concrete-faced rock fill main 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 Darul Aman (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 main Beris Dam and its spillway are founded on a sequence of massive to thick bedded conglomerate and gritstone with some sandstone and mudstone that is mapped as the Semanggol Formation of Triassic age (Teoh, 1992). Conglomerate predominates at the right abutment and underneath the dam, whilst at the left abutment and spillway, the conglomerate is inter-bedded with gritstone and coarse sandstone (Tajul & Ismail, 2003).

The matrix-supported, polymict conglomerate contains gravel to pebble-sized clasts of black to dark

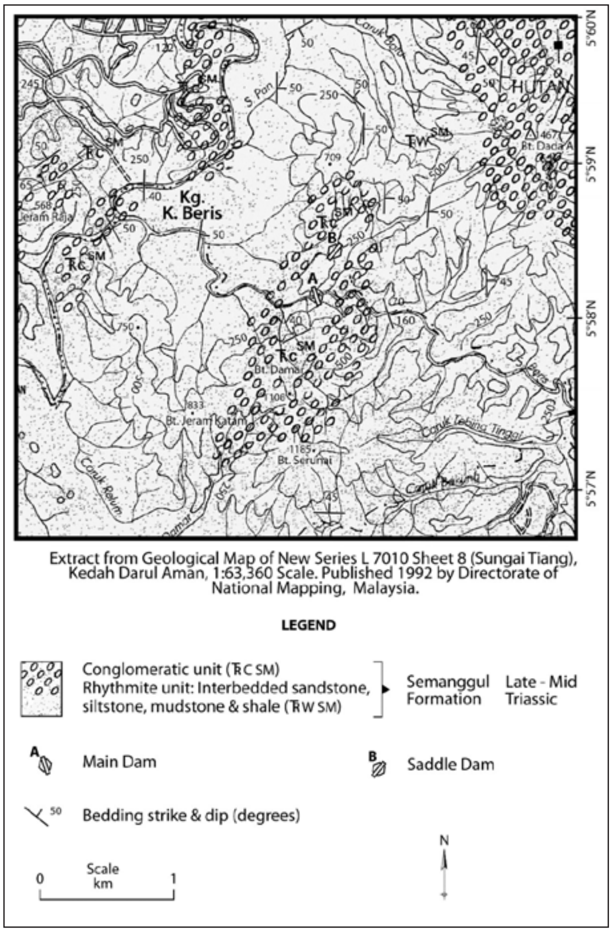

Figure 1: Geological setting of the Beris main and saddle Dams.

slate and mudstone, chert, quartz and other rock fragments, whilst the matrix comprises coarse sandy to gritty materials of quartz, feldspar and rock fragments. The rocks were said to be generally hard, compact and well indurated; requiring several blows of the geological hammer to collect 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 and hard 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).

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).

RESULTS

Petrography of investigated sandstones

The 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. The clasts are 1 to 4 mm in size, whilst grains in the matrix are 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, 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 sandstones

Bulk and dry unit weights show some variation with grain size; the pebbly sandstone with a dry unit weight of 25.35 kN/m^3, whilst the coarse, and medium, grained sandstones have dry unit weights of 25.33, and 25.36, kN/m^3, and the fine grained sandstone, a dry unit weight of 25.81 kN/m^3 (Table 1). Values of dry density mirror those of the dry unit weight; the pebbly sandstone with a dry density of 2,585 kg/m^3, the coarse, and medium, grained sandstones with dry densities of 2,583, and 2,586, kg/m^3, respectively, and the fine gained sandstone with a dry density of 2,632 kg/m^3 (Table 1). The fine grained sandstones are thus the densest rock material investigated with the maximum values of unit weight and density.

Apparent porosities reflect to some extent differences in grain size with the pebbly sandstone having an average porosity of 3.9%, whilst the fine grained sandstone has a value of 2.2%. The coarse and medium grained sandstones, however, have a similar porosity value of 3.8% (Table 1).

The specific gravity of mineral grains in the different sandstones shows little variation and ranges between 2.62 and 2.64 (Table 1). This limited variation is not unexpected in view of the closely similar composition of the mineral grains present.

Compressional and shear wave velocities

Compressional wave velocities show a distinct decrease with increasing grain size; the fine grained sandstone having a velocity of 5.867 km/s, whilst the medium, and coarse, grained sandstones have velocities of 5.793, and 5.612 km/s, respectively, and the pebbly sandstone, a velocity of 5.171 km/s (Table 2). Shear wave velocities show a less distinct decrease with increasing grain size; the fine grained sandstone having a velocity of 2.572 km/s, whilst the medium, and coarse, grained sandstones, have velocities of 2.457, and 2.477, km/s, respectively, and the pebbly sandstone, a velocity of 2.210 km/s (Table 2).

Table 1: Physical properties of sandstones 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
Pebbly Sandstone						
PS 1	26.02	25.73	3.0	2,653	2,624	2.63
PS 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						
CS 1	25.69	25.32	3.7	2,619	2,582	2.62
CS 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						
MS 1	25.83	25.46	3.7	2,634	2,597	2.63
MS 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						
FS 1	25.96	25.72	2.4	2,647	2,622	2.64
FS 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

Table 2: Ultrasonic pulse velocities and dynamic elastic constants of sandstones from the Semanggol Formation.

Sample Number	S Wave Velocity (km/s)	P Wave Velocity (km/s)	Poisson's Ratio	Modulus of Elasticity (GPa)	Bulk Modulus (GPa)	Modulus of Rigidity (GPa)
Pebbly Sandstone						
PS 1	2.111	5.033	0.393	32.570	50.882	11.688
PS 2	2.310	5.308	0.383	37.583	53.637	13.585
Average	2.210	5.171	0.388	35.076	52.260	12.637
Coarse grained Sandstone						
CS 1	2.470	5.575	0.378	43.415	59.229	15.755
CS 2	2.483	5.650	0.380	43.984	61.256	15.933
Average	2.477	5.612	0.379	43.700	60.243	15.844
Medium grained Sandstone						
MS 1	2.503	5.859	0.388	45.164	67.448	16.265
MS 2	2.410	5.726	0.392	41.668	64.508	14.963
Average	2.457	5.793	0.390	43.416	65.978	15.614
Fine grained Sandstone						
FS 1	2.443	5.751	0.390	45.503	65.871	15.650
FS 2	2.702	5.983	0.372	52.917	68.853	19.286
Average	2.572	5.867	0.381	48.210	67.292	17.468

It is to be noted that the propagation of ultrasonic pulse velocities in the investigated specimens is at an angle of about 15° to inherent bedding planes. Bedding planes, however, are only clearly seen in the laminated, fine grained sandstones and not in the medium, to coarse, gained, and pebbly, sandstones.

Dynamic elastic constants

Dynamic elastic constants computed from the ultrasonic pulse velocities show variations with grain size, except for Poisson's ratio (**ν**), which is a measure of the compressibility of material perpendicular to the applied stress, and has limited variation, ranging from 0.372 to 0.393 (Table 2).

The modulus of elasticity (or Young's modulus) (*E*) refers to the ratio of longitudinal normal stress to longitudinal normal strain and shows a general decrease with increasing grain size (Table 2). The fine grained sandstone has a modulus of elasticity of 48.210 GPa whilst the medium and coarse grained sandstones have values of 43.416, and 43.700, GPa, respectively, and the pebbly sandstone, a modulus of 35.076 GPa (Table 2).

The bulk modulus *(K*) defines the resistance of material to elastic compression and shows a clear decrease with increasing grain size (Table 2). The fine grained sandstone has a bulk modulus of 67.292 GPa, whilst the medium, and coarse, grained sandstones have values of 65.978, and 60.243, GPa, respectively, and the pebbly sandstone, a value of 52.260 GPa (Table 2).

The modulus of rigidity (*G*), or shear modulus, defines the ratio of shear stress to shear strain and shows a general decrease with increasing grain size (Table 2). The fine grained sandstone has a modulus of rigidity of 17.468 GPa, whilst the medium and coarse grained sandstones have values of 15.614, and 15.844, GPa, respectively, and the pebbly sandstone, a value of 12.637 GPa (Table 2).

DISCUSSION

Compressional and shear wave velocities

Compressional wave velocities have been shown to decrease with increasing grain size, though the shear wave velocities show a less distinct trend (Table 2). Plots of wave velocities versus dry unit weights furthermore, show a positive trend with rather low, squared correlation coefficients for both compressional (R^2=0.0693) and shear (R^2=0.0622) waves (Figure 2). Plots of wave velocities versus apparent porosity, however, show a negative trend with low squared correlation coefficients for compressional (R^2=0.1371) and shear (R^2=0.1332) waves (Figure 3).

The increase in velocities with increasing dry unit weights is an expected phenomena as several studies have shown that there is such an increase in rock materials with an increase in density (Lama & Vutukri, 1978). In the case of the investigated sandstones, the increase in pulse velocities with an increase in dry weights would thus be indicative of an increase in density with a decrease in grain size (Figure 2). The decrease in ultrasonic pulse velocities with an increase in apparent porosity is furthermore, reflective of the decrease in density with an increase in grain size (Figure 3).

Increasing velocities of compressional and shear waves with decreasing grain size are thus considered to reflect increasing densities that result from a more dense arrangement (or closer packing) of constituent particles in the investigated sandstones.

Published local data of relevance is limited to the compressional and shear wave velocities of 4.679 to 5.210 km/s, and 2.177 to 3.413 km/s, respectively, determined on 'hard' sandstones from the Kenny Hill Formation (Nurul Huda *et al.*, 2019). The shear wave velocities are comparable with those of the present study, though the compressional wave velocities are lower. The 'hard' sandstones of the Kenny Hill Formation with unit weights of between 29.62 and 30.42 kN/m^3 furthermore, appear to be denser than those of the Semanggol Formation.

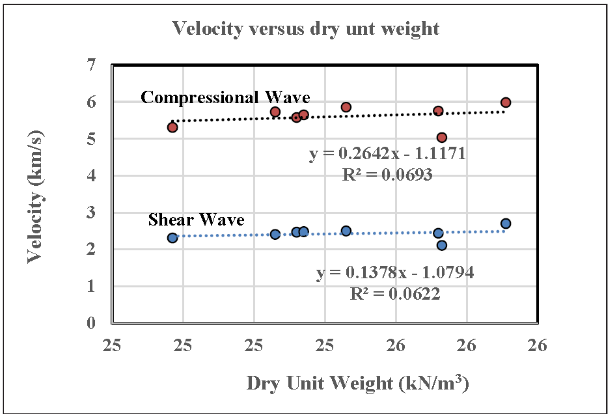

Figure 2: Compressional and shear wave velocities versus dry unit weight.

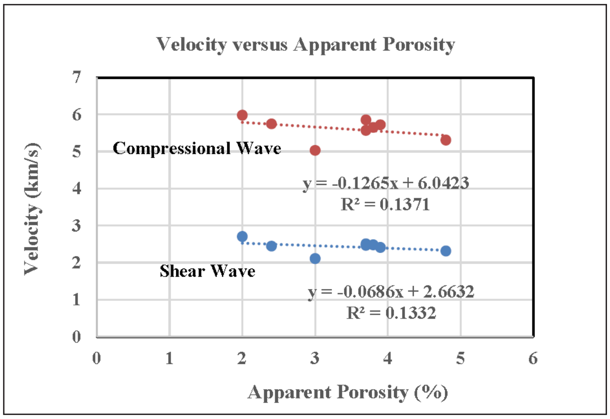

Figure 3: Compressional and shear wave velocities versus apparent porosity.

A number of empirical relationships have been proposed in Peninsular Malaysia to correlate ultrasonic pulse velocities with the strength of rock materials. Goh *et al*. (2016) for instance, proposed two empirical relationships that could be used to predict the unconfined compressive strength of granites and schists from the compressional wave velocity. No attempt, however, is made in the present study to correlate ultrasonic pulse velocities with published point load strength indices [$Is_{(50)}$] as the pulse velocities were measured at an angle (about 15°) to inherent bedding, whilst the point load tests were carried out parallel to bedding (Raj, 2019).

Dynamic elastic constants

Dynamic elastic constants, calculated from the measured velocities, have been shown to increase in values with a decrease in grain size (Table 2). Plots of the modulus of elasticity versus dry unit weights furthermore, show a positive trend with a low squared correlation coefficient (R^2=0.1549) (Figure 4). Plots of the bulk modulus, and modulus of rigidity, versus dry unit weights also show positive trends with low squared correlation coefficients of R^2=0.1372, and R^2=0.1271, respectively (Figures 5 and 6).

It is to be noted that the increase in values of elastic constants with an increase in dry unit weights is very similar to that shown by the compressional and shear wave velocities (Figure 3). It can therefore, be inferred that increasing values of the dynamic elastic constants with decreasing grain size reflect increasing densities that result from a more dense arrangement (or closer packing) of constituent particles in the investigated sandstones.

For purposes of comparison, the results of an unconfined compression test (with measurement of axial and circumferential strain) on one of the fine grained sandstone cores is presented in Table 3 (Raj, in prep). The said sandstone has an unconfined compressive strength of 136.2 MPa and overall, average values of 0.1072 for Poisson's ratio, 46.392 GPa for the modulus of elasticity, and 20.823 GPa for the modulus of rigidity (Table 3). A detailed analysis furthermore, shows that values of Poisson's ratio and modulus of elasticity vary with the compressive stress (Table 4). Poisson's ratio is low (<0.17) for low to moderate stresses (<130 MPa) and only reaches a value of 0.324 close to failure (130 to 135 MPa) (Table 4). The static modulus of elasticity, however, shows large values (>50 GPa) at low stresses (<20 MPa) and somewhat low values (<48 GPa) at high stresses (20 to 130 MPa) (Table 4).

Computed dynamic Poisson's ratios for the sandstones show a limited variability (Table 2) and thus indicate that the sandstones, although composed of particles of different size, would compress in a similar manner under applied stress. The unconfined compression test on the fine grained sandstone furthermore, shows that only close to failure does Poisson's ratio have the relatively large value of 0.324; this value being close to the calculated value of 0.381 (Tables 2 and 4). Values of the dynamic Poisson's ratio calculated from ultrasonic pulse velocities are therefore, only likely to be applicable under high compressive stresses (Birch, 1966).

Values of the dynamic modulus of elasticity (*E*) are seen to decrease with increasing grain size and range from

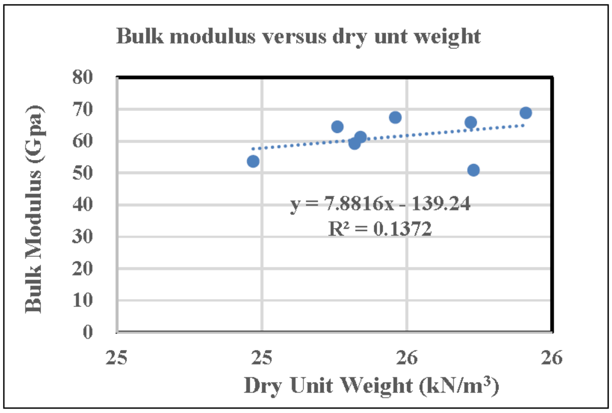

Figure 5: Dynamic bulk modulus versus dry unit weight.

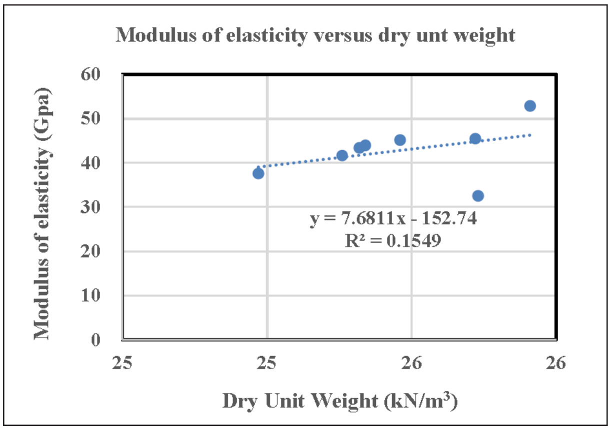

Figure 4: Dynamic modulus of elasticity versus dry unit weight.

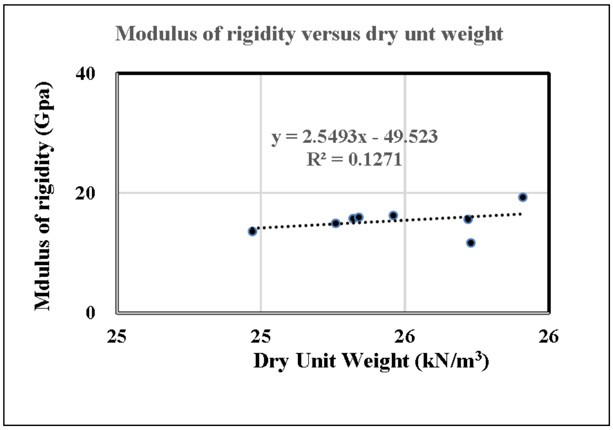

Figure 6: Dynamic modulus of rigidity versus dry unit weight.

Table 3: Results of unconfined compression test on fine grained, laminated sandstone (Raj, in prep.).

Parameter	Value	Comments
Unconfined compressive strength (UCS)	136.2 MPa	
Poisson's ratio	0.1072	Stress range: 4.3 to 78.5 MPa
Modulus of elasticity (E) (GPa)	46.392 GPa	
Modulus of Rigidity (G) (GPa)	20.823 GPa	

Table 4: Static elastic constants from unconfined compression test on fine grained, laminated sandstone (Raj, in prep.)

Compressive Stress	5-10 MPa	10-20 MPa	20-30 MPa	30-40 MPa	40-60 MPa	60-80 MPa	80-100 MPa	100-125 MPa	125-130 MPa	130-135 MPa
Poisson's Ratio	0.068	0.059	0.059	0.071	0.087	0.104	0.126	0.151	0.172	0.324
Modulus of Elasticity	64.53 GPa	52.72 GPa	47.00 GPa	47.74 GPa	46.91 GPa	46.40 GPa	46.61 GPa	44.90 GPa	42.86 GPa	32.82 GPa

32.570 to 52.917 GPa (Table 2). These calculated moduli are considered to be good approximations of static moduli of elasticity for the unconfined compression test on the fine grained sandstone yielded an overall static modulus of elasticity of 46.392 GPa; a value that is close to the calculated modulus of 48.210 GPa (Tables 3 and 2).

Values of the dynamic bulk modulus *(K)* are seen to decrease with increasing grain size and range from 50.882 to 68.853 GPa (Table 2). As the bulk modulus defines the resistance of a material to elastic compression, it is expected that the investigated clastic rocks will require large loads (or stresses) for any volume change.

Values of the dynamic modulus of rigidity (*G*) are seen to generally decrease with increasing grain size and range from 19.286 to 11.688 GPa (Table 2). These calculated moduli are considered to be good approximations of static moduli of rigidity for the the unconfined compression test on the fine grained sandstone yielded an overall modulus of rigidity of 20.823 GPa; a value close to the calculated dynamic modulus of 17.468 GPa (Tables 3 and 2).

Relevant published data in Peninsular Malaysia is only limited to the study by Nurul Huda *et al*. (2019) on 'hard' sandstones from the Kenny Hill Formation. Unconfined compression tests yielded static moduli of elasticity ranging from 8.98 to 24.80 GPa, bulk moduli of 10.85 to 23.07 GPa, and shear moduli of 3.30 to 10.89 GPa. The dynamic elastic constants determined in the present study are, however, of much larger values and indicate that sandstones form the Semanggol Formation are not as easily deformed as those from the Kenny Hill Formation.

CONCLUSIONS

Ultrasonic pulse measurements have shown that velocities of compressional and shear waves through sandstones of the Semanggol Formation increase with decreasing grain size. Pebbly sandstone has compressional and shear wave velocities of 2.210, and 5.171, km/s, whilst coarse grained sandstone has velocities of 2.477, and 5.612, km/s, respectively. Medium grained sandstone has compressional and shear wave velocities of 2.457, and 5.793, km/s and fine grained sandstones, velocities of 2.572, and 5.867 km/s, respectively. Dynamic elastic constants computed from the ultrasonic velocities also increase in values with decreasing grain size; Poisson's ratio ranging from 0.37 to 0.39, the modulus of elasticity from 35.076 to 48.210 GPa, the bulk modulus from 52.260 to 67.292 GPa and the modulus of rigidity from 12.637 to 17.468 GPa. Increasing velocities and elastic constants with decreasing grain size are considered to result from a more dense arrangement of constituent grains as shown by increasing dry unit weights. Comparison with the results of an unconfined compression test on a fine grained sandstone indicate that the ultrasonic elastic constants are good approximations of static elastic constants.

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REFERENCES

AIT (Asian Institute of Technology), 1981. Sonic velocity test for intact rock material. Chpt. XI in 'Laboratory Manual for Rock Testing'. Div. of Geotechnical Engineering & Transportation Engineering, Asian Inst. of Technology, Bangkok, Thailand, 175-189.

ASTM (American Society for Testing Materials), 1976. Suggested method for laboratory determination of pulse velocities and ultrasonic elastic constants of rock. American Society for Testing and Materials, D845-69, ASTM Standards, 341-348.

Birch, F., 1966. Compressibility; Elastic Constants. Chpt. 7 in

'Handbook of Physical Constants'. Geol. Soc. America, Mem. 97, 97-168.

DID (Department of Irrigation and Drainage), 2018. Beris Dam. Ministry of Water, Land and Natural Resources, Malaysia. retrieved from: https://www.water.gov.my.

Farmer, I.W., 1968. Engineering Properties of Rocks. E & F.N. Spon Ltd., London. 180 p.

Fjaer, E., Holt, R.M., Horsrud, P., Raaen, A.M. & Risnes, R., 1992. Petroleum Related Rock Mechanics, Dev. in Petroleum Science, No.33. Elsevier, Amsterdam. 338 p.

Goh, T.L., Abdul Ghani Rafek, Ailie Sofyiana Serasa, Azimah Hussin & Lee, K.E., 2016. Use of ultrasonic velocity travel time to estimate uniaxial compressive strength of granite and schist in Malaysia. Sains Malaysiana, 45(2), 185-193.

GBRRL (Great Britain Road Research Laboratory), 1952. Soil Mechanics for Road Engineers. Road Research Laboratory, Dept. of Scientific and Industrial Research. Her Majesty's Stationary Office, London. 541 p.

ISRM (International Society Rock Mechanics), 1979. Suggested methods for determining water content, porosity, density, absorption and related properties and swelling and slake durability index properties. Int. J. Rock Mech. Min Sci. & Geomech. Abstr., 16, 141-156.

Lama, R.D. & Vutukuri, V.S., 1978. Handbook on Mechanical Properties of Rocks - Testing Techniques and Results, V.II. Trans Tech. Publications, Germany. 481 p.

Nurul Huda, A., Haryati, A. & Hamid, N.H., 2019. Characterizing P-wave velocity and elastic properties of sedimentary rocks for foundation of building. Jour. Mech. Engng., Univ. Teknologi MARA (UiTM), Malaysia, 16(2), 199-210.

Obert, L. & Duvall, W.I., 1976. Rock Mechanics and the Design of Structures in Rock. John Wiley & Sons Inc., New York. 650 p.

Raj, J.K., 1996. Ultrasonic pulse velocities and elastic moduli of igneous rock materials from the Ajil area, Terengganu Darul Iman. Warta Geologi, 22(1), 1-9.

Raj, J.K., 2004a. Some physical and mechanical properties of porphyritic hyperstene microdiorite from the Tawau area, Sabah, East Malaysia. Warta Geologi, 30(3), 51-92.

Raj, J.K., 2004b. Physical and mechanical properties of a meta-rhyolitic tuff from the Dinding Schist. Warta Geologi, 30(5), 177-182.

Raj, J.K., 2019. Point load strength of clastic sedimentary rocks from the Semanggol Formation, Beris Dam, Kedah Darul Aman. Warta Geologi, 45(4), 393-399.

Raj, J.K. (in prep). Post-failure behavior of a fine grained sandstone from the Semanggol Formation, Beris Dam, Kedah Darul Aman (in preparation).

Tajul, A.J. & Ismail, Y., 2003. Influence of discontinuity on over-breaks and under-breaks in rock excavation - case study from Beris Dam. Bulletin of the Geological Society of Malaysia, 46, 75-86.

Teoh, L.H., 1992. Geology and Mineral Resources of the Sungai Tiang Area, Kedah Darul Aman. Map Rept. 5, Geol. Survey of Malaysia, Govt. Printers, Ipoh. 92 p.

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Geochemical characterization of pottery shards unearthed from Kampung Baru Archaeological Site, Kedah, Malaysia

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Abstract: Candi Kampung Baru is situated in the Kampung Baru Archaeological Site, and it is one of the temple sites that used bricks as the main construction material. Based on the Global Positioning System, Candi Kampung Baru is located at N 05.58215°, E 100. 38004°. Apart from bricks, granite stones were also used as the pillar base of the construction's structure. This study is an analytical approach on the pottery properties of clays discovered at the Kampung Baru Archaeological Site. X-ray diffraction (XRD), X-ray fluorescence (XRF) and physical analysis have been performed on these potsherds. 15 pottery shard samples were analysed to determine the chemical and mineralogical characteristics of the pottery shards. The results indicate a local provenance of these samples. The mineral content in the pottery samples also indicate the presence of minerals, such as quartz, illite, datolite and microcline. Furthermore, the physical analysis conducted uncovered a variety of motifs that adorned the earthenware, such as lines, nets, square and floral motifs. The mineral content and physical observation of the pottery shards indicate that the open burning technique was used to produce these pottery shards due to the presence of illite mineral in the pottery shards. The mineral content (namely illite) also shows that the samples were baked at a temperature between 650°C and 750°C. The content of the major and trace elements also proves that these potteries were produced from the same source and it is proposed that local raw materials were used in the production of the potteries, from which the nearest source that could be detected is at the Muda River basin. Moreover, the involvement of the local community in producing the potteries should not be refuted, as this proves that the knowledge of producing pottery by the local community had already started since the evolution of the Neolithic culture at the Muda River basin since 4000 to 5000 years ago.

Keywords: Pottery, Kedah, Kampung Baru Archaeological Site, Muda River, Bujang Valley, X-ray diffraction (XRD), X-ray fluorescence (XRF)

INTRODUCTION

Archaeological study on artifacts (namely pottery, ceramic and beads) since the late 20th century in Malaysia has been employing interdisciplinary analysis by using chemical, geological and physical analytical techniques. By using the chemical and mineralogical analyses, the place of origin of the raw materials used for pottery or other type of artifacts should be given due attention. In order to identify if local raw materials have been used in pottery productions, the identification of specific chemical elements can help to distinguish locally made pottery from the imported ones. Compositional analysis of the ancient pottery found at the Kampung Baru Archaeological Site was carried out in order to determine the content of mineral, major and trace elements contained in the pottery sherds. Data obtained from the subsequent pottery analysis have been compared with the composition data of clay material around the Bujang Valley. It is important to conduct material composition analysis of the ancient pottery of this site, as it can help determine the provenance of raw materials used to produce the pottery, if it was locally made or otherwise.

The mineral content of pottery was determined through the use of the X-Ray diffraction (XRD) analysis, whereas the X-Ray fluorescence (XRF) analysis was used to determine the trace and major elements of the samples. The XRD and XRF analyses have also provided new data on the origin and technology of prehistoric pottery in Malaysia (Treloar, 1978; Mohd Kamaruzaman *et al*., 1991; Chia, 1997; Asyaari, 1998; Ramli *et al*., 2011, Moradi *et al*., 2013, Sarhaddi-Dadian *et al*., 2017), glass beads (Ramli *et al*., 2017), bronze drum (Jusoh *et al*., 2012), and ancient bricks (Ramli & Rahman, 2013; Ramli *et al*., 2013; Siti Norbaini *et al*., 2015).

Furthermore, the XRD and XRF analyses also have been conducted not only in Malaysia, but in other archaeological related researches throughout the Southeast Asian countries. The XRD and XRF analyses were conducted on ceramic (Ngun *et al.*, 2011), glass (Dararutuna *et al*., 2012), pottery (Malee & Thiansem, 2016), clay materials (Aidhia Rahmi & Helendra, 2018), and rock painting (Lebon *et al*., 2019; Nadya Nurdini *et al*., 2020).

The Kampung Baru Archaeological Site (N 05.58215°, E 100.38004°) was discovered during the Sungai Muda exploration work that was carried out from 2010 to 2011. It is one of the archaeological sites associated with the Ancient Kedah that thrived from the 9th century CE until 11th century CE (Ramli *et al*., 2018; Mohd Shamsul Bahari *et al*., 2018; Mori & Ramli, 2019a, 2019b). The site is located along the banks of the Muda River in the area of Kampung Baru, Kota Kuala Muda, Kedah (Figure 1). Based on the discovery of a Neolithic community settlement at Guar Kepah, it is a clear evidence that the Muda area, which comprises the states of Kedah and Penang, was inhabited since 4000 to 5000 years ago (Mokhtar, 2012; Shaiful *et al.*, 2018). The distance between Kota Kuala Muda with the nearest town, Sungai Petani, is 22 kilometres. The distance between this site and the Muda River is only about 100 metres. Mount Jerai can be seen from the front view (north) of this site. Before this site was discovered, it was used by the local community as a Muslim burial ground, and the impact of the Muda River flood mitigation project has uncovered a few bricks from a *candi* (temple) located at this site. This site is also located close to the Sungai Mas Archaeological Site, as well as the Permatang Pasir *Candi*. The position of this site, which is close to the Sungai Mas Archaeological Site, is an important point, as the Sungai Mas was once the administrative centre and entrepot for Ancient Kedah.

MATERIALS AND METHODS

The research methods used in this study includes physical analysis, as well as the XRD and XRF analyses of the pottery samples.

Physical analysis

The physical analysis has been performed on all 7595 potsherds discovered at this site, according to its excavation trench and spit (and later according to its respective cultural layer). This is to ensure that accurate data could be obtained. The first step in this analysis was to clean each of these artefacts before classifying them into several sections, based on their characteristics. During this process, the pottery was identified for any decorations on its surface. If there was any, its type, shape, and methods in which the decoration were made was documented. The measurement of each individual findings during the excavation was also recorded.

Clay samples

Data of the X-Ray diffraction (XRD) and X-Ray fluorescent (XRF) of clay samples were derived from Ramli (2012). The clay samples were taken from the area along the Muda River, the Baru River, the Bujang River and the Terus River. Samples were also taken from the vicinity of Mukim Kota, Mukim Bukit Meriam and Mukim Merbok.

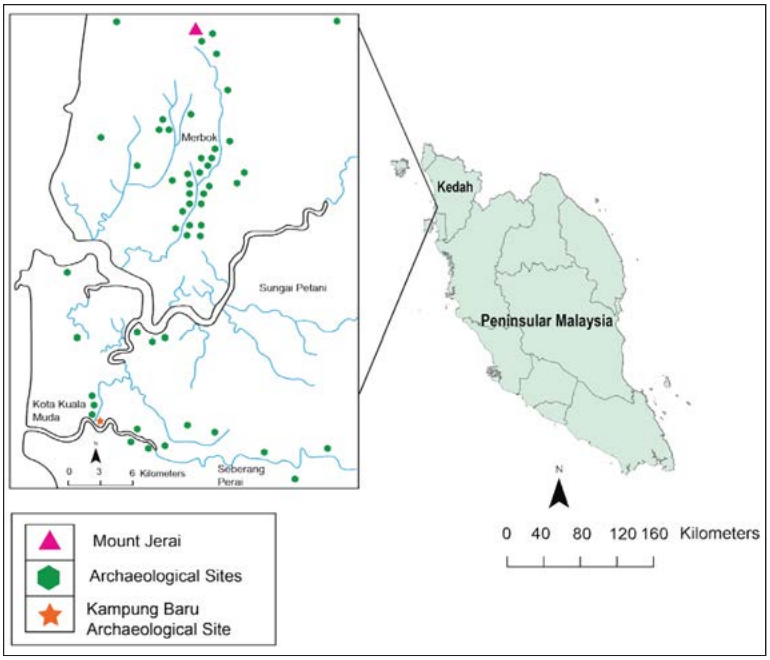

Figure 1: Location of Kampung Baru Archaeological Site.

XRD and XRF analysis

A total of 15 pottery samples from the Kampung Baru Archaeological Site were taken to the lab for cleaning, and were labelled with the names TTKB 1, TTKB 2, TTKB 3, TTKB 4, TTKB 5, TTKB 6, TTKB 7, TTKB 8, TTKB 9, TTKB 10, TTKB 11, TTKB 12, TTKB 13, TTKB 14, and TTKB 15 (refer to Figure 2 and Figure 3). The analysis was conducted to determine the mineral content in the ancient pottery samples. Samples weighing 0.4 g were refined and heated up for one hour at a temperature of 105 °C, and mixed until they turned homogenous with the flux powder, Spectroflux 110 (product of Johnson and Mathey). These mixtures were baked for one hour in a furnace with a temperature of 1100 °C. The homogenous molten was then moulded in a container and cooled gradually into pieces of fused glass with the thickness

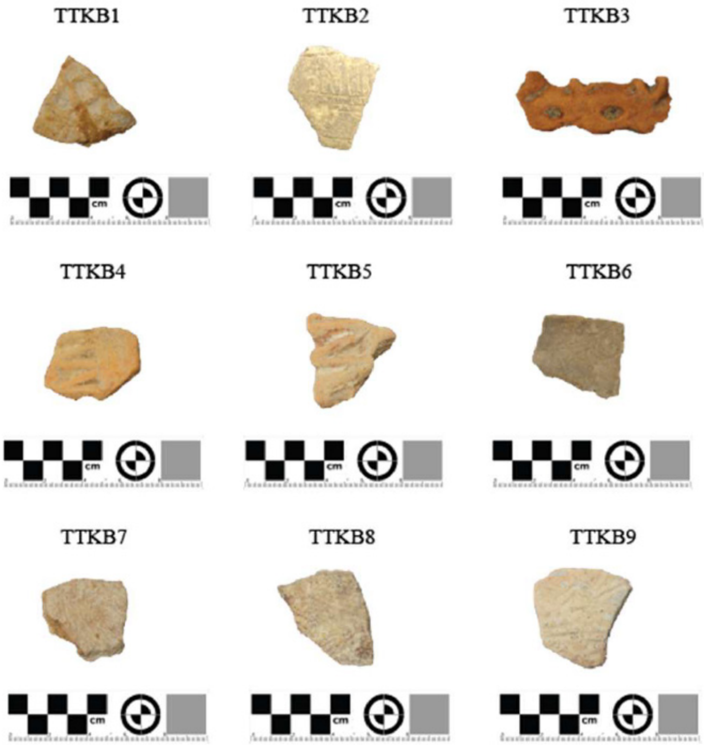

Figure 2: Pottery samples TTKB1 to TTKB9 from the Kampung Baru Archaeological Site.

Figure 3: Pottery samples TTKB10 to TTKB15 from the Kampung Baru Archaeological Site.

of 2 mm and diameter of 32 mm. In result, the samples were ensured to have a ratio of 1:10 dilution. Samples in the form of fused glass were prepared to analyse traces of major elements, such as Si, Na, K, Ca, Fe, Al, Ti, Mn, and Mg. This was then followed with the preparation of pressed pallet samples in order to analyse their trace elements, such as As, Ba, Ce, Cr, Cu, Ga, Ni, Pb, Rb, Sr, Th, V, Zn, and Zr.

These samples were prepared by mixing 1.0 g of samples with 6.0 g of boric acid powder and then the pressure of 20 psi was applied by using hydraulic pressure equipment. The samples of the fused pallet and pressed pallets were then analysed by using the Philips PW1480 equipment. Samples in the form of very fine powder were put into the pellets (sample holder) and then analysed by using the X-ray Diffraction instrument (D500 Diffractometer Siemens). A scatter plot diagram of MgO versus TiO_2 was then performed to demonstrate the differences among the group and was analysed using Microsoft Excel software. The main purpose was to discern the distribution of the samples in the group and to subsequently compare them with the elements in the clay samples. The applicability of the analytical methods for the multi-elemental analysis by XRF of the glass beads was evaluated by the analysis of certified reference material, 315 Fire Brick (Calibration: G-FBVac28 mm) for major elements and certified reference materials, SY-2 (Calibration: Trace Element P-20) for trace elements. The CRM was also used as the quality control material of the analytical procedure.

Table 1: Decorated pottery parts.

Parts	Quantity
Body	1688
Merged Parts	9
Lid	1
Total	1698

Table 2: Non-decorated pottery parts.

Parts	Quantity
Body	3971
Lip	1634
Neck	144
Lid	39
Merged Parts	64
Base	23
Handle	10
Kendi Spout	10
Total	5897

RESULTS

Physical analysis

There were 7595 sherds of pottery found at the Kampung Baru Archaeological Site during the excavation. However, the excavation did not discover any perfect pottery that were still intact, but only fragments of them in different sizes. Although the pottery was found to be imperfect, the results of typology and physical analyses conducted were able to identify different types of pottery found at this site, such as bowls, pots, jars, crocks, and *kendi* on some of the potsherds. The sherds of pottery found at the Kampung Baru Archaeological Site have also been divided into several identified parts, such as their body, lips, neck, foot, nozzle, handle, merged parts and lid.

The total number of decorated pottery found at this site were in 1698 pieces, while the classification of the decorated pottery sections is as shown in Table 1. In addition, the quantity of non-decorated pottery found in the Kampung Baru archaeological site are 5897 fragments, while the classification of the pieces of pottery is as shown in Table 2.

The analysis on the pottery also found that there were several types of decorative patterns used on the surface of the pottery. The most used decorative pattern type is the straight line motif, as well as the net motif. In addition, there were also decorative patterns that were modelled on the surrounding environment, such as flowers and grass. The floral decorations were clearly visible on the fragments of the pottery found at this site. Circular shapes were also found embedded on the pottery bodies and would be often adorned with other patterns, such as straight lines, flowers and even grass (Table 3). Some of the decorations on the pottery body can be seen in Figure 2 and Figure 3.

XRD and XRF analysis

The composition analysis on the potsherd samples from the Kampung Baru archaeological site was carried out to determine its geo-chemical and mineral contents. The composition analysis on the potsherds helped to determine if local raw material was used to produce these potteries. The mineral content in the pottery samples showed the presence of minerals, such as quartz, illite, datolite and microcline (see Figure 4). The mineral contents of each sample is shown in Table 4. From the table, it is clear that the quartz was present in each sample. Microcline was present in each sample, except for sample TTKB1, whilst datolite was present in sample TTKB1 only. The mineral content such as illite shows that the samples were baked at a temperature between 650 °C- 750 °C. Based on their mineral content, it indicated that the pottery sherds were made by the same raw material accepted for sample TTKB1.

The contents of the major elements in the pottery fragments can be referred to in Table 5. The analysis

Table 3: Motifs on the pottery.

Motif	Quantity
Straight line (cord marked)	1440
Net (Carved wood)	99
Straight line (incised)	66
Net (cord marked)	39
Flower (incised)	22
Triangle (incised)	6
Straight line and zigzag	3
Straight line and cross (incised)	3
Flower and circle (incised)	3
Square (impressed)	2
Line (Shell, impressed)	2
Zigzag (incised)	2
Line and Net (cord marked)	1
Line (Carved wood)	1
Line, zigzag, and triangle	1
U shape (incised)	1
Cross (incised)	1
Zigzag and square (incised)	1
Line and shell impressed	1
Zigzag, line, cross, and plant	1
Line and circle (incised)	1
Line and plant	1
Square (incised)	1

shows that the pottery fragments contained 54.59 per cent to 72.98 per cent dry weight silica. The percentage of dry weight for aluminium elements is between 13.59 per cent and 20.06 per cent. While iron elements contain a dry weight percentage of 3.31 per cent to 11.74 per cent. Further to this, the percentage of dry weight for potassium elements ranged from 1.58 per cent to 2.75 per cent, while dry weight calcium ranged from 0.07 per cent to 0.49 per cent. The percentage of dry weight for titanium elements ranged from 0.54 per cent to 0.95 per cent, while dry weight phosphorus ranged from 0.13 per cent to 1.54 per cent. The percentage of dry weight magnesium and sodium elements was 0.26 per cent to 1.27 per cent and 0.12 per cent to 0.66 per cent. Sulphur and manganese elements contain a percentage of dry weight 0.03 per cent to 0.42 per cent and 0.01 per cent to 0.14 per cent, respectively. Figure 5 shows the scatter plot graph for percentage of dry weight of Al_2O_3 and SiO_2 elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley.

Based on the scatter plot graph, it can be suggested that most of the pottery sherds had the same compositional content of Al_2O_3 and SiO_2 with clay samples taken from the surrounding area in Bujang Valley. Figure 6 shows the scatter plot graph for percentage of dry weight of MgO and TiO_2 elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley.

The contents of trace elements in the pottery samples from this site can be referred to in Table 6. The analysis showed only zirconium, zinc, rubidium and strontium were present in all samples. Copper was present in all samples except sample TTKB11, while chromium was present in all samples, except in samples TTKB5 and

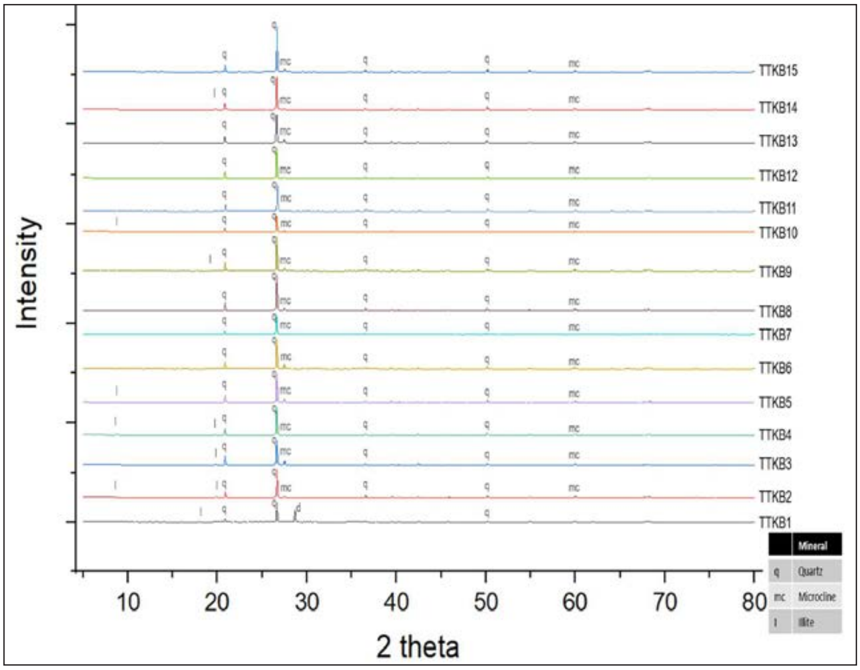

Figure 4: X-Ray diffraction pattern of the Kampung Baru Archaeological Site pottery sherd samples.

Table 4: Mineral content in pottery samples of the Kampung Baru Archaeological Site.

Sample	Mineral
TTKB1	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite SiO_5HCaB Datolite
TTKB2	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB3	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB4	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB5	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB6	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB7	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB8	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB9	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB10	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB11	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB12	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB13	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB14	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB15	SiO_2 Quartz $KAlSi_3O_8$ Microcline

TTKB11. Nickel was also present in all samples, except in samples TTKB11 and TTKB12. Zirconium content ranged from 200 to 300 ppm while zinc content ranged from 71 to 200 ppm. Rubidium and strontium content ranged from 100 to 200 ppm and 29 to 92 ppm. Copper content ranged from 31 to 300 ppm, while chromium content ranged from 79 to 200 ppm. Lead content is between 55 and 600 ppm, whereas nickel content is between 34 and 100 ppm. Figure 7 shows the scatter plot graph for the concentration of nickel and strontium elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley. Based on the scatter plot graph, it can be suggested that most of the pottery sherds have similarities with the contents of nickel and strontium in clay samples taken in the vicinity of the Muda, Bujang and Terus basins. It showed that the pottery from the Kampung Baru archaeological site were made by using local raw materials found in Kedah. However, there is also a pottery with a high lead content – the TTKB2 sample – with a reading of 600 ppm. It is proposed that, in addition to locally manufactured pottery, there were also pottery that were brought from outside of Ancient Kedah, as high lead content would often be found in pottery of Indian origin (Caleb, 1991).

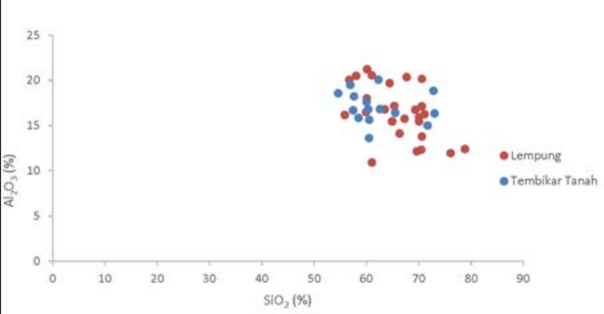

Figure 5: Percentage of dry weight (%) of Al_2O_3 and SiO_2 elements for the Kampung Baru Archaeological Site pottery samples (tembikar tanah) and clay samples (lempung) in the Bujang Valley.

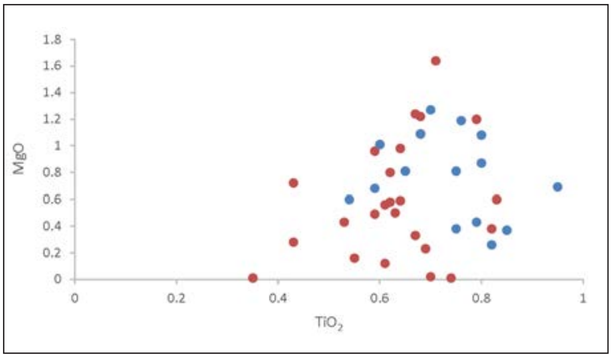

Figure 6: Percentage of dry weight (%) of MgO and TiO_2 elements for the Kampung Baru Archaeological Site pottery samples (red) and clay samples in the Bujang Valley (blue).

DISCUSSION

According to the quantity of pottery sherds discovered here, it was clearly determined that the pottery was mostly used to serve domestic and religious purposes. Past excavations that were conducted in Kedah have discovered a lot of pottery; in fact, the pottery was the

Table 5: Major elements in the pottery samples of the Kampung Baru Archaeological Site.

Sample	Dry Weight (%)										
	SiO_2	Al_2O_3	Fe_2O_3	K_2O	CaO	TiO_2	P_2O_5	MgO	Na_2O	SO_3	MnO
TTKB1	60.33	16.79	8.14	1.65	0.21	0.65	0.41	0.81	0.15	0.12	0.05
TTKB2	58.50	15.84	9.99	1.82	0.43	0.60	1.16	1.01	0.16	B.D.L	0.05
TTKB3	54.59	18.57	8.10	2.42	0.40	0.76	0.32	1.19	0.66	0.09	0.03
TTKB4	57.42	16.69	11.74	1.62	0.49	0.68	0.88	1.09	0.15	B.D.L	0.14
TTKB5	71.68	15.00	4.28	1.88	0.21	0.70	0.13	1.27	0.23	B.D.L	0.03
TTKB6	62.59	16.81	6.45	1.70	0.18	0.75	0.39	0.38	0.13	0.08	0.02
TTKB7	60.01	17.60	5.61	1.76	0.20	0.82	1.12	0.26	0.12	0.10	0.04
TTKB8	72.79	18.84	3.31	1.87	0.13	0.80	0.28	0.87	0.16	0.04	0.01
TTKB9	60.52	15.63	7.30	1.58	0.10	0.79	0.91	0.43	0.17	0.36	0.01
TTKB10	56.88	19.49	5.67	1.97	0.07	0.85	1.54	0.37	0.17	0.42	0.01
TTKB11	60.50	13.59	3.36	2.21	0.10	0.54	0.23	0.60	0.17	0.03	B.D.L
TTKB12	72.98	16.32	3.64	2.75	0.18	0.59	0.43	0.68	0.28	0.15	0.03
TTKB13	57.59	18.22	7.80	2.59	0.08	0.95	0.95	0.69	0.12	0.25	0.04
TTKB14	65.51	16.40	4.95	2.07	0.37	0.75	0.68	0.81	0.22	0.03	0.01
TTKB15	62.29	20.06	4.44	1.95	0.25	0.80	0.17	1.08	0.18	0.05	0.01

B.D.L = Below Detection Limit

Table 6: Trace elements in the pottery samples of the Kampung Baru Archaeological Site.

Sample	Element (ppm)										
	BaO	ZrO_2	ZnO	Rb_2O	SrO	Cr_2O_3	CuO	NiO	As_2O_3	Nb_2O_5	PbO
TTKB1	300	200	200	100	38	100	56	69	B.D.L	24	100
TTKB2	600	200	200	100	57	100	200	84	3	B.D.L	600
TTKB3	700	200	100	100	92	200	200	97	15	12	100
TTKB4	800	200	200	100	57	97	100	100	25	B.D.L	400
TTKB5		300	89	100	42	B.D.L	41	45	22	18	B.D.L
TTKB6	700	300	100	100	29	100	81	77	B.D.L	26	100
TTKB7		300	100	100	38	100	64	39	B.D.L	B.D.L	100
TTKB8	300	300	200	100	39	92	300	66	9	19	70
TTKB9	400	300	100	100	32	100	100	60	B.D.L	21	100
TTKB10		300	100	100	32	94	45	56	42	38	67
TTKB11		200	71	100	29	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L
TTKB12	400	200	71	200	50	79	35	B.D.L	B.D.L	16	69
TTKB13	400	300	100	200	33	100	60	54	13	30	98
TTKB14	400	300	100	100	54	98	44	45	B.D.L	23	B.D.L
TTKB15		300	81	100	46	100	31	34	6	18	55

#B.D.L = Below Detection Limit

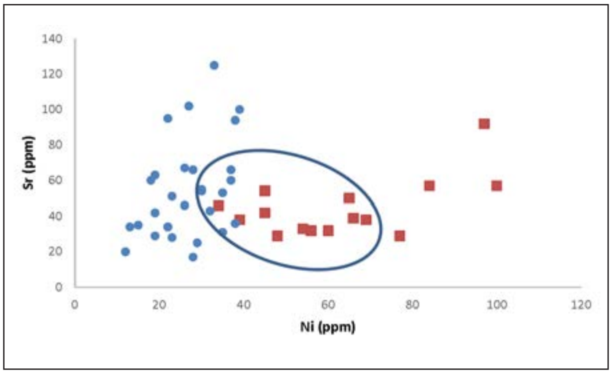

Figure 7: Concentration distribution graphs of strontium against nickel for the Kampung Baru Archaeological Site Pottery samples (red) and clay samples in the Bujang Valley (blue).

most discovered artefact that is associated with the Ancient Kedah. During the Protohistoric Time, the pottery was largely used because it was produced in mass, as proven by the number of pottery found in Kedah (Nik Hassan Shuhaimi & Asyaari, 2008). Besides that, the availability of local pottery also played its part, as in the Ancient Kedah, it would be easier to get the locally made pottery than the imported ceramics, especially the ones from China. Based on the pottery part discovered here, it is concluded that it was mostly used domestically as daily equipment and also in religious functions by the devotees who patronised the *candi* here. Furthermore, the devotees also used the pottery as a container – particularly water – as *kendi* spouts were also found at this site.

The analysis conducted on the decorations found that the pottery from this site also bore complex motifs. The adornment of complex motifs showcases the ability of local artisans in producing fine pottery. In order to produce complex decoration or motif, one would need high expertise to create it in minute details. The complex decoration of pottery from the Kampung Baru Archaeological Site were made using the incising technique, as only 100 of the sherds were made by using this technique, while there are another three sherds which combine incising and pressing techniques. There is no doubt that in the Ancient Kedah, the demand for complex motifs on decorated pottery had existed. It is also worth mentioning that, judging by the fine quality of the sherds discovered, it is suggested that the Malays of Ancient Kedah (including the devotees of the *candi* at this site) chose functionality more than the aesthetics of the ware. This suggestion was made based on two facts: 1) the quantity of undecorated pottery compared to the decorated ones, and 2) the comparison of quantity between the pottery with the imported ceramics that adorn with more complex decorations (Mori & Ramli, 2019a, 2019b).

Besides basic decorations that incorporated lines or nets as their main motif, there were also floral motifs that adorned the surface of the pottery. Although floral motif only comprised less than 1.6 per cent of the total of decorated pottery sherds found, this discovery strengthens the fact that functionality and practicality of pottery was not the only factor that was taken into account by the devotees in choosing their ware for the *candi*. Considering the existence of more complex decorations – especially the pottery that bore floral motifs – this is not deemed peculiar, as the Malays often used their surroundings and natural environment as an inspiration to their art. To a certain extent, the local and cultural philosophy was also a source of inspiration for their artwork. This can be seen not only on the decorations of the pottery, which used flowers and grass as adornment, but also in other aspects of the Malay lifestyle, such as the *pantun*. The usage of natural surroundings in the Malay *pantun* was a reflection of not only the Malay thought, but also to their philosophy, which was embodied in their aesthetic appreciation for art (Zarina & Anida, 2018).

The pottery found in the Kampung Baru Archaeological Site was a locally made product and had its own aesthetic value. The discovery of stone tools and *batu sondol* (an equipment used for pottery making, especially in the Malay Peninsular) makes up the evidences of pottery making activities that took place in the vicinity of this site. Archaeological data of past excavations also showed that pottery discovery in the area around Sungai Mas and Muda River were in large quantities. For example, the pottery discovery in Sungai Mas in the year 1981 found 4211 fragments of pottery, while in 2006, 1209 fragments of pottery were discovered (Nuratikah *et al.*, 2018). The discovery of pottery in large quantities at the Kampung Baru archaeological site and the Sungai Mas Archaeological Site indicated that there was a local pottery making industry in Ancient Kedah. This is because it is difficult to import large amounts of pottery from other regions, as it is more fragile than other ceramics; thus, the people of Ancient Kedah had a tendency to manufacture their own pottery, as it was discovered in the Kampung Baru archaeological site. Moreover, the XRD and XRF analyses conducted on the selected pottery samples also found that local raw materials were used to produce it.

CONCLUSION

A total of 7595 sherds of pottery were analysed in this study using physical analysis, and 15 samples were then analysed using the XRD and XRF analyses method. The chemical and mineralogical characteristics of these pottery sherds have indicated the source of the raw material. The mineral contents in the pottery samples showed the presence of minerals, such as quartz, illite, datolite and microcline; whereas the physical analysis conducted found that there were varieties of motifs involved in the adorations of the earthenware, such as lines, nets, square and floral motifs. The mineral contents and physical observation of the pottery sherds indicated that the open burning technique was used to produce these pottery sherds due to the presence of illite mineral in the pottery sherds. The mineral contents (namely ilite) also suggested that the samples were baked at a temperature between 650 °C and 750 °C. The contents of the major and trace elements indicated that these potteries were produced from the same source, and it is proposed that local raw materials were used in the production of the potteries, where the nearest source that could be detected was at the Muda River basin. The involvement of the local community in producing the potteries should not be refuted, and this proved that the knowledge of producing pottery by the local community had already started since the evolution of the Neolithic culture at the Muda River basins since 4000-5000 years ago.

ACKNOWLEDGEMENTS

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REFERENCES

Aidhia Rahmi & Helendra, 2018. Relationship between the Clay Composition and the Soil Source in West Sumatera. Jurnal Penelitian Pendidikan IPA, 5(1), 48-52.

Asyaari, M., 1998. X-Ray Flourescence Analysis of Clay Pottery in Perak. Jurnal Arkeologi Malaysia, 11, 1 – 40. (In Malay).

Caleb, H., 1991. Construction Materials: Type, Uses and Application. The Geological Society of America, New York.

Chia, S., 1997. Prehistoric pottery sources and technology in Peninsular Malaysia, based on compositional and morphological studies. Malaysia Museum Journal, 33, 91 – 125.

Dararutana, P., Won-In, K., Intarasiri, S., Kamwanna, T., Tancharakorn, S., Sirikulrat, N. & Hauzenberger, C.A., 2012. X-Ray Spectrometry Study on Historical Decorative Glasses in Thailand: Lanna-Style Glass. Advanced Materials Research, 620, 330–334.

Jusoh, A., Sauman, Y., Rahman, N.H.S.N. & Ramli, Z., 2012. Scientific analysis of samples of some artefacts metals age in Malaysia. Social Sciences (Pakistan), 7(6), 772-777.

Lebon, M., Gallet, X., Bondetti, M., Pont, S., Mauran, G., Walter, P., Bellot-Gurletf, L., Puauda, S., Zazzog, A., Forestierh, H., Auetrakulviti, P. & Zeitounj V., 2019. Characterization of painting pigments and ochres associated with the Hoabinhian archaeological context at the rock-shelter site of Doi Pha Kan (Thailand). Journal of Archaeological Science, 26, 101855.

Malee, U. & Thiansem, S., 2016. Analytical Study of Ancient Pottery from the Archaeological Site of Ban Bo Suak from Nan Province, Thailand. Key Engineering Materials, 690, 18–22.

Mohd Kamaruzaman, A.R., Mohd Deraman, Ramli Jaya & Mohd Ali Sufi, 1991. Scientific study of clay pottery finds in Pulau Kalumpang, Perak: Preliminary Results. Jurnal Arkeologi Malaysia, 4, 59 – 73. (In Malay).

Mohd Shamsul Bahari, A.H., Ramli, Z., Muhammad Nu'man Mohd Nasir & Mori, J., 2018. The Application of Digital Reconstruction in the Documentation and Interpretation of Candi Kampung Baru, Kota Kuala Muda, Kedah. International Journal of Engineering & Technology, 7 (3.9), 52-54.

Mokhtar, S., 2012. Archaeology: Early Settlements in Seberang Perai and Penang Island. In: Muhammad Haji Salleh (Ed.), Early History of Penang. Penerbit Universiti Sains Malaysia, Pulau Pinang, 1-16.

Moradi, H., Hossein Sarhaddi Dadian, Ramli, Z. & Rahman, N.H.S.N.A., 2013. Compositional analysis of the pottery shards of Shahr-I Sokhta, South Eastern Iran. Research Journal of Applied Sciences Engineering and Technology, 6(4), 654–659.

Mori, J. & Ramli, Z., 2019a. Variety of Ceramic Types at Candi Kampung Baru Site, Kota Kuala Muda, Kedah (Phase 2 Excavation). Jurnal Arkeologi Malaysia, 32(1), 41-51. (In Malay).

Mori, J. & Ramli, Z. 2019b. Trades Ceramic found in Candi Kampung Baru Site, Kota Kuala Muda, Kedah. In: Suresh Narayanen, Nasha Rodziadi Khaw & Mokhtar Saidin (Eds.), Arkeologi Kedah Tua: sumbangan data terkini dari perspektif warisan, seni & budaya. Penerbit PPAG dan Koridor Utara Malaysia, Pulau Pinang, 88-98. (In Malay).

Nadya Nurdinia, Evi Maryantia, Mualliful Ilmi, Pindi Setiawan, Saiyasombat, C., Grandprix Thomryes Marth Kadja & Ismunandar, 2020. Physicochemical investigation of prehistoric rock art pigments in Tewet Cave, Sangkulirang-Mangkalihat Site, East Kalimantan-Indonesia. Journal of Archaeological Science: Reports, 31, 102345.

Ngun, B.K., Hasmaliza Mohamad, Shamsul Kamal Sulaiman, Okada, K. & Zainal Arifin Ahmad, 2011. Some ceramic properties of clays from central Cambodia. Applied Clay Science, 53(1), 33–41.

Nik Hassan Shuhaimi Nik Abd. Rahman & Asyaari Muhamad, 2008 Clay Pottery in Bujang Valley. In: Nik Hassan Shuhaimi Nik Abd. Rahman (Ed.) *L*embah Bujang: Dari perspektif arkeologi dan pelancongan, ATMA UKM, Bangi, 176-177. (In Malay).

Nuratikah, A.B., Ramli, Z. Muhammad Numan Mohd Nasir, Wan Noor Shamimi Wan Azhar, Siti Salina Masdey & Mori, J., 2018. The environment and archaeological findings of Sungai Mas archaeological sites (site 32/34). Journal of Food, Agriculture & Environment, 16(2), 194 – 200.

Ramli, Z., 2012. The process of acculturation of Indian culture and the transformation of knowledge of the Ancient Kedah society based on archaeological data and scientific studies. Ph.D. Thesis. Universiti Kebangsaan Malaysia. (In Malay).

Ramli, Z. & Rahman, N.H.S.N.A., 2013. Composition analysis of ancient Bricks, Candi Bukit Kechil, Bujang Valley, Kedah. Research Journal of Applied Sciences, Engineering and Technology, 6(5), 924–930.

Ramli, Z., Nasir, M.N.M., Samian, A.L., Harun, N.Z., Hadi, M.S.B.A., Bakar, N.A. & Supian, N.S.M., 2018. XRD and XRF Analysis of the Ancient Bricks from Candi Kampung Baru, Kedah. Journal of the Malaysian Institute of Planners, 16(1), 314 – 323.

Ramli, Z., Rahman, N.H.S.N.A., Jusoh, A. & Sauman, Y., 2011. X-ray diffraction and X-ray fluorescent analyses of prehistoric pottery shards from Ulu Kelantan. American Journal of Applied Sciences, 8(12), 1337–1342.

Ramli, Z., Rahman, N.H.S.N.A., Samian, A.L. & Yarmo, M.A., 2013. X-Ray Diffraction and X-Ray Flourescence of ancient bricks of Candi Bukit Pendiat (Site 17), Bujang Valley, Kedah. Research Journal of Applied Sciences, Engineering and Technology, 6(6), 1094–1100.

Ramli, Z., Rahman, N.Q.A., Hussin, A., Hasan, S.N.I.S. & Dali, A.M., 2017. Compositional analysis of Sungai Mas, Kuala Selinsing and Santubong glass beads. Mediterranean Archaeology and Archaeometry, 17(2), 117-129.

Sarhaddi-Dadian, H., Moradi, H., Ramli, Z. & Purzarghan, V., 2017. X-ray fluorescence analysis of the pottery shards from dahan-E ghulaman, the achaemenid site in Sistan, east of Iran. Interdisciplinaria Archaeologica, 8(1), 35–42.

Shaiful, S., Mokhtar Saidin, Nurul Amira Md. Isa, Nor Khairunnisa Talib & Shyeh, S.K., 2018. Guar Kepah: Evidence of Neolithic Burial in Shell Mound. Jurnal Antarabangsa Dunia Melayu, 11(2), 231-251. (In Malay).

Siti Norbaini, S., Rosli Hj Mahat, Yusoff Mohd Amin, Price, D.M. & Bradley, D.A., 2015 Thermoluminescence dating analysis at the site of an ancient brick structure at Pengkalan Bujang, Malaysia. Applied Radiation and Isotopes, 105, 182-187.

Treloar, F.E., 1978. Chemical analysis of iron, iron slag and pottery remains of the prehistoric iron industry of the Sarawak River delta. The Sarawak Museum Journal, 26(47),126-133.

Zarina, T. & Anida, S., 2018. The Metaphor of the Kiambang Flower in the Malay Pantun Based on Relevance Theory And Cross- Referene Framework. International Journal of Education, Psychology and Counseling, 3(16), 1-7. (In Malay).

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Pelantar benua dari perspektif undang-undang laut: Suatu pengenalan

(Continental shelf from the perspective of the Law of the Sea: An introduction)

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Abstrak: Hak sesebuah negara pesisir ke atas dasar lautan dan subtanih berhadapannya ditentukan oleh beberapa peruntukan dalam Konvensyen Undang-Undang Laut PBB 1982 (UNCLOS), khususnya Artikel 76 bagi pelantar benua. Nota ringkas ini bertujuan untuk memberi pengenalan ringkas mengenai konsep "pelantar benua" dalam konteks Artikel 76. Konsep ini penting bagi negara pesisir menetapkan had luar pelantar benua yang melampaui 200 batu nautika (M) dari garis pangkal (pantai). Dengan penentuan had luar pelantar benua, hak berdaulat sesebuah negara pesisir ke atas kawasan dasar laut yang melepasi garisan 200 M bagi tujuan explorasi dan eksploitasi sumber asli, diberi pengiktirafan tanpa keraguan mengikut undang-undang laut antarabangsa UNCLOS. Penentuan kawasan pelantar benua melampaui garisan 200 M adalah berdasarkan prinsip dalam Artikel 76 bahawa pelantar benua adalah persambungan semulajadi wilayah daratan sesebuah negara pesisir. Bidang geologi juga memain peranan utama dalam prosedur menentukan had luar persambungan itu, yang sekaligus memastikan had luar pelantar benua mengikut Artikel 76. Dicadangkan "pelantar benua" diberi makna khusus selaras dengan Artikel 76, manakala istilah "pentas benua" kekal dengan penggunaan asal sebagai kawasan laut cetek di pinggir benua.

Kata kunci: pelantar benua, pentas benua, UNCLOS, Artikel 76, zon maritim

Abstract: The entitlement of a coastal State over the seabed and subsoil in front of its landmass is provided for in the United Nations Convention on the Law of the Sea 1982 (UNCLOS), in particular Article 76 for the continental shelf. This short note in Malay gives a brief introduction to the concept of the "continental shelf" in the context of Article 76. This concept is important as a means by which coastal States may establish the outer limit of their continental shelves beyond 200 nautical miles (M) measured from the territorial sea baselines. Once the outer limits have been established, coastal States are then able to exercise with certainty their sovereign rights over the extended continental shelf for the purposes of exploring and exploiting the natural resources of the seabed and subsoil, as provided for by UNCLOS. The establishment of the outer limits of the continental shelf beyond 200 M is based on the principle of natural prolongation of land territory in Article 76. Geology also plays an important role in the process of determining the extent of the prolongation in accordance with the provisions of Article 76. For authors and students of this topic in Malay, it is proposed that the synonymous Malay terms for continental shelf – "pelantar benua" and "pentas benua" – be given specific meanings for use in their legal and geological contexts, respectively.

Keywords: continental shelf, continental platform, UNCLOS, Article 76, maritime zones

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[1] Penulis adalah Ahli Suruhanjaya Had Pelantar Benua (2012-2022), yang berpengkalan di Pertubuhan Bangsa-Bangsa Bersatu (PBB) New York. Segala pandangan yang dinyatakan dalam nota ini adalah pandangan penulis semata-mata dan tidak semestinya menggambarkan pandangan Suruhanjaya Had Pelantar Benua atau mana-mana pihak lain. [Disclaimer: The views expressed in this note are solely of the author's and do not necessarily reflect the views of the Commission on the Limits of the Continental Shelf or any other parties.]

PENGENALAN

Dengan 70% permukaan bumi diliputi lautan, kita mungkin tertanya-tanya: lautan yang sebegitu luas itu milik siapa? Apabila kita berada di pantai dan memandang ke arah lautan, kita pasti memikirkan laut itu milik kita sebagai sebuah negara pesisir[2]. Namun, sejauh manakah lautan ini menjadi hak milik sesebuah negara pesisir? Adakah hanya sejauh mata memandang? Dalam kurun ke-17, kuasa sesebuah kerajaan ke atas kawasan perairan pantai ditentukan dengan "peraturan peluru meriam", iaitu jarak maksima peluru meriam besi apabila ditembak kearah lautan. Inilah permulaan jarak 3 batu nautika (M)[3] dari pantai yang terpakai di bawah undang-undang laut antarabangsa bagi menetapkan keluasan "laut wilayah" sesebuah negara. Dengan peredaran zaman dan perkembangan teknologi, kaedah ini tidak lagi memadai bagi menentukan kedaulatan dan bidang kuasa maritim sesebuah negara. Jadi, bagaimanakah sesebuah negara pesisir dapat menentukan sejauh mana ia berhak ke atas lautan serta dasar lautan yang berhadapan pantainya?

Tujuan nota ringkas ini adalah untuk memberi sedikit pengenalan mengenai suatu konsep geologi iaitu "pelantar benua" dan aplikasinya dalam undang-undang laut antarabangsa bagi menentukan sejauh mana sesebuah negara pesisir berhak ke atas lautan yang berhadapan dengannya. Adalah diharapkan penulisan dalam Bahasa Melayu ini juga dapat merentas jurang maklumat dalam bidang yang khusus ini, yang mana hampir semua penerbitan yang berkaitan didapati di dalam Bahasa Inggeris, termasuk tulisan saya yang terdahulu (Madon, 2017, 2020).

ZON MARITIM DALAM UNDANG-UNDANG LAUT (UNCLOS)

Sebelum adanya undang-undang laut antarabangasa, yang bermula dengan Konvensyen Geneva 1958, diikuti dengan beberapa konvensyen lagi dan terkini Konvensyen Undang-Undang Laut PBB 1982 ("United Nations Convention on the the Law of the Sea 1982" atau kata-pendeknya UNCLOS)[4], lautan dianggap sebagai "tidak berpunya" dan boleh dituntut oleh sesiapa saja, terutama kuasa-kuasa besar. Kewujudan UNCLOS boleh dikatakan sebagai kejayaan terbesar PBB bagi mengawal aktiviti maritim dan memelihara lautan bagi kepentingan dan kesejahteraan kesemua masyarakat dunia. Diratifikasi oleh 168 buah negara PBB, UNCLOS yang dianggap sebagai "Perlembagaan Laut Dunia" ini mengandungi lebih 300 Artikel bagi tujuan menyelaras undang-undang laut di seluruh dunia. UNCLOS menggariskan panduan untuk negara pesisir menetapkan undang-undang domestik masing-masing dengan hasrat agar negara-negara berjiran tidak bertelagah atas isu-isu maritim, termasuk isu sempadan dan hak berdaulat. UNCLOS juga menjadi asas kepada pembahagian zon-zon maritim yang terpakai di seluruh dunia, seperti laut wilayah, zon ekonomi eksklusif dan pelantar benua (Rajah 1). Di Malaysia, beberapa undang-undang domestik berkaitan lautan selaras dengan UNCLOS telah digubal di Parlimen; antaranya Akta Pelantar Benua 1966, Akta Zon Ekonomi Eksklusif 1984, Akta Garis Pangkal Zon Maritim 2006 dan Akta Laut Wilayah 2012.

Selain mentakrifkan "laut wilayah" sebagai zon berjarak 12 M dari garis pangkal, antara peruntukan penting UNCLOS dalam penentuan zon maritim ialah Zon Ekonomi Eksklusif (ZEE). Dengan terbentuknya ZEE, setiap negara pesisir diberi hak berdaulat secara eksklusif bagi menjalankan aktiviti ekonomi di pelantar benua masing-masing hingga ke jarak 200 M dari garis pangkal. Hak berdaulat negara pesisir termasuk sebarang aktiviti maritim dan penerokaan dan eksploitasi sumber asli (termasuk sumber bernyawa seperti perikanan atau tidak bernyawa seperti petroleum dan mineral), khusus bagi negara pesisir tersebut sahaja dan tidak boleh dicerobohi oleh negara lain tanpa kebenaran[5].

PELANTAR BENUA DAN PRINSIP "PERSAMBUNGAN SEMULAJADI"

Konsep "pelantar benua", yang asalnya dari bidang geologi, diadapatasi dan digunapakai dalam undang-undang laut antarabangsa, khususnya Artikel 76 UNCLOS bagi memberi peluang kepada negara pesisir memperluaskan kawasan dasar laut dibawah bidang kuasa mereka hingga ke luar garisan 200 M, iaitu luar sempadan ZEE (Rajah 1). Tetapi hak berdaulat negara pesisir ke atas kawasan dasar laut di luar ZEE ini diperuntukan oleh UNCLOS hanya bagi tujuan menerokai dan mengeksploitasi sumber asli dasar laut dan subtanihnya yang tak hidup atau hidupan setempat yang tidak beralih[6].

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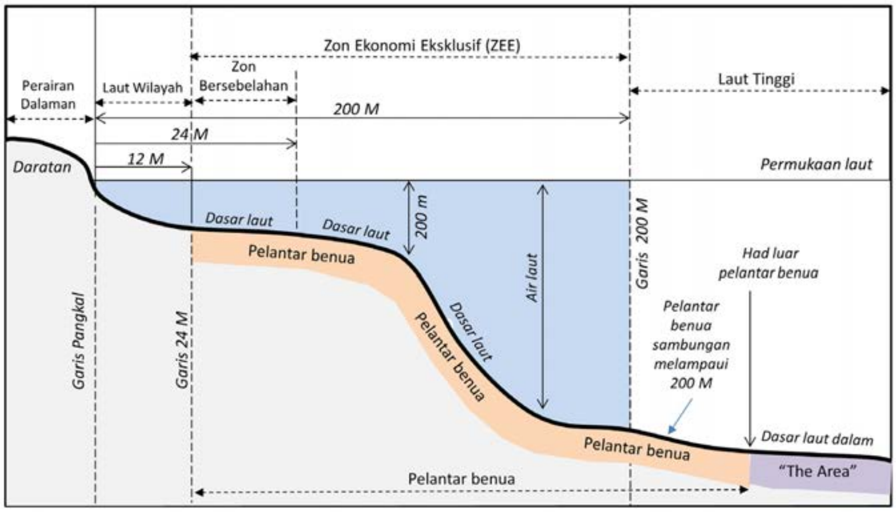
2 Negara pesisir adalah negara yang berhadapan dengan laut atau lautan.

3 batu nautika = 1.852 kilometer. Simbol "M" biasa digunakan bagi istilah Inggerisnya "nautical mile", dan digunapakai dalam tulisan ini.

4 Konvensyen Undang-Undang Laut Bangsa-Bangsa Bersatu atau "United Nations Convention on the Law of the Sea" (UNCLOS) bermula pada tahun 1958 di Geneva (dikenali sebagai UNCLOS I), dan seterusnya pada tahun 1960 (UNCLOS II), 1973 (UNCLOS III) dan terakhir UNCLOS 1982.

5 perenggan 2, Artikel 77 UNCLOS. https://www.un.org/Depts/los/convention_agreements/texts/unclos/part6.htm

6 perenggan 4, Artikel 77 UNCLOS. https://www.un.org/Depts/los/convention_agreements/texts/unclos/part6.htm



Rajah 1: Lakaran keratan rentas pinggir benua menunjukkan zon-zon maritim dan garis-garis utama bagi pembahagian zon menurut UNCLOS. Menurut definasi Artikel 76 UNCLOS, pelantar benua adalah dasar laut dan subtanih di pinggir benua (kawasan yang dilorek berwarna oren), tidak termasuk air laut di atasnya. Rajah ini diubahsuai daripada laman web CLCS http://www.un.org/depts/los/clcs_new/marinezones.jpg.

Ia tidak termasuk khazanah hidupan yang terdapat di dalam air laut tinggi.

Persambungan pentas benua melebihi had ZEE ini diharuskan berdasarkan suatu prinsip penting yang disebut dalam perenggan 1 Artikel 76 UNCLOS, iaitu pelantar benua adalah "persambungan semulajadi wilayah daratan" sesebuah negara pesisir. Prinsip ini bermaksud persambungan daratan milik sesebuah negara pesisir ke bawah paras laut secara semulajadi menjadi "wilayah" milik negara pesisir itu juga dan, dengan demikian, adalah tertakluk di bawah bidang kuasa negara tersebut. Penting bagi sesebuah negara pesisir dalam konteks had luar pelantar benua ialah menentukan "sejauh manakah" persambungan daratan itu melebihi garisan 200 M, apa yang disebut sebagai "had luar pelantar benua".

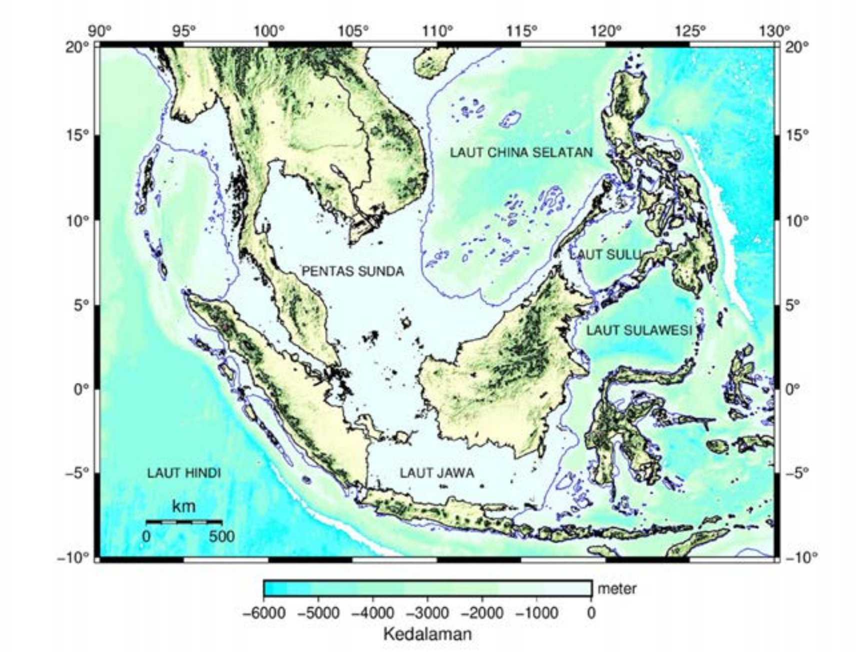
Sebelum kita dapat menentukan jarak ke had luar pelantar benua (seperti dalam Rajah 1), amat penting bagi kita memahami konsep "pelantar benua" (istilah Inggeris, "continental shelf") yang dipinjam dari bidang sains bumi, khususnya geologi. Disamping itu, perenggan 1 Artikel 76 juga mengatakan bahawa pelantar benua meliputi kawasan dasar laut melepasi laut wilayah "sehingga ke tepian luar pinggir benua". Maka, selain dari pelantar benua, kita perlu memahami juga apakah itu "pinggir benua".

Selari dengan konsep pelantar benua sebagai "persambungan semulajadi wilayah daratan", sepertimana yang disebut di atas, perenggan 3 Artikel 76 pula menganggap pinggir benua sebagai "persambungan daratan yang terbenam" dibawah lautan. Kedua-dua prinsip "persambungan" ini adalah konsep yang sama, melainkan perenggan 1 mendefinasikan pelantar benua dengan menyentuh tentang status politik daratan (iaitu sebagai "wilayah" milik negara pesisir) manakala perenggan 3 hanya menyifatkan pinggir benua dari segi fizikal (geologi). Namun, untuk mencari tepian luar (penghujung) pinggir benua bagi menentukan had luar pelantar benua kita perlu fahami dahulu apakah itu pinggir benua dalam konteks geologi, dan bagaimana ia digunakan untuk menentukan had luar pelantar benua. Inilah topik yang akan dibincang seterusnya di dalam nota ini.

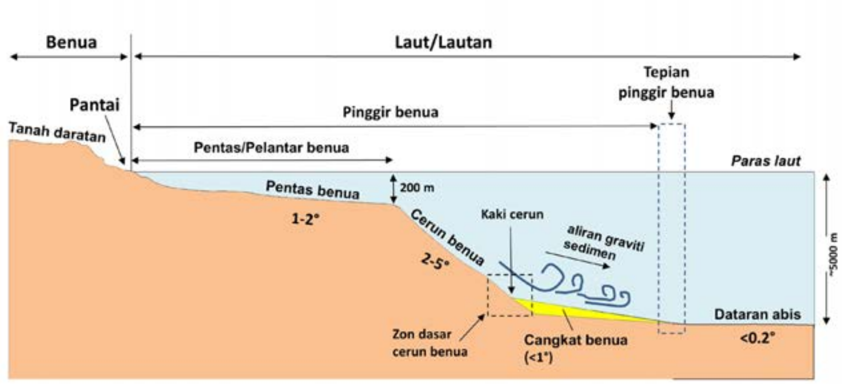
GEOMORFOLOGI PINGGIR BENUA

Apabila kita lihat peta dunia, kesemua kawasan daratan benua dikelilingi lautan yang kedalamannya tidak melebihi lebih kurang 200 m. Di rantau Asia Tenggara, umpamanya, terdapat kawasan perairan cetek yang luas mengelilingi Semenajung Tanah Melayu, Sumatra dan Jawa (Rajah 2). Kecetekan laut di kawasan ini adalah disebabkan dasar laut di situ hampir mendatar dengan kecerunan tidak lebih dari 1 atau 2°. Kawasan inilah yang dipanggil dalam istilah Melayu "pentas benua" atau "pelantar benua" (Istilah Geologi, 1988). Pentas Sunda yang mengelilingi Semenanjung Tanah Melayu (Rajah 2) adalah antara pentas benua yang paling luas di dunia (LaFond, 2020), dengan kelebaran sehingga 800 km, hampir sama jarak di antara Kuching dan Kota Kinabalu. Selain "pentas" dan "pelantar" benua, beberapa istilah berkaitan juga terdapat dalam Istilah Geologi (1988), seperti yang tersenarai dalam Jadual 1. Istilah-istilah ini akan digunakan dalam perbincangan seterusnya mengenai konsep pelantar benua dan aplikasinya dalam penentuan had luar pelantar benua.

Lakaran dalam Rajah 3 memberi gambaran rupabentuk pelantar benua yang biasa kita lihat di muka



Rajah 2: Peta Asia Tenggara menunjukkan kawasan perairan yang mengelilingi daratan, bermula dengan kawasan cetek ("pentas benua") hingga ke kedalaman 200 m (garisan nipis warna biru yang melingkungi kawasan cerah di sekeliling daratan) termasuk Pentas Sunda. "Pelantar benua" mengikut Artikel 76 UNCLOS boleh merangkumi kawasan pentas benua dan bersambung hingga ke lautan dalam (kawasan biru gelap). Peta ini dibuat oleh penulis berdasarkan data digital batimetri dan topografi dari pengkalan data GMRT (Ryan *et al*., 2009).



Rajah 3: Elemen-elemen geomorfologi pinggir benua dan sekitarannya. Maklum bahawa dari segi geologi, pelantar dan pentas benua adalah elemen yang sama.

bumi, dan menunjukkan kaitan antara elemen-elemen geomorfologi pelantar benua yang tersenarai dalam Jadual 1. Antara elemen yang penting ialah "pinggir benua" (istilah Inggeris "continental margin"), yang secara amnya merangkumi tiga elemen geomorfologi iaitu pentas benua (continental shelf), cerun benua (continental slope) dan cangkat benua (continental rise).

Seperti yang dikatakan tadi, pentas benua adalah kawasan yang hampir mendatar dan ditenggelami air cetek kurang daripada 200 m. Cerun benua pula menjunam ke laut dalam dengan kecerunan 2° atau lebih hingga beribu meter di bawah paras laut. Disebabkan kecerunannya yang lebih tinggi, cerun benua adalah kawasan yang kurang stabil dan kerap mengalami keruntuhan dasar laut yang mencetuskan peraliran sedimen mengikut daya graviti (aliran turbidit). Sedimen yang terhakis dari pentas dan cerun benua melalui proses ini akan terendap di kaki cerun benua dan membentuk lapisan atau prisma sedimen yang kecerunan permukaaannya kurang daripada cerun benua, hampir sama seperti di pentas benua (<1°). Kawasan dasar laut di sini disebut "cangkat benua", yang mana penghujungnya ke arah lautan boleh dianggap sebagai "tepian luar pinggir benua". Cangkat benua bersempadan dengan dasar laut dalam yang mendatar, iaitu dataran abis (Rajah 3). Oleh kerana perbezaan kecerunan antara penghujung cangkat benua dan dataran abis amat kecil, sempadan di antara dua elemen geomorfologi ini tidak nyata. Sebab itu penentuan tepian luar pinggir benua, iaitu sempadan di antara cangkat benua dan dataran abis, adalah salah satu cabaran besar dalam proses penentuan had luar pelantar benua.

PELANTAR BENUA DALAM GEOLOGI DAN UNDANG-UNDANG LAUT

Perlu ditekankan disini bahawa ada sedikit perbezaan dalam penggunaan istilah "pelantar benua" dari segi geologi berbanding dengan undang-undang laut mengikut UNCLOS. Ini adalah berikutan Artikel 76 dalam UNCLOS mendefinasikan "pelantar benua" seperti berikut (terjemahan parafrasa secara ringkas perenggan 1 Artikel 76):

"Pelantar benua sesebuah negara pesisir merangkumi kawasan dasar laut dan subtanih yang terletak di antara laut wilayah hingga ke tepian luar pinggir benua ATAU hingga ke 200 batu nautika dari garis pangkal, jika jarak ke tepian luar pinggir benua kurang daripada 200 batu nautika."

Definasi ini bermakna pelantar benua yang biasa difahami oleh ahli kajibumi, seperti dalam Rajah 3, mungkin berlainan daripada pelantar benua (continental shelf) yang diperuntukkan dalam Artikel 76 UNCLOS. Lebih khusus, had luar pelantar benua mengikut Artikel 76 boleh ditentukan secara automatik pada garisan 200 M dari garis pangkal, walaupun tepian luar pinggir benua tak sampai ke garisan 200 M. Apabila tepian luar pinggir benua didapati melebihi 200 M dari garis pangkal, had luar pelantar benua boleh ditentukan berdasarkan lokasi tepian luar pinggir benua itu dengan mengikut kaedah khusus yang ditertera dalam Artikel 76 UNCLOS. Kesimpulannya, kelebaran semulajadi pinggir benua merupakan faktor penting dalam menentukan samada had luar pelantar benua sesebuah negara pesisir akan berada di luar garisan 200 M.

Jadual 1: Istilah geologi berkaitan pelantar benua yang terkandung dalam buku Istilah Geologi (1988) bersamaan istilah Inggeris. Dalam Bahasa Melayu pelantar benua dan pentas benua dianggap sinonim, sepertimana "continental shelf" dan "continental platform" dalam Bahasa Inggeris. Namun, "continental shelf" lebih digunapakai dalam literatur geologi moden berbanding "continental platform". Tepian benua atau "continental edge" jarang dijumpai kegunaannya dalam literatur. Dalam nota ini, cangkat benua digunakan bagi "continental rise".

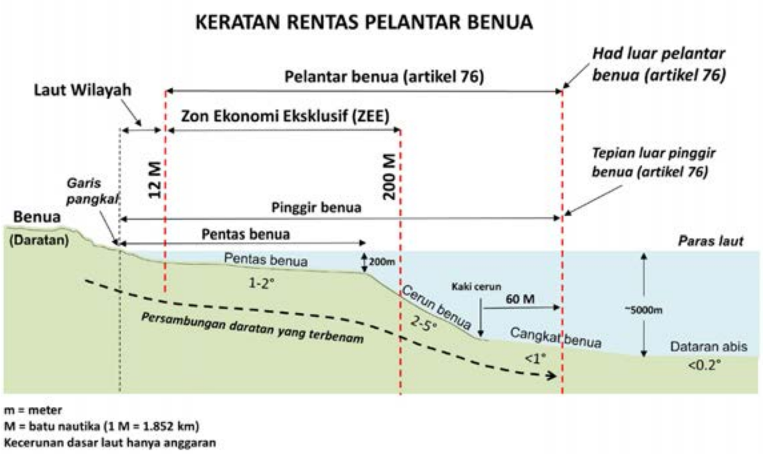
Istilah Melayu	Istilah Inggeris
Pelantar benua	Continental platform
Pentas benua	Continental shelf
Teres benua	Continental terrace
Pinggir benua	Continental margin
Tepian benua	Continental edge
Cerun benua	Continental slope
Cangkat benua/Jendul benua	Continental rise
Dataran abis	Abyssal plain

Dalam literatur antarabangsa, kawasan pelantar benua yang melampaui 200 M dari garis pangkal disebut dengan pelbagai istilah, antaranya "pelantar benua melampaui 200 M" (continental shelf beyond 200 M), "pelantar benua luaran" (outer continental shelf) atau "pelantar benua sambungan" (extended continental shelf) (antaranya, Curiel, 2010; Magnússon, 2013; Mossop, 2016). Sebagaimana yang dinyatakan diatas, oleh kerana tepian luar pinggir benua tidak mudah ditentukan dengan tepat, proses penentuan had luar pelantar benua melebihi 200 M biasanya lebih rumit dan perlu mengikut kaedah dan formula tertentu.

ANTARA "PELANTAR" DAN "PENTAS" BENUA

Perbezaan definisi pelantar benua dalam geologi dan undang-undang laut telah menyebabkan sedikit kekeliruan terminologi apabila Artikel 76 UNCLOS mula diimplementasi pada 1997 berikutan penubuhan Suruhanjaya Had Pelantar Benua (CLCS). Antara punca kekeliruan itu ialah kerana istilah Inggeris "continental shelf" digunapakai dalam kedua-dua konteks, geologi dan undang-undang. Dalam literatur geologi Bahasa Inggeris, istilah "pelantar benua" yang terjemahan literalnya "continental platform" (contoh, Parker, 1997), jarang digunakan dalam konteks geomorfologi pinggir benua tetapi lebih kepada mencirikan bekas lautan cetek kuno yang kini berada di atas paras laut dan membentuk sebahagian daripada kawasan teras benua (kraton) tertua di dunia (contoh, Thompson & Turk, 1998). Walaubagaimanapun, setelah hampir 25 tahun berlalu, penggunaan "continental shelf" dalam konteks undang-undang laut tidak lagi menjadi isu dan rata-rata pengamal undang-undang dan pakar geologi mengakui dan menerima perbezaan kegunaan istilah ini mengikut konteks.

Dalam Bahasa Melayu, dua istilah bagi "continental shelf" digunakan secara sinonim juga, iaitu pelantar benua dan pentas benua (Jadual 1). Bagi mengelakkan kekeliruan dan percanggahan terminologi dalam penggunaan semasa, terutama dalam undang-undang laut, dan oleh kerana wujudnya dua istilah dalam Bahasa Melayu yang hampir sama maksudnya, adalah dicadangkan "pelantar benua" dan "pentas benua" masing-masing diberi makna dan penggunaan yang lebih khusus seperti berikut (lihat Rajah 4). Manakala "pentas benua" bermaksud kawasan laut cetek yang melandai dengan kecerunan tak lebih dari 2° (iaitu kekal maksud asal), "pelantar benua" diberi makna yang lebih spesifik, selaras dengan definasi "continental shelf" dalam Artikel 76. Dengan penggunaan sedemikian, istilah



Rajah 4: Lakaran keratan rentas Pelantar Benua menurut Artikel 76 UNCLOS yang merangkumi ciri-ciri penting elemen geomorfologi seperti pentas, cerun dan cangkat benua yang mempunyai kecerunan berbeza. Kawasan pinggir benua, yang dianggap sebagai "persambungan wilayah daratan yang terbenam", terdiri daripada ketiga-tiga elemen tersebut, manakala Pelantar Benua dan garis hadnya hanya ditentukan berdasarkan garis tepian luar pinggir benua, mengikut kaedah yang tertera dalam Artikel 76 UNCLOS. Contoh spesifik yang dipaparkan di sini ialah apabila tepian luar pinggir benua ditentukan dengan salah satu formula dalam Artikel 76 iaitu 60 M dari kaki cerun benua. Rajah diadaptasi dari Madon (2017).

"pentas benua" bersifat geologi dan saintifik manakala "pelantar benua" khusus bersifat "undang-undang".

PROSEDUR PENENTUAN HAD LUAR PELANTAR BENUA

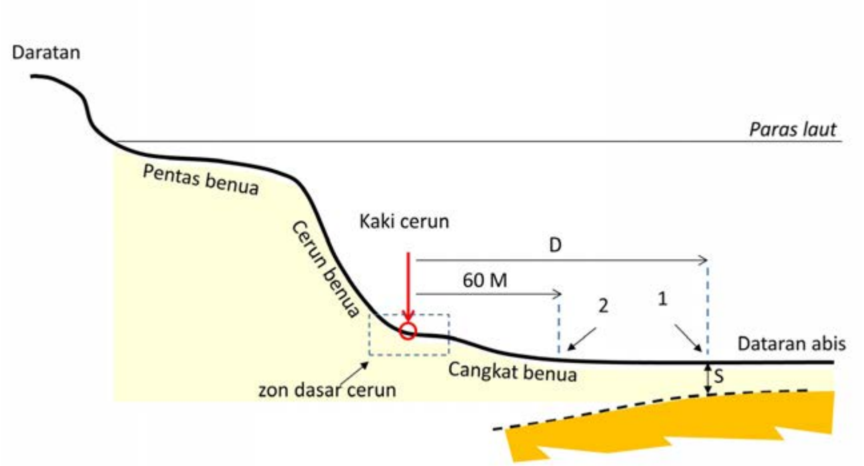
Secara amnya, sesebuah kawasan dasar laut yang terletak di luar garisan 200 M dari garis pangkal boleh dianggap sebahagian dari pelantar benua sesebuah negara apabila terbukti (melalui data geologi dan morfologi dasar laut) bahawa dasar laut tersebut adalah persambungan daratan negara tersebut. Dengan lain kata, kesemua elemen-elemen geomorfologi dalam Rajah 3 perlu dikenalpasti, terutamanya penghujung atau tepian luar pinggir benua. Rajah 5 menunjukkan empat langkah penting yang perlu dilaksanakan dengan sistematik bagi menentukan had luar pelantar benua. Setiap langkah prosedur ini adalah bertujuan mengenalpasti elemen geomorfologi pelantar benua yang kritikal dan akan memberi kesan kepada elemen yang berikutnya. Oleh itu setiap langkah perlu dilaksana dengan teliti supaya had luar pelantar benua dapat ditetapkan dengan sebaik mungkin.

Proses penentuan had luar pelantar benua bermula dengan (Langkah 1) mengenalpasti zon dasar cerun benua, yang biasanya mudah dikenalpasti sebagai kawasan di dasar cerun benua yang menunjukkan perubahan kecerunan yang ketara, daripada beberapa darjah (cerun benua) ke hampir mendatar (cangkat benua) (lihat contoh dalam Rajah 6). Berikutnya, lokasi kaki cerun benua (Langkah 2, Rajah 5) ditentukan dengan menempatkan satu titik di dalam zon dasar cerun tadi di mana perubahan kecerunan itu berlaku dan ini perlu ditentukan dengan tepat melalui pengiraan matematik (CLCS, 1999).

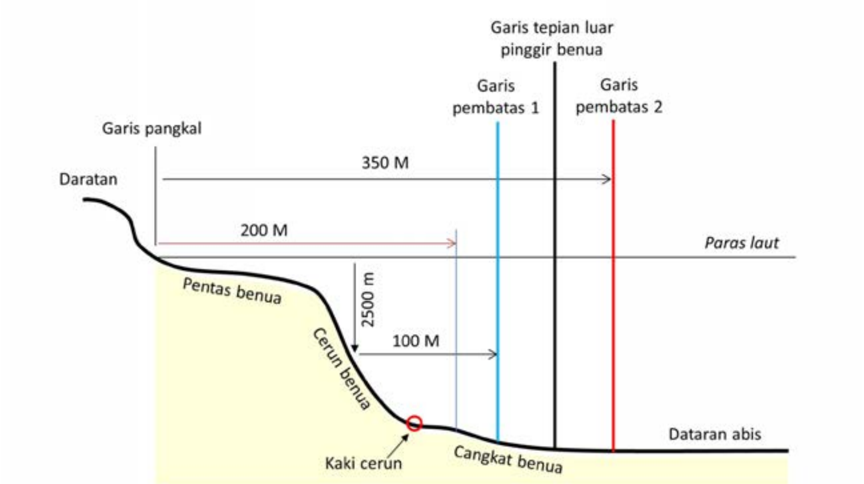
Rajah 5: Empat langkah penting dalam aliran proses penentuan had luar pelantar benua.

Penentuan had luar pelantar benua yang dipaparkan dalam Rajah 6 hanyalah satu contoh yang paling mudah, dimana had luar pelantar benua dan tepian luar pinggir benua jatuh pada lokasi yang sama. Untuk menggariskan had luar pelantar benua, Artikel 76 UNCLOS (perenggan 4) memberi ruang kepada negara pesisir memilih di antara dua formula bagi menentukan lokasi tepian luar pinggir benua (langkah 3 dalam Rajah 5). Rajah 6 secara ringkas menunjukkan bagaimana dua formula itu digunakan. Setelah lokasi kaki cerun ditentukan dengan tepat dalam zon dasar cerun benua (iaitu langkah 1 dan 2 dalam Rajah 5), tepian luar pinggir benua boleh digariskan dengan menggunakan antara dua formula. Formula pertama: menurut Artikel 76, perenggan 4a(i), lokasi tepian luar pinggir benua adalah dimana ketebalan lapisan sedimen (S) di dasar laut hendaklah sekurang-kurangnya 1% daripada jarak terdekat di antara lokasi tersebut dan kaki cerun benua (D). Dengan kata lain, S hendaklah sekurang-kurangnya 0.01D (lokasi 1 dalam Rajah 6). Formula kedua: menurut Artikel 76, perenggan 4a(ii), lokasi tepian luar pinggir benua hendaklah tidak lebih daripada 60 M jaraknya dari kaki cerun benua (lokasi 2 dalam Rajah 6, seperti contoh dalam Rajah 4).

Langkah 4 dan terakhir dalam prosedur penentuan had luar pelantar benua (Rajah 5) melibatkan proses



Rajah 6: Dua pilihan bagi menentukan tepian luar pinggir benua menurut Artikel 76 perenggan 4a. Setelah lokasi kaki cerun dikenalpasti dalam zon dasar cerun, tepian luar pinggir benua boleh ditentukan dengan menggunakan antara dua formula, mengikut kesesuaian data dan faktor geologi. Hasilnya berbeza. Formula dalam Artikel 76 perenggan 4a(i) menghasilkan Lokasi 1 iaitu jarak D di antara kaki cerun dan lokasi 1, dimana ketebalan lapisan sedimen S tidak kurang dari 0.01D. Lebih mudah ialah formula dalam Artikel 76 perenggan 4a(ii) yang menghasilkan Lokasi 2 iaitu jarak 60 M diukur dari kaki cerun.



Rajah 7: Langkah 4 (terakhir, lihat Rajah 5) dalam proses penentuan had luar pelantar benua ialah memastikan ia tidak melampaui pembatas yang disebut dalam perenggan 5 Artikel 76. Ada dua jenis pembatas: Pembatas 1 – garisan100 M diukur dari garis 2500 m kontur batimetri, dan Pembatas 2 – garisan 350 M diukur dari garis pangkal. Negara pesisir boleh memilih pembatas yang akan memberi kelebihan kawasan pelantar benua. Dalam contoh hipotetikal ini, pembatas 2 akan terpilih sebab ia lebih jauh ke arah lautan berbanding tepian luar pinggir benua. Maka dengan pembatas 2, tepian luar pinggir benua akan menjadi had luar pelantar benua. Jika pembatas 1 dipilih, had luar pelantar benua akan jatuh pada garis pembatas 1.

semakan samada garis tepian luar pinggir benua yang diukur mengikut formula dalam perenggan 4a Artikel 76 tidak melampaui garis pembatas yang ditetapkan mengikut perenggan 5 Artikel 76. Dalam ertikata lain, kawasan pelantar benua sesebuah negara pesisir tidak seharusnya melampaui garis pembatas yang ditetapkan oleh Artikel 76 UNCLOS. Rajah 7 menunjukkan dua jenis garis pembatas yang boleh digunakan oleh negara pesisir bagi menentukan had luar pelantar benua: (1) garisan 100 M yang diukur dari garisan 2500 m kontur batimetri, atau (2) garisan 350 M yang diukur dari garis pangkal. Pilihan pembatas yang sesuai adalah bergantung kepada faktor geologi dan geomorfologi pinggir benua berkenaan, berdasarkan beberapa kriteria yang ditetapkan dalam perenggan 5 Artikel 76 serta garis panduan CLCS (1999). Oleh kerana kriteria menentukan pembatas lebih rumit dan memerlukan perbincangan geologi dan teknikal yang mendalam, ia tidak dapat dibincang dalam nota ringkas ini. Bagaimanapun, penting dinyatakan bahawa faktor geologi dan geomorfologi (iaitu bentuk fizikal) pinggir benua memain peranan penting dalam menentukan jenis pembatas yang sesuai bagi sesuatu kes tuntutan had pelantar benua. Maka sebab itu amat penting bagi negara pesisir mengemukakan data-data saintifik (geologi dan hidrografi) yang lengkap bagi menyokong tuntutan yang dibuat. Antara beberapa kemungkinan, Rajah 7 menunjukkan hanya satu contoh situasi dimana tepian luar pinggir benua terletak di antara dua alternatif garisan pembatas. Dalam situasi sebegini sudah pasti, sebagaimana yang diharuskan oleh Artikel 76, pembatas yang memberi kelebihan kepada negara pesisir akan terpilih bagi menetapkan had luar pelantar benua.

Amat penting untuk difahami bahawa keluasan pelantar benua menurut Artikel 76 mungkin lebih besar atau kecil daripada keluasan ZEE (200 M) atau keluasan pentas benua itu sendiri. Ini bergantung kepada geologi dan bentuk fizikal semulajadi atau geomorfologi pinggir benua tersebut (Rajah 3). Disinilah bidang geologi memainkan peranan penting dalam proses penentuan had luar pelantar benua. Metodologi penentuan had luar pelantar benua dihuraikan secara terperinci dalam beberapa penerbitan penting untuk rujukan negara pesisir termasuk daripada CLCS sendiri (CLCS, 1999; Cook & Carleton, 2000; DOALOS, 2006).

KAITAN ZON EKONOMI EKSKLUSIF (ZEE), PELANTAR BENUA DAN LAUT TINGGI

Seperti yang ditunjukkan dalam Rajah 4, oleh sebab pelantar benua (mengikut Artikel 76) dan ZEE bertindih, ZEE berkemungkinan membentuk sebahagian dari pelantar benua, ataupun sepenuhnya jika tepian pinggir benua tidak sampai ke garisan 200 M. Namun, perlu ditekankan bahawa hak berdaulat negara pesisir ke atas dasar laut pelantar benua yang melampaui jarak 200 M dari garis pangkal (iaitu melebihi ZEE) adalah terhad kepada sumber asli dasar laut dan subtanihnya yang tak hidup (contoh – mineral, termasuk petroleum) ataupun hidupan setempat tetapi tidak beralih (contoh – karang)[7]. Ini bermakna air lautan di luar garisan 200 M serta segala kandungannya dari permukaan ke dasar laut, seperti hidupan laut dan sebagainya, tidak termasuk dalam hak kedaulatan negara pesisir. Menurut UNCLOS, lautan di luar garisan 200 M dari garis pangkal, walaupun dasar lautnya ditakrif sebagai pelantar benua, masih diklasifikasi sebagai laut tinggi (istilah Inggeris "high seas", Rajah 1) yang tidak dikuasai oleh mana-mana negara. Di laut tinggi masyarakat dunia diberi kebebasan menjalankan aktiviti maritim seperti pelayaran, penerbangan lintas, perikanan, dan kajian saintifik, tertakluk kepada peraturan tertentu dengan mengambil kira hak dan kepentingan negara-negara lain[8]. Dengan ini juga, perlu difahami bahawa pelantar benua di luar garisan 200 M bukanlah wilayah (territory) negara pesisir. Status pelantar benua hanya memberi hak kepada negara pesisir ke atas sumber asli di dasar laut dan subtanihnya sahaja.

Hasil kekayaan sumber petroleum yang diperolehi dari kawasan ZEE yang hingga kini dinikmati rakyat Malaysia adalah satu sebab utama betapa pentingnya hak negara pesisir dikawal dan dipelihara. Kadar penemuan minyak di pelantar benua negara semakin menurun kebelakangan ini dan dijangkakan bakal susut sepenuhnya. Sebagaimana amalan negara lain, penerokaan mencari takungan minyak yang lumayan telah mula dijalankan semakin jauh dari daratan hingga ke laut dalam dan hampir berdekatan dengan sempadan perairan. Malah, beberapa negara pesisir lain telah berjaya menjalankan aktiviti explorasi dan exploitasi petroleum dari dasar laut pelantar benua yang terletak melebihi 200 M dari garis pangkal (Madon, 2020). Di Malaysia, penemuan petroleum di laut dalam (kedalaman dasar laut lebih 200 m) sejak tahun 2000 telah merancakkan aktiviti penerokaan di pelantar benua berdepan Sabah dan Sarawak sehingga mencecah garis sempadan maritim negara di Laut China Selatan. Dijangkakan aktiviti penerokaan ini lambat laun akan merentas garisan 200 M. Maka amatlah penting bagi had luar pelantar benua Malaysia ditentukan dan diiktiraf secara sah menurut UNCLOS, supaya penerokaan sumber asli dapat dijalankan tanpa sebarang keraguan terhadap hak berdaulat negara.

Had luar pelantar benua amat penting juga kerana dasar laut dalam yang berada di luar bidang kuasa dan kawalan negara pesisir adalah dianggap sebagai "Warisan Bersama Umat Manusia". Prinsip "Common Heritage of Mankind" ini tertera dalam Artikel 136 UNCLOS yang menyebut dengan amat jelas (terjemahan): "*Kawasan [laut dalam] serta sumbernya adalah warisan bersama umat manusia*". Ini bermakna kawasan di luar had pelantar benua tidak dimiliki sesiapa tetapi segala sumber hasil ekonomi yang diperolehi di sana harus dinikmati semua negara dunia, termasuk bukan negara pesisir ("land-locked states"). Bagi penyelenggaraan dan perlesenan aktiviti ekonomi dan pengagihan royalti dari sumber hasil yang bakal diperolehi dari kawasan laut dalam di luar had pelantar benua, UNCLOS memberi mandat kepada Lembaga Dasar Laut Antrabangsa (ISA)[9] mengurus bagi pihak kesemua negara dunia yang meratifikasi UNCLOS.

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7 perenggan 4, Artikel 77 UNCLOS. https://www.un.org/Depts/los/convention_agreements/texts/unclos/part6.htm.

8 Kebebasan di laut tinggi termaktub dalam Artkel 87 UNCLOS. https://www.un.org/Depts/los/convention_agreements/texts/unclos/part7.htm

9 "International Seabed Authority" yang berpengkalan di Kingston, Jamaica, juga di bawah naungan PBB.

TUNTUTAN DAN PENGESYORAN HAD LUAR PELANTAR BENUA

Artikel 76 menetapkan bahawa penentuan had luar pelantar benua adalah berdasarkan data geologi dan morfologi dasar laut yang perlu dikemukakan oleh negara pesisir yang menuntut kepada Suruhanjaya Had Pelantar Benua (CLCS)[10], Badan bebas yang berpengkalan di Ibu Pejabat Pertubuhan Bangsa-Bangsa Bersatu (PBB) di New York, Amerika Syarikat, ini mempunyai dua tugas utama: meneliti data-data dan dokumen tuntutan yang dikemukan oleh negara-negara pesisir, dan mengesyorkan kepada negara-negara pesisir kaedah penentuan had luar pelantar benua mereka, menurut peruntukan dalam Artikel 76 UNCLOS. Perlu dijelaskan bahawa, sebagai badan teknikal, mandat CLCS adalah mengeluarkan "pengesyoran"[11] kepada negara pesisir berkenaan had luar pelantar benua berdasarkan pada data saintifik yang diserahkan. Mandatnya bukan untuk menentukan sempadan maritim antara negara-negara yang berdaulat yang berhak menentukan persempadanan sesama mereka.

Antara data-data yang biasa diserahkan kepada CLCS adalah termasuk data batimetri, seismik, dan data-data geofizik dan geologi yang boleh membantu dalam pencirian dan penelitian geologi pinggir benua berkenaan. Ini bagi memastikan sesuatu kawasan yang dituntut itu sah merentas garisan 200 M dari garis pangkal dan boleh diklasifikasikan sebagai kawasan pelantar benua menurut Artikel 76 UNCLOS dan garis panduan CLCS. CLCS dalam dokumen terbitannya CLCS (1999) memberi garis panduan untuk memudahkan negara pesisir menyediakan data dan dokumen berkaitan bagi menyokong sesuatu tuntutan had luar pelantar benua.

CLCS dianggotai oleh 21 pakar dalam bidang geologi, geofizik dan hidrografi yang terpilih dan dilantik dari kalangan negara yang meratifikasi UNCLOS. Sejak penubuhannya pada tahun 1997, CLCS telah menerima 96 tuntutan atau "penyerahan"[12] dan hanya 35 sahaja telah disyorkan setakat ini. Memandangkan penelitian CLCS ke atas sesuatu tuntutan itu mengambil masa yang lama (ada yang sehingga 10 tahun), dan jumlah tuntutan semakin meningkat, kerja suruhanjaya bebas ini berkemungkinan tidak akan dapat diselesaikan dalam tempoh 30 tahun lagi. Walaubagaimanapun, mandat yang diberi kepada CLCS oleh UNCLOS amat penting bagi melaksanakan hasrat UNCLOS, khususnya Artikel 76, supaya hak negara pesisir yang menuntut pelantar benua sambungan mereka, termasuk Malaysia, dapat disyorkan secara adil, saksama dan berpatutan.

KESIMPULAN

Pelantar benua adalah antara zon maritim yang diperuntukkan dalam undang-undang laut UNCLOS. Ia merangkumi kawasan dasar laut dan subtanihnya dari sempadan laut wilayah hingga ke had luar pelantar benua yang lazimnya di tepian luar pinggir benua.

Konsep pelantar benua yang diadaptasi dari bidang geologi merangkumi elemen-elemen geomorfologi pinggir benua, termasuk pentas, cerun dan cangkat benua.

Kawasan pelantar benua yang melampaui garisan 200 M dari garis pangkal ditentukan mengikut peruntukan Artikel 76 UNCLOS atas prinsip bahawa dasar laut di situ adalah "persambungan semulajadi wilayah daratan" negara pesisir.

Penentuan had luar pelantar benua sambungan yang melampaui 200 M, seperti yang dikehendaki oleh UNCLOS, adalah bertujuan memberi hak berdaulat kepada negara-negara pesisir bagi tujuan menjalankan aktiviti penerokaan dan eksploitasi sumber asli di pelantar benua mereka dengan sah tanpa keraguan. Penakrifan had luar pelantar benua mengikut UNCLOS juga sekaligus memberi ketetapan status kawasan laut dalam yang tertinggal di luar had pelantar benua (disebut dalam Bahagian XI UNCLOS sebagai "The Area") sebagai "Warisan Bersama Umat Manusia".

Penentuan had luar pelantar benua perlu mengikut kaedah yang telah ditetapkan olah Artikel 76 UNCLOS dan garis panduan CLCS yang dilantik bagi mengesyorkan kepada negara pesisir had luar pelantar benua masing-masing berdasarkan data hidrografi, geologi dan geofizik yang dikemukakan.

Istilah geologi dalam Bahasa Melayu perlu ditambahbaik untuk memenuhi keperluan bidang geologi khusus dalam undang-undang laut antarabangsa mengikut perkembangan semasa. Antara cadangan yang dikemukakan dalam nota ini ialah penggunaan khusus bagi istilah "pelantar benua" dan "pentas benua".

PENGHARGAAN

Penulis mengucapkan terima kasih kepada kedua-dua pewasit atas cadangan dan komen yang diterima bagi membaiki nota ini. Juga kepada Majlis Keselamatan Negara dan Universiti Malaya atas sokongan yang diterima semasa penulisan ini dibuat.

10 Commission on the Limits of the Continental Shelf (CLCS) https://www.un.org/Depts/los/clcs_new/clcs_home.htm https://www.un.org/Depts/los/convention_agreements/texts/unclos/part6.htm

11 Istilah Inggeris bagi dokumen yang dikeluarkan CLCS apabila selesai penelitian tuntutan ialah "Recommendations".

12 Tuntutan pelantar benua disebut sebagai "Submission" dalam Bahasa Inggeris, mungkin sebab aksi membuat tuntutan melibatkan penyerahan data-data dan dokumen-dokumen secara fizikal di Ibu Pejabat PBB. Senarai penyerahan oleh negara pesisir hingga kini boleh dilihat di laman web CLCS, https://www.un.org/depts/los/clcs_new/commission_submissions.htm

RUJUKAN / REFERENCES

CLCS, 1999. Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf. Official document of the Commission on the Limits of the Continental Shelf, CLCS/11. Downloadable from the CLCS website, http://www.un.org/depts/los/clcs_new/commission_documents.htm.

Cook, P. & Carleton, C.M., 2000. Continental Shelf Limits: The Scientific and Legal Interface. Oxford University Press, New York. 350 p.

Curiel, R., 2010. Overlapping claims for an extended continental shelf in the northeastern part of South America facing the Atlantic Ocean. Research Paper, United Nations - Nippon Foundation Fellowship Programme, 204 p. https://www.un.org/Depts/los/nippon/unnff_programme_home/fellows_pages/fellows_papers/curiel_0910_venezuela.pdf. Last accessed 24 April 2021.

DOALOS, 2006. Training Manual for delineation of the outer limits of the continental shelf beyond 200 nautical miles and for preparation of submissions to the Commission on the Limits of the Continental Shelf. United Nations Division of Ocean Affairs and the Law of the Sea, New York, United Nations Publication.

Istilah Geologi, 1988. Dewan Bahasa dan Pustaka, ISBN 983-62-0529-2.

LaFond, E. C., 2020. South China Sea. Encyclopedia Britannica, 16 Apr. 2020, https://www.britannica.com/place/South-China-Sea. Accessed 24 April 2021.

Madon, M., 2017. The continental shelf – five decades of progress (1966-2016). Bulletin of the Geological Society of Malaysia, 63, 145-156. https://doi.org/10.7186/bgsm63201707.

Madon, M., 2020. Exploration and exploitation of non-living natural resources on the continental shelf beyond 200 nautical miles: a status review. Bulletin of the Geological Society of Malaysia, 70, 17 - 28.

Magnússon, B., 2013. Outer continental shelf boundary agreements. International and Comparative Law Quarterly, 62(2), 345-372. doi:10.1017/S0020589313000067.

Mossop, J., 2016. The Continental Shelf Beyond 200 Nautical Miles: Rights and Responsibilities. Oxford Uni. Press, New York. 278 p.

Parker, S.P. (Ed.), 1997. McGraw-Hill Dictionary of Geology and Mineralogy. New York: McGraw-Hill.

Ryan, W.B.F., S.M. Carbotte, J.O. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weissel, V. Ferrini, A. Goodwillie, F. Nitsche, J. Bonczkowski & R. Zemsky, 2009. Global Multi-Resolution Topography synthesis. Geochem. Geophys. Geosyst., 10, Q03014. doi: 10.1029/2008GC002332

Thompson, G.R. & Turk J., 1998. Introduction to Physical Geology. Saunders College Publ., Univ. California. 432 p.

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Reconnaissance of Kenny Hill Formation outcrops in the Rawang area, northern Selangor, Malaysia

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Abstract: New outcrops of Paleozoic meta-sediments northwest of Kuala Lumpur expose the deformational effects of the Late Paleozoic-Mesozoic‒collisions between various Gondwana-derived continental fragments as they amalgamated to form the core of SE Asia. Over a duration of 6 months, beginning in August 2020, we conducted field trips within northern Selangor to new laterally extensive outcrops for field observations, structural mapping and to measure and log the stratigraphic section. This paper focuses on Upper Paleozoic Kenny Hill Formation outcrops in northern Selangor. The most studied is the heavily weathered Jalan Rawang-Bestari Jaya (JRBJ) outcrop, which is characterised by a steeply dipping (southwest), upward-coarsening succession of sandstones and shales interpreted as a system of ephemeral fluvial channels possibly related to Gondwana glaciation. Concretions within bedding planes and fractures were possibly formed around organic material. Less than 4 km to the east, the Scientex development has excavated fresher outcrops of the same rocks dipping to the NE. Metamorphic lineation is not present in either outcrop location. In addition, a monocline is exposed at outcrop location number 3 nearby. Finally, at Bukit Botak, 14 km to the southwest, a system of westward verging thrust faults, back thrusts and normal faults can be viewed and an angular unconformity or decollement marks the contact between the Upper and Lower Paleozoic. These laterally extensive outcrops are rare and are quickly subject to intense tropical weathering, the encroachment of jungle vegetation and urban development. Historic mapping and prior stratigraphic, structural, and petrographic studies have been conducted in the area, but these relied on poor exposures. As suburban development escalates in the area, we hope that new outcrops, featuring multi-dimensional views of these formations, such as the four described in this paper, will complement the earlier work.

Key words: Upper Paleozoic, Kenny Hill Formation, Rawang

EARLIER WORK

The area of this study was first described by J.B. Scrivenor in “The Geological History of the Malay Peninsula” published in 1913. The earliest geologic mapping was published by Willbourn in 1922 and relied on tin mines for fresh rock exposures. At that time, without the benefit of urban development, fresh outcrops were rare and regional maps were constructed by recognizing the soils specific to the type of weathered bedrock below (Yin, 2011). Roe’s (1951) report on the Rasa and Kuala Selangor areas for the Geologic Survey Department began prior to World War II, but many of his notes were lost during the occupation. J.B. Alexander (1959) compiled the works describing the pre-Tertiary successions in Peninsular Malaysia and published geologic maps (1965) as Director of the Geologic Survey. C.R. Jones (1966) applied the geosynclinal theory to the Paleozoic rocks on the Malay Peninsula. Gobbett (1965) and Yin (2011) described the formations of the Klang Valley. Yin’s work was completed in 1961 and published by the Director General, Minerals and Geoscience Department Malaysia as Map Report 22 (2011) which includes the Kuala Lumpur geologic map. In 1973, Gobbett & Hutchison compiled “Geology of the Malay Peninsula (West Malaysia and Singapore)”. This was the main reference for the stratigraphy, structural, and metamorphic history at the time and the forerunner to “The Geology of Peninsular Malaysia”, edited by Charles Hutchison and Denis Tan (2009). Dr. Lee Chai Peng authored the chapter on Paleozoic Stratigraphy, which compiles the works of many of the previously cited researchers (Lee, 2009). He also chaired the Malaysian Stratigraphic Central Registry Database Subcommittee, responsible for publishing the Stratigraphic Lexicon of Malaysia (Lee *et al.*, 2004).

Of particular importance to this study is the earlier work on the Kenny Hill Formation by Tjia (1974, 1980 & 2004), works by Tan & Yeap (1977), Harun & Tjia (1984) and Tjia (1986) on structures, Hashim (1985) and

Chen (2004) on age, and by Lee (1996, 2001, 2009), Tjia (1974, 2004), and Dodd *et al.* (2019) on the depositional environment. Other important publications include the most recent publication by Metcalfe (2017) summarizing all his earlier work on the tectonic evolution of SE Asia. Other references cited within this paper and unpublished student theses contributed to the geological understanding.

REGIONAL GEOLOGY

The continental core of SE Asia was constructed by the amalgamation of continental fragments that were rifted from the northern and eastern margins of Gondwana and were reformed when the oceanic basins between them were subducted and destroyed (Hutchison, 2009b; Metcalfe, 2017 and references therein). The Sibumasu microcontinent (Figure 1), which extends from northern Thailand to Sumatra, rifted apart from Gondwana during the Early to Middle Permian and was pulled northward by the subduction of the Paleo-Tethys oceanic crust beneath Sukothai Island Arc on the margin of Indochina (Barber *et al.*, 2011). Indochina was itself a fragment that rifted from Gondwana during the Early Devonian, determined from the age of the oldest Paleo-Tethys sediments (Figure 2), and amalgamated with other Gondwana fragments. Note that SE Asia has been rotated clockwise by the Cenozoic collision of India with Asia, thus, the paleo-northward movement of Sibumasu now appears from the left in the figures.

The adjacent fragments, or terranes, often have vastly different fossil assemblages, such as the Late Paleozoic sediments on Sibumasu, which have cool weather flora and fauna (Fortey & Cocks, 1998; Metcalfe, 2017) and evidence of the Early Permian Gondwana glaciation (Stauffer & Lee, 1986; Tjia, 2004) while Indochina's Late Paleozoic climate was tropical (Cocks *et al.*, 2005; Hutchison, 2009b; Metcalfe, 2009). In addition, the fossil affinities on Sibumasu measure its progression northward over time, where Cambrian-Ordovician faunas have a strong resemblance with Australia, an independent biota developed during the Carboniferous to Permian followed by proximity dispersion with Indochina of similar flora and fauna (Fang, 1994). Paleomagnetic data supports a northward movement of Sibumasu, from high southern latitudes to the equator, while provenance studies using zircon geochronology are useful in Gondwana reconstructions and in dating the rifting and collision events of the various pieces (Searle *et al.*, 2012; Metcalfe, 2017).

During the Indosinian Orogeny, I-type granite plutons were emplaced on Indochina and the Sukothai Arc (Barber, *et al.*, 2011; Ghani, 2009) until Sibumasu reached the subduction zone in the Late Triassic. Heat from crustal thickening and decay of radioactive elements (Barber *et al.*, 2011; Searle & Morley, 2011) or slab break-off (Metcalfe, 2017) generated the heat that partially melted the crust, forming magma which rose and emplaced the tin-rich S-type granite plutons that coalesced into the Main Range granite batholith. Searle *et al.* (2012) propose that the subduction of the Meso-Tethys on the trailing edge of Sibumasu began much earlier (Late

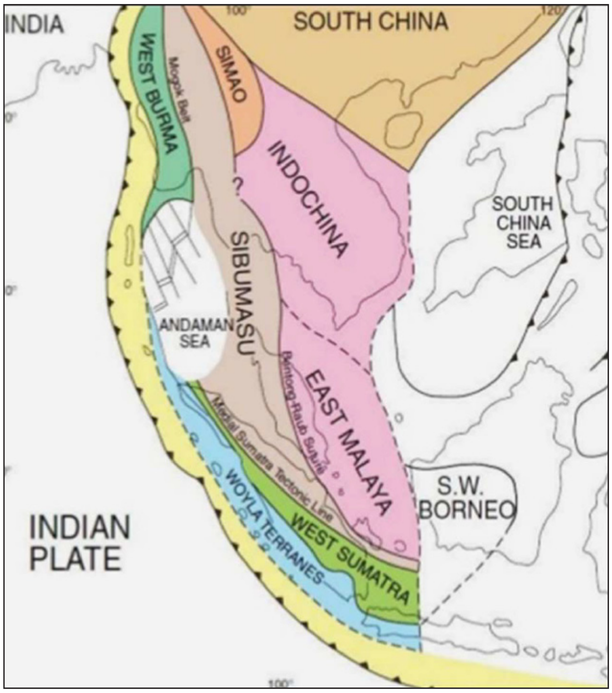


Figure 1: Gondwana derived microcontinents amalgamated to form the core of SE Asia (From Metcalfe, 2017).

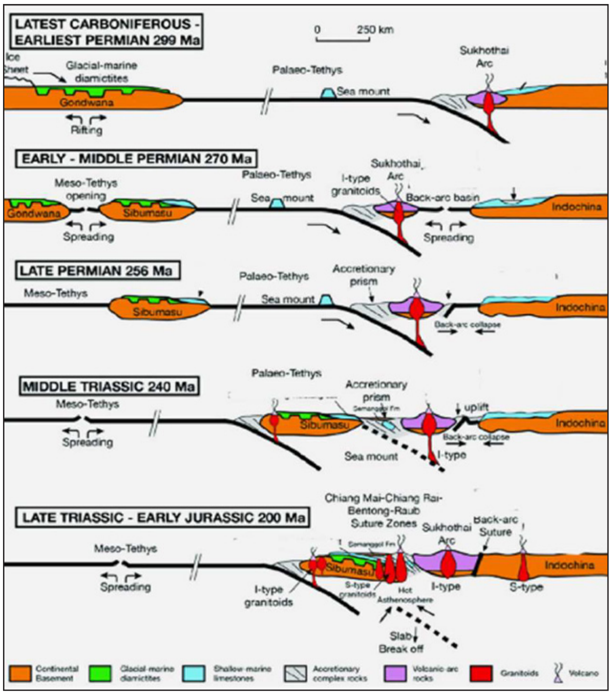


Figure 2: The collision of Sibumasu with Indochina.(Indosinian Orogeny) Modified from Metcalfe, 2017.

Permian) to explain the mixture of I and S-type granites across Peninsular Malaysia. Their emplacement created contact metamorphic aureoles in the sediments on the margins of both Sibumasu, the Sukothai Arc, and the accretionary wedge between them (Metcalfe, 2017). Away from this zone the effects were superimposed by regional metamorphism (Roe, 1951; Gan, 1992).

Recent publications suggest an alternative scenario for the extensive, lateral emplacement of S-type granite plutons, where the leading edge of Sibumasu became more buoyant following the slab break-off and was thrust over the Sukothai Arc (Leslie *et al.*, 2020). There are only three documented examples along the leading edge of Sibumasu, with one in Singapore and another in northern Thailand (Barber, 2011; Leslie *et al.*, 2020), suggesting this is a local occurrence while the dominant stress translated into the Upper Paleozoic sediments is away from the suture zone (presently westward), confirming our observations.

In either case, granitic intrusion and metamorphism of the accretionary wedge and continental margin sediments and westward verging thrust sheets of Paleozoic rocks on Sibumasu generated a variety of metamorphic rock types that have been exhumed and eroded. Though correlation within this zone is difficult it is now interpreted as a suture zone between accreted terranes that preserved a section of the Paleo-Tethys Ocean, which was subsequently nearly destroyed by the emplacement of the Main Range granites. Known as the Bentong-Raub Suture Zone, it can be traced along the margin of Sibumasu to the Inthanon Zone in Thailand, while similar zones are found between microcontinent fragments throughout SE Asia (Barber, 2011; Hutchison, 2009b; Metcalfe, 2017).

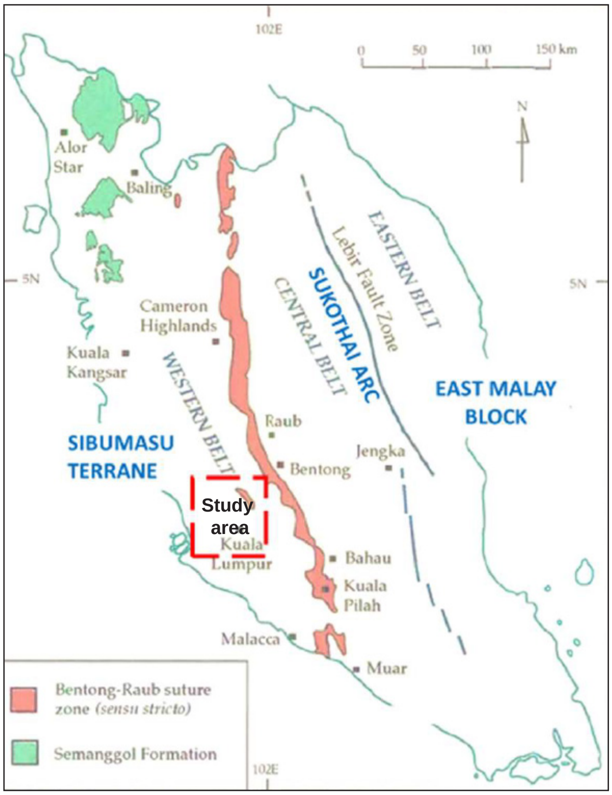


Figure 3: Peninsular Malaysia and study area.

The Bentong-Raub Suture Zone separates the Western Belt, or Sibumasu from the Indochina/East Malay Block, which also includes the Sukothai Arc. Together they form three elongate, northwest-southeast trending terranes on Peninsular Malaysia (Figure 3) which have long been recognized for their differences in geological, structural, and metamorphic characteristics, and in mineral emplacemen. Evidence of the continent and arc collision was preserved in the Lower Paleozoic sediments that were deposited along the margins of Sibumasu while it was still attached to Gondwana. The effects of the Indosinian orogeny subjected the Lower Paleozoic rocks to regional metamorphism, transforming them into phyllites, shists or quartzites. Orientation of the foliation in these rock types would preserve evidence of stress fields (Shuib, 2009; van der Wal, 2014). Within the study area, foliated Upper Paleozoic rocks were not well preserved, and Lower Paleozoic outcrops are rare. However, in the Upper Paleozoic rocks, such as the Kenny Hill Formation, large scale tectonic folding and thrusting shows a general westward (present day) transportation, which fits the general model of a foreland fold-thrust belt in a continent-to-continent collision (Tjia, 1980, 1986; Shuib, 2009). In the few places where the contact between the Upper and Lower Paleozoic is exposed, the Lower Paleozoic rocks have been reported to be intensely folded, the result of multiple deformations (Hutchison, 2009a; Roe, 1951). However, the only documented Paleozoic deformation event on Sibumasu, until recently, was Devonian rifting. Some of the deformation has been attributed to slumping (Shuib, 2009), others suggest it all occurred during the Indosinian Orogeny (van de Wal, 2014). An Early to Middle Ordovician absolute age has recently been proven from meta volcanic rocks in the greater Klang Valley (Long *et al.*, 2018). The interpretation of post-collision Andean style volcanics on the Sibumasu margin of Gondwana implies a dynamic stress regime capable of deforming the Paleozoic succession in Western Malaysia.

STRATIGRAPHIC SUCCESSION OF THE STUDY AREA

We relied on the published geologic maps for formation and ages of the outcrops. The most recent (9th) edition of the 1:750,000 Geologic Map of Peninsular Malaysia, published in 2014 by the Director General Minerals and Geoscience Department Malaysia, is based on time-rock units, however the scale is not sufficient. A grid of 1:63,360 geologic maps, entitled *New Series L 7010* are the latest edition published by the Department of Minerals and Geoscience and most of them are included in a geologic *Map Report* specific to the area they cover. A composite of 6 of the new geologic maps covering Selangor (Figure 4) illustrates some of the issues in an area where geologic mapping began in 1911. Maps were initially published using local formation names. As new data became available, updated maps were published using the coloring convention at that time. The Stratigraphic Lexicon, published in 2004 (Lee *et al.*), is a useful correlation reference while the ongoing studies continually contribute new information on the depositional and structural setting of the Paleozoic formations on Sibumasu.

The stratigraphic sequence for northern Selangor (Figure 5) is derived from the same geologic maps: No. 85, Rawang (undated), No. 94, Kuala Lumpur (Yin, 2011), and No. 102, Sepang (Baba, 2019). This study uses the succession on the far right of Figure 5.

LOWER PALEOZOIC

The study area lies mainly within the Rawang Sheet, Map No. 85. The map is a redrafted version of the Rasa and Kuala Selangor maps included in Roe's 1951 District Memoir 7, updated with modern geologic formation names (Figure 4). The oldest rock unit on Map 85 is the Ordovician-Silurian Terolak Formation, which is reported to consist of both arenaceous and argillaceous metaquartzite, schist, phyllite, pyroxene schist and limestone with graphite schist. Ordovician fossils were found in the limestone beds, which, along with the graphite schist continue south to the next sheet, Map 94, Kuala Lumpur. Here the pale green colors used for the Silurian to Ordovician sequence on Map 85 become tan on Map 94. This map is attached to Report 22 (Yin, 2011), where the Terolak Formation is the equivalent of the Hawthornden Formation.

UPPER PALEOZOIC

Across the entire study area, a sequence of fine to medium grained clastic sediments overlies the Lower Paleozoic formations, makes up most of the hilltops and weathers to a distinctive reddish-brown soil. Named Kenny Hill Formation, after the former name of the type-locality on Map 94, the Carboniferous rocks extend north on to Map 85, where the colors used on the maps change from light blue to brown, while the age changes from Carboniferous to Permian (Figures 4 & 5). The Belata Formation is named after the type-locality, Bukit Belata, on the next map to the north, Map 76, Tanjung Malim and extends southward across Map 85. Cited as equivalent formations (Lee *et al.*, 2004) The Kenny Hill

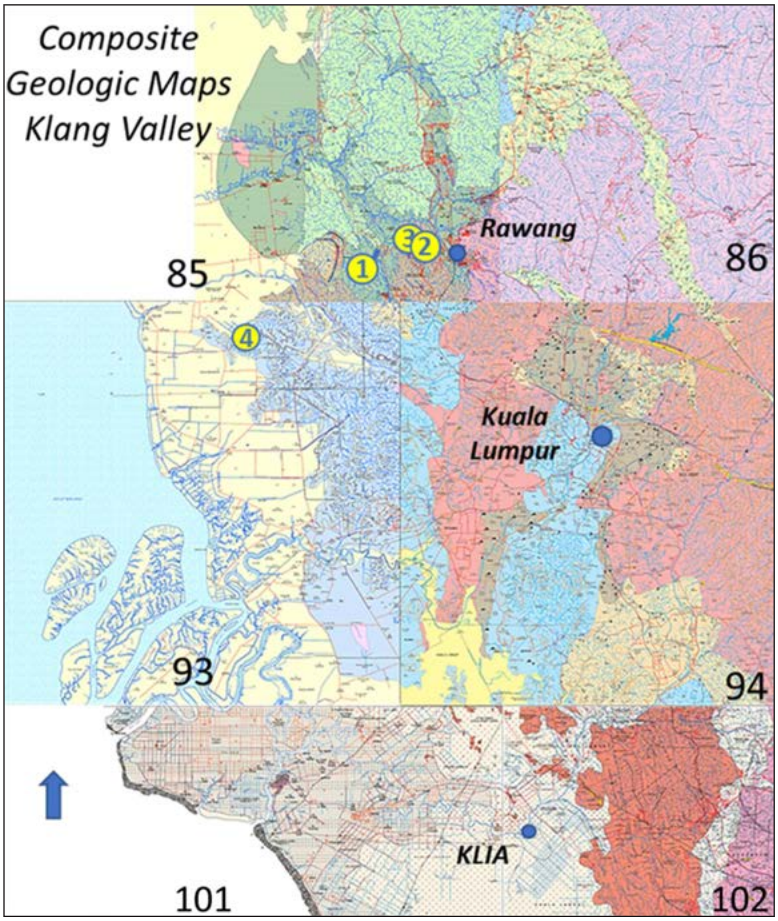


Figure 4: A merge of 6 geologic maps over the greater Klang Valley showing the locations of outcrops in this study. Maps: 85-Rawang, 86-Kuala Kubu Bahru, 93-Kuala Selangor, 94-Kuala Lumpur, 101-Telok Datok, 102-Sepang. Courtesy Director General, Minerals and Geoscience Department, Malaysia.

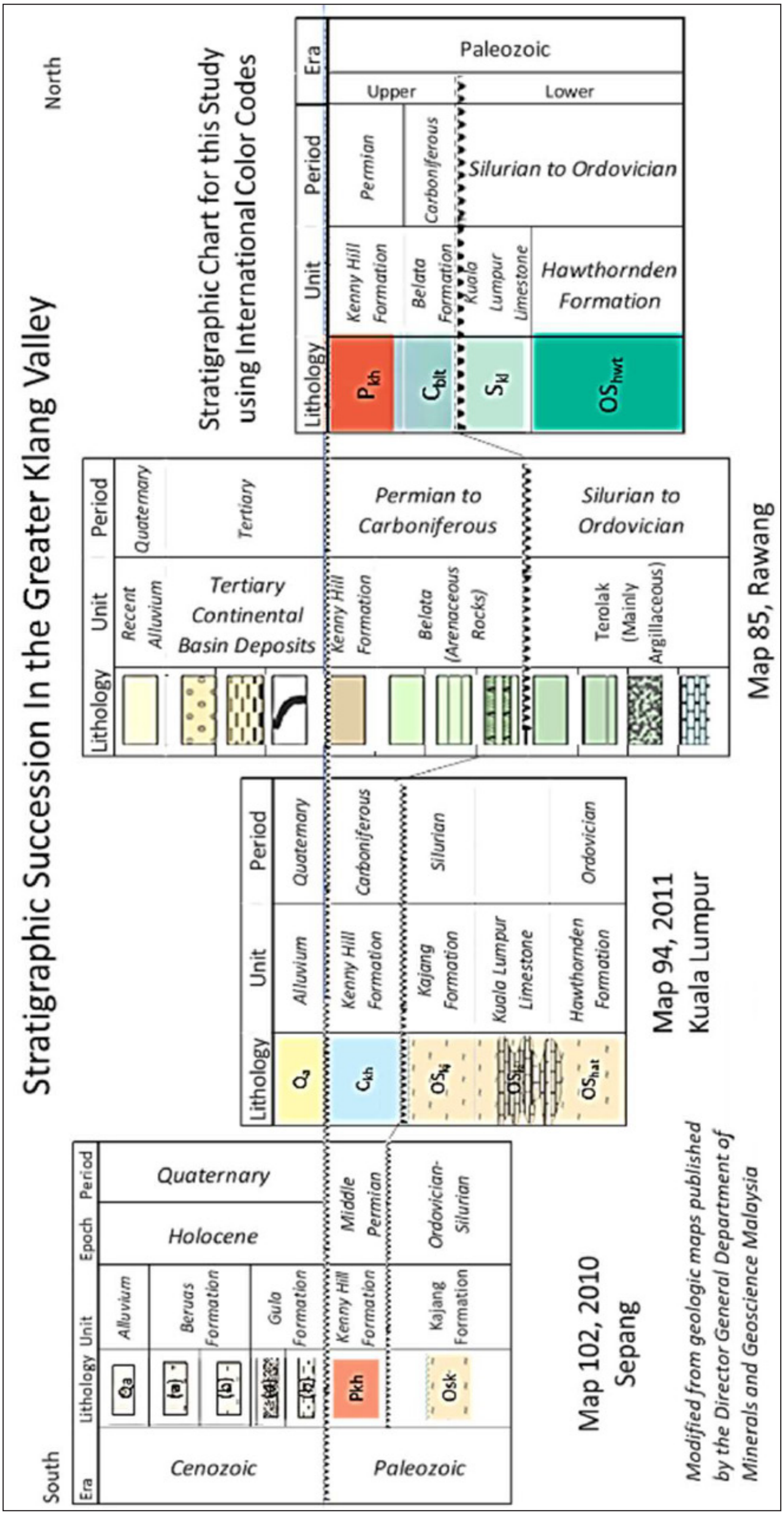


Figure 5: Stratigraphic succession defined on geologic maps across the study from south (left) to north. Modified from geologic maps published by the Director General Minerals and Geoscience Department Malaysia.

and Belata formations together make up the Carboniferous to Permian succession on Map No. 85 (Figure 5). At a convenient break in the mapping in the southern part of Map 85 the two formations change names and colors, though no difference in the rock descriptions is noted by Roe (1951) or by the authors of this study. Since the bulk of the study area lies within the south of Map 85, we use Kenny Hill Formation for all the Upper Paleozoic outcrops.

Because it covers much of the heavily urbanized greater Kuala Lumpur area, stratigraphic correlation of the upper Paleozoic is a tempting, but elusive endeavor. Generally barren of macrofossils, a Middle Permian age was assigned to the Kenny Hill Formation after identification of an ammonoid in the of southern Selangor (Hashim, 1985). The scarcity of macro fossils in the Kenny Hill Formation is thought to be related to the sub-polar climate (Lee, 1996; 2001). Lower Carboniferous radiolarian chert, indicative of a deeper ocean basin in a cool climate, are distributed along the margins of the Paleo-Tethys Ocean (Jasin & Harun, 2011) and in northwest Peninsular Malaysia, these cherts serve as the basal marker for the Carboniferous-Permian succession. In Northern Selangor, the Belata Formation has a basal chert facies while in Southern Selangor the cherts are grouped together with the Kenny Hill Formation. Laboratory testing of Kenny Hill Formation samples collected near the University of Malaya in Kuala Lumpur in 1993 identified several species of spores that individually ranged from the Lower Devonian to Jurassic (Chen *et al.*, 2002), with a Late Permian peak occurrence density (see Appendix A). Thus, the Kenny Hill Formation has been assigned to a deepwater, early Carboniferous cherts, Middle Permian shallow Marine sediments and Late Permian continental deposits.

Successful stratigraphic correlation of the Carboniferous to Permian succession elsewhere on Peninsular Malaysia, has led to alternative methods to uncover uniqueness in the Upper Paleozoic sediments. The Al_2O_3/SiO_2 ratio measured in Paleozoic black shales on Peninsular Malaysia (Baiomy *et al.*, 2016), determines if the source material for the shale was broken down primarily by chemical or mechanical weathering. This is usually a function of the climate, and intervals of Upper Paleozoic wet and dry cycles have been documented. Another study of the measure the changes over time in the primary stress fields that affected the Paleozoic rocks on Peninsular Malaysia, and their relative movement (Tjia, 1986b). Though geochemical and structural correlation cannot provide absolute dates, they would be useful tools for constraining the relative timing of structural deformation and correlation of coeval depositional environments. As excavation continues, there is always the possibility that new macrofossil specimens will be recovered that will further constrain the depositional facies and timing of the structural deformation.

OUTCROP DESCRIPTIONS

The outcrop locations on Figure 4 are described in Figure 6. Figures 10-27 are located on the satellite photo in Appendix B.

JRBJ outcrop

The JRBJ outcrop lies within a 20-hectare excavation on the north side of Jalan Rawang-Bestari Jaya (B29) near the intersection of Jalan Tasik Puteri (Figure 7). Initially cleared in 2013, aggregate from the site was used in the residential development south of the road. Activity abated in 2015 and only began again in 2020. Steeply dipping beds of sandstone, mudstone and shale are exposed on a steep slope along the northwest (335 degrees) boundary of the excavation site. Rather than just a single quarry face, this outcrop has ridges and a cleared floor so that one can view the strata from multiple angles.

When Roe (1951) mapped the area, he recognized similar facies in the metasediments and grouped them together, naming them the Arenaceous Series and Calcareous Series. He annotated the accuracy of his geological boundaries on his maps, using a solid line for “correct to within 100 yards”, a dashed line for “correct within ¼ mile”, and dotted lines where boundaries were less definite. Contacts in this area were usually obscured by thick tropical vegetation and Roe relied on topography

	Name	Full Name	Location-DMS	Location Decimal Degrees
1	JRBJ	Jalan Rawang-Bestari Jaya	3019’29.93”N 101030’28.80”E	3.323889 101.50778
2	Scientex	Scientex Rawang	3018’58”N 101032’34”E	3.31611 101.542778
3	Jalan Anggun 2	Monocline north of Jalan Anggun 2	3019’18”N 101030’18”E	3.321667 101.505
4	Bukit Botak 3 Unconformity outcrop	HW B104/Jalan Simpang Tiga Jeram-Bukit Botak 3 Unconformity outcrop	3014’01”N 101023’09”E	3.233611 101.385833

Figure 6: Outcrop names and locations.

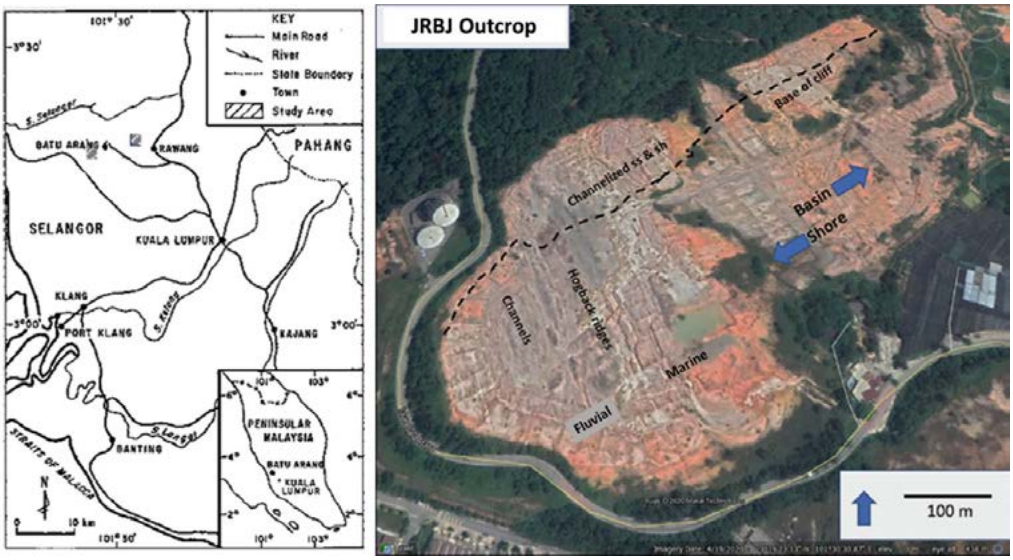


Figure 7: JRBJ location and satellite photo.

Figure 8: Formation contacts in yellow over satellite photo of the Rawang area. Satellite courtesy of Google maps.

and changes in soil characteristics and color to map the contact between the two series, annotating his map with a dotted line. This boundary is now recognized as an important unconformity between Upper and Lower Paleozoic formations. When his map was redrafted and replaced, all the geological boundaries on Roe's map were redrawn as solid lines on the current geologic map. In addition, Roe noted the strike and dip and the schistosity and jointing patterns; none were included on the new map. It is a shame in this digital age that important information is lost rather than being stored.

This boundary was superimposed onto a satellite photo covering of 3 of the 4 outcrops in this study (Figure 8). The yellow dashed line is the mapped contact between the Upper Paleozoic Kenny Hill Formation and the Lower Paleozoic Hawthornden/Terolak Formation. Lower Paleozoic rocks were not found at or near these 3 outcrops, confirming this contact is not exact and could mispositioned greater than ¼ mile (400 m.).

The cliff face exposes approximately 680 m of heavily weathered, slightly metamorphosed sandstone, siltstone, and shale dipping 30-50 degrees to the southwest. The rocks are described from freshly broken exposures and are consistent with observations at other outcrop locations. Because of intense tropical weathering, the colors may not be original (Figure 10).

Beginning at the northeast, or right edge as one faces the outcrop, thin beds (2-10 cm) of gray and maroon mudstone (Figure 11) are interspersed with thicker (~1 m) yellow mudstone, reddish-brown sandstone beds and

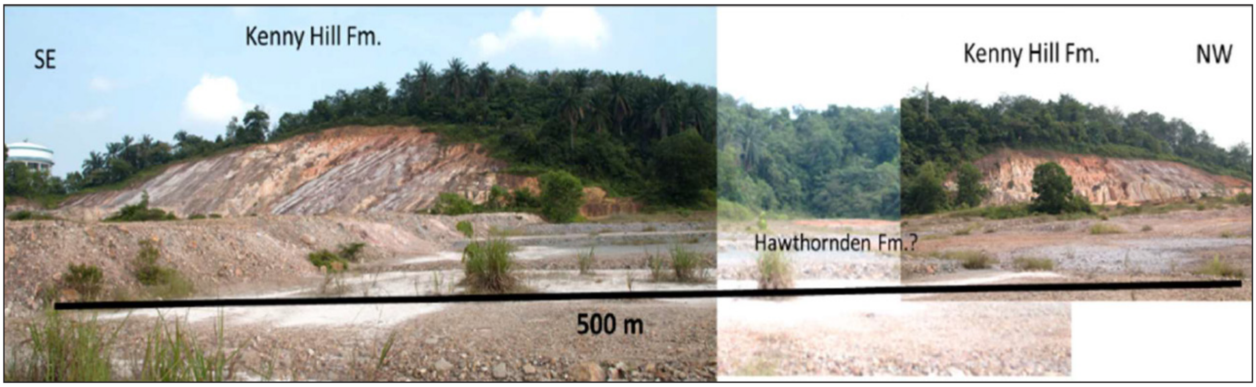


Figure 9: A composite photo of the JRBJ outcrop. The geologic map places the contact between Upper Paleozoic Kenny Hill Formation and Lower Paleozoic Hawthornden Formation in the low area between the hills, extending toward the viewer.

Figure 10: The heavily weathered northeast end of the outcrop. Top of bedding is to the left.

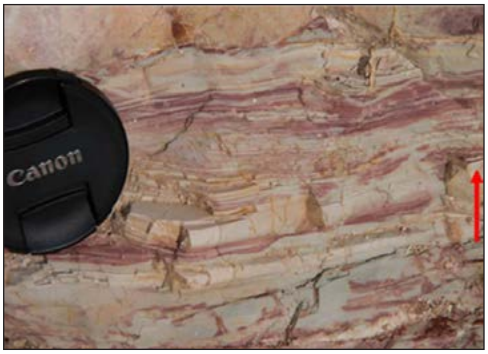


Figure 11: Finely laminated maroon and gray shale common in the Kenny Hill Fm. Arrow points to top of beds.

gray shales (Figure 12). These maroon and gray shales are common to every Kenny Hill outcrop in the area. A brown iron oxide cement fills fractures and joints, which are seen to stand out in relief due to differential weathering. Abundant lateritic concretions and nodules are present (Figure 13). Here the section is heavily weathered and gravitational slumping of the hillside, combined with the more resistant pattern of cement-filled joints complicated establishment of the bedding orientation. However, where the hillside is stable the beds strike NNW and dip 30-60 degrees WSW (Figure 11).

Continuing southwest along the outcrop, the gray to white shale and mudstone layers are up to 1.0 meter thick. Tan-gray sandstone units have sharp basal contacts showing load structures, well preserved ripples, cross stratifications, scours, pinch-outs, and ball-and-pillow structures are seen (Figure 14). The sands are riddled with concretions, generally near the base of the beds. Concretions have soft centers and ~1.0 cm iron oxide rims. Fractures are filled with the same iron oxide cement (Figure 15). Continuing along the outcrop, several black-purple layers of resistant sand separate bleached white siltstone layers that are approximately 1 meter thick (Figure 16). Studies referenced in this paper document the bleaching of sandstone and siltstone, where under reducing conditions, reservoir fluids will remove metal ions, especially iron. In addition, if CO_2 is present, it reacts with the iron (Fe^3) to form siderite concretions at impermeable barriers in the reservoir (Ming *et al.*, 2017). The fluid also interacts with calcite cement in fracture fillings or in the rock matrix to form siderite (Loope *et al.*, 2012).

Figure 12: Bleached massive sandstone, sharp basal contact with maroon and gray shale.

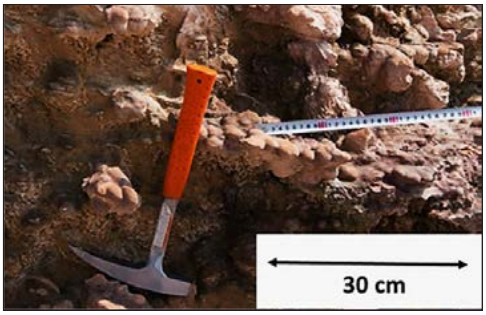


Figure 13: Concretions reforming (?) on iron rich cement between fractures and beds.

Figure 14: Bleached siltstone above iron-stained shale highlighting load structures.

Figure 15: Sharp basal contact between tan sandstone and maroon and white mudstone with load structures, concretions and fractures preserved by iron cement filling (upper 2 arrows). Eroded concretions with soft interiors (lower arrow).

Figure 16: Layers of bleached siltstone with black and purple sands between them.

Figure 17: Burrows or root casts.

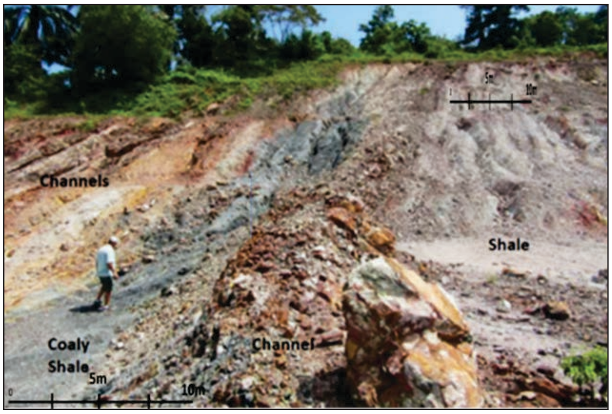


Figure 18: A sequence of channels sands and shales with a graphite rich layer dipping 48 degrees. to the SW. There are two scales in the photo to show bed thickness near the top and bottom of the outcrop. View is WSW.

The next sandstone units are yellow to reddish-brown. Tube-like burrows averaging 0.5 cm in diameter and matching previously described trace fossils (Stauffer, 1973; Tan & Yeap, 1977) were found where they had eroded from the formation and are indicative of a marine estuary (Figure 17).

Thicker, stacked channels of gray and buff-colored sandstone are more prevalent moving southwest along the sequence. Excavation and differential weathering created resistant hogback ridges of that strike, away from the cliff face outcrop, exposing the top and base of the layers. Here the thickest black shale (~3.5 m) is exposed (Figure 18). The basal contact of a shingled, stacked sandstone channel sequence is preserved on the escarpment below one hogback ridge (Figure 19). A large fault is noted parallel to the bedding plane, the softer fault

Figure 19: Basal contact of a shingled channel sandstone bodies below a hogback ridge formed by the 30 degree dip to the SSW.

Figure 20: Fault parallel to bedding plane.

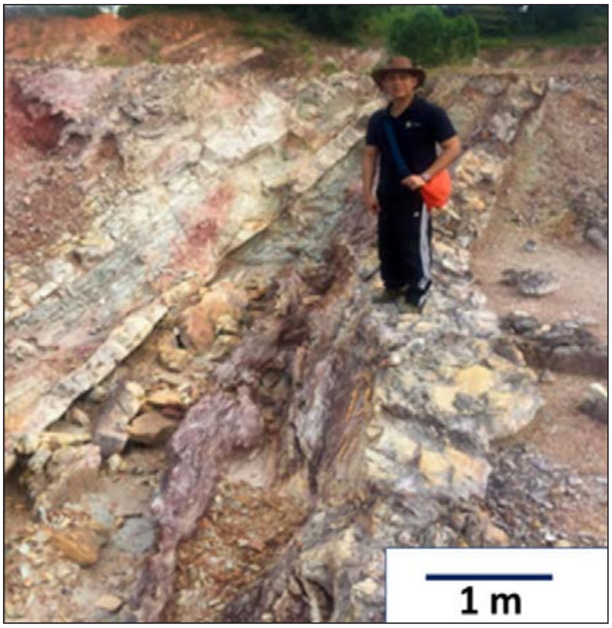


Figure 21: Sandstone channels dipping 50-60 degrees, as a result, the softer shales have differentially eroded.

gouge is weathered out, creating a trough that marks the fault (Figure 20). Nearby, the softer shale and mudstone is eroded in beds dipping 50-60 degrees, preserving a relief of channel lenses (Figure 21).

An interesting feature is seen along the dip slope of a ridge, at the paleo-top of a gray sandstone unit. A purple-gray, or yellow, crust has precipitated over underlying brown (iron-oxide?) material, which at first appeared to be roots or burrows (Figures 22-24). The coating occurs on the fracture-filling iron-oxide cement where it is exposed on southwest facing slopes. Between two ridges, in less resistant layers, the joint pattern is preserved by differential weathering (Figure 25). This phenomenon was previously described by H.D. Tjia in 1974 in the Kenny Hill Formation at Bukit Pantai in Kuala Lumpur. A sample of a concretion was later dissected using a rock saw and revealed a cross section that looks like a plant or tree root (Figure 26). It is still unknown at this time if the concretions have an organic origin or if roots had grown and propagated into the fractures. Nearby, a large, cylinder shaped object 28 cm in diameter and 80 cm long was found. Too large and heavy to carry from the field for proper analysis, we cannot help wondering if this was once of organic origin or a large concretion (Figure 27).

JRBJ Discussion

Overall, the section coarsens upward from northeast to southwest as individual sandstone layers become thicker, though the grain size within the upper sandstone beds appears to be the same as the lower beds. A sedimentary log of the outcrop illustrates the facies objectively by highlighting the repeating facies and narrowing interpretation options. Figure 28 is a detailed composite log of the 9 depositional patterns and their grouping into mega-facies.

The complete log for the JRBJ outcrop is in Appendix C. The pattern of repeating Facies 1 and 2 is typical in a deltaic setting and possible in a tidal or wave dominated delta with an intermittent sediment supply. Overall, the facies are a shallow marine to continental environment, where intermittent flooding supplies plenty of sediment that is reworked into barrier mouth bars and shoals during dry periods. Sediment rates are high during floods, with rip-up clasts and erosive beds and soft sediment loading. An estuary or lagoon forms behind the barrier island, with bioturbated sediments in the lagoon and swallow nearshore. The clay and silt deposits of Facies 1a to Facies 1c are deposited in deeper water, while the silts and shale

Figures 22 and 23: The bluish concretion appears to be a precipitate on the iron oxide cement that fills the joints and is present between beds, as seen elsewhere in the outcrop.

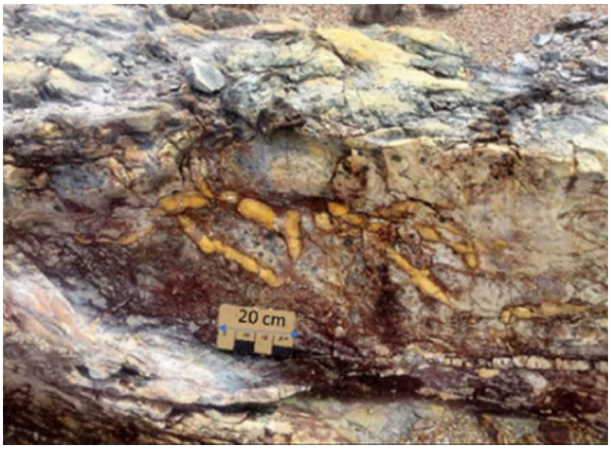


Figure 24: A yellow concretion has precipitated where iron rich cement in the fractures is exposed along this dip-slope.

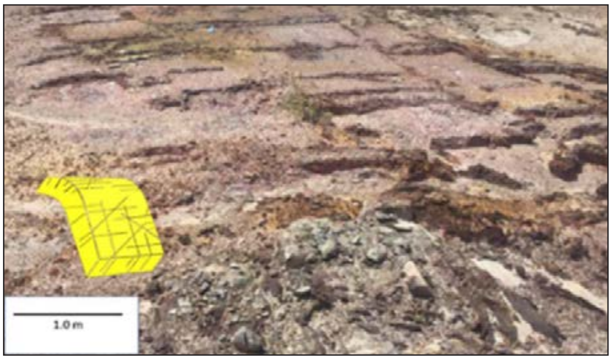


Figure 25: Fracture pattern in relief on ground excavated less than 5 years prior to the photo.

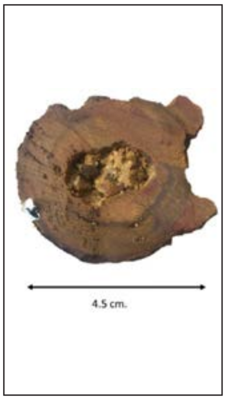


Figure 26: Small concretion from the JRBJ outcrop dissected by a rock saw.

Figure 27: Unidentified object. Could it be a possible Permian palm plant?

between the channel deposits in Facies 4a and Facies 4b are probably overbank deposits. While the bioturbated sands occurred a shallow marine environment or estuary, the rest of the outcrop appears devoid of any animal fossils or trace fossils, except for concretions. According to Lee (1996) the Kenny Hill Formation should have preserved fossils; the sediments are relatively unaltered by metamorphism and fresh samples, unaffected by weathering, can be found at new construction sites. Yet, the only fossils are a single Lower-Middle Permian ammonite and some crinoid stems found south of Kuala Lumpur (Hashim, 1984) the spores with a Late Permian-Triassic affinity near University of Malaya (Chen, 2002) and Devonian to Carboniferous radiolarians were found in cherts at Dengkil in southern Selangor (Jasin & Harun, 2011).

The large number of concretions merited an investigation, where it was learned that large concretions can form rapidly during early diagenesis and they often nucleate around decaying organic matter which could explain the lack of fossils. More likely, at this location, the non-fossiliferous Kenny Hill Formation was deposited downstream from a barren, arid periglacial landscape of a distal outwash plain at low latitudes devoid of

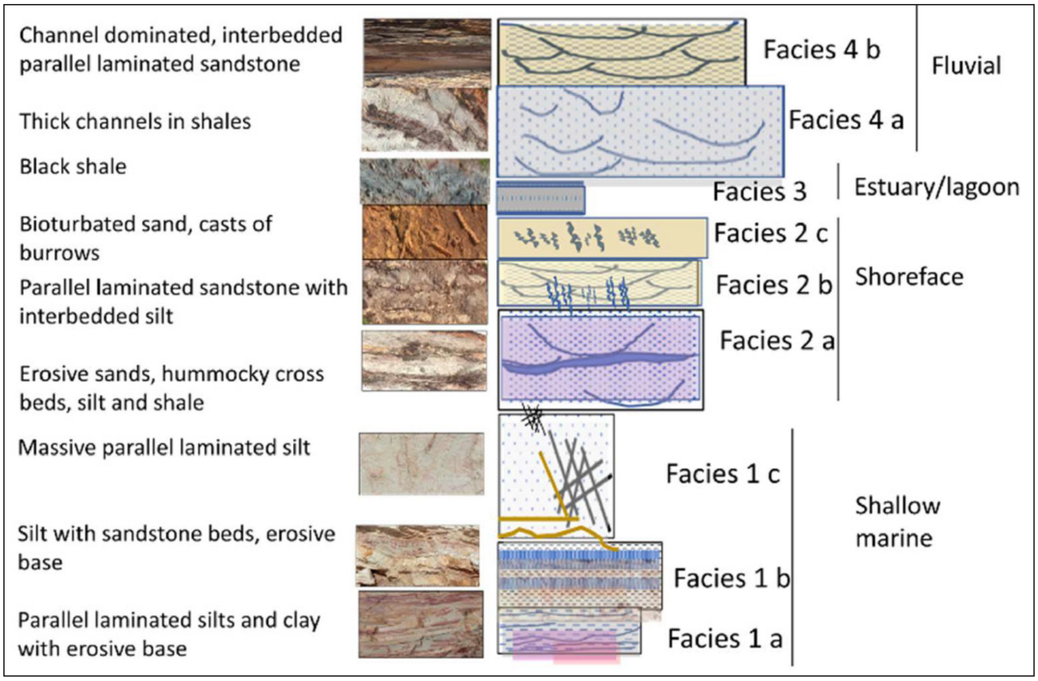


Figure 28: Composite facies log of the JRBJ outcrop shows the transition from shallow marine to littoral to fluvial deposition.

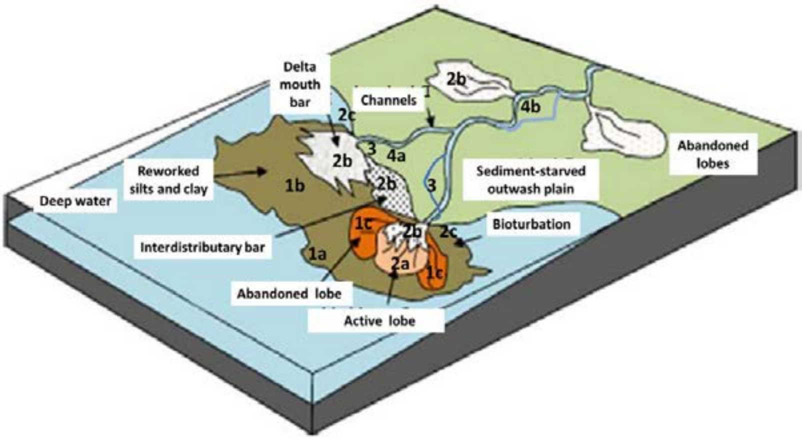


Figure 29: Interpretation of the depositional environment of Kenny Hill Formation sediments at the JRBJ outcrop, northern Selangor. Modified after Siddiqui *et al.*, 2017.

vegetation, such as the environment depicted in Figure 29 (Stauffer & Lee, 1986; Tjia, 2004). An ephemeral, fluvial-deltaic depositional setting, where sheet sands are rapidly deposited over soft sediments following periodic glacial outburst floods supplied the river systems and the delta with a rapid influx of sediment. (Dodd *et al.*, 2019). Facies 1a and 1b and Facies 2a and 2b are the result of rapid deposition on the shelf while Facies 1c appears to be sediments reworked by currents during times of low sediment input.

Glacial diamictites were deposited in grabens on Sibumasu as it rifted from Gondwana during the opening of the Meso-Tethys Ocean, and it is possible that Kenny Hill Formation sediments were preserved along its leading edge in grabens formed by earlier rifting of the Gondwana margin. The bulk of the Kenny Hill Formation continued to accumulate as a clastic wedge on the leading edge of Sibumasu, beginning with a deepwater accumulation siliceous sediments during the Lower Carboniferous. Progressively shallower marine sedimentation, and eventually continental deposits accumulated through the Permian, until the Indosinian Orogeny, when the Kenny Hill Formation was incorporated into the foreland-fold thrust belt which deformed the Paleozoic sediments.

ADDITIONAL OUTCROPS

Other outcrops in the vicinity that require further investigation are noted because of their unique characteristics and need for immediate study before they are destroyed.

Scientex Rawang

Less than 4 km due east from the JRBJ outcrop, on the east side of Persiaran Anggun, just north of Aeaon Mall Rawang, new excavation for a residential and commercial development have exposed sands and shales of the Kenny Hill Formation that dip 8-30 degrees to the northeast (Figure 30). Yellow to buff-colored massive sands up to 4 meters thick lie above the lower unit (Figure 30). The lower section is characterised by a fine-grained, thinly bedded maroon and white colored unit over 8 meters thick that weathers to gray. Tan sand lenses have developed Liesegang rings staining (Figure 31). This rock is remarkably like Facies 1 a and b, the maroon and white shale described at the JRBJ outcrop. Normal faults, downthrown to the west, are exposed in south-facing excavations. The faults appear to sole into a bedding-plane decollement (Figure 32).

Jalan Anggun 2

Across the road, just 0.8 km west, the hillside was cleared and excavated, revealing a large monocline fold in the Kenny Hill Formation (Figures 33 & 34). This outcrop was not yet investigated before press time due to the 2021 Covid-19 travel restrictions. Elsewhere in the Selangor, the Kenny Hill Formation has been deformed into isoclinal and even recumbent folds cut by low angle thrust faults that show a general westward tectonic transportation of the Kenny Hill formation resulting from stress perpendicular to the N-S striking fold axes (Harun & Tjia, 1984). We plan to study this fold in more detail.

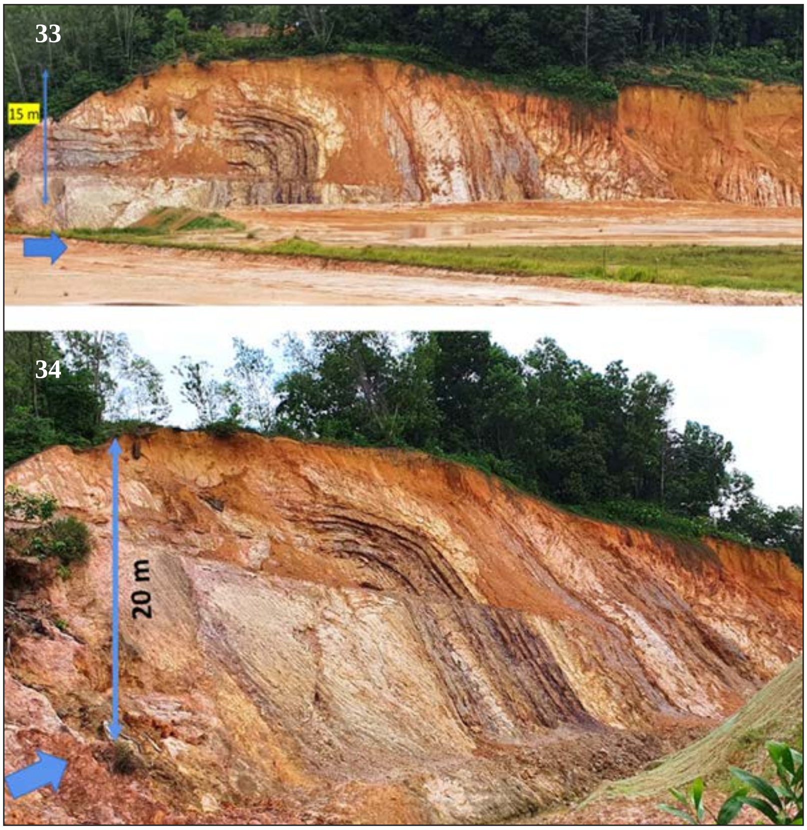
Puncak Alam

13 km southeast of the JRBJ outcrop, the Kenny Hill Formation is being quarried at Bukit Botak (also named Bukit Cerakah) along Jalan Simpang Tiga Jeram (B104) for road fill. The white and maroon silty layer we saw at the outcrops to the northeast (Facies 1a and b) are present here as well. The extensive outcrop of Kenny Hill Formation is cut by normal faults (Figure 35), an angular unconformity (Figure 36) and low angle thrust faults and back thrusts (Figures 37 & 38). Figure 39 is a possible interpretation of the thrust faults in the outcrop that shows tectonic movement is to the right (present day west). Near to the base of the hill an angular unconformity places the Kenny Hill Formation in contact with a highly deformed, dark. fine-grained sediment (Figures 40-41). This appears to be the Upper/Lower Paleozoic contact documented elsewhere in the Klang Valley, such as where the Kenny Hill Formation lies unconformably above the Hawthornden Formation (Yin, 2011). The outcrop is below Bukit Botak peak, a popular hiking destination just 4 km west of Puncak Alam. Based on the position of excavating equipment and the new West Coast Highway under construction nearby, it is likely that most of this outcrop will be removed or will be obscured by slope stability measures (Figures 42-43).

Figure 30: Sharp contact between maroon and white shale that weathers to gray overlain by a 1.5 m thick massive sandstone. The beds strike 50 degrees NW and dip 32 degrees NE.

Figure 31: Tan sandstone lens with Liesegang rings staining and cross-bedded maroon and white shale the weathers to gray.

Figure 32: Approximately 10 m cliff of Kenny Hill Formation at the Scientex outcrop showing faulting and folding typical at this site. View is to the southeast, beds are dipping 50 degrees NNE.



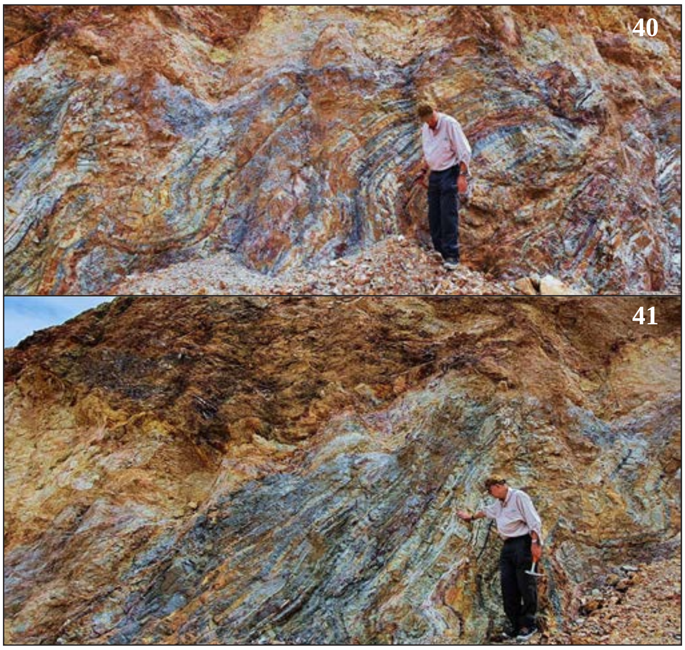
Figures 33 and 34: Monoclinal folding typical of the Kenny Hill Formation. Large arrow points northward.

Figure 35: Normal faults or back-thrusts in the Kenny Hill Formation at Bukit Botak. View is southwest.

Figure 36: Angular unconformity marked by red line, Kenny Hill Formation above red line.

Figures 37 and 38: View to the south of faulting and folding in the Kenny Hill Formation at Bukit Botak showing evidence of movement to the right.

Figure 39: A a possible interpretation of the faulting in Figure 38.



Figures 40 and 41: Views of an angular unconformity between the Upper Paleozoic Kenny Hilll Formation above and highly deforemed Lower Paleozoic sediments below in a north facing outcrop at Bukit Botak.

Figure 42: Heavy mining activity at Bukit Botak for new West Coast Hwy. Red arrow points to dragline excavator on the top, 120 m above viewer.

Figure 43: The outcome for many outcrops. The covered slope is 25 m high.

SUMMARY

The outcrops we investigated result from the ongoing development of the greater Klang Valley. New and equally large outcrops are expected to be exposed as more development occurs. These exposures supply a wealth of new data to supplement the earlier studies and improve understanding of the underlying bedrock. Because the Kenny Hill Formation underlies most of the area to the west of Kuala Lumpur, further sedimentological and biostratigraphic studies are important to assist future development, including minimizing risk above ground for building and infrastructure (Leslie *et al.*, 2020). From an exploration standpoint, the outcrops are useful analogues of co-eval subsurface sedimentary succession currently untested in the offshore basins (Mazlan *et al.*, 2020). We hope these observations inspire detailed studies in the future.

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REFERENCES

Alexander, J.B., 1959. Pre-Tertiary Stratigraphic Succession in Malaysia. Nature, 183, 230-231.

Alexander, J.B., 1965. Geological Map of Malaysia, 6th edition (Diamond Jubilee), 1:500,000. Geologic Survey Department, West Malaysia.

Baba, Mohd Fadlee, 2019. Geology and Mineral Resources of Telok Datok-Sepang, Selangor. Director General Minerals and Geoscience Department, Malaysia.

Baiomy, H., Ulfa, Y., Mohd Nawawi, Padmanabhan & Mohammed Noor Akmal Anuar, 2016. Mineralogy and Geochemistry of Palaeozoic Black Shales from Peninsular Malaysia: Implications for their Origin and Maturation. International Journal of Coal Geology, 165, 90-105.

Barber, A.J., Ridd, M.F. & Crow, M.J., 2011. The Geology of Thailand. The Geological Society London. 626 p.

Chen, B., Mustaffa Kamal Shuib & Khoo, T.T., 2002. Dating the Kenny Hill Formation: Spores to the Fore. Warta Geologi, 28, 189-191.

Cocks, L.R.M., Fortey, R.A. & Lee, C.P., 2005. A review of Lower and Middle Paleozoic biostratigraphy in west peninsular Malaysia and southern Thailand in its context within the Sibumasu Terrane. Journal of Asian Earth Sciences, 24(6), 703-717.

Director General, Department of Minerals and Geoscience, 2009. Geological Map of Kuala Kubu Bahru. Director General Minerals and Geoscience Dept. Malaysia.

Dodd, T.J.H., Ng Tham Fatt, Qalam A'Zad Rosle, Leslie, A.G., Dobbs, M.A. & Gillespie, M.R., 2019. New insights into the sedimentology of the Kenny Hill Formation, Peninsular Malaysia. National Geoscience Conference Abstracts in Warta Geologi, 45, 196-197.

Fang, Zong-Jie, 1994. Biogeographic Constraints on the Rift-Drift-Accretion History of the Sibumasu Block. Journal of Southeast Asian Sciences, 9, 375-385.

Fortey, R.A. & Cocks, L.R.M., 1998. Biogeography and Paleogeography of the Sibumasu Terrane in the Ordovician: A Review. In: Hall, R. & Holloway, J.D. (Eds.), Biogeography and Geological Evolution of SE Asia. Backhuys Publishers, Leiden, The Netherlands, 43-56.

Gan, A.S., 1992. Geology and Mineral Resources of the Tanjong

Malim Area. Minerals and Geoscience Department Malaysia, Map Report 4. 115 p.

Geological Map of Rawang. Director General Minerals and Geoscience Dept. Malaysia.

Ghani, A.A., 2009. Plutonism. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 211-231.

Gobbett, D.J., 1965. The Lower Paleozoic Rocks of Kuala Lumpur. Federation Museums Journal, 9, 67-69.

Gobbett, D.J. & Hutchison, C.S., 1973. Geology of the Malay Peninsula. Wiley Interscience, New York. 438 p.

Harun, Z. & Tjia, H.D., 1984. Overturned Folds, Superposed Thrusts and Structural Overprints near Sungai Buah, Selangor. Bulletin of the Geological Society of Malaysia, 17, 225-236.

Hashim, A.S., 1985. Discovery of an Ammonoid (*agathiceras sp.*) and Crinoid Stems in the Kenny Hill Formation of Peninsular Malaysia, and its Significance. Warta Geologi, 11, 205-212.

Hutchison, C.S. & Tan, D.N.K., 2009. Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur. 479 p.

Hutchison, C.S., 2009a. Metamorphism. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 233-247.

Hutchison, C.S., 2009b. Tectonic Evolution. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 309-330.

Jasin, B. & Harun, Z., 2011. Lower Carboniferous (Tournaisian) radiolarians from Peninsular Malaysia and their significance. Bulletin of the Geological Society of Malaysia, 57, 47-54.

Jones, C.R., 1968. Lower Paleozoic Rocks of Malay Peninsula. American Association of Petroleum Geologists Bulletin, 52, 1259-1278.

Khoo, S. & Tan, B.K., 1983. Geological Evolution of Peninsular Malaysia. In: Proceedings of Workshop on Stratigraphic Correlation of Thailand and Malaysia, 1, Technical Papers Geological Society of Thailand & Geological Society of Malaysia, 253-290.

Lee, C.P., 1996. Probable reasons for the paucity of the fossil record in the Kenny Hill Formation. In: Seminar on Marine Sedimentation and Biota in Malaysian Geological Record-Abstracts. Warta Geologi, 22, 84.

Lee, C.P., 2001. Scarcity of Fossils in the Kenny Hill Formation and its Implications. Gondwana Research, 4, 675-677.

Lee, C.P., Leman, M.S., Hassan, K., Nasib, B.M. & Karim, R., 2004. Stratigraphic Lexicon of Malaysia. University of Malaysia, Kuala Lumpur. 162 p.

Lee, C.P., 2009. Paleozoic Stratigraphy. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 55-86.

Leslie, A.G., Dobbs, M.R., Ng Tham Fatt, Rosle, Q.A., Noh, M.R. Mohd., Dodd, T.J.H. & Gillespie, M.R., 2020. The Ukay Perdana Shear Zone in Kuala Lumpur: A crustal-scale marker of early Jurassic orogenic deformation in Peninsular Malaysia. Bulletin of the Geological Society of Malaysia, 69, 135-187.

Long, X.Q., Ghani, A.A., Yu-Ming, Hao-Yang, L. Saidin, M. Roselee, H. Hassan, M.H.A., Aziz, J.H.A., Tham., F.N., Ali, M.A.M. & Zulkifley, M.T.M., 2018. Absolute Age Evidence of Early to Middle Ordovician Volcanism in Peninsular Malaysia. Current Science, 115, 2291-2296.

Loope, D.B., Kettler, R.M., Weber, K.A., Hinrichs, N.L. & Burges, D., 2012. Rinded iron-oxide concretions: hallmarks of altered siderite masses of both early and late diagenetic origin. Sedimentology, 59, 1769–1781.

Mazlan, M., Jong, J., Kessler, F.L., M. Hafiz Damanhuri & Mohd Khairil Azrafy Amin, 2020. Pre-Tertiary basement subcrops beneath the Malay and Penyu basins, offshore Peninsular Malaysia: Their recognition and hydrocarbon potential. Bulletin of the Geological Society of Malaysia, 70, 163-193.

Meor Hafik Amir Hassan, Yeow Boon Sim, Lee Chai Peng & Abdul Hadi Abdul Rahmam, 2013. Facies Analysis of the Uppermost Kubang Pasu Formation, Perlis: A Wave-and Storm-influenced Coastal Depositional System. Sains Malaysiana, 42, 1091-1100.

Metcalfe, I., 2009. Late Palaeozoic and Mesozoic Tectonic and Palaeogeographical Evolution of SE Asia. In: Buffetaut, E., Cuny, G., LeLeouff, J. & Suteethorn, V. (Eds.), Late Paleozoic and Mesozoic Ecosystems in S.E. Asia. The Geological Society of London, Special Publications, 315, 7-23.

Metcalfe, I., 2013. Gondwana Dispersion and Asian Accretion: Tectonic and Palaeogeographic Evolution of Eastern Tethys. Journal of Asian Earth Sciences, 66, 1–33.

Metcalfe, I., 2017. Tectonic Evolution of Sundaland. Bulletin of the Geological Society of Malaysia, 63, 27-60.

Ming, X.R., Liu, L., Yu, M., Bai, H.G., Yu, L. Peng, X.I. & Yan, T.H., 2017. Bleached mudstone, iron concretions, and calcite veins: a natural analogue for the effects of reducing CO_2-bearing fluids on migration and mineralization of iron, sealing properties, and composition of mudstone cap rocks. Geofluids, 16, 1017-1042.

Parry, W. T., 2011. Composition, nucleation, and growth of iron oxide concretions. Sedimentary Geology, 233, 53-68.

Roe, F.W., 1951. The Geological and Mineral Resources of the Neighborhood of Kuala Selangor and Rasa, Selangor, Federation of Malaysia With an Account of the Geology of Batu Arang Coalfield. Memoir No. 7, Geological Survey Department, Federation of Malaysia. 164 p.

Scrivenor, J.B., 1913. The Geological History of the Malay Peninsula. Quarterly Journal of the Geological Society, 69, 343-371. https://doi.org/10.1144/GSL.JGS.1913.069.01-04.22.

Searle, M.P. & Morley, C.K., 2011. Tectonic and Thermal Evolution of Thailand in the Regional Context of S.E. Asia. In: Barber, A.J., Ridd, M.F. & Crow, M.J. (Eds.), The Geology of Thailand. The Geological Society London. 626 p.

Searle, M.P., M. J. Whitehouse, L. J. Robb, A. A. Ghani, C. S. Hutchison, M. Sone, S.W.-P. Ng, M. H. Roselee, S.-L. Chung & G. J. H. Oliver, 2012. Tectonic Evolution of the Sibumasu-Indochina Terrane Collision Zone in Thailand and Malaysia: Constraints from new U-Pb Zircon Chronology of SE Asian Tin Granitoids. Journal of the Geological Society, 169, 489-500.

Shuib, M.K., 2009. Structures and Deformation. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 271-308.

Siddiqui, Numair Ahmed, Abdul Hadi A. Rahman, Chow Weng Sum, Wan Ismail Wan Yusoff & Mohammad Suhaili bin

Ismail, 2017. Shallow-marine Sandstone Reservoirs, Depositional Environments, Stratigraphic Characteristics and Facies Model: A Review. Journal of Applied Sciences, 17, 212-237.

Stauffer, P.H., 1973. The Kenny Hill Formation. In: Gobbett, D.J. & Hutchison, C.S. (Eds.), Geology of the Malay Peninsula, Wiley Interscience, New York, 87-91.

Stauffer, P.H. & Lee, C.P., 1986. Late Paleozoic Glacial Marine Facies in Southeast Asia and its Implications. GEOSEA V Proceedings II. Bulletin of the Geological Society of Malaysia, 20, 363-397.

Tan, B.K. & Yeap, B.K., 1977. Structure of the Kenny Hill Formation, Kuala Lumpur, and Selangor. Bulletin of the Geological Society of Malaysia, 8, 127-129.

Tjia, H.D., 1974. Inverted facing of Kenny Hill Formation at Bukit Pantai, Kuala Lumpur. Geological Society of Malaysia Newsletter, 51, 1-2.

Tjia, H.D., 1980. Recumbent Folds in Rocks of Kenny Hill Formation Indicate Sense of Tectonic Transport. Warta Geologi, 6, 23-24.

Tjia, H.D., 1986. Geological Transport Directions in Peninsular Malaysia. GEOSEA V Proceedings Vol. II. Bulletin of the Geological Society of Malaysia, 20, 149-177.

Tjia, H.D., 2004. Periglacial involutions, large, folded recumbent folds and tectonic overprints at Putrajaya. Bulletin of the Geological Society of Malaysia, 48, 97-102.

Van der Wal, J.L.N., 2014. The Structural Evolution of the Bentong-Raub Zone and the Western Belt around Kuala Lumpur, Peninsular Malaysia. Master's Thesis, Utrecht University. 109 p.

Willbourn, E.S., 1922. An Account of the Geology and Mining Industries of South Selangor and Negeri Sembilan. Baptist Mission Press, Calcutta. 115 p.

Yin, E.H., 2011. Geology and Mineral Resources of the Kuala Lumpur-Kelang Area. Minerals and Geoscience Department Malaysia Map Report 22, 87 p.

Yoshida, H., Yamamoto, K., Minami, M., Katsuta, N., Sin-ichi, S. & Metcalfe, R., 2018. Generalized conditions of spherical carbonate concretion formation around decaying organic matter in early diagenesis. Nature.com Scientific Reports, DOI:10.1038/s41598-018-24205-5.

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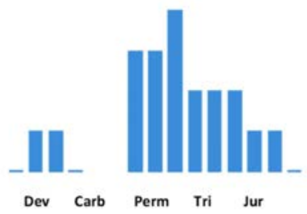
APPENDIX A - C

APPENDIX A

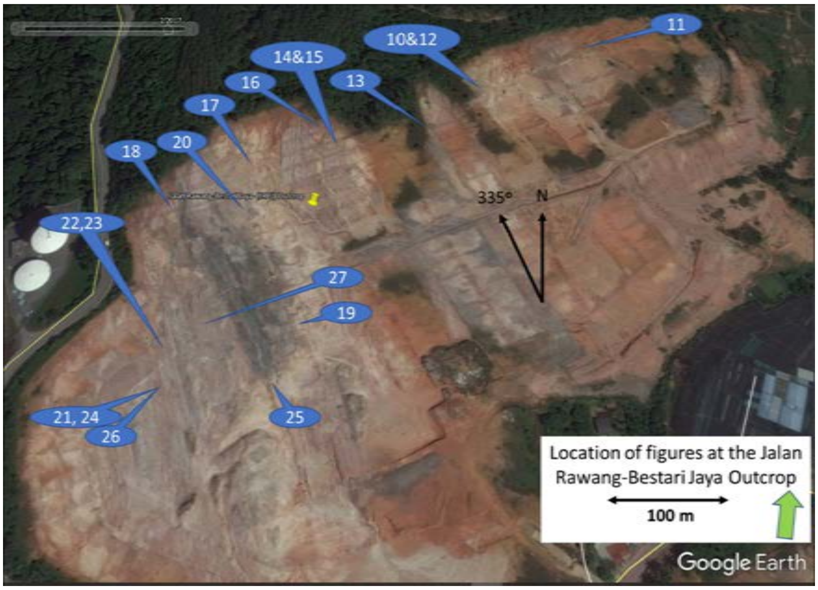
Distribution of Spores referenced in: Chen, B., Mustaffa Kamal Shuib & Khoo, T.T., 2002. Dating the Kenny Hill Formation: Spores to the Fore. Warta Geologi, 28, 189-191.

Graph showing the distribution of the spores listed over time.

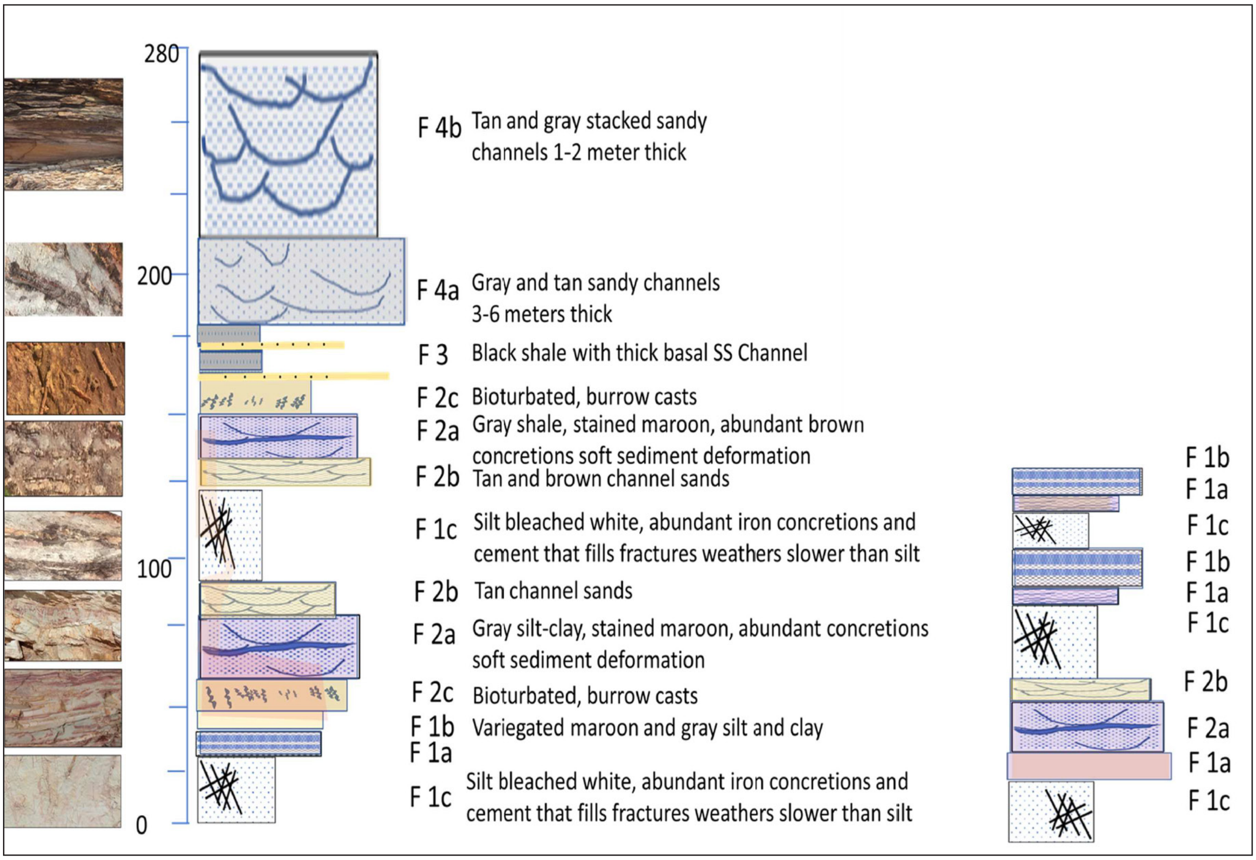


- *Leiotriletes* sp
- *Punctatisporites* sp
- *Dictyotriletes* sp
- *Verrucosisporites microtuberculatus* (Loose) Smith and Butterworth
- ? *Lycospora* spp
- *Acanthotriletes* sp

APPENDIX B
Jalan Rawang-Bestari Jaya Figure locations



APPENDIX C
Sedimentary Logs



33rd National Geoscience Conference

Urban Geoscience & IR 4.0

5th – 8th April 2021 | Virtual Conference
Bandar Baru Bangi, Selangor

Jointly organized by:

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WELCOME MESSAGE

Patron

HJ. HISAMUDDIN BIN TERMIDI
DIRECTOR GENERAL,
DEPARTMENT OF MINERALS AND GEOSCIENCES MALAYSIA (JMG)

Esteemed Speakers, Ladies and gentlemen,

I am deeply honoured to be one of the Patrons for the 33rd National Geoscience Conference. Indeed, it gives me great pleasure to welcome all of you to this 4-day event, which includes a 2-day technical session on the 5th - 6th April, followed by a 2-day post conference workshop on the 7th and 8th April.

As you all know, the National Geoscience Conference or NGC, is a premier geoscientific event in Malaysia that has been held annually, bringing together geologists, engineers, practitioners, scientists, academicians and students from multifarious geoscience related backgrounds and applications. The NGC series covers a wide spectrum of geosciences subjects, from fundamental geology to engineering and geohazards, conservation and geo tourism, explorations, environmental impacts, global warming, climate change and even broach on matters of professional ethics and laws. This extensive range of topics provide an excellent coverage for all participants to discuss the current challenges and the future of geosciences in Malaysia.

The objective of this conference is to enable experts and professionals from various geoscience disciplines to exchange ideas, experiences, and technological knowhow that will contribute in national development in line with the Fourth Industrial Revolution (IR 4.0). The theme 'Urban Geoscience and IR 4.0 is appropriately chosen for this year's NGC, as the IR 4.0 is going to drastically change how we live, work and communicate. At the same time, our cities are facing problems of limited resources, space and geohazards due to the rapid urbanisation taking place in our country. Hence, it is imperative that we take advantage of IR 4.0 to complement the latest methodology and technology advancement in urban geoscience to ensure sustainable development of our cities. We need to fully utilise IR 4.0 to enhance our research in mineral and geoscience so that we can develop alongside with all the other developed countries.

Since its inaugural event in 1986, the NGC has never missed a series except for last year, and we know who to blame for all the fallouts last year. Due to the global pandemic situation, the 33rd NGC had to be postponed and was brought over to 2021. Today, for the first time in its longstanding history, the NGC conference is being held virtually, to comply with the standard operating procedures stipulated by the National Security Council and curb the outbreak of Covid-19. In my humble opinion, this is where we need to apply IR 4.0 technology with urban geoscience to resolve issues and challenges of post Covid-19. The 33rd NGC is jointly organised by Geological Society Malaysia, Department of Mineral and Geoscience Malaysia, Institute of Geology Malaysia, Universiti Kebangsaan Malaysia, and Universiti Tenaga Nasional. I would like to take this opportunity to thank all the co-organisers for their cooperation and contributions in making this event a 'virtual reality', pun intended. My sincere gratitude and deepest appreciation go to the committee members for their hard work and dedication in ensuring the smooth running of this event.

Last but not least, I would like to thank all the keynote speakers and presenters for their precious time and sincere effort to share their expertise and divulge their profound knowledge. Thanks to all NGC participants for joining this web conference. I look forward to catch up on some of the latest developments in the geoscience's technology. I hope that all of you will make full use of this platform for your capacity building and knowledge enhancement.

With that note, I wish you 'Happy Conferencing'. Thank you.

WELCOME MESSAGE

Patron

GS ABD RASID JAAPAR, P. GEOL
PRESIDENT, GEOLOGICAL SOCIETY MALAYSIA (GSM)

Greetings!

Thank you for your interest in attending the Virtual National Geoscience Conference (NGC) 2020/2021, which will be held from April 05 to 08, 2021. This 33rd annual event is a landmark geoscience event in Malaysia, and we are pleased to invite our international counterparts to meet virtually this year.

The Geological Society Malaysia (GSM) together with Universiti Tenaga Nasional (UNITEN), Universiti Kebangsaan Malaysia (UKM) and Department of Mineral and Geoscience Malaysia as well as Institute of Geology Malaysia will be organizing the NGC 2020/2021.

GSM exists to promote the professional, scientific and academic endeavors of geoscientist, as well as the advancement of the geosciences in Malaysia and in South East Asia. Hence, the NGC aims to meet this challenge by inviting and bring together geoscience professionals and experts in the various interrelated disciplines to discuss, reflect and share technology and experience that will enhance geoscientists' contribution to the country's growth in line with the achievements of the Fourth Industrial Revolution (IR 4.0).

We hope you will find quality opportunities that will enhance your geoscience knowledge from this event.

Thank you.

FOREWORD

Vice Chancellor

YBHG. PROF. DATO' TS. DR. MOHD EKHWAN HJ. TORIMAN
UNIVERSITI KEBANGSAAN MALAYSIA (UKM)

Dear colleagues and friends,

Today, it is vital to empower and promote the exchange of information and technology and its effect on society's enhancement. One way to embrace this is by pursuing lifelong learning.

Thus, it is an honour and privilege for Universiti Kebangsaan Malaysia (UKM) to be the host for 33rd National Geoscience Conference organised by Geological Society Malaysia (GSM) in collaboration with Department of Mineral and Geosciences Malaysia (JMG), Institute of Geology Malaysia (IGM), and Universiti Tenaga Nasional (UNITEN).

Looking at the multidisciplinary themes in geosciences that include General Geology (Quaternary & Marine Geology), Engineering Geology & Geohazards, Environment & Climate Change, Conservation Geology & Geotourism, Petroleum Geology & Exploration, and Advancement in Geophysics & Remote Sensing, I believe this conference not only will enrich the participants' perspectives, but also can be a stepping stone for geoscientist to establish and celebrate cohesive joint collaborations and networking of future research directions.

This conference is also a platform to celebrate and appreciate past accomplishments and renewed friendships.

Lastly, I would like to thank all of the conference participants for their contributions, which are the foundation of this conference. I hope that you will have a productive and fun-filled time at this very special conference.

Thank you.

FOREWORD

Vice Chancellor

PROF. DATO' IR. DR. KAMAL NASHARUDDIN BIN MUSTAPHA, FASc, FIEM
UNIVERSITI TENAGA NASIONAL (UNITEN)

Dear colleagues and friends,

First of all, lets us express our gratitude to Allah S.W.T with His consent and permission, we can gather today in conjunction of 33rd National Geoscience Conference organised by GSM in collaboration with IGM, JMG, UKM and UNITEN which is held for the 33rd time in Bandar Baru Bangi, Malaysia.

This conference is part of the initiative strategy to promote and exchange the expertise between all the participants to develop and strengthen the fields of mineral and geoscience investigation, services, research and also to develop beneficial programs. As we move forward through this modern era, the application of information and technology in mineral and geoscience field has becoming the emerging trends of challenges for all of us. This technology has improved our quality of life through the utilisation and management of the earth's natural resources.

The 33rd National Geoscience Conference 2020/2021 goal is to provide the knowledge enrichment and innovative technical exchange between participants from the academia and industries in the field of geoscience as listed at the related topic of interests. I hope that this conference can serves as a good platform to exchange the information of development and innovation as well as new collaborations between scholars, academics, geologies, scientist and other practitioners.

Last but not least, I would like to express my appreciation to all the committee members for organizing this conference and thank you to all the participants for their contributions for this conference. Thank you very much and I hope the conference will be a great success.

Thank you.

FOREWORD

Chairman

HJ. MOHD ZULKEFLI CHE SOH
DIRECTOR,
DEPARTMENT OF MINERALS AND GEOSCIENCES MALAYSIA (JMG)
SELANGOR / WILAYAH PERSEKUTUAN (SWP)

Greetings from NGC 2020/2021 Committee,

On behalf of the Committee, it is my great pleasure to welcome you to the 33rd National Geoscience Conference, Bandar Baru Bangi, Selangor, Malaysia, 5 to 8 April 2021. The conference includes eight technical sessions: Geology & Geohazards, Advancement in Geophysics & Remote Sensing, Environment & Climate Change, Minerals, Geothermal & Groundwater Resources, Conservation Geology & Geotourism, Petroleum Geology & Exploration, General Geology (Quaternary & Marine Geology), and Ethics, Laws & Professional Practices. These sessions will disseminate the latest research results and findings to discuss with the practitioners, researchers and academics. In this first conference, 60 papers were submitted by authors from various countries, with the majority being local authors. Of these, about 71% the papers were accepted and are be presented at the conference.

We are honoured and delighted to have Inaugural Prof. H.D. Tjia Memorial Lecture by YBhg. Prof. Emeritus Dato' Dr. Ibrahim Komoo, our prominent guests as our special program. The conference features five distinguished keynote speakers: YBrs. Tn. Hj. Azlikamil Napiah, Director General, Malaysian Space Agency (MySA), Prof. Dr. Josaphat Tetuko Sri Sumantyo, Professor, Department of Environmental Remote Sensing, Chiba University, Prof. Dr. Jimmy Jiao, Professor, Department of Earth Sciences, Hong Kong University, and Mr. Bruce Napier, Leader, 3D Visualisation System, British Geological Survey, UK. The paper submission and reviewing process was managed using the EasyChair system. Finally, the conference would not be possible without the excellent papers contributed by authors.

We thank all the authors for their contributions and their participation in NGC 2020/2021. We hope that this program will further stimulate research in geoscience, and provide practitioners with better techniques, algorithms, and tools for deployment. We feel honored and privileged to serve the best recent developments in the field of Urban Geosciences in I.R. 4.0 to you through this exciting program.

Thank you.

Co-Chairman I
Assoc. Prof. Dr Rohayu Che Omar,
P. Geol.

Co-Chairman II
Assoc. Prof. Dr Habibah Hj. Jamil,
P. Geol.

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President, Geological Society of Malaysia

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CONFERENCE PROGRAM

05 APRIL 2021 (ROOM #1) - EMCEE: DR. NOR SHAHIDAH MOHD NAZER	
TIME	**AGENDA**
08.15	Admission of registered participants
08.30	Welcoming Address by
	YBrs. Mr. Abd Rasid Jaapar, President, Geological Society of Malaysia
	Officiating Speech by
	YBrs. Tn. Hj. Hisamuddin Termidi, Director General, Department of Mineral and Geoscience Malaysia
09.00	Inaugural Prof. H.D. Tjia Memorial Lecture by
	YBhg. Prof. Emeritus Dato' Dr. Ibrahim Komoo *"I'm a Geologist: A Student, Mentee and Colleague of H. D. Tjia - A Journey to Engineering Geology, Conservation Geology, Geoparks and Geotourism"*
09.30	Keynote Speaker #1
	YBrs. Tn. Hj. Azlikamil Napiah, Director General, Malaysian Space Agency (MySA) *"Space Tech: An Innovative Prospect for Geoscience"*
10.00	Technical Session 1A: Engineering Geology & Geohazars (ROOM #1) **Chairperson: Dr. Ferdaus Ahmad**
	Technical Session 2A: Advancement in Geophysics & Remote Sensing (ROOM #2) **Chairperson: Dr. Norbert Simon**
12.00	Keynote Session **(ROOM #1)** - Emcee: Dr. Nor Shahidah Mohd Nazer
	Keynote Speaker #2
	Prof. Dr. Josaphat Tetuko Sri Sumantyo Professor, Department of Environmental Remote Sensing, Chiba University *"Microwave Remote Sensing Technology for Land Surface Monitoring"*
12.30	Technical Talk from Inno Lab Engineering Sdn. Bhd. (Platinum Sponsor)
13.00	*Break*
13.50	Admission of registered participants
14.00	Technical Session 1B: Engineering Geology & Geohazards **(ROOM #1)** **Chairperson: Dr. Badariah Solemon**
	Technical Session 2B: Advancement in Geophysics & Remote Sensing **(ROOM #2)** **Chairperson: Dr. Mohd Hariri Arifin**
17.00	***End of Conference Day 1***

06 APRIL 2021 (ROOM #1) - EMCEE: DR. AFIKAH RAHIM	
TIME	**AGENDA**
08.45	Admission of registered participants
09.00	Keynote Speaker #3
	Prof. Dr. Jimmy Jiao Professor, Department of Earth Sciences, Hong Kong University *"Impact of Land Reclamation on Coastal Groundwater System"*
09.30	Technical Session 3: Environment & Climate Change **(ROOM #1)** **Chairperson: Ir. Intan Nor Zuliana Baharuddin**
	Technical Session 4: Minerals, Geothermal & Groundwater Resources **(ROOM #2)** **Chairperson: Dr. Norsyafina Roslan**
10.40	Technical Session 5: Conservation Geology & Geotourism **(ROOM #1)** **Chairperson: Dr. Tanot Unjah**
12.10	Keynote Session **(ROOM #1)** - Emcee: Dr. Afikah Rahim
	Keynote Speaker #4
	Mr. Bruce Napier Leader, 3D Visualisation System, British Geological Survey *"Virtual Landscapes and Geology"*
12.30	Symbolic presentation of laptop donation to a university representative
	Symbolic of the prize presentation to geo-photography contest winners
13.00	*Break*
13.50	Admission of registered participants
14.00	Technical Session 6: Petroleum Geology & Exploration **(ROOM #1)** **Chairperson: Dr. Nur Iskandar Taib**
	Technical Session 7: General Geology (Quaternary & Marine Geology) **(ROOM #2)** **Chairperson: Mr. Abdullah Sulaiman**
15.15	Technical Session 8: Ethics, Laws & Professional Practices **(ROOM #2)** **Chairperson: Mr. Ahmad Nizam Hasan**
16.30	Closing Ceremony **(ROOM #1)** - Emcee: Ms. Nur Anati Azmi
	Special Announcement for Awards Presentation by
	YBrs. Mr. Abd Rasid Jaapar, President, Geological Society of Malaysia a) Hutchison Student Award 2019/2020 for Universiti Kebangsaan Malaysia b) Hutchison Student Award 2019/2020 for Universiti Malaysia Kelantan c) Hutchison Student Award 2019/2020 for Universiti Malaya d) Haile Young Geoscientist Award 2020
	Closing Remark by
	Assoc. Prof. Dr. Rohayu Che Omar Chairman of NGC 2020/2021 Symbolic of Mandate Handover to NGC 2022 Delegates (Sarawak)
17.00	***End of Conference Day 2***

PRESENTATION SCHEDULE OF VIRTUAL NATIONAL GEOSCIENCE CONFERENCE 2020/2021
05 APRIL 2021 (ROOM #1)

TECHNICAL SESSION 1A: ENGINEERING GEOLOGY & GEOHAZARDS CHAIRPERSON: DR. FERDAUS AHMAD			
TIME	NO. ID	PRESENTER	TITLE
10.10	03	Karthigeyan Al. Ramanathan	Ground Settlement Resulting from Urban Tunneling: Comparison of Predictions and Actual Settlement
10.30	16	Abdul Halim Abdul Latiff	Probabilistic Seismic Hazard Analysis of Kuala Pilah Region
10.50	46	Sumi Amariena Hamim	City Growth and Inundation Area in Palembang City: Flood Events and Its Causes
11.10	M11	Ashanira Mat Deris	Estimation of slope failure based on the support vector machine and decision tree methods
TECHNICAL SESSION 1B: ENGINEERING GEOLOGY & GEOHAZARDS CHAIRPERSON: DR. BADARIAH SOLEMON			
14.05	19	Siti Noor Shafiqah Badrolhisham	Local Site Effect Evaluation through Horizontal-to-Vertical Spectral Ratio (HVSR) in Johor Bahru.
14.25	20	Bailon Golutin	Intensity of Strong Ground Motion of 2015 Ranau Quake
14.45	24	Zulaika Farhani Salehudin	Penilaian Geologi Kejuruteraan dan Subpermukaan Terhadap Kesesuaian Pembangunan di Kawasan Bukit Batu Kapur, Gunung Ginting, Ipoh, Perak
15.05	M08	Ashanira Mat Deris	Hybridization of artificial neural network and grey relational analysis for the prediction of slope stability
15.05	45	Ismail Abd Rahim	Faktor-Faktor Penyebab Tanah Runtuh Zen Garden

05 APRIL 2021 (ROOM #2)

TECHNICAL SESSION 2: ADVANCEMENT IN GEOPHYSICS & REMOTE SENSING CHAIRPERSON: DR. NORBERT SIMON			
TIME	NO. ID	PRESENTER	TITLE
10.10	23	Nurul Shafiqah Amir	Satellite-derived facies map as a holistic approach for facies mapping in Holocene Kepulauan Seribu complexes, North-West Java Basin, Indonesia
10.30	29	Yasir Bashir	Seismic Interpretation and Inversion leading to an accurate Reservoir Characterization in a Central Luconia Carbonate Field, Offshore Sarawak, Malaysia
10.50	35	Muhammad Khairel Izzuan Ismail	Estimation of Depth & Volume of Waste Materials by Using 2D & 3D Resistivity Method at Kepong, Kuala Lumpur
11.10	37	Ahmad Khairul Abd Malik	The Effect of Particle Sizes Toward Resistivity and Chargeability for Earth Material Interpretation
11.30	41	Zaki Alias	A Case Study of Mineral Exploration in East Coast Economic Region (ECER) Using High Resolution Airborne Magnetic and Radiometric Survey

CHAIRPERSON: DR. MOHD HARIRI ARIFIN			
14.05	43	Fathoni Usman	Mount Semeru Volcanic Activities Monitoring using Remote Sensing of Multi-Temporal Data Set
14.25	44	Andi Mohd Hairy Ansar	Surface Deformation Changes Monitoring using Persistent Scatterer Interferometry: A Review
14.45	40	Azalea Kamellia Abdullah	Deep Forest Cover Classification of Consecutive Landsat Imageries over Borneo
15.05	48	Rasyikin Roslan	Resistivity Profiling Survey as Guide in Preparation Estimation Geotechnical Pile Capacity Calculation
15.25	47	Annisa Kurnia Shalihat	Impact Detection of Spatiotemporal Changes in Built-up Area on Surface Urban Heat Islands in Palembang City using Satellite Imagery Data

06 APRIL 2021 (ROOM #1)

TECHNICAL SESSION 3: ENVIRONMENT & CLIMATE CHANGE CHAIRPERSON: IR. INTAN NOR ZULIANA BAHARUDDIN			
TIME	NO. ID	PRESENTER	TITLE
09.40	17	Muhammad Hazim Bin Yaacob	Identification of Total Suspended Particulate (TSP), PM10 and PM2.5 Sources at Quarry Site by Multivariate Analysis Couple with Wind Speed and Direction Data
10.00	18	Mohd Zaid Md Sharif	Experimental Floating Phytoremediation of Acid Mine Drainage by Vetiver Grass (Chrysopogon zizianiodes) Under Controlled Environment
10.20	39	John Jong	Lessons Learnt from Environmental Impacts and Social Concerns Associated with Onshore Petroleum Exploration Activities, NW Sarawak

06 APRIL 2021 (ROOM #2)

TECHNICAL SESSION 4: MINERALS, GEOTHERMAL & GROUNDWATER RESOURCES CHAIRPERSON: DR. NURSYAFINA ROSLAN			
TIME	NO. ID	PRESENTER	TITLE
09.40	36	Aziman Madun	The Instability of Iron Content In Groundwater in Metasedimentary Rock Formation
10.00	M02	Mazlan Madon	Updated Geothermal Gradient and Heat Flow Maps of Offshore Malaysia
10.20	38	Naseem Akhtar	Statistical technique evaluates the levels of heavy metal in groundwater across the Jhansi district, Bundelkhand area, India
10.45	M06	Mohammad Muqtada Ali Khan	Significance of Silica Geothermometry in Groundwater Studies of Quaternary Aquifers in Kelantan

06 APRIL 2021 (ROOM #1)

TECHNICAL SESSION 5: CONSERVATION GEOLOGY & GEOTOURISM CHAIRPERSON: DR. TANOT UNJAH			
TIME	NO. ID	PRESENTER	TITLE
10.45	05	Muhammad Ashahadi Dzulkafli	Radiolaria Perm Awal dan Ammonoid dari Kuari Jalan Ladang Harmoni Pos Blau, Baratdaya Kelantan
11.05	M12	Ros Fatihah Muhammad	Preservation of Naga Mas Fossil: Threats and Strategies for Moving Forward
11.25	04	Fakhruddin Afif Bin Fauzi	Geology and Stream Sediment Geochemistry of Sungai Bahoi – Charok Jawa Area, Ulu Muda Forest Reserve, Kedah
11.45	M10	Atilia Bashardin	The Comparison of Suspected Sauropod's Track at Bukit Panau, Kelantan and Sauropod's Track from Ban Nom Tum, Thailand

06 APRIL 2021 (ROOM #1)

TECHNICAL SESSION 6: PETROLEUM GEOLOGY & EXPLORATION CHAIRPERSON: DR. NUR ISKANDAR TAIB			
TIME	NO. ID	PRESENTER	TITLE
14.05	08	Siti Sorhana Syazwani Mokhtar	Structural Evolution and Interpretation of the 'I' field, NW Malay Basin: Miocene Age
14.25	31	Amita Mohd Ali	Petrographic Study of Core Samples from J Reservoirs, Southeast Malay Basin, Malaysia
14.45	11	Tsara Kamilah Ridwan	Stratigraphic characteristics in shallow marine reservoirs by utilizing well and seismic attributes data, Northern Malay Basin
15.05	21	Siti Nur Fathiyah Jamaludin	Validating the structural trend of Central Luconia Province through Airborne Full Tensor Gradiometry (FTG) Gravity
15.25	30	Hasnol Hady Ismail	The Late Miocene to Late Pliocene Depositional Sequences and Structural Developments of the West Baram Delta Basin, Offshore Sarawak, East Malaysia.
15.45	32	Amita Mohd Ali	Ichnofacies Evaluation as an Inventive Approach in Reservoir Analysis for Delineating Stratigraphic Sequences and Interpreting Depositional History: An Example from Shoreface and Wave-Influenced Delta Deposits in Sarawak Basin, Malaysia

06 APRIL 2021 (ROOM #2)

TECHNICAL SESSION 7: GENERAL GEOLOGY (QUATERNARY & MARINE GEOLOGY) CHAIRPERSON: MR. ABDULLAH SULAIMAN			
TIME	NO. ID	PRESENTER	TITLE
14.05	01	Babangida M. Sarki Yandoka	Coastal-Shallow Marine Depositional System of Cretaceous Sediments of Jessu Formation, Northern Benue Trough, Nigeria
14.25	10	Muhammad Hafeez Jeofry	The origin of ice shelf channels at Institute and Möller ice stream grounding zones, West Antarctica
14.45	M09	Ajab Singh	Preservational attributes and mineralogy of Youngest Toba Tuff ash, Padang Terap, and Lenggong Valley, Peninsular Malaysia

06 APRIL 2021 (ROOM #2)

TECHNICAL SESSION 8: ETHICS, LAWS & PROFESSIONAL PRACTICES CHAIRPERSON: MR. AHMAD NIZAM HASAN			
TIME	NO. ID	PRESENTER	TITLE
15.15	M03	Hasnida Mohamed Haniffa	Application of Construction Suitability Map in Sustaining the Highland Development from Geohazard in Malaysia
15.35	M04	Fatin Farihah Baharudin	Role of Geoscientist in Sustainable Highland Development in Malaysia
15.55	M05	Nur Fatin Julia Maznan	The Understanding of Geological Terrain Mapping Among Stakeholders for a Highland Development in Malaysia

SPECIAL PROGRAM & KEYNOTE SPEAKERS

SPECIAL PROGRAM

INAUGURAL PROF. H.D. TJIA MEMORIAL LECTURE

BY PROF. EMERITUS DATO' DR IBRAHIM KOMOO

" I'm a Geologist: A Student, Mentee and Colleague of H. D. Tjia - A Journey to Engineering Geology, Conservation Geology, Geoparks and Geotourism "

KEYNOTE SPEAKER 1:

TUAN HAJI AZLIKAMIL HAJI NAPIAH
DIRECTOR GENERAL
MALAYSIAN SPACE AGENCY (MYSA)

"Space Tech: An Innovative Prospect for Geoscience"

KEYNOTE SPEAKER 2:

PROF. DR. JOSAPHAT TETUKO SRI SUMANTYO
CENTER FOR ENVIRONMENTAL REMOTE SENSING (CEReS),
CHIBA UNIVERSITY, JAPAN

"Microwave Remote Sensing Technology for Land Surface Monitoring"

KEYNOTE SPEAKER 3:

PROF. DR. JIMMY JIAO
HONG KONG UNIVERSITY

"Impact of Land Reclamation on Coastal Groundwater System"

KEYNOTE SPEAKER 4:

MR. BRUCE NAPIER
C3D VISUALISATION SYSTEM,
BRITISH GEOLOGICAL SURVEY

"Virtual Landscapes and Geology"

CONFERENCE ABSTRACTS

TECHNICAL SESSION 1: ENGINEERING GEOLOGY & GEOHAZARDS

PAPER ID 03

Ground settlement resulting from urban tunnelling: Comparison of predictions and actual settlement

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Abstract: In Malaysia, tunnelling activities in urban areas have been widely carried out in order to reduce road congestion due to the increasing population. The effectiveness of tunnelling method has been proven in many projects, as it is capable in providing an easier method of transportation such as Light Rail Transit (LRT) and Mass Rapid Transit (MRT) in Malaysia. However, tunnelling works found to be effected towards the above surface structure. This has become a concern since various sinkholes, ground settlement and blowouts occurred globally due to the improper tunnelling monitoring, procedure and most importantly understanding the ground behaviour due to the tunnel excavation. An attempt incorporating empirical models established by previous researches to quantitatively asses these effects have delivered such a promising solution to this problem. By using these methods, a simple and early prediction of ground settlement can be compared and assessed with regards to the tunnel design parameters implemented in various project sites. The projects sites involved in this study are Museum Station of the Klang Valley Mass Rapid Transit (KVMRT Line 1) and the Serangoon Interchange Station of the Singapore Mass Rapid Transit Circle Line (SMRT CL 3). While, these projects sites will be compared to the upcoming tunnelling project at Shah Alam Station of the Light Rail Transit 3 (LRT 3). The predicted settlement induced by tunnelling can be determined by using the Peck (1969) formula. This formula is highly dependent on the maximum settlement above tunnel axis (Svmax), horizontal distance from tunnel axis (x) and width of tunnel axis to the point of inflection of the settlement trough (i). Besides that, the actual settlement during tunnelling period by installing instrumentations at Museum Station and Serangoon Interchange Station will be adopted. These results obtained will then be compared with respective project sites and assessed based on the safety limits sets by relevant authorities namely MRT Corp Development Building Control (2018) and Peila *et al.*, 2019. Thus, a brief comparison of predicted settlement and actual settlement induced by tunnelling works can be obtained with alignment to the respective safety limits.

Keywords: Tunnelling, ground behaviour, predicted settlement, actual settlement, safety limits

PAPER ID 16

Probabilistic seismic hazard analysis of Kuala Pilah region

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Abstract: The study focuses on the development of probabilistic seismic hazard analysis of Kuala Pilah, Negeri Sembilan. This area is chosen as there was a series of earthquakes reported occurred in the Kuala Pilah region, in between 2007 to 2009, with the maximum magnitude of 3.5 mb. Although there is no report of fatality and destruction caused by the earthquakes, it is crucial to identify the potential seismic hazard that may cause in the future from a bigger local earthquake as well as the impact of regional strong earthquake from Sumatra. Besides probabilistic seismic hazard analysis (PSHA) method, this study also incorporates Horizontal to Vertical Spectral Ratio (HVSR) analysis in order to examine the soil site effects by determining the properties of the soil such as resonant frequency, amplification factor and seismic vulnerability index. The peak ground acceleration (PGA) of the Kuala Pilah region was computed for 2% and 10% probability of exceedance by using seismic sources such as Sumatran subduction zone, Sumatran strike-slip fault zone as well as local faults. In the HVSR analysis, the dominant frequency of the region is in between 2 to 11 Hz with the amplification factor of 2 to 14. With the higher resonant frequency showing an increasing trend towards the eastern side of Kuala Pilah, there is a high possibility of soft sediments amplification for high magnitude localize earthquake. Nevertheless, the PSHA analysis indicates the peak ground motion intensity of 2% and 10% probability of exceedance are 0.09 g and 0.055 g respectively. From both results, it is concluded that high seismic hazard probability will occur if any high magnitude ruptures originated from local Bukit Tinggi-Kuala Pilah fault zone with less influence was determined from Sumatran earthquake activity.

Keywords: Probabilistic seismic hazard, peak ground acceleration, horizontal-to-vertical spectral ratio, Kuala Pilah

PAPER ID 46

City growth and inundation area in Palembang City: Flood events and its causes

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Abstract: Flood is an irreversible condition where improper planning of land development will be causing inundation and flash flood. This paper presents one decade of urban growth in Palembang City, where the expansion of the built-up area showed a correlation to flood and inundation. Remote sensing data from cloudless composite scenes of Landsat 7 and Landsat 8 were used. Selected training area for supervised classification of land cover has conducted in Google Earth Engine (GEE). The processed images were analysed separately to overlay them with the historical flood events locations. The analysis found that the accuracy of training and classification processes was good, with more than 90% accuracy. It is found that, in one decade, 33% of the built-up area incremented, 38% reduction of a water body and the bare land area were significantly increased with more than 3100 ha. There is a correlation in spreading locations of flooded areas in which 2019, at least four new locations were subjected to inundation.

Keywords: Urban growth, inundation, built area, remote sensing, Google Earth Engine

PAPER ID MD11

Estimation of slope failure based on the support vector machine and decision tree methods

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Abstract: For the past decades, the estimation of slope failure using machine learning (ML) methods has become a new trend among researchers. Slope failure is one of the geo-hazard phenomena in which a slope fails because of the soil or rock's decreased self-retainability due to rainfall or an earthquake. This failure may give a severe impact on human beings or the environment. The prediction of slope failure is a complex real-world problem because

it involves with the geometric and physical factors such as lithology, presence of rainfall, topography and also weathering. Conventionally, the prediction of a slope failure can be conducted using traditional methods such as the finite equilibrium method (FEM) and limit equilibrium method (LEM). However, these methods have their own limitations, including the process are taking a longer time and quite tedious. Furthermore, with such a large number of assumptions, LEM cannot guarantee its efficiency in dealing with varying geometry or material variations. FEM is also criticized due to its inefficiency for small probability levels despite a large amount of computational power required. Thus, the prediction of slope failure using ML methods acts as an alternative method to the conventional methods. The current study applies two widely used ML methods: support vector machine (SVM) and decision tree (DT) for the prediction of slope failure for the soil slope. A number of 148 slope cases extracted from the previous studies is used as the case study for the development of prediction models with six input parameters, namely "unit weight, cohesion, internal friction angle, slope angle, slope height and pore pressure ratio," and factor of safety (FOS) as the output parameter. The slope cases data were divided into 80% training dataset and 20% testing dataset for both SVM and DT models. The prediction results were validated based on the statistical analysis and it shows that the SVM model gives higher efficiency than the DT model with 97% accuracy.

Keywords: Slope failure, support vector machine, machine learning, decision tree

PAPER ID 19

Local site effect evaluation through Horizontal-to-Vertical Spectral Ratio (HVSR) in Johor Bahru

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Abstract: Earthquake is one of the common natural disaster that occurs worldwide which causes catastrophic damage towards the affected area either by the earthquake event itself or earthquake-induced natural disaster such as tsunami and landslides. Malaysia is known to have little to no seismic activities but an incident in Ranau, Sabah in 2015 had taken the whole nation by surprise with magnitude 6 and caused 18 casualties. This event had shown that Malaysia have yet to be prepared for such occurrence again. The possibility of experiencing tremors due to far-field earthquake also should not be disregarded as Malaysia is located in between high seismicity events which are the Philippines Plate in the east and the Indo-Australian Plate in the west. It is known that seismic waves will be attenuated into harmless waves after propagating for quite a distance from the source. Thus, theoretically said that the site that is closest to the earthquake sources will experience much worst hazard compared to a far distance site due to the wave attenuation. An earthquake with short-period ground motion will attenuated relatively quick and the vibrations will only affect a mid-rise building or a single-story structure. A long-period earthquake ground motions will travel for a longer distance without being attenuated and a tall structure will experience far greater shaking as the structure resonates. It was reported that cracks were visible on one of the building in Gelang Patah, Johor Bahru due to the far-field earthquake originated from Sumatra earthquakes on 25 July 2004 with magnitude of Mw 7.3. Hence, a far-field earthquake cannot be taken lightly and should be addressed properly by conducting suitable method to reduce aftermaths of earthquake occurrences. This study aims to evaluate the local site effect in Johor Bahru by generating seismic microzonation maps from the measurements of natural frequency and amplification factor through the application passive seismic survey known as Horizontal-to-Vertical Spectral Ratio (HVSR). A gridded acquisition survey design of 50 points with 1 km x 1 km interval had been plotted around Johor Bahru prior to data collection. The time recording for microtremor data at each point is set approximately for 60 minutes. The analysis of microtremor data collected in Johor Bahru shows that the area is dominated by loose alluvium deposits and stiff soil, with the average natural frequency ranging from 1 to 3 Hz. While the extracted amplification factor from HVSR curves depicts the lowest value of 1.61 and the maximum value is 8.65 which is significantly high. The integration of both parameters shows that the site having lower natural frequency reading and high application factor requires more attention and mitigation plan compared to other region as it is more vulnerable towards any impact of earthquakes.

Keywords: HVSR, microtremor, earthquakes, local site effect

Paper ID 20

Intensity of strong ground motion of 2015 Ranau quake

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Abstract: Strong ground motion with magnitude 6.0 ML jolted Ranau on 5 June 2015. Based on longitude and latitude location, the earthquake epicenter was located just at the left side which towards west of prominent Lobou-Lobou fault that runs through NNE-SSW in Kundasang area. The ground motion shaking causing substantial damage to building in Ranau such as SJK Pai Wen, mosque in Ranau town, SMK Agama Ranau teacher's quarters flat building and a block of classroom building, Hospital Ranau flat building, Ranau Police quarters building, SK Kundasang teacher's quarters flat building, SMK Agama Mohamad Ali Teacher's quarters, SK Ratau teacher's houses and a unit of villa in Dreamworld resort Kundasang. Strong ground wave also cauusing severe cracks on prominent building such as Ranau Millimewa shopping mall, Perkasa Hotel building, SMK Agama Mohamad Ali building, SMK Ranau building, Ranau Police building, Hospital Ranau building, mosque in Ranau town building, SJK Pai Wen Building, Ranau shoplot building and most of the houses in Kundasang and Ranau has suffered moderate to severe crack. Glass wall in Ranau BSN and Maybank were also shattered. The quake ground motion causing 18 peoples died, injured 22 people and causing mega landslide in Mount Kinabalu. The severe effects of this strong ground motion was due to strong intensity of VII and intensity of VIII which located between 1 km to 20 km from the earthquake epicenter. Those houses and building that was attenuated to intensity of VI and below did not suffer any damage except moderate to severe crack on concrete wall due to to seismic wave amplification particularly those concrete houses and buildings that sitting on loose geological layer such as alluvium, terrace deposit, peat area and uncompacted man made fill slope. Those houses that sitting on alluvium area in Ranau has suffered moderate to severe crack caused by seismic wave ground motion amplication of the loose geological strata.

Keywords: Ground motion shaking, Lobou-Lobou Fault, intensity, earthquake, ground amplification

Paper ID 24

Penilaian geologi kejuruteraan dan subpermukaan terhadap kesesuaian pembangunan di kawasan bukit batu kapur, Gunung Ginting, Ipoh, Perak

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Abstrak: Pembangunan yang pesat di sekitar Bandaraya Ipoh telah meningkatkan permintaan untuk pembinaan infrastruktur terutamanya unit-unit perumahan kepada penduduk setempat. Satu tapak kajian yang berhampiran dengan Gunung Ginting, Ipoh, Perak telah dipilih bagi pembinaan unit-unit perumahan oleh pemaju. Kedudukan tapak projek yang terletak di tepi perbukitan batu kapur ini memerlukan kajian terperinci dari aspek kestabilan cerun batu kapur serta keadaan subpermukaan yang selamat untuk dimajukan. Selain itu, penyiasatan bawah permukaan menggunakan kaedah keberintangan elektrik (E.R.I) yang dipadankan dengan rekod log lubang gerudi juga dilakukan di tapak projek bagi menganalisa keadaan bawah permukaan. Sebanyak tiga garis survei keberintangan elektrik

dengan menggunakan protokol Dwikutub-Dwikutub dipilih bagi mendapatkan maklumat bawah permukaan sehingga kedalaman 20 m. Pemilihan kaedah-kaedah ini adalah bagi mendapatkan keputusan yang lebih menyeluruh terhadap kesesuaian pembangunan di kawasan berkenaan.

Kata kunci: Kestabilan cerun, pengimejan keberintangan elektrik, lubang gerudi

PAPER ID M08

Hybridization of artificial neural network and grey relational analysis for the prediction of slope stability

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Abstract: Landslide is a common geological disaster that causes significant damage all over the world. Landslide occurrences may be triggered naturally due to the earthquake or rainfall, or human activities such as construction and deforestation. With the advent of computational intelligence technology, the prediction of slope stability using machine learning (ML) approaches has gained popularity for landslide susceptibility modeling. This study applies the ML approach, artificial neural network (ANN), to develop a slope stability prediction model. The development of the ANN prediction model consists of a feed-forward back propagation algorithm with a multi-layer perceptron network. Six slope parameters were used as the input factors with 46 slope cases. It is observed that ANN is capable of predicting complex problems such as slope stability. However, this prediction model's performance can be improved by hybridization of ANN with grey relational analysis (GRA). The proposed model is expected to enhance the performance of the prediction model by analyzing the slope data and eliminating the unnecessary data samples. During the pre-processing phase, the GRA identifies the significant factors of the slope parameters to the output parameter, a factor of safety (FOS), based on the correlation levels of input-output sequences to produce the new dataset for training and testing. Then, the new dataset will be trained using ANN to get the prediction result. The results were then analyzed based on the receiver operating characteristic (ROC) values and accuracy percentage. It shows that the hybrid prediction model of ANN and GRA gives 0.999 ROC value and 99% accuracy, compared to 0.929 and 91% for a single ANN model.

Keywords: Statistical machine learning, artificial neural networks, grey relational analysis, slope failure

PAPER ID 45

Faktor-faktor penyebab tanah runtuh Zen Garden (The causing factors of Zen Garden landslide)

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Abstrak: Kawasan Kundasang selatan adalah sebahagian daripada kawasan 'Kompleks Gelinciran Kundasang' yang cerunnya bergerak secara perlahan dan boleh bergerak pantas apabila curahan hujan melampaui keadaan biasa. Pada 10hb April 2011, beberapa kampung di sekitar kawasan ini termasuk pusat peranginan Zen Garden berada dalam keadaan cemas apabila berhadapan dengan tanah runtuh dalam pelbagai skala dan menyebabkan lebih 35 keluarga terpaksa meninggalkan rumah mereka. Kampung Kundasang Lama dan pusat peranginan Zen Garden terjejas paling

teruk. Gelinciran didapati melibatkan kawasan selebar 200 m dan panjang 450 m, jatuh menegak lebih 20 m dan teranjak puluhan meter menuruni cerun. Akibatnya, lebih 80-unit bilik di pusat peranginan musnah dan rumah kampung di kaki cerun terangkat beberapa meter. Pelbagai penyiasatan dan kajian dilakukan oleh pihak berkuasa tempatan dan para penyelidik berkenaan faktor yang menyebabkan kejadian tanah runtuh tersebut namun tiada yang menyeluruh dan lengkap. Oleh itu, kertas kajian ini dilakukan untuk merungkai faktor penyebab kejadian tanah runtuh di Kundasang selatan, dengan penumpuan kepada kawasan sekitar pusat peranginan Zen Garden. Kaedah yang digunakan adalah kajian perpustakaan, kajian penderiaan jauh, pemetaan geologi, pemetaan geodinamik, survei kerintangan, kajian makmal dan analisis data. Hasil kajian mendapati faktor penyebab dibahagikan kepada semulajadi (litologi, keadaan geologi, zon sesar, ketakselanjaran, gempa bumi, koluvium, curahan hujan, paras air bawah tanah dan luluhawa) dan aktiviti manusia (pengubahan sistem saliran, penambakan, pemotongan cerun dan aktiviti pertanian).

Kata Kunci: Zen Garden, tanah runtuh, Kompleks Gelinciran Kundasang, Formasi Trusmadi, koluvium, geodinamik

CONFERENCE ABSTRACTS

TECHNICAL SESSION 2: ADVANCEMENT IN GEOPHYSICS & REMOTE SENSING

PAPER ID 23

Satellite-derived facies map as a holistic approach for facies mapping in Holocene Kepulauan Seribu complexes, north-west Java Basin, Indonesia

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Abstract: The analogue study between Holocene carbonate and ancient counterpart is not odd in studying the relationship of architectural complex and heterogeneity features of carbonate components. Holocene carbonate platforms are valuable for describing facies distribution and facies heterogeneity. Analogue study assists exploration geologists to predict facies distribution, volume, and reservoir quality. This could enhance the opportunities for more detailed and accurate environmental facies mapping for Holocene carbonate platforms such as Kepulauan Seribu modern reef complexes located in Java Basin Indonesia. In this study, satellite images acquired through open access sources; OpenStreet map and Aerial Bing. Satellite data was processed using single band images (blue, green, and red bands, which is sensitive to radiation in a narrow band of visible light). The carbonate platform features analyzed on the satellite image of the study area are classified into three main facies namely reef sand apron, subtidal reefal margin, and shallower subtidal lagoon through supervised classification technique intended for generating environmental facies map.

Keywords: Holocene carbonate, remote sensing, geomorphological features

PAPER ID 29

Seismic interpretation and inversion leading to an accurate reservoir characterization in a Central Luconia carbonate field, offshore Sarawak, Malaysia

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Abstract: Seismic data acquired in the field show the subsurface reflectors or horizon among the geological strata, while the seismic inversion converts this reflector information into the acoustic impedance section which shows the layer properties based on lithology. The research aims to predict the porosity to identify the reservoir which is in between the tight layer. So, the output of the seismic inversion is much more batter than the seismic as it is closer to reality such as geology. Seismic inversion is frequently used to determine rock physics properties, for example, acoustic impedance and porosity. Carbonate reservoirs exhibit complex pore structures and heterogeneity which increases the difficulty of their characterization. In this research, we aim to predict the porosity of the carbonate reservoir in Central Luconia, Sarawak. The objectives are accomplished through a cross-plot of porosity and acoustic impedance (AI) (Bashir *et al*., 2019). We also utilize the seismic attribute interpretation and deterministic seismic inversion for this research. Acoustic impedance result from seismic inversion is compared to porosity in the zone of interest. The correlation in the zone of interest indicates the porosity estimate in the range of 10% - 35%. With help from the inversion results and porosity-impedance relationship, a conclusion is drawn that the zone of interest has the potential for a hydrocarbon reservoir. The novelty of our method is to integrate multiple geophysical approaches such as seismic attribute, interpretation, and seismic inversion in delineating reservoir which shows the possibility of hydrocarbon accumulation.

Keywords: Seismic, porosity, hydrocarbon reservoir

PAPER ID 35

Estimation of depth and volume of waste materials by using 2D and 3D resistivity method at Kepong, Kuala Lumpur

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Abstract: Environmental hazards, industrial, and municipal wastes assessment were carried out. RES2-D geophysical method was applied, capable of identification and quantification of the industrial wastes, buried hazardous materials, (BHM), and their effects on the subsurface stratum, from the moderately saturated zones to fully saturated zones housing the aquifer units underneath the water table. Six RES2-D survey profiles were respectively acquired along E-W and N-S directions. The perpendicular arrangement of the RES2-D survey lines was tenaciously designed to make possible the municipal solid waste (MSW) quantification, with sufficient length of survey lines set at 200 m and electrode spacing of 5 m, to cover as much detail segments of the MSW as possible. The six RES2-D inversion results helped in the subsurface stratum classification into three layers, namely; soft layers, which encompasses the waste materials with varied resistivity values i.e., 0–100 Ω-m, at 10-15m depths. The consolidated layers produced varied resistivity values i.e., 101–400 Ω-m, at 15-20m depths. The bedrock has the highest resistivity values i.e., 401 – 2000 Ω-m, at depths > 20m. The estimated volume of the waste materials was 312,000 m^3, using 3-D Oasis Montaj modeling via rectangular prism model generated from the inverted RES2-D.

Keywords: Environmental hazard assessment, industrial & municipal wastes characterization, depth and volume of the waste materials, Kepong, Kuala Lumpur, Peninsular Malaysia

PAPER ID 37

The effect of particle sizes toward resistivity and chargeability for earth material interpretation

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Abstract: The common method for subsurface modelling is using the geophysical electrical resistivity method via injecting the current to the subsurface to determine the resistivity and chargeability value of the earth material. There are multiple factors which may influence the result, such as the coarse grain, fine grain, type of soil, and water content. In this study, the effects of particle sizes i.e. coarse grain and fine grain towards the resistivity and chargeability value are assessed. The coarse grain consists of gravel and sand sizes, meanwhile fine grain consists of silt and clay sizes. The gravel size samples are being varied from sample sieve size passing 50 mm and retained at 37.5 mm, 28 mm, 20 mm, 11.2 mm, 6.7 mm, 5 mm and 2.36 mm. Meanwhile, the sand size samples are being varied from sample sieve size passing 2 mm and retained at 1.18 mm, 0.85 mm, 0.60 mm, 0.43 mm, 0.30 mm, 0.20 mm, 0.15 mm and 0.063 mm sieve. Whereas, for fine grain of clayey silt and silt clay are samples size passing 0.063 mm sieve. The devices used for the experiment are Terrameter LS2 and soil box to measure the resistivity and chargeability. The water used in this study has constant resistivity and chargeability of 102 Ωm and 0.41 ms, respectively. The resistivity values for the fully soaked gravels and sands range from 78 Ωm to 162 Ωm and 86 Ωm to 121 Ωm, respectively. The chargeability values for fully soaked gravels and sands ranges from 5.57 ms to 7.87 ms and 2.04 ms to 12.31 ms, respectively. The resistivity values of silty clay and clayey silt at liquid limit are 37 Ωm and 56 Ωm respectively. The chargeability values for the silty clay and clayey silt samples are 1.7 ms and 1.2 ms, respectively. The resistivity value decreased with decreasing particle size. Meanwhile, the chargeability value increased with decreasing size. Further increases of water content exceeding the liquid limit for fine grain i.e. fully soaked condition causes no substantial changes in resistivity and chargeability value as the value began to plateau.

Keywords: Resistivity, chargeability, coarse grain, fine grain

PAPER ID 41

A case study of mineral exploration in East Coast Economic Region (ECER) using high resolution airborne magnetic and radiometric survey

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Abstract: The Department of Mineral and Geoscience Malaysia conducted a high resolution airborne geophysical survey in 2016 involving the East Coast Economic Region. The objectives were to outline geological unit, trace structures and define a target area for mineral follow up exploration. A total of 105 target areas mainly iron, gold and tin were generated using integrated interpretation of geophysical data and existing geological data. Geophysical signals which defined a target area include isolated magnetic high, area of diffuse magnetic response and broad areas of increased radiometric response. Useful lithology and structural information interpreted from geophysical data were consolidated with existing geological information to produce a more comprehensive interpretation. This article reviewed in progress exploration at target area P-18 Pulau Manis and K-04 Sungai Kapas. Isolated magnetic high at Pulau Manis was investigated in detail involving deep drilling, 3D geophysical modelling and lithological mapping resulted in the discovery of four layers of iron ore. Gold mineralization at Sungai Kapas demonstrated the role of deep granitoid intrusion and splays faults controlling the gold deposition. Gold potential was encouraging as indicated by gold discovery during field survey, thus deep drilling is anticipated in 2021. This article is a brief review of geophysical data manipulation and its potential in inducing new ideas and perspective for mineral exploration in Malaysia.

Keywords: Geophysical survey, East Coast Economic Region, magnetic, radiometric, splay fault, gold, mineralization, iron ore

PAPER ID 43

Mount Semeru volcanic activities monitoring using remote sensing of multi-temporal data set

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Abstract: Mount Semeru is Java's highest volcano and one of the most active, erupting continuously since 1967. Mount Semeru's eruptive events have been recorded since the early 1800s. The associated geohazard caused by volcanic activity can be evaluated with the emerging technology of earth observation from space. This study aims to investigate recent volcanic and eruptive activity using multi-spectral optic data and Synthetic Aperture Radar (SAR) in a multi-temporal data set for geohazard detection. The areas affected by land deformation and lava flows will be identified. The importance of lava flow mapping in assessing the vulcanic threat cannot be overstated. The data from Sentinel-1's mission of Single Look Complex (SLC) data and Ground Range Detected (GRD) data will be analysed in this paper for one year, from early 2020 to the last eruption events in January to March 2021. The various bands of multi-spectral imageries from Sentinel-2's mission are used to create composite images to map the lava flow. The analysis is carried out using SNAP Desktop and Google Earth Engine (GEE), with final processing in a Geographical Information System (GIS) application. The yearly land deformation velocity of Mount Semeru's crater can be seen in this study. The lava flow mapping is compared to the lava flow map from the past. It is observed that a land subsidence velocity of 0.4 m occurred surrounding the crater of Mount Semeru, and the lava flown to the altitude of 2,900 m to 2,400 m. Using remote sensing radar data, which is not hampered by weather condition, has allowed the researcher and authority to set appropriate mitigation planning and action to minimise the volcanic hazard's impact on the surrounding settlements.

Keywords: Single Look Complex, ground range detected, Sentinel-1, Sentinel-2, volcanic activities, land subsidence, lava flow

PAPER ID 44

Surface deformation changes monitoring using persistent scatterer interferometry: A review

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Abstract: Development of Interferometric Synthetic Aperture Radar (InSAR) have been revolutionized in line with the technology's sophistication. It is contributed to the high precision of measurements from satellite imagery to be used in surface deformation monitoring measurements. Deformation of the earth surface is a result from the environmental issues such as landslides, volcanoes, earthquakes, underground water excessive extraction and another phenomenon. InSAR data time series analysis has been a valuable tool for measuring and analyzing the displacement of the Earth's surface. The method known as Persistent Scatterer Interferometric Synthetic Aperture Radar (PS InSAR) which provides millimeter accuracy measurements of the surface deformation. Hence, this article is an attempt to review the four Persistent Scatterer Interferometry (PSI) techniques which have been developed for deformation measurements. A few case studies in practicing PSI techniques are summarized to determine the ability of this technique. Future outlooks are also discussed on realising the PSI technique in Malaysia and its important in supporting various agency in Malaysia. In conclusion, this review will contribute to the technique that suitable for Malaysia and better planning for development in this country.

Keywords: Interferometric Synthetic Aperture Radar (InSAR), surface deformation, Persistent Scatterer Interferometry (PSI)

PAPER ID 40

Deep forest cover classification of consecutive landsat imageries over Borneo

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Abstract: Forest cover represents the spatial distribution and arrangement of aboveground canopy extent formed from the collection of plant crowns over a region. The contiguity is attributed to forest ecosystem conditions and defined for a healthy supply of ecosystem services. Mapping the forest cover is significant in generating the baseline information to support the sustainable management of natural resources and thus valuable for supporting the 12th and

15th targets of the Sustainable Development Goal (SDG). Conventional in-situ mapping is less favourable considering the difficulty to estimate the spatial extent and thus integrating attributes in regular updates which can be impractical for long period measurement. Therefore, satellite remote sensing offers a reasonable mapping routine at a better economy and prompt deliverable extraction. Yet, satellite image processing is inevitable to persistent cloud cover, missing pixels, mixed pixel problem, undiscernible normality in training data, Hughes phenomenon, and complex classification routines among others. As a result, this requires massive time and considerable skills to achieve high accuracy mapping. Recent advancement by deep learning image classification algorithms such as Convolutional Neural Networks (CNN) attains higher accuracy mapping with low human interruption. Deep learning enables the accommodation of complex mechanisms and non-linearity into the training model to promote better accuracy during the classification process and faster processing time over a large amount of data. This study aims to classify and assess the accuracy of forest cover over Borneo using deep learning classifiers and thus to predict the forest cover extent regarding the impact of deforestation variables. The deep learning functional model is developed from training samples from the reflectance data of Landsat-8 OLI/TIRS and Landsat 7 ETM+ acquired from 1999 to 2020. About 6,106 scenes with cloud cover less than 25% at 30-meter spatial resolution were analysed. The neural network is trained by digitally identified features of forest cover and deforestation variables using several band combinations. The record of deforestation variables is used to assess the accuracy of the forest cover map and generate the prediction model of the forest ecosystem provisional resources. As a result, this study presents the 10-year forest cover evolution and the predicted spatial extent for the next decade. It highlights the potential of deep learning on the long-term measurement of forest cover monitoring for efficient assessment towards sustainable forest management.

Keywords: Forest cover, satellite remote sensing, deep learning classification

PAPER ID 48

Resistivity profiling survey as guide in preparation estimation geotechnical pile capacity calculation

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Abstract: The development of critical infrastructure in the quaternary marine deposit requires detailed preliminary information to design a plan for construction. Soil data collection of the physical and mechanical properties of the soil collected, recorded, and analysed to investigate the soil condition in the proposed development area. Usually, soil drilling techniques are a priority for contractors and civil engineering practice to get early information on the condition of the site to be developed. However, in this research, the resistivity profiling used to initial relationship using soil resistance value with SPT-N value. This research aims to obtain parameters that used in estimation early design, especially in determining geotechnical pile capacity.

Keywords: Critical infrastructure, resistivity, pile capacity, laboratory test, Mackintosh probe

PAPER ID 47

Impact detection of spatiotemporal changes in built-up area on surface urban heat islands in Palembang City using satellite imagery data

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Abstract: Climate change is an issue of global concerns. Urban Heat Island is a phenomenon where the city's air temperature with high building density is higher than the surrounding open-air temperatures in the village and the suburbs with the less dense built-up area. Population in Palembang City has been increased by almost 10% in the last five years. The demand for land for the built-up area has also increased. The population and the demand for housing have increased the surface temperature, which triggered the Urban Heat Island phenomenon (UHI). This paper presents an effort to determine the dynamics effects of built areas changes on urban land surface temperature (LST) during five years (2013-2019) for Palembang City. Remote sensing data of Landsat (i.e. TM, ETM+, and OLI/TIRS) is used with the machine learning algorithms to quantify the effect of land use and land cover changing. The results showed that in the observed period, there was a size increase in built-up area by 13% while the surface temperature raised from 18°C - 33°C to 22°C - 40°C. The biggest changes in the built-up area occurred in 2018, and the highest increase in surface heat occurred in 2019.

Keywords: Urban growth, climate change, urban heat island, remote sensing, machine learning algorithms

CONFERENCE ABSTRACTS

TECHNICAL SESSION 3: ENVIRONMENT & CLIMATE CHANGE

PAPER ID 17

Identification of Total Suspended Particulate (TSP), PM_{10} and $PM_{2.5}$ sources at quarry site by multivariate analysis couple with wind speed and direction data

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Abstract: The effectiveness of combining principle component analysis (PCA) with wind speed and direction data was demonstrated in this paper. The air quality data (TSP, PM10 and PM2.5) from a quarry in Manjung, Perak was analyzed. Three independent air pollution sources were identified by PCA. The spatial distribution of the sources was obtained by coupling PCA with wind data, which helped in the monitoring of air quality index according to the annual limits established in the legislation. The coupling of PCA with wind data proved and be useful in extracting further information on source contributions and locations.

Keywords: Quarry, particulate matter, Principle Component Analysis (PCA), TSP, PM_{10}, $PM_{2.5}$

PAPER ID 18

Experimental floating phytoremediation of acid mine drainage by vetiver grass (Chrysopogon zizianiodes) under controlled environment

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Abstract: Acid mine drainage (AMD) is an acidic effluent and formed when sulfide minerals are exposed to oxidizing conditions in mining sites. Various types of AMD remediation via chemical or passive biological technology have been studied in order to minimize AMD discharge which causes health and environmental issues. The main objective of this work was to investigate the effect of vetiver grass (Chrysopogon zizianiodes) on water quality of AMD by using floating phytoremediation technique. A six-month experiment has been conducted which included samplings of AMD and limestones, planting of vetiver grass and phytoremediation activity. The AMD sampled from the iron mining site at Bukit Besi, Terengganu had an acidic pH of 2.58 and high level of heavy metal such as Fe, Al and Mn. Four different sets of experiment were implemented to compare the result of water quality; (i) unfiltered Bukit-Besi AMD without vetiver or unfiltered-untreated (UU) water, (ii) limestone filtered AMD without vetiver or filtered-untreated (FU) water, (iii) unfiltered Bukit-Besi AMD with vetiver treatment or unfiltered-treated (UT) water, and (iv) limestone-filtered with vetiver treatment or filtered-treated (FT) water. Chemical analysis for water quality in each set was conducted every 15 days until end of experiment. There was highest net removal of heavy metal (Fe, Al and Mn) and best pH neutralization through floating phytoremediation of limestone-filtered with vetiver treatment (FT). This experiment shows that floating phytoremediation technique by using vetiver grass can remediate AMD naturally over certain period of time.

Keywords: Acid mine drainage, metal removal, floating phytoremediation, vetiver grass, passive treatment

PAPER ID 39

Lessons learnt from environmental impacts and social concerns associated with onshore petroleum exploration activities, NW Sarawak

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Abstract: The onshore Baram Delta, located in NW Sarawak is the birthplace of petroleum production in Malaysia. The Miri oilfield was first discovered in 1910 and abandoned in 1972 with intermittent exploration activities in the late 1980's to early 1990's. To rejuvenate exploration interest and to identify remaining hydrocarbon potential of the study area, in 2009-2010, JX Nippon acquired gravity, then regional 2D seismic data, followed-by exploration well drilling from 2011-2014. This presentation discusses the social-environmental impacts and concerns associated with the mentioned petroleum exploration activities, from acquisition of seismic where explosives and vibroseis were used as a source of propagating signal, to exploration drilling with petroleum chemicals such as water-based muds used to facilitate drilling operations. Overall, the inquiry addresses operational challenges, security of explosive storage and concern for handling explosives in the field, the social-environmental impacts of seismic acquisition operations, as well as removal of drilling fluid chemicals and disposal of contaminated cuttings. Containment procedures and mitigation measures undertaken to alleviate these social-environmental impacts are discussed according to the guidelines and regulatory requirements provided by the Environmental Impact Assessment (EIA), in conjunction with PETRONAS Procedures and Guidelines for Upstream Activities (PPGUA) and the company's Health, Safety and Environment (HSE) Management System. In the final analysis, significant environmental and social challenges

were certainly encountered while planning and conducting petroleum exploration activities in the study area. These challenges include problems related to topographic variabilities, permitting issues, compensations for affected lands and cash crops; layout constraints, drilling operations, well control measures for blowout prevention, traffic controls, potential damage to infra-structures, explosive and equipment transportation. However, with proper planning, regular communications with the local authorities, awareness sessions conducted for the affected parties, together with the support of the local community the operations have managed to mitigate these social and environmental concerns; and successfully acquired nearly 900-line km of seismic across many villages, longhouses, and city area. Subsequently, four exploration wells were also drilled successfully in the exploration block without untoward incidents. We are glad to report that both seismic and drilling operations were conducted safely with minimal interruptions to people and environment, while providing short-term employment opportunities for the locals.

Keywords: Environmental impacts, Miri, NW Sarawak, petroleum exploration, seismic acquisition

CONFERENCE ABSTRACTS

TECHNICAL SESSION 4: MINERALS, GEOTHERMAL & GROUNDWATER RESOURCES

PAPER ID 36

The instability of iron content in groundwater in metasedimentary rock formation

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Abstract: One of the major factors affecting the natural chemistry and the quality of the groundwater is the geology of a watershed. Water percolating through the subsurface comes in contact with the soil particles and thus gets influenced by the constituent minerals. Mineral elements derived from the rocks through which groundwater flows can affect the pH of the water, the water's taste, and eventually may cause staining on material surfaces like sinks, tiles and clothing which mostly is caused by the presence of iron if left untreated. With rapid utilization and exploration of groundwater, multiple efforts have been put in to optimize and improve the quality of groundwater for consumptions and daily usage. Based on the quality control from National Water Quality Standards for Malaysia (NWQS) the acceptable iron level in groundwater is 0.3 mg/L for drinking and 1 mg/L for raw water. In this study, the content of iron (Fe) from two tube wells at 100 meter depth and 75 meters apart are monitored for eleven months period. For the purpose of this study, the first and second tube wells are labelled A and B. The data collected from both tube well shows no consistency on the content of iron from both tube well A and B throughout the observation period. The inconsistency of data in the iron level from both tube wells sometimes shows a sudden spike in the iron level from the groundwater and this should be considered when treating the groundwater for daily and consumption purposes. For Tube well A, the highest level of iron recorded is 7.5 mg/L and the lowest 0.05 mg/L, and the average level of iron throughout the observation period is 2.3 mg/L. For Tube well B, the highest iron level is 8.3 mg/L and at times there are even zero traces of iron found in the groundwater and the average level of iron throughout the observation period for tube well B is 1.1 mg/L. This observation is important for designing the water filtered system at maximum capability to filter the highest iron content in groundwater.

Keywords: Groundwater, tube well, iron

PAPER ID M02

Updated geothermal gradient and heat flow maps of offshore Malaysia

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Abstract: An update of the geothermal gradient and heat flow maps for offshore Malaysia is presented based on available data and information compiled from the archives of PETRONAS and its partners. More than 600 new datapoints calculated from bottom-hole temperature (BHT) data from oil and gas wells were added. In addition, about 150 datapoints were taken from heat flow probe measurements at the sea floor in the deep-water areas off Sarawak and Sabah, along with direct measurements of sediment thermal conductivity. In general, the data show that the Malay Basin has relatively high geothermal gradients (average ~47 °C/km). Higher gradients in the basin centre are attributed to crustal thinning due to extension. The Sarawak Basin has similar above-average geothermal gradients (~45°C/km), whereas the Baram Delta area and the Sabah Shelf have considerably lower gradients (~29 °C/km to ~34 °C/km). These differences are attributed to the underlying tectonic setting; the Sarawak Shelf, like the Malay Basin, is underlain by an extensional terrane, whereas the Sabah Basin and Baram Delta east of the West Baram Line are underlain by a former collisional margin (between Dangerous Ground rifted terrane and Sabah). The deep-water areas off Sarawak and Sabah (North Luconia and Sabah Platform) show relatively high geothermal gradients overall, averaging 80 °C/km in North Luconia and 87 °C/km in the Sabah Platform. Using the appropriate sediment thermal conductivity models, the geothermal gradients were converted to heat flows. The average heat flows are: Malay Basin (92 mW/m^2), Sarawak Shelf (95 mW/m^2) and Sabah Shelf (79 mW/m^2). In addition, the average heat flows for the deep-water areas: Sabah deep-water fold-thrust belt (66 mW/m^2), Sabah Trough (42 mW/m^2), Sabah Platform (63 mW/m^2) and North Luconia (60 mW/m^2). The results of this study further enhanced our insights into the similarities and differences between the various basins and their relationships to tectonic history and hydrocarbon occurrences.

Keywords: Geothermal gradient, thermal conductivity, heat flow, Malaysia, temperature data

PAPER ID 38

Statistical technique evaluates the levels of heavy metal in groundwater across the Jhansi district, Bundelkhand area, India

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Abstract: For human use, groundwater is a critical resource. Because of natural and anthropogenic activities, groundwater pollution is reducing water quality across the Jhansi district, Bundelkhand area. The Bundelkhand Gneissic Complex (BGC) and granite terrain in the southern part of Achaean to recent era, and alluvial plains or highly eroding composite plains in the northern part of the district of the Quaternary period, make up this area. As a result, the aim of this study was to use a multivariate statistical technique like factor analysis (FA), Pearson correlation coefficient (r), and cluster analysis to investigate heavy metal concentrations using an inductively coupled plasma-mass spectrometer (ICP- MS) and to analyse water quality and contamination source in groundwater using multivariate statistical techniques like factor analysis (FA), Pearson correlation coefficient (r), and cluster analysis (CA). The results of the ICP-MS were compared to WHO (2017) and BIS (2017) criteria (2012). The concentration of Al was within reasonable limits, and the range of As, Cd, Cu, Pb, and Zn were lower than acceptable limits, while the concentrations of Fe, Mn, and Ni in the rest of the groundwater samples were higher than allowable limits. Furthermore, the PCA findings revealed three factors that were responsible for the data structure, accounting for 77.416 percent of the overall variance of the dataset, which was specified by three variables: 37.954 percent, 23.331 percent, and 16.132 percent. Whereas the results of factors 1, 2, and 3 indicated that (Cu, Pb, Zn), (Al, Mn), and (As, Ni) showed strong positive loading, indicating that the sources of these metals were naturally occurring and over-application of pesticides and fertilisers in agriculture, respectively. Furthermore, the obtained results of (r) revealed a strong positive correlation of Cu with Pb (r = 0.921), a moderate relationship of Mn with Al (r = 0.619), As with Ni (r = 0.496), Cr with Co (r = 0.556), Cu with Zn (r = 0.700), Fe with Pb (r = 0.541), and Pb with Zn (r = 0.709), as well as a negative correlation of Cd with Zn (r = -0.502), Cr with Cu (r = -0.528), Zn (r = -0.522) and (r = -.0923). The finding of (r) revealed that the positive correlation was a common source and the negative association was a separate source of groundwater, as well as that this relationship between heavy metals means that one variable increase while the other decreases and inversely. Furthermore, CA results revealed three clusters: A, B, and C, each of which suggested low to high emissions due to weathering and anthropogenic activities. Overall, 50% of groundwater samples were suitable for drinking and irrigation, while 50% of samples were not suitable for people use. In addition, this study suggests that groundwater be treated before it is used for human use.

Keywords: Groundwater, water quality, heavy metal concentrations, ICP-MS

PAPER ID M06

Significance of silica geothermometry in groundwater studies of Quaternary aquifers in Kelantan

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Abstract: The distribution of silica concentration in shallow quaternary aquifers in parts of Kelantan, Malaysia were assessed to monitor the groundwater and surface-water interaction, to determine the depths, residence time duration of groundwater and to evaluate groundwater contamination by correlating silica with hydrogeochemical data. In the present study, silica concentrations were analyzed in 29 groundwater samples during two time periods. The concentration of silica ranged from 6.3 mg/l to 23.4 mg/l for pre-season (2016) and 6.2 mg/l to 23.5 mg/l for post-season (2016). By employing silica geo-thermometry based on chalcedony equation, the range of temperature estimated from 3.09 °C to 37.61 °C during pre-season and 0.90 °C to 37.79 °C for post-season which under normal geothermal conditions would correspond to a depth range of 0.02 km to 0.32 km during pre-season and 0.01 km to 0.32 km for post-season by considering an average heat flow of 30 °C/km. These shallow depths (below 0.32 km) of groundwater circulation are pretty reasonable for such deficient silica concentrations. Such low silica levels reflect minimal involvement of anthropogenic activities and small residence time of groundwater in terms of rock-water interaction. These low silica values also show that the water in the area is of recent meteoric and through surface water interaction.

Keywords: Silica concentration, shallow aquifers, Kelantan, Malaysia

CONFERENCE ABSTRACTS

TECHNICAL SESSION 5: CONSERVATION GEOLOGY & GEOTOURISM

PAPER ID 05

Radiolaria Perm Awal dari kuari Jalan Ladang Harmoni, Pos Blau, baratdaya Kelantan

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Abstract: Radiolaria berusia Sakmarian (Perm Awal) telah ditemukan daripada jujukan rijang yang berselang lapis dengan batu lumpur bertuf daripada kuari Jalan Ladang Harmoni, Pos Blau, Gua Musang. Sebanyak 21 spesies radiolaria telah dikenal pasti dan terdiri daripada *Pseudoalbaillella lomentaria* Ishiga & Imoto, *Pseudoalbaillella sakmarensis* (Kozur), *Pseudoalbaillella scalprata postscalprata* Ishiga, *Pseudoalbaillella* cf. *internata* Wang, *Pseudoalbaillella* sp. A, *Pseudoalbaillella* sp. B., *Hegleria mammilla* (Sheng & Wang), *Hegleria* sp., *Ruzhenchevispongus rotundus* Feng, *Ruzhenchevispongus girtyi* Nazarov & Ormiston, *Ruzhenchevispongus triradiatus* Wang, *Latentifistula patagilaterala* Nazarov & Ormiston, *Latentifistula texana* Nazarov & Ormiston, *Latentifistula crux* Nazarov & Ormiston, *Latentibifistula triacanthophora* Nazarov & Ormiston, *Quinqueremis robusta* Nazarov & Ormiston, *Pseudotormentus kamigoriensis* De Wever & Caridroit, *Ormistonella robusta* De Wever & Caridroit, *Copicyntra* sp., *Copiellintra* sp., *Stigmosphaerostylus itsukaichiensis* (Sashida & Tonishi). Kesemua spesies-spesies dari singkapan ini boleh dimasukkan ke dalam Zon Himpunan *Pseudoalbaillella lomentaria* mewakili usia Sakmarian Awal.

Keywords: Radiolaria, Sakmarian, Perm Awal, Pos Blau

PAPER ID M12

Preservation status of Gua Naga Mas fossil, threats and strategies for moving forward

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Abstract: The rare, almost complete felid fossil of Gua Naga Mas (identified a Panthera tigris) has attracted various studies since its discovery in 1992, indicating its importance for education and research. It has also been given attention by the media, indicating significance value to the public. The in-situ fossil site has been gazetted under a protection act and developed as a geosite for Kinta Valley Geopark since 2018. However, the invaluable fossil has been subjected to potential natural degradation and various man-made threats with no visible proper management in place. It is exposed to fumes, tremor from drilling/blasting and fire hazards for years. We suggest some moving forward strategies for better protection of the country's natural heritage, to avoid further degradation or unfortunate implication.

Keywords: Geosite, felid fossil, heritage

PAPER ID 04

Geology and stream sediment geochemistry of Sungai Bahoi – Charok Jawa area, Ulu Muda Forest Reserve, Kedah

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Abstract: A study on geology and geochemistry of Sungai Bahoi – Charok Jawa Area in Kedah has been conducted to update the uncovere portion of geological map and to determine the distributions of heavy elements based on stream sediment samples. The study area generally consists of Late Triassic igneous intrusion and sedimentary rocks mainly of Carboniferous Kubang Pasu Formation and minor Silurian to Devonian Kroh Formation. The conducted field mapping has successfully discovered a band of brecciated phyllites along parts of granite – phyllite contact zone and confirmed the occurrences of cave-contained limestone hill in the study area. Geochemical results and interpretations indicate the occurrences of 6 multielement anomaly areas containing mostly Sn as the main constituent throughout the study area. Further studies on geoheritage values of the limestone hill and mineralization pattern of tin in the study area are highly recommended.

Keywords: Geoheritage, geochemistry, tin, limestone

PAPER ID M10

The comparison of suspected sauropod's track at Bukit Panau, Kelantan and sauropod's track from Ban Nom Tum, Thailand

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Abstract: In the middle of year 2020, a profound palaeontological discovery had shocked the nation amid a global pandemic crisis. The almost circular structures exposed on sandstone formation found in Tanah Merah, Kelantan was claimed to be the footprint tracks of the infamous Early Jurassic to Late Cretaceous herbivore, the Sauropod. This had drawn national attention to Bukit Panau, a hill topography situated 30 kilometres from Tanah Merah Town where the tracks were observed. However, this discovery is not new. In 2018, a group of scientists had visited Bukit Panau and discussed these structures in a joint workshop attended by Malaysian and Thailand geologists. This paper intends to provide scientific insights of the claim which appeared in a conference proceeding in 2020. These suspected footprint tracks were exposed on a surface of a thick layer of sandstone belonging to the Panau Formation. Panau Formation is characterised by coarsening upward sequence of sedimentary rocks ranging from pebbly sized conglomerate, arenaceous facies to argillaceous facies. Fragmented plant fossils such as *Frenelopsis* sp., *Otozamites* sp., *Calamites* sp., and *Pecopteris* sp. were recovered from argillaceous facies suggesting Cretaceous age. These flora assemblages also suggested a continental depositional environment. Seven irregular circles which vary in sizes (70 to 90 centimetre) structures were observed on the plane. Two of these structures exhibit smaller and concave internal structures. Comparison has been made between 'tracks' structures of Bukit Panau with the better-preserved Sauropod footprint tracks found in Ban Nom Tum, Thailand. The comparison was based on significant criteria that are typically observed in Sauropod footprints such as the distance and angle in between footprints, the internal structure normally present during the preservation (i.e track walls and displacement rims), and the geometry of the footprints (pes and manus). This study suggests that the structures in Bukit Panau provide insufficient data to be convincingly identified as the footprints of a Sauropod. Further analysis on the absolute age of Panau Formation based on radiometric dating is recommended in order to confirm its age which is currently relatively dated as Cretaceous.

Keywords: Trace fossil, dinosaur track, palaeontology, Panau Formation

CONFERENCE ABSTRACTS

TECHNICAL SESSION 6: PETROLEUM GEOLOGY & EXPLORATION

Paper ID 08

Structural evolution and interpretation of the 'I' field, northwest Malay Basin: Miocene age

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Abstract: The Malay Basin is a structural oddity in Sundaland, with extremely thick Cenozoic sequences in the relatively stable centre. The earliest rift in the Malay Basin began in the Paleogene, caused by an episode of transtension along the Axial Malay Fault Line, a NW-SE trending shear zone. A significant inversion occurred during the Middle Miocene, resulting in the reactivation of the Malay Basin axial shear zone and the creation of large-scale E-W trending folds. This regional N-S compression came from the south, most likely due to the indentation of the Australian Plate in Sundaland's southern margin. Using attribute map computation and a complex seismic trace analysis tool, we concentrate on the Late Miocene structural understanding and evolution of the north-western part of the Malay Basin in this research. To detect structural irregularities, post-stack seismic data was used to calculate the cosine of phase, variance, dip, azimuth, curvature, and discontinuity attributes. We display a network of normal faults active in the Late Miocene to Pliocene-recent, characterised by steep planes crosscutting the top of a prominent anticline, by computing and interpreting volume attribute, 3d time-slice, and surface attribute. Two major fault systems affected the sedimentation in this region. A set of E-W faults is intersected by a set of N-S faults. The faults predate the anticline and show that extensional deformation occurred

in the Late Miocene to Pliocene. This extension may be tectonic in origin or propelled by sedimentary loads on top of various post-inversion morphologies.

Keywords: Structural evolution, Miocene polyphase, geometric attribute, NW Malay Basin

PAPER ID 31

Petrographic study of core samples from J Reservoirs, southeast Malay Basin, Malaysia

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Abstract: A petrographic study has been carried out on fifty-five (55) core samples from J Reservoirs, southeast Malay Basin. The study involved deriving data from thin-section, scanning electron microscopy and X- Ray diffraction analyses, and these analyses were carried out as one of the work scopes from Hydrocarbon Recovery Technology (HRT) research project. The main objectives of the study were (1) to obtain petrographic properties; (2) to study the diagenetic events and their sequences; (3) to predict reservoir quality and (4) to identify possible production problems of the samples. The samples analysed are from 6 lithofacies i.e S1 Unstratified locally cross-bedded; S2 Unstratified locally cross- bedded with parallel and ripple cross-lamination; S41 Clayey (5-10%), unstratified highly bioturbated, S42 Clayey (5-20%), unstratified highly bioturbated; S43 (15-40%), unstratified highly bioturbated and MI Silty mudstone. The samples represent J20, J25 & J30 reservoir units in southeast Malay Basin. The samples are categorised under sublitharenites, litharenites and subarkoses. Quartz is the major framework grains followed by feldspars, sedimentary rock fragments, glauconite and other accessory grains. Non-expanding clay minerals (kaolinite, chlorite and illite) is predominantly analysed and occurs as the major clay assemblages followed by the expandable clays of mixed layers illite, smectite and smectite. The presence of glauconite suggests deposition in a marine environment. Sandstone Textural Properties observed are fine to medium-grained, poorly to well sorted, and texturally immature to mature. Seven diagenetic events were observed, and they are (1) compaction, (2) pyrite precipitation, (3) siderite cementation, (4) calcite cementation, (5) dissolution of feldspar and unstable grains, (6) quartz overgrowth, and (7) clay authigenesis. Reservoir quality of the sandstones is ranging from very good to very poor. Good quality reservoir sands are from samples S1 and S2, poor quality reservoir sands are samples from S41, S42, S43 and M1 facies. Porosity is poor to good, and it is mainly contributed by primary intergranular pores with a minor contribution from secondary intragranular pores. Main controlling factors for porosity and permeability variations are depositional environment (grain size and sorting) and diagenesis (compaction and cementation). Major factors observed that contribute to porosity and permeability destruction in the sandstones are illitisation (grain-coating and grain bridging illite and/or illite/smectite), kaolinitisation (pore-filling kaolinite booklets) and mechanical compaction. Migration of fine detrital clays and dispersed kaolinite booklets and swelling of expandable clays of smectite component were identified as two potential production problems.x

Keywords: Sand reservoir, thin-section, scanning electron microscopy, X- Ray diffraction analyses

PAPER ID 11

Stratigraphic characteristics in shallow marine reservoirs by utilizing well and seismic attributes data, northern Malay Basin

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Abstract: Shallow marine deposits are part of hydrocarbon reserves which have high heterogeneity rock properties. Understanding the distribution of shallow marine stratigraphy is an essential part of a successful exploration and production strategy. The integration core, well log, and seismic data are essential to determine the detail of facies distribution. This study aims to evaluate the reservoir depositional facies distribution based on sequence stratigraphy concept, seismic interpretation, and seismic attributes thus reducing the risk of oil exploration and improving the success rate. To ensure the objective is achieved, stratigraphy interpretation has been classified using integrating between geological and geophysical data. Based on the characteristic of logs, biostratigraphy and core data, five depositional environments have been interpreted in this study including in-distributary channel, delta plain (flood plain shale), crevasse splay, delta front shale (prodelta), and mouth bar. Whereas, the lithologies that influence the study area were gas sand, brine sand, shale, and coal. Integration of two seismic attributes from post- stack and prestack seismic data; Spectral Decomposition and SQs attributes were used to determine better facies distribution. Both seismic attributes showed the same characteristic that could optimize good facies characterization. Based on the log and SQs attributes, gas has been accumulated in the middle of the field which was a top anticline and showed high SQs values. The interval of the target area generally influenced by regression systems where on the lower formation was dominated by the transition depositional environment and changed to be dominant of delta plain. This was showed in the bellow interval that has occurred mouth bar and in the upper part, the mouth bar deposition was changed to be crevasse splay which has occurred in delta plain.

Keywords: Depositional environment, spectral decomposition, SQs attributes

PAPER ID 21

Validating the structural trend of Central Luconia province through airborne Full Tensor Gradiometry (FTG) gravity

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Abstract: A set of Full Tensor Gradiometry (FTG) Gravity vintage proprietary data for Central Luconia in offshore Sarawak is made available for academic purposes. FTG data is the direct measurement of the gravity field in all directions which determines minute changes in density distribution in all tensor components, which include the X, Y and Z domains. The vertical integration of TZZ domain is most useful since the data captures short to intermediate wavelengths that is not always available in conventional gravity. The anomalies expressions on Tzz map produced from 20-50 km wavelengths filter are dominated by numbers of isolated domal and elongated gravity anomalies ranges from positive to negative values. When overlay with seismic profiles, the features observed on the Tzz gravity map matched well with the position of the carbonate build-ups, both the pinnacle and elongated shape. Extracted depth profiles from the FTG data indicate shallow structures at depth less than -2000 m with features similar to Cycle IV/V top carbonate and the deeper structures at depth approximately -3500 to 4000 m equivalent to the Cycle I or Pre-Cycle sediments. Two deep seated wells that reached sediments of Cycle I & II overlay precisely within the FTG

data coverage. FF6 well was drilled on a low-density contrast of FTG data whilst LH1 well is found to be drilled at the edge of a high-density contrast structure. A low-density contrast FTG data represents a deeper section of the basin, which related to depression, subsidence or structurally deep. At the same time, a high-density contrast structure represents elevated, uplifted or less sedimentary cover location. Cross examinations with seismic data crossing these two wells reveal elongate graben, bounded with normal listric faults on both sides just underneath FF6 well, while LH1 sit directly on top of horst block with high angle fault. Through synthetization of airborne gravity with seismic interpretation and validation of the wells, we can increase the confidence in mapping the structural trend for Central Luconia and eventually revise the marking of the stratigraphic horizons on seismic data.

Keywords: Full Tensor Gradiometry (FTG), stratigraphic

PAPER ID 30

The Late Miocene to Late Pliocene depositional sequences and structural developments of the West Baram Delta basin, offshore Sarawak, East Malaysia

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Abstract: The West Baram Delta (WBD) basin is a structurally complex region with an abundance of hydrocarbon that has been produced and yet to be discovered. Within the basin, there is a drastic increase of sedimentary thickness occurred across the growth fault, contributed to major challenges for the sequence framework correlation to be established throughout the basin. Understanding the growth fault development in terms of age-based within the study region is critical for better accuracy in reservoir correlation, reservoir distribution and structural trap analyses. 3D seismic mega-merge of the West Baram Delta was used to interpret the third order Tejas B (TB) stratigraphic sequences. From the structure maps of the maximum flooding surfaces (MFS) and sequence boundary (SB), thickness maps were generated for the system tracts of the corresponding sequence, mainly the highstand and transgressive system tracts. Then, structural restoration using a method of layer back stripping and fault blocks shifting were conducted to study the depositional and structural evolution of the basin. The Late Miocene to Late Pliocene sequence and structural developments of the basin were mainly controlled by growth faulting activities which are divided into seven stages: 1) WBD TB3.1 (~10.6Ma-~8.5Ma), 2) WBD TB3.2 (~8.5Ma- ~6.7Ma), 3) WBD TB3.3 (~6.7Ma—~5.6Ma), 4) WBD TB3.4 (~5.6Ma-~4.2Ma), 5) WBD TB3.5 (~4.2Ma- ~3.8Ma) 6) WBD TB3.6 (~3.8Ma-~3.0Ma) and 7) WBD TB3.7 (~3.0Ma-~1.9Ma) sequences. The high sediment supply rate is believed to provide conducive mechanisms for the gravity-induced syn-depositional growth faults to be initiated, which observed from WBD TB3.1 until WBD TB3.4. The growth faults in the basin were developed stage by stage from the south (landward) to the north (basinward) driven by the progradation of shoreface and delta sedimentation. The Northwest-Southeast wrench- induced compression which happened in Pliocene to Quaternary has caused basin inversion, where the trending of the fold axes is in the Northeast-Southwest orientation. The wrench-induced compression deformation was prominent at the proximal part of the basin, where its deformation extends distally down to the Baram field. The deformation developed the anticlinal features and faulting within this region. The intensity of the wrench-induced deformation decreases basinward, which is the reason why beyond the Baronia field, the deformation is less prominent. The distal part of the basin is mainly controlled by the gravity-induced syn-depositional growth faults tectonic style since the wrenching is not prominent. The six third-order depositional sequences established as WBD TB3.1 to WBD TB3.7 sequences with a complex growth-faulted structure development in the West Baram Delta give a new insight of understanding the depositional and structural evolution through time which may lead to a better stratigraphic correlation and hydrocarbon trap analyses at the field scale.

Keywords: West Baram Delta (WBD) basin, stratigraphic correlation, hydrocarbon trap analyses

PAPER ID 32

Ichnofacies evaluation as an inventive approach in reservoir analysis for delineating stratigraphic sequences and interpreting depositional history: An example from shoreface and wave-influenced delta deposits in Sarawak basin, Malaysia

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Abstract: The B-A core from Field B in Sarawak Basin is studied for delineating stratigraphic sequences and interpreting depositional history. The core is unfortunately quite weathered and several intervals are broken up so a continuous depositional history is not possible. An overall picture of the depositional settings is however able to be determined from the sections that are clean enough to display bed boundaries, lithologies, sedimentary structures, bioturbation distributions and trace fossil assemblages. The succession begins with a number of shallowing upwards offshore to shoreface parasequences from the base upwards to 7932.4 feet with no evidence of deltaic influence. This part of the core generally shows relatively pervasive bioturbation, especially in the more distal facies which tend to be thoroughly bioturbated. A thin deltaic interval is observed between 7932.4 feet and 7883.9 feet where bioturbation is sporadically distributed. Deltaic influence is obvious but not pronounced suggesting the unit represents a wave- dominated delta. The base of this interval is marked by a mudclast and gastropod lags, whereas the overlying proximal lower shoreface deposits contain locally occurring clay drapes and phytodetritus suggesting deltaic deposition. A strong shift to deltaic deposition is clearly marked at the interval between 7907.7 feet and 7860.6 feet, where unburrowed clay drapes and phytodetritus are common, and bioturbation is very sporadically distributed ranging from Bioturbation Index (BI) 0-4. This parasequence is interpreted as sparcely bioturbated prodelta upwards to very sparsely burrowed mouthbar deposits. Between 7860.0 feet and 7810.3 feet, the succession consists of stacked fine- to medium-grained sandstone units with abundant carbonaceous detritus. The succession from 7806.4 feet up to 7431.8 feet contains seven parasequences of heavily bioturbated upper offshore upwards to heavily bioturbated to sporadically bioturbated lower shoreface deposits. Evidence of minor deltaic influence is present throughout suggesting part of this succession may represent a wave-dominated delta. Most of the deposits display strong levels of bioturbation and minimal evidence of storm deposition. A very pervasively bioturbated transgressive deposit that contains very large and complex Rosselia rotates is described between 7382 feet and 7380.8 feet, indicating very slow sedimentation rates in a lower offshore setting during transgression. Abundant overprinting of individual trace fossils also proposes very slow deposition rates and the continuous reworking of the substrate over a long period of time. The last interval of the core described covering core depth between 7292.5 feet and 7258.4 feet consists of two shallowing upwards, storm-dominated shoreface parasequences. The succession starts with a pervasively bioturbated upper offshore deposit between 7292.5 feet and 7267.6 feet and later it can be seen that the units shallow upwards through moderately bioturbated to sparsely bioturbated storm-dominated lower shoreface and finally to middle shoreface example for shoreface and wave-influenced delta facies understanding as it records a depositional gradient from lower offshore environments in an open marine setting through shoreface environments (locally affected by proximity to a contemporaneous delta system), to more coastal environments that are mouthbar with brackish water assemblages.

Keywords: Delineating stratigraphic sequences, depositional history

CONFERENCE ABSTRACTS

TECHNICAL SESSION 7: QUATERNARY & MARINE GEOLOGY

PAPER ID 01

Coastal-shallow marine depositional system of cretaceous sediments of Jessu Formation, northern Benue Trough, Nigeria

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Abstract: The Jessu Formation is one of the marine Cretaceous formations in the Northern Benue Trough of Nigeria. Facies analysis, facies associations, facies successions and stratigraphical relationships was carried out on the Jessu Formation outcrops, in order to re-construct the paleodepositional environment and propose a depositional model for the studied successions. Five composite sedimentary logs were measured. Ten (10) facies were identified on the bases of lithology, grain size, sedimentary structures and degree of bioturbation. These facies form four (4) facies associations, namely: the FA-1 (offshore marine), FA-2 (lower shoreface), FA-3 (middle shoreface) and FA-4 (upper shoreface). These facies associations form coarsening upward units from offshore marine to shoreface which suggests a regressive shoreface deposit for the Jessu Formation. The coarsening upward nature of the facies succession indicated a storm and wave influenced coastal-shallow marine depositional system.

Keywords: Shoreface, coastal, shallow marine, Jessu Formation, Yola Sub-basin

PAPER ID 10

The origin of ice shelf channels at Institute and Möller ice stream grounding zones, West Antarctica

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Abstract: Moderate Resolution Imaging Spectroradiometer (MODIS) imagery reveals meandering channels on the surface of ice shelves, 10s of km in length and 2-3 km wide, originating from the grounding lines of fast-flowing ice streams, referred to as 'M' channels, they form as a consequence of a locally thinner ice associated with selective

upwards erosion beneath the ice shelf. Focused, linear basal melt forms 'U' channels, 1-300 m high concave channels carved into the base of the ice shelf; the M channels develop due to the relative difference in surface elevation between thicker versus thinner floating ice. The association between M channels and ice stream grounding line points to subglacial water as the agent of basal ice-shelf melt. Such systems have been shown to be associated with both soft- and hard-bedded landforms, which act to route basal water. Both the Möller and Institute ice streams in the Weddell Sea sector of West Antarctica are associated with ice-shelf channels. Here, using radio-echo sounding data collected by the British Antarctic Survey in the austral summer of 2008/09 and 2011/12 and the Center for Remote Sensing of Ice Sheets during the airborne geophysical surveys in 2012, 2014 and 2016, we investigate how these channels are formed by upstream subglacial conditions. For the Institute Ice Stream, we find that the hard-bedded landform explanation holds, where basal water is channelled beside the landform and, when mixed with cavity water, flows upwards into the corrugation developed by upstream ice flow around it. For the Moller Ice Stream, however, we propose an alternative mechanism for ice-shelf channelling. Subglacial water flows in a well-organised manner along the base of a deep but otherwise smooth basal trough. This trough also moulds the ice sheet base, such that at the point of flotation it is characterised by a notable convex profile. When the water exits the ice sheet, after mixing with ice shelf water it flows upwards beside lower elevation convex feature and etches an ice-shelf channel offset laterally from the axis of the upstream basal tough. These results demonstrate that while ice-shelf channels are associated with basal landforms at the grounding line, there are at least three ways in which they can be generated.

Keywords: MODIS, West Antarctica, ice shelves, ice stream

PAPER ID M09

Preservational attributes and mineralogy of Youngest Toba Tuff ash, Padang Terap, and Lenggong valley, Peninsular Malaysia

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Abstract: The Youngest Toba Tuff (YTT, ca. 75 ka) eruption, Sumatra, Indonesia had dispersed enormous fine-grained pyroclastic material over entire Southeast Asia including Peninsular Malaysia. These ash remains constituting 1-4 m thick vertical profiles, occasionally mixed with the host sediments, are well preserved in the Quaternary alluvial sediments of Padang Terap and Lenggong valley of Perak river, Malaysia. The same has been investigated to understand their preservational attributes and mineralogy to interpret the transportation history, depositional setup, and mineralogical composition. To achieve the same, detailed field investigation, grain size analysis, XRD and microscopic studies of a total of 23 ash samples belonging to both the river basins have been conducted. Widely distributed tephra in the Padang Terap river basin is light gray to light greenish-gray, fine-grained, semi-consolidated, and structured in nature that ranges from 1 1.5 m thick in thickness. Based on its bedding geometries, this ash is considered reworked. Whereas, the same in the Lenggong valley is retrieved as primary, secondary, and compact reworked ashes that are deposited in close association with each other. These ashes are attributed together with light gray, light greenish-gray to grayish orange-pink colors, powdery to semi-consolidated appearance, and massive to structure nature attaining 2-4 m thicknesses. The grain size data of ash, obtained by both sieve analysis and laser diffraction technique, revealing higher percentages of fine-grained fractions, indicate calm water conditions during their deposition and suspension as the prime mode of sediment transport. Microscopically, the ash comprises predominantly of vitric glass masses, minor occurrences of minerals, and unidentifiable fine admixture. Glass shards are represented dominantly by bubble walled morphology and pumice that are mostly fine-grained with sharp and angular edges. The XRD analyses of both bulk ash and clay fractions of the same show good representations of quartz followed by kaolinite, biotite, orthopyroxene, and magnetite in the former and, kaolinite, illite, chlorite, corrensite, montmorillonite, quartz, and calcite in the later. The dominant presence of quartz and clay minerals in the samples also indicates the reworking of the tephra. These studies together suggest that the tephra, after their settlement in both the river basins have traveled for a short distance in the serene fluvial environments.

Keywords: Youngest Toba Tuff, volcanic ash, grain size, glass shards, Quaternary

CONFERENCE ABSTRACTS

TECHNICAL SESSION 8: ETHICS, LAWS & PROFESSIONAL PRACTICES

PAPER ID M03

Application of construction suitability map in sustaining the highland development from geohazard in Malaysia

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Abstract: Sustainable Development Goals (SDGs) number 11 highlights the essentials of preparing sustainable cities and communities. This includes sustaining highland development from any geohazard such as landslides. To achieve this effort, a lot of policies and guidelines were established in Malaysia including Construction Suitability Map (CSM). CSM is an important tool in preliminary stage of a highland development where it able to identify possible geohazards and percentage of existence of water bodies or any cut slope of the proposed development area can be identified. However, despite the general agreement about the effectiveness of CSM, the usage of CSM among the developer are still low and less work has been reported on effectiveness of CSM application. Thus, this work aim to analyse the effectiveness of CSM application on 22 selected projects of various highland developments around Malaysia. Based on the findings, 10 projects were under suitable development classes and remaining projects need to change their layout or development structure based on the development class before they can proceed with any development.

Keywords: Sustainable Development Goals (SDG), geohazard, geology terrain mapping, development classes, resilient, highland development

PAPER ID M04

Role of geoscientist in sustainable highland development in Malaysia

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Abstract: Above a million Malaysian were affected by natural disasters over the last two decades where landslides and flooding were the highest geological disasters recorded. Malaysia is fairly safe from tremor-induced landslides given the ideal geographical location outside the Ring of Fire. Previous studies conclude that Malaysia's landslides are mainly affected by improper design, and construction and maintenance errors in highland development. Thus, this has raised concerns on sustainability practices of highland development in Malaysia as geological disasters in highland areas have been occurring continuously since 1919. This shows that improper development persists regardless of the slope properties, buffer zones, and other contributing geological factors. Stopping constructions or development in highland areas is not an option for big cities like Kuala Lumpur and Penang as most suitable low-lying areas are limited and already crowded with roads and buildings. Therefore, this paper emphasizes on the need for geological input from geoscience practitioners to support the sustainable development of highland areas in accordance with the United Nations Sustainable Development Goals, and current guidelines and legislations. Studied landslides

are secondary data collected from previous published journals, books, related agencies, and internet searches. The historical landslides studied and classified according to the Varnes Landslide Classification (1978) show that there are urgent demands for geological input in future highland development as similar patterns of errors and failures were observed from previous disasters. The errors include insufficient ground investigation, improper understanding of soil and slope properties, poor drainage designs, and unsuitable geotechnical decisions to uphold and strengthen the slope. A full-time supervision from geoscience experts is vital in hill-site projects as altered terrain could vary the slope properties and affect its stability. Plus, having a good practice throughout the development processes aligns well with the United Nations Sustainable Development Goals as a sustainable city should be safe from hazards, and able to provide career opportunities for its citizens.

Keywords: Geoscience, geohazard/geological disasters, landslide, sustainable development, highland, Sustainable Development Goals

PAPER ID M05

The understanding of geological terrain mapping among stakeholders for a highland development in Malaysia

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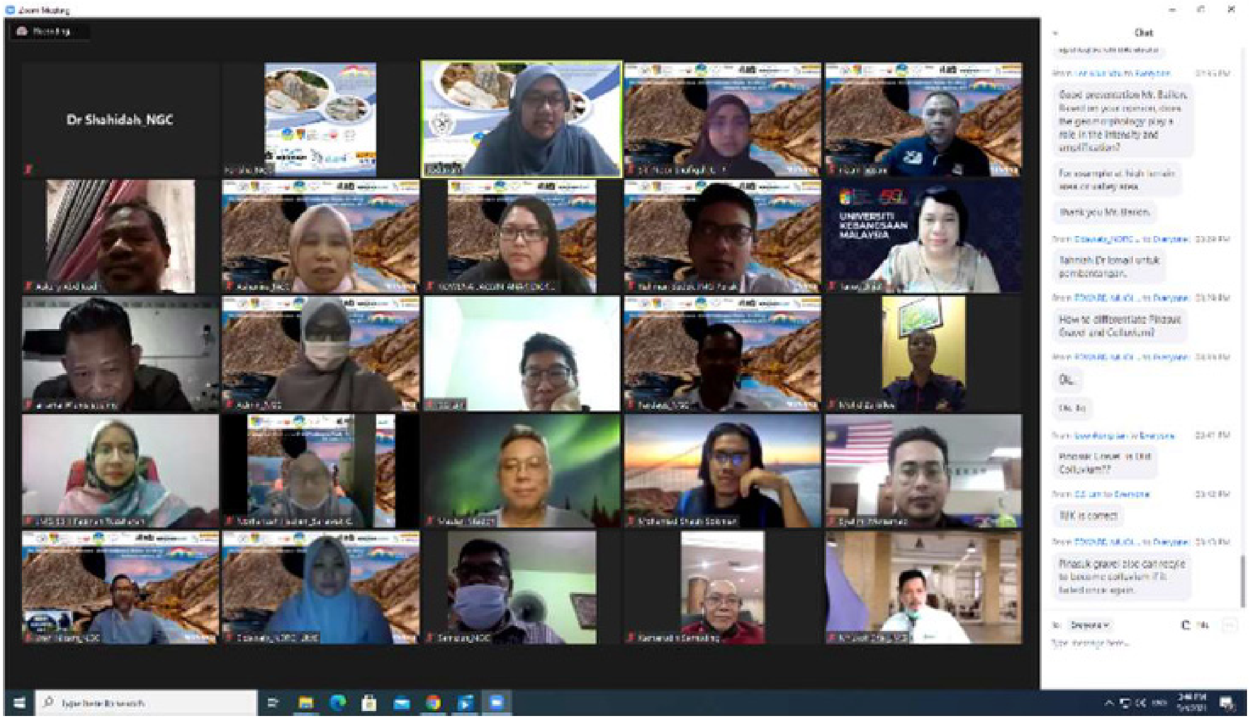
Abstract: The occurrence of landslides on slopes has posed a serious risk on areas of development in Malaysia for the past decades. In response to such geohazards, the Geological Terrain Mapping (GTM) method was adapted in a hilly & highland development. The four attributes for a Geological Terrain Classification make it easier to identify the area that are prone to geohazard. The introduction of this system in 2009 serves as guidance towards sustainable development planning and disaster risk reduction in the country. GTM is also considered as one of the effort in meeting the requirement of Sustainable Development Goals (SDGs) for vision 2050. Despite its establishment, landslide disasters in highland developments still kept increasing. Therefore, this study aims to determine the current level of awareness and understanding regarding GTM. Specifically, the awareness of the major key players in development: the stakeholders. To test the hypothesis that there is a lack of awareness regarding GTM among developers in Malaysia, an online survey was distributed to stakeholders in the development industry across Malaysia. 42 respondents from both government and private sectors with difference profession were asked to respond to sets of questions covering highland development guidelines, GTM, sustainability, and disaster risk reduction (DRR). Analysis of local landslide study cases using the S.W.O.T and P.E.S.T.E.L was also carried out to understand the implications that geohazards have on sustainability. The results showed that more than half of the respondents knew the existence of GTM. Despite knowing the existence of GTM, the stakeholders do not completely understand the uses of GTM. Other than that, they do not understand the importance of the system in sustainability and disaster risk reduction. Based on the questionnaire, nearly half of the respondent holds a less knowledge about the SDGs and DRR. This disparity suggests the lack of actual understanding regarding GTM among stakeholders in the country as well as its vital role in sustainability and risk control. The questionnaire also seek the opinion of the public for suitable approach that should be implemented to ensure the GTM is fully understand by the all the stakeholders in Malaysia.

Keywords: Geological Terrain Mapping (GTM), Sustainable Development Goals (SDGs), Disaster Risk Reduction (DRR)

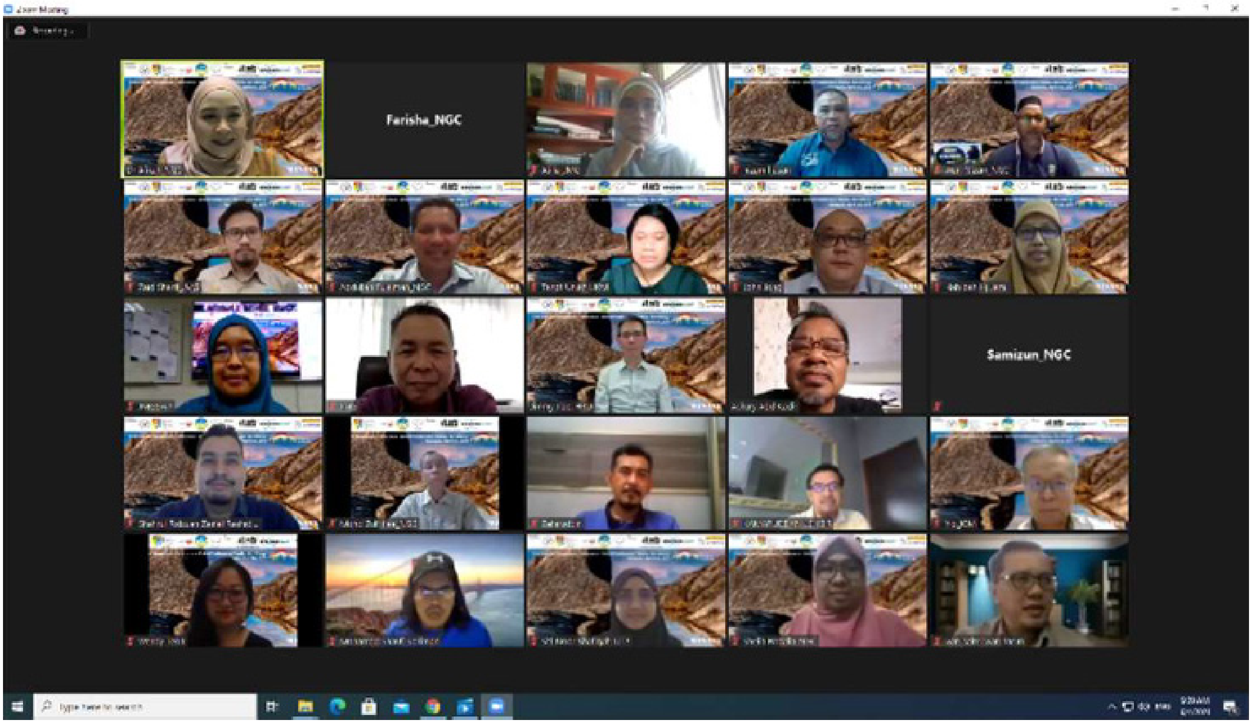
PICTURES

33rd NGC Virtual Conference - Organizing Committee

PERTEMUAN PERSATUAN (MEETINGS OF THE SOCIETY)



PERTEMUAN PERSATUAN (MEETINGS OF THE SOCIETY)



Acknowledgement to Peer Reviewers (2020)

In appreciation of the enormous contribution they make to the Society's publications, we would like to thank the scholars and experts below who have participated in the peer review process of manuscripts submitted for consideration for publication in the Bulletin of the Geological Society of Malaysia and Warta Geologi in 2020:

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Abdul Halim Abdul Latif

Abdull Halim Abdul

Abdullateef Onimisi Jimoh

Abraham Simanjuntak

Agus Budhie Wijatna

Ahmad Farid Abu Bakar

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Wan Nurzalia Wan Saelan

Yasir Bashir

Zakaria Endut

Zuliskandar Ramli

Zuhar Zahir

THANK YOU

LAPORAN PROGRAM KHAS GSM 2021/2022

BANTUAN KOMPUTER RIBA KEPADA PELAJAR IJAZAH SARJANA MUDA GEOLOGI DI UNIVERSITI AWAM MALAYSIA DIBAWAH KATEGORI KELUARGA B40

Pandemik Covid-19 mewujudkan fenomena baru di dunia dan Malaysia termasuk dalam bidang pendidikan. Pelajar di universiti awam turut terjejas sesi pembelajaran dan pembelajaran secara talian menjadi pilihan utama.

Pembelajaran dalam talian memerlukan para pelajar mempunyai peralatan dan bahan yang cukup. Ini termasuk pemilikan sebuah komputer riba dan keperluan internet untuk pembelajaran.

Oleh itu, sebagai persatuan geologi yang utama di Malaysia, Persatuan Geologi Malaysia (Geological Society of Malaysia (GSM)) turut sama membantu meringankan beban para pelajar terutama pelajar daripada golongan B40 dengan membekalkan sebuah komputer riba pada golongan sasaran yang memenuhi kriteria. Rajah 1 menunjukkan perjalanan program yang bermula apabila diluluskan oleh Ahli Majlis GSM pada mesyuarat bertarikh 29 Januari 2021.

Rajah 1: Ringkasan perjalanan bantuan khas komputer riba GSM 2021/2022.

Seramai 11 orang pelajar dari pelbagai universiti awam telah disenarai pendek sebagai penerima dan Jadual 1 menunjukkan senarai penerima mengikut universiti dan penyumbang yang terlibat.

Lampiran 1 menunjukkan beberapa bukti serahan komputer riba dan surat penghargaan daripada salah sebuah universiti iaitu Universiti Malaysia Kelantan (UMK) dan dokumen berkaitan.

GSM berharap dengan usaha kecil ini, para pelajar mendapat suntikan semangat untuk terus berjuang dalam situasi pandemik yang penuh cabaran. Semoga kita sama-sama menyokong antara satu sama lain dalam dunia geologi di Malaysia ini.

Terima kasih kepada penyumbang dari industri dan persendirian yang sentiasa menyokong program GSM. Terima kasih juga kepada Ahli Majlis GSM 2020/2021 yang diketuai oleh Tuan Presiden; En Abd Rasid Jaapar yang memberi sokongan penuh untuk melaksanakan usaha ini dan terima kasih kepada semua ahli GSM yang setia menjadi ahli dan menyumbang setiap tahun supaya program seperti ini dapat diteruskan pada masa yang diperlukan.

Semoga para penerima dapat memanfaatkan sepenuhnya komputer riba yang diberikan dan turut dapat menyumbang kepada persatuan dan komuniti geologi pada masa akan datang.

Laporan disediakan oleh:
Norazianti binti Asmari (Pen. Setiausaha GSM),
Pelaksana,
Program Khas Pandemik, GSM 2020/2021
Mac 2021

Jadual 1: Senarai penerima komputer riba - Projek Khas GSM Pandemik.

Bil.	**Penyumbang**	**Universiti**	**Kemudahan Yang Ada Pada Masa Kaji Selidik Untuk Pembelajaran?**	**Adakah ibu bapa anda terjejas pekerjaan akibat pandemik/ bencana/banjir?**
1.	GSM/GTR	Universiti Kebangsaan Malaysia	Telefon Pintar; Data Internet	Ya
2.	GSM/GSR	Universiti Malaysia Kelantan	Telefon Pintar	Ya
3.	GSM/GSR	Universiti Malaysia Kelantan	Telefon Pintar; Data Internet	Ya
4.	GSM/SGR	Universiti Malaysia Kelantan	Data Internet	Ya
5.	GSM/GSSB	Universiti Malaysia Kelantan	Telefon Pintar; Data Internet	Ya
6.	GSM/Pn Azimah	Universiti Malaysia Kelantan	Telefon Pintar; Data Internet	Ya
7.	GSM/Dr Mazlan	Universiti Teknologi Petronas	Data Internet	Ya
8.	GSM	Universiti Sains Malaysia	Telefon Pintar; Data Internet	Ya
9.	GSM	Universiti Malaya	Telefon Pintar	Ya
10.	GSM	Univerisiti Kebangsaan Malaysia	Telefon Pintar	Ya
11.	GSM	University Malaysia Sabah	Telefon Pintar	Ya

Singkatan:

GSM : Geological Society of Malaysia

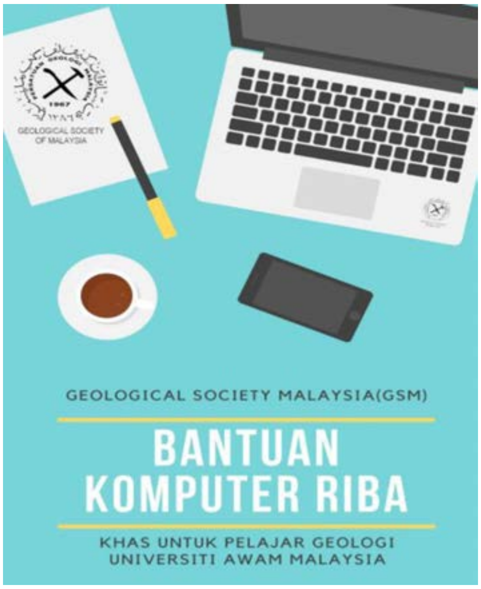
GTR: Geo Technology Resources

GSR: Geo Solution Resources

SGR: Sepakat Geohydro Resources

GSSB: Geo Strata Sdn Bhd

LAMPIRAN 1



Penyumbang Industri :

GEO SOLUTION RESOURCES

https://geosolutionresources.com/

GTR

https://www.geotechnologyresources.com

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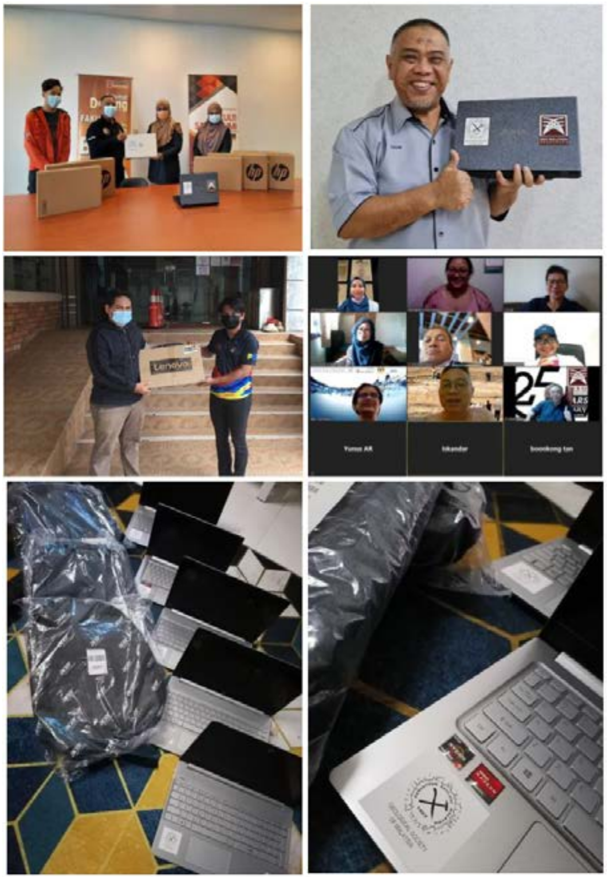

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TARIKH (*Date*) : 23 MAC 2021

En Abd Rasid Jaafar
Presiden
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Tuan,

UCAPAN PENGHARGAAN DAN TERIMA KASIH

Dengan segala hormatnya perkara di atas dirujuk.

2. Adalah dimaklumkan bahawa pihak fakulti telah menerima keputusan pemilihan bagi penerima bantuan komputer riba yang telah dijalankan oleh pihak Geological Society of Malaysia (GSM) pada 19 Februari 2021 yang lalu. Seramai lima (5) orang pelajar yang terpilih merupakan pelajar dari program Geosains, Fakulti Sains Bumi, Universiti Malaysia Kelantan. Bantuan ini bukan hanya dapat meringankan bebanan pelajar yang berada dalam kalangan keluarga kategori B40 tetapi sekaligus membantu pelajar semasa pembelajaran dalam situasi pandemik covid-19 ini

3. Sehubungan dengan itu, pihak Fakulti Sains Bumi dan Universiti ingin mengambil kesempatan ini untuk merakamkan setinggi-tinggi penghargaan dan ucapan terima kasih kepada tuan kerana telah membantu pelajar-pelajar berkenaan.

4. Segala perhatian, kerjasama dan tindakan tuan berhubung perkara ini amatlah dihargai dan didahului dengan ucapan terima kasih.

Sekian.

"RAJA BERDAULAT, RAKYAT MUAFAKAT, NEGERI BERKAT"

"PRIHATIN RAKYAT: DARURAT MEMERANGI COVID-19"

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

(PROF. MADYA TS. DR. MOHAMAD FAIZ BIN MOHD AMIN)
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N.S. HAILE PUBLICATION AWARD 2020/2021 – Ms. Teng Yu He

The N.S. Haile Publication Award for 2020/2021 was awarded to Ms. Teng Yu He for her paper entitled "First Cretaceous fish fauna from Malaysia", published in the Journal of Vertebrate Paleontology*, DOI: 10.1080/02724634.2019.1573735. The paper is a milestone in paleontological research in Malaysia, whereby hundreds of Cretaceous fish remains were carefully examined and identified, and never before reported, including six species of hybodont sharks, along with dinosaur and turtle remains from the Cretaceous non-marine sediments in central Pahang. This is the first time Cretaceous fish fossils were reported from Malaysia. The paper is part of Ms. Teng's M.Sc. project at the University of Malaya (UM), supervised by Dr. Masatoshi Sone, who is her second co-author. The paper was written with five other co-authors: Ren Hirayama, Masataka Yoshida, Toshifumi Komatsu, Suchada Khamha and Gilles Cuny.

Ms. Teng graduated with a Bachelor degree in Science, major in Geology from the University of Malaya in 2011. As a PETRONAS scholar, she served the company after graduation as a geologist in the then Petronas Management Unit. During her spare time, she continued to be actively involved in paleontological expeditions with a team led by her former supervisor at UM. In 2014, the team discovered the first dinosaur remains in Pahang, Malaysia. Together with the dinosaur, abundant fish micro-remains were found from the same site. This eventually became the project of Ms. Teng's Masters degree when she decided to leave the petroleum industry and pursue her passion in paleontology. After completing her Masters in Geology, she joined the Academy of Sciences Malaysia (ASM) where she is currently serving as a science and technology policy analyst.

The N.S. Haile Publication Award was formerly known as the "Young Geoscientist Publication Award". It was established by GSM's founding president, Neville S. Haile, for "good publications by young geologists below the age of 30".

Upon receiving the award, Ms. Teng wrote:

"What I learned from the process of writing and publishing is that it is a process that needs to be passion-driven. It requires endurance and perseverance to constantly pick yourself up from rejection, realise your limit and break it through. Just like any research work, the answer is never enough, nor finalised. It is a process of thinking and presenting your thoughts in the most precise way possible. I had a steep learning curve in terms of both academic and personal growth during the preparation of my first paper. It is of course not my sole effort. It would not be possible without tremendous guidance from my supervisor and co-authors. Lastly, I wish that we can always put "curiosity" above "expectation", so the process is filled with excitement."

* Reference: Teng, Y. H., M. Sone, R. Hirayama, M. Yoshida, T. Komatsu, S. Khamha & G. Cuny, 2019. First Cretaceous fish fauna from Malaysia. Journal of Vertebrate Paleontology (Q1 in SCImajo Journal Rank), DOI: 10.1080/02724634.2019.1573735.

The following photos are courtesy of Ms. Teng's, from her collection.

By:
Mazlan Madon

Photo 1: Ms. Teng Yu He during a field trip in Cameron Highlands (Gunung Irau).

Photo 2: Ms. Teng in the lab, preparing fossils for further study and identification.

Photo 3: Close-up of fossil sample preparation.

Photo 4: Fish teeth in the rocks collected during the expeditions.

UPCOMING EVENTS*

May 23-26, 2021: ACE 2021, Denver, Colorado. Visit event website at https://ace.aapg.org/2021 for further details.

May 25-26, 2021: Conference on Mixed/Hybrid Systems (Turbidite, MTDs and Contourites) on Continental Margins, Lisbon, Portugal. For details, contact the Events and Office Administrator at +44 (0) 203 962 4468.

May 26-28, 2021: Digital Subsurface Conference in Latin America (online). Contact acs@eage.org for questions regarding this event.

June 10-13, 2021: Euro-Mediterranean Conference for Environmental Integration, Sousse, Tunisia. Please visit https://www.emcei.net/ to obtain more information about the event.

June 16 - 17, 2021: Professional Course On Geosite Development and Management, GGCS - Geosite 02: Essential in Geosite Mapping. Time and venue to be confirmed. Send email to: information.ggcs@gmail.com or call (+60) 3 8920 3506 for further details.

July 26-28, 2021: Unconventional Resources Technology Conference (URTeC 2021), Houston, Texas. For further information, please visit: https://urtec.org/2021.

July 27-29, 2021: EAGE Guyana-Suriname Basin Conference, Georgetown, Guyana and Online. Contact acs@eage.org for questions regarding this event.

August 3-5, 2021: Professional Course On Geosite Development and Management, GGCS - Geosite 03: Advance in Geosite Mapping. Time and venue to be confirmed. Send email to: information.ggcs@gmail.com or call (+60) 3 8920 3506 for further details.

September 6-7, 2021: EAGE Workshop on Computational Sciences for New Energy and Oil Recovery, Kuala Lumpur, Malaysia and Online. For further information and inquiries about the event, please contact the organiser at : asiapacific@eage.org.

September 26-October 1, 2021: ACE 2021 and SEG 2021 (a joint annual meeting), Denver, Colorado. Visit event website (https://ace.aapg.org/2021) for more details.

September 27-29, 2021: Integrated Process-Based Geological Modeling in Exploration and Production, Abu Dhabi, United Arab Emirates. Visit https://www.aapg.org/global/middleeast/events to obtain more details about the event.

October 4-7, 2021: 14th Middle East Geosciences Conference and Exhibition; Bahrain. To find out more, visit website https://geo-expo.com/conference/, or contact Mr. Abeer Al Zubaidi at email: aapgme@aapg.org.

October 5-6, 2021: The Stratigraphy of Sundaland: Current Perspectives and Future of the Science. 9:00 a.m.–4:00 p.m. Virtual Workshop via Zoom (Singapore, Singapore time). For details, please check event website, at https://www.aapg.org/global/asiapacific/events/virtual/articleid/59741/the-stratigraphy-of-sundaland-current-perspectives-and-future-of-the-science#pricing.

October 12-13, 2021: EAGE Conference on Seismic Interpretation using AI Methods - Going Beyond Machine Learning, Online. For further information and inquiries about the workshop, please contact EAGE Asia Pacific: Tel.: + 60 3 2722 0140, E-mail: asiapacific@eage.org / registrations@eage.org

October 24-27, 2021: AAPG 2021 International Conference & Exhibition (ICE); Muscat, Oman. Further details will be made available, visit https://www.aapg.org/events/conferences/ice.

November 23-24, 2021: High CO_2, High Contaminant Challenging Fields and Alternative Energy - Impact and Monetization. 8:00 a.m.–5:00 p.m. Virtual Workshop via Zoom (Singapore, Singapore time). Visit https://store.aapg.org/events/registration.aspx?event=S7329000 for event details.

November 28-30, 2021: RECSO EnviroSpill 2021 Conference and Exhibition, Kingdom of Bahrain. For enquiries, contact : Kiran Gulzar Ahmed, info@rescoenvirospill.org; webpage: www.rescoenvirospill.org.

* Subject to re-evaluation by the organizers

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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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Journal article:
Suntharalingam, T., 1968. Upper Palaeozoic stratigraphy of the area west of Kampar, Perak. Geol. Soc. Malaysia Bull., 1, 1-15.

Book:
Hutchison, C.S., 1989. Geological Evolution of South-east Asia. Clarendon Press, Oxford. 368 p.

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).

Tables

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