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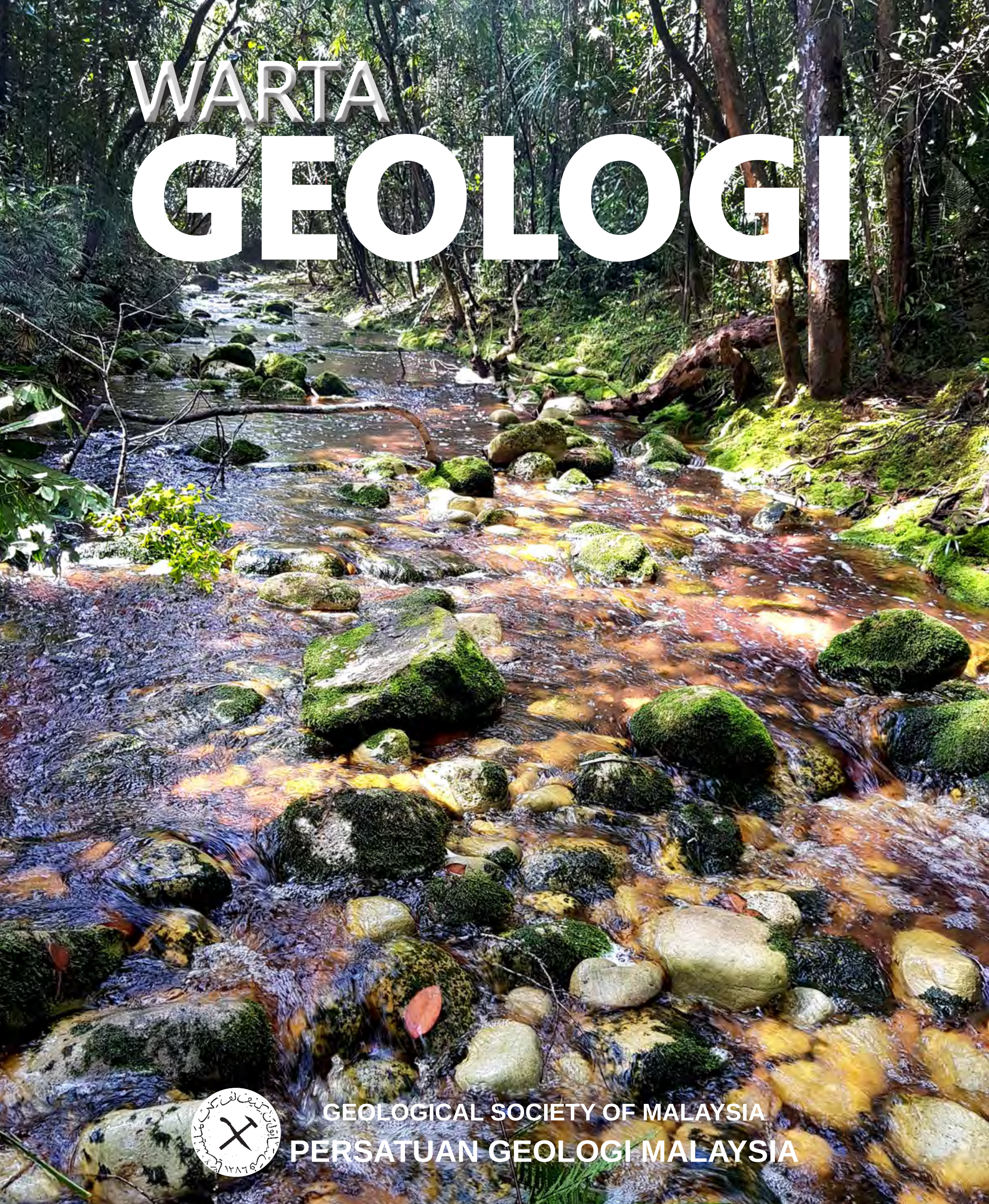

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Cover photo: Quartz Sandstone Unit, Gagau Formation at the upstream of Pertang River in Kelantan National Park. Photo by Mohd Syakir Sulaiman taken during the Mesozoic expedition organised by UMK, August 2017.

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Slake durability indices of fresh shales and sandstone from the Gemas Formation, Ayer Hitam, Johor Darul Takzim

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Abstract: At the slope cut between km 81.30 and 81.05 (southbound) of the North-South Highway near Ayer Hitam are exposed dark grey to black, fresh (unaltered) shales and fine grained sandstones of the Middle to Upper Triassic Gemas Formation. The strata with bed thicknesses of between 0.2 and 1.5 m, strike about 165^o and dip eastward at 35^o to 43^o. The shales have an average dry unit weight of 24.85 kN/m^3 and an average apparent porosity of 5.9%, whilst the sandstone has an average dry unit weight of 24.83 kN/m^3 and an average apparent porosity of 4.8%. Slake durability indices (Id_2) of the shales for two standard cycles of wetting and drying are between 99.1% and 99.6%, whilst indices (Id_4) for four cycles are between 99.0% and 99.5%. Slake durability indices (Id_2) of the sandstone for two standard cycles of wetting and drying are between 99.2% and 99.3%, and for four cycles (Id_4) between 98.4% and 98.5%. It is concluded that the fresh (unaltered) shales and sandstone are of "extremely high durability" and suitable for use as highway embankment or construction material (rock fill).

Keywords: slake durability indices, Gemas Formation

INTRODUCTION

Several earth materials, particularly those with a high clay content, are prone to swelling, weakening or disintegration when exposed to short-term weathering processes of a wetting and drying nature. Such slaking characteristics or weatherability of earth materials are of practical importance in engineering projects and can influence the stability of excavations with time as well as the design of fills and the surface durability of canal and tunnel walls (Morgenstern & Eigenbrod, 1974).

The weatherability of clay-rich rock materials probably presents the most problems because their degree of induration may cause observers to be misled concerning their performance when exposed to the elements (Johnson & DeGraff, 1988). In view of this, the slake durability test was devised as a means of assessing the resistance offered by a rock material to weakening and disintegration when subjected to two standard cycles of drying and wetting. Standardized procedures for the slake durability test are provided in manuals published by the International Society for Rock Mechanics (ISRM, 1979) and the Asian Institute of Technology (AIT, 1981).

The Colorado Department of Transport (CDOT, 2015) furthermore, notes that shales as highway embankments (or construction material) should be classified as being soil-like (non-durable) or rock-like (durable). Two methods of test were recommended to distinguish durable shales that can be used in rock fills from non-durable shales that must be placed and compacted as soil. The first method is the qualitative jar-slake test which involves six descriptive degrees of slaking determined from visual observation. The second method employs the slake durability apparatus where a number of oven-dried rock blocks are submerged in water and rotated in a wire drum cage. The jar-slake test is recommended as the basic screening test, whilst the slake durability test is considered to be the main index test. Identification of shales as being soil-like (non-durable) or rock-like (durable) is based on the slake durability index (Id) and the character of the retained wet rock materials (CDOT, 2015).

In Malaysia, there is limited published data on the durability of rock materials with Azman Kassim & Edy Tonnizam Mohammad (2007) stating that the slake durability index (Id_2) for two standard cycles of testing decreased with an increase in the weathering grade of sandstones and shales from the Mersing area. Zainab Mohamed *et al.* (2007) discussed the characterization and classification of weathered Kenny Hill Formation rocks and presented results of jar-slake tests as well as tests with the slake durability apparatus. Edy Tonnizam Mohamad *et al.* (2011) reported that jar slaking tests were more suitable for determining the durability of highly (Grade IV), and completely (Grade V), weathered shales and sandstones from the Mersing area rather than tests with the standard slake durability apparatus.

In this geological note are presented the results of tests carried out with the slake durability apparatus on fresh (unaltered), dark grey shales and fine grained sandstone from the Gemas Formation that outcrop along the North-South Highway close to the town of Ayer Hitam in Johor State.

GEMAS FORMATION

The name ‘Gemas Formation’ was adopted by Lum (1982) to replace the term ‘Gemas Beds’ which had earlier been applied by Foo (1972) to denote the Middle to Upper Triassic sedimentary-pyroclastic sediments outcropping in northwest Johor. In the Gemas area, the Gemas Formation is mainly composed of rapidly alternating inter-beds of shale, sandstone, tuff, and tuffaceous sandstone and shale, with minor lenticular bodies of conglomerate and limestone. There are several fossil locations in the area, with 3 locations yielding faunal assemblages of shell imprints of pelecypods and ammonites which give a reliable Middle to Upper Triassic age (Lum, 1982).

The Gemas Formation has a general north-northwest strike (340°) with moderate to steep dips (>35°) towards both east-northeast and west-southwest. Joints are well developed in all the rock units with bedding data indicating a single phase of folding (Lum, 1982). The joints show variable strikes with steep to vertical dips, though the major set strikes east-northeast. Minor normal and reverse faults with displacements of up to several tens of centimeters are seen in places, while major faults are marked by slickensides, quartz-filled fissures and sheared outcrops (Lum, 1982).

Earthworks for the North-South Highway between Yong Peng and Ayer Hitam in northwest Johor have resulted in several slope cut exposures of the Gemas Formation (Figure 1). At the 27 m high cut between km 81.30 and 81.05 (south-bound) was exposed in the lower two benches, fresh (unaltered), dark grey to black, shales and fine grained sandstones. Overlying the fresh bedrock is some 14 to 18 m of *in situ* moderately to completely weathered shales and sandstones characterized by light grey to white colours (Plate 1). The shales are the predominant lithology with bed thicknesses of 0.5 to

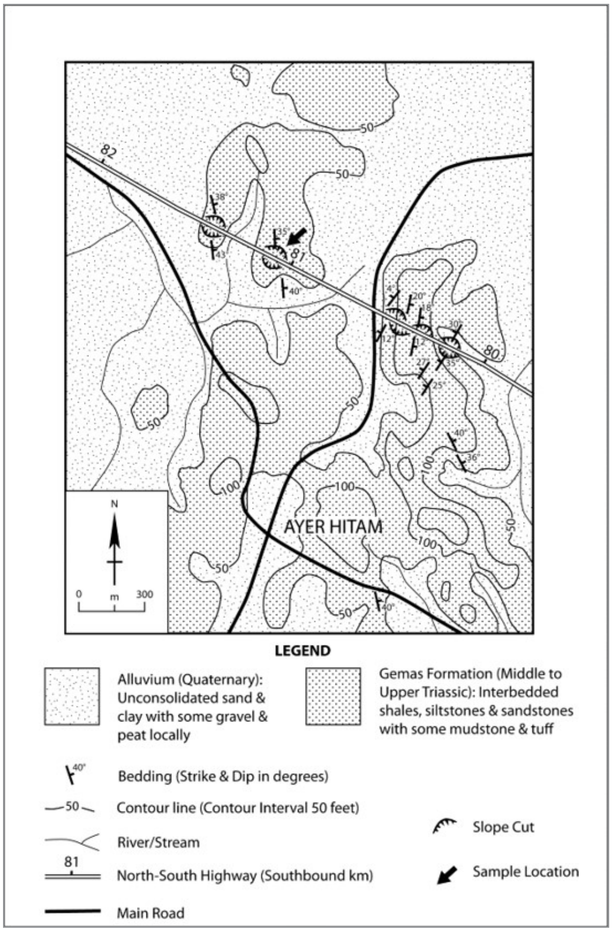

Figure 1: Geology map of the Ayer Hitam area, Johor Darul Takzim. (After Sanisah Binti Ahmad, 1992).

Plate 1: View of shales and sandstones during excavation works.

1.5 m, whilst the fine grained sandstone beds are 0.2 to 1.0 m thick. Joints of variable orientations and lengths are present within the beds which strike about 165°, and dip eastwards at 35° to 43°.

METHODOLOGY

Several large blocks (each about 0.09 m^3 in volume) of fresh (unaltered), dark grey shales and fine sandstone were first collected in the field and taken to the laboratory where they were diamond-sawn into smaller tetrahedral blocks. The visible textural and structural features of each of these blocks was then described before the densities, unit weights and apparent porosities of representative specimens were determined according to the saturation and bouyancy technique described in ISRM (1979) and AIT (1981).

The corners of the tetrahedral blocks were then rounded off, and about ten of them (each weighing about 40 to 60 g) selected to give a total weight of about 400 to 600 g for each test specimen. A total of seven specimens were tested with the slake durability apparatus; five for the dark grey shales (Samples GA and GC) and two for the dark grey, fine grained sandstone (Sample GB).

Each of the specimens (comprising some ten rock blocks) was oven-dried at 105°C overnight, and then placed in the drum of the slake durability apparatus. The weight of the drum and test specimen was then determined (Weight A) before the drum was covered with a lid and placed in the trough attached to the motor-drive unit. The trough was filled with tap water to a level some 20 mm below the drum axis, and the drum rotated at 20 rev/min for a period of 10 minutes. The drum (with the retained specimen) was then removed from the trough and oven-dried (over-night) at 105°C before the weight was measured (Weight B). The same process was repeated and the oven-dried weight of the drum and retained specimen determined (Weight C). The drum was then oven-dried (over-night) at 105°C and its weight determined (Weight D).

The slake durability index (Id_2) for the two cycles of wetting and drying was then calculated as a percentage ratio of the final to initial dry specimen weight as follows:

$$\text{Slake durability index } (Id_2)\ \% = ((C-D)/(A-D)) \times 100$$

Repetition of the wetting and drying cycles with determination of oven-dry weights will give slake durability indices for increasing numbers of cycles.

The apparatus used for the slake durability tests was manufactured by ELE (Engineering Laboratory Equipment) and consisted of a base-mounted, motor-drive unit that allowed rotation of drums at 20 revolutions per minute. Four mesh drums and four water tanks could be attached to the motor-drive unit with quick-release assemblies to allow for the simultaneous testing of four samples.

RESULTS

Densities, unit weights and apparent porosities of representative specimens of the two dark grey shales (Samples GA and GC), and single fine grained sandstone (Sample GB) tested, are shown in Table 1. The dark grey shales have average dry densities of 2,525 kg/m^3, and 2,544 kg/m^3, and average dry unit weights of 24.76 kN/m^3, and 25.42 kN/m^3. The dark grey shales (Samples GA and GC) also have average apparent porosities of 6.8%, and 4.9%, respectively. The dark grey fine grained sandstone has an average dry density 2,533 kg/m^3, an average dry unit weight of 24.83 kN/m^3, and an apparent porosity of 4.8%. The relatively large values of dry density and dry unit weight, as well as low values of apparent porosity, indicate that the fresh (unaltered) shales and sandstone are indurated and dense.

Slake durability indices (Id_2) of the dark grey shales for two standard cycles of wetting and drying are between 99.1% and 99.7%, whilst similar indices (Id_4) for four standard cycles are between 99.0% and 99.5% (Table 2). The slake durability index (Id_5) of one dark grey shale sample for five standard cycles of wetting and drying furthermore, is 99.4% (Table 2). Slake durability indices (Id_2) of the sandstone for two standard cycles of wetting and drying are between 99.2% and 99.3%, while those (Id_4) for four standard cycles are between 98.4% and 98.5% (Table 2).

In view of the slake durability indices for two cycles of wetting and drying (Id_2) exceeding 99.0%, the fresh (unaltered), dark grey shales and fine grained sandstone can be classified as being of "extremely high durability" according to the classification proposed by Franklin & Chandra (1972).

DISCUSSION

It is not surprising that the fresh (unaltered), dark grey shales and fine grained sandstone of the Gemas Formation are of "extremely high durability" in view of their indurated nature as shown by their high densities and unit weights as well as low apparent porosities. The fresh, dark grey shales furthermore, would be classified as being rock-like shales (durable) in terms of the Colorado Department of Transport classification of shales (CDOT, 2015).

Locally published data with which the present results can be compared is that of Azman Kassim & Edy Tonnizam Mohammad (2007) who reported a slake durability index (Id_2) after two cycles of testing of 91.6% for a slightly weathered (Grade II) shale, and between 82.5% and 87.1% for a moderately weathered (Grade III) shale. Though the age of the shales is not known, the reported values compare favorably with the presently determined slake durability index (Id_2) of between 99.1% and 99.7% for fresh (unaltered) shales (Samples GA and GC) from the Gemas Formation. The durability indices (Id_2) of

Table 1: Physical properties of fresh (unaltered) dark grey shales and fine grained sandstone from the Gemas Formation.

Sample Number	Lithology	Dry Density (kg/m^3)	Saturated Density (kg/m^3)	Apparent Porosity (%)	Dry Unit Weight (kN/m^3)	Saturated Unit Weight (kN/m^3)
GA 1a1	Dark grey Shale	2,577	2,642	6.5	25.27	25.91
GA 1a2		2,444	2,519	7.5	23.97	24.70
GA 1d1		2,547	2,611	6.4	24.98	25.61
GA 1e3		2,530	2,599	6.9	24.81	25.49
Mean		2,525	2,593	6.8	24.76	25.43
GC 2a	Dark grey Shale	2,598	2,620	2.3	25.48	25.69
GC 2c		2,533	2,550	1.7	24.84	25.01
GC 2d		2,581	2,653	7.2	25.31	26.02
GC 3b		2,519	2,542	2.3	24.70	24.93
GC 4a		2,529	2,594	6.5	24.80	25.44
GC 4d		2,560	2,624	7.3	25.10	25.73
GC 4h		2,490	2,563	7.3	24.42	25.13
Mean		2,544	2,592	4.9	24.95	25.42
GB 1a	Dark grey, fine grained Sand-stone	2,466	2,539	7.3	24.18	24.90
GB 1d		2,560	2,566	0.6	25.10	25.16
GB 2a		2,545	2,600	5.5	24.96	25.50
GB 2b		2,515	2,554	4.0	24.66	25.05
GB 2c		2,518	2,572	5.4	24.69	25.22
GB 2f		2,536	2,596	6.0	24.87	25.46
GB 3e		2,588	2,634	4.7	25.38	25.83
Mean		2,533	2,580	4.8	24.83	25.30

Table 2: Results of slake durability tests on fresh (unaltered), dark grey shales and fine grained, sandstone from the Gemas Formation.

Sample Number	Lithology	Cycle 1 Slake Durability Index (Id_1)	Cycle 2 Slake Durability Index (Id_2)	Cycle 3 Slake Durability Index (Id_3)	Cycle 4 Slake Durability Index (Id_4)	Cycle 5 Slake Durability Index (Id_5)
GA 1	Dark grey Shale	99.8	99.6	99.6	99.5	-
GA 2		99.9	99.7	99.6	99.5	99.4
GC 1	Dark grey Shale	99.5	99.1	99.1	99.0	-
GC 2		99.8	99.6	99.4	99.2	-
GC 3		99.8	99.6	99.6	99.5	-
GB 1	Dark grey, fine grained Sandstone	99.5	99.2	98.8	98.5	-
GB 2		99.7	99.3	98.7	98.4	-

the fresh (unaltered), shales from the Gemas Formation also compare favorably with the durability index (Id_1) of 92% for a single cycle of wetting and drying reported by Zainab Mohamed *et al.* (2007) for a highly weathered shale from the Kenny Hill Formation.

The slake durability indices (Id_2) of fresh (unaltered), fine grained sandstone from the Gemas Formation of between 99.2% and 99.3% for two standard cycles of wetting and drying, compare favorably with the single cycle durability index (Id_1) of 98% reported by Zainab Mohamed *et al.* (2007) for a slightly weathered sandstone from the Kenny Hill Formation. The slake durability indices (Id_2) of fresh (unaltered), fine grained sandstone from the Gemas Formation also compare favorably with the slake durability index (Id_2) after two cycles of testing of 94.3% for a slightly weathered (Grade II) sandstone, and 79.0% for a moderately weathered (Grade III) sandstone reported by Azman Kassim & Edy Tonnizam (2007).

CONCLUSION

It is concluded that fresh (unaltered), dark grey shales and fine grained sandstones from the Gemas Formation are of "extremely high durability" and suitable for use as highway embankment or construction material (rock fill).

ACKNOWLEDGEMENT

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Mineralogical evidence from Bukit Bunuh impact crater and its contribution to prehistoric lithic raw materials

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Abstract: The Centre for Global Archaeological Research (CGAR), USM has conducted a geoarchaeology research at Bukit Bunuh, Lenggong since 2008, and has proven that the site is an *in-situ* Paleolithic and meteorite impact crater. Recent studies and researches in geology and geophysics have also proven that Bukit Bunuh is a meteorite impact crater. The evolution of archaeological studies in Lenggong valley had made it being listed as one of UNESCO world heritage sites on 30 July 2012 through its chronology and importance to the country and world. The evidence of handaxe embedded in the suevite with the dating 1.83 million years shows a clear connection between archaeology and geology at Bukit Bunuh. The Paleolithic humans at Bukit Bunuh had chosen different raw materials to be used as stone tools and their equipment. Most of the stone tools were from cherty metasediment and quartzite, while some were made from suevite and quartz. The Planetary and Space Science Center (PASSC), based at University New Brunswick, Canada, has listed six criteria for indentifying an area as a recognized meteorite impact area. One of the criteria is the presence of high pressure mineral polymorphs within *in situ* lithologies. This mineralogical research focused on identifying high pressure minerals. Samples taken in this research was heavy minerals. The samples were collected using panning method at Bukit Bunuh, Lenggong and its vicinity. Sampling was done in three phases and 51 samples were analyzed using XRD. As a result, the analysis indicates the presence of high pressure mineral polymorphs in the samples such as stishovite, coesite, akimotoite, ringwoodite, reidite and wadsleyite. This may be the main reason why the edges of the stone tools, especially the flake tools and chunk tools mostly show that they have not been retouched. In addition, the identification of these minerals has proven that the rocks at Bukit Bunuh were good raw materials in terms of strength and durability compared to other types of rocks. Interpretation of lithic industry technology at Bukit Bunuh shows that manufacturing technology by Paleolithic humans are advanced with their raw materials.

Keywords: Heavy minerals, high polymorph minerals, raw materials, Bukit Bunuh

INTRODUCTION

This mineralogical study was made at Bukit Bunuh, Lenggong and its vicinity. The study was made to identify high pressure polymorph minerals as the evidence of the existance of an impact crater. Polymorph minerals are two or more minerals that have the same chemical composition but different atomical arrangement and crystal structure. High pressure polymorph minerals are formed from the shock pressure by the shock wave of a meteorite impact. These minerals formed naturally when the original rocks recrystallize at high pressure and temperature. Polymorphism is the ability of a particular chemical composition to crystallize in the form of minerals depending on temperature and pressure, or both (Rafferty, 2012). For example, the polymorph minerals coesite and stishovite belong to high pressure silica polymorph that is formed due to shock pressure. Despite its simple chemical composition, silica shows rich polymorphism at elevated pressure and temperature (Hemley *et al*., 1996; Stöffler & Langenhorst, 1994; Teter *et al*., 1998). A variety of dense polymorphs of elements, oxides and silicates have been found by laboratory high-pressure experiments. In nature, shocked meteorites are the most important source of high-pressure minerals, in addition to impact crater rocks, mantle xenoliths, inclusions in diamond, and ultrahigh-pressure metamorphic (UHP) rocks. It is not easy to fully characterize such high-pressure minerals because of their very small grain size and low abundance. However, state-of-art equipments such as electron microscopy, X-ray diffractometry, and micro-Raman spectroscopy enable the identification of such small crystalline grains (Tomioka, 2011; Miyahara & Tomioka, 2012). Textures, crystallography and chemical properties of a natural high pressure minerals not only provide us with information to understand the impact of meteorite events but also clues on the structure and dynamics of the Earth's depth. The Planetary and Space Science Centre (PASSC) that stores the database on impact cratering on Earth has listed the criteria to identify the impact structure, and one of the criteria is the presence of high pressure mineral polymorphs within *in situ* lithologies (microscopic evidence and requiring proof via X-ray diffraction, etc.). Therefore, this research was conducted with the aim to identify the high pressure minerals based on presence of heavy minerals and its relationship with the raw materials of stone tools. Quantitative and continuous approaches are more apparent through the diversity of physical properties of lithic raw materials and its type. The discovery of stone tools can be seen as a unique combination of raw material structure, composition and morphology. Hardness and surface roughness provide a broader view by providing the detailed information to complete the research (Lerner *et al*., 2007).

STUDY AREA

Bukit Bunuh impact structure (c. 100°58.5′E, 5°4.5′N) is a complex crater. Bukit Bunuh lies between Banjaran Titiwangsa and Banjaran Bintang. Geophysical method proved that the study area is underlain by highly fractured granitic bedrock with a depth of 5-50 m from the ground (Rosli, 2016). The study area covers Bukit Bunuh and its vicinity. The discovery of handaxe embedded in suevite rocks has shown the earliest signs of human living in Southeast Asia with the dating of 1.83 ma. The excavations that was done in 2001 to 2003 and 2008 to 2010 had exposed evidence that Bukit Bunuh is an *in-situ* Paleolithic workshop and were used from time to time.

The Paleolithic humans had populated continuously at Bukit Bunuh more than 1.83 million years ago, 500,000 years ago, 270,000 years ago, 40,000 years ago and 30,000 years ago based on the excavation records. Among the artifacts found are stone tools and tools such as cores, choppers, handaxes, flake tools, pebble tools, anvils and debitages from a variety of rock types and clear of the association. The early population had used suevite, cherty metasediment, quartz and quartzite as their raw materials (Mokhtar, 2006; Mokhtar, 2010; Nor Khairunnisa *et al*., 2016). In general, Bukit Bunuh is a Paleolithic Complex with different raw materials at different time scale. Bukit Bunuh also revealed the use of raw materials from impact meteorite rocks to make stone tools and equipment in lithic industry.

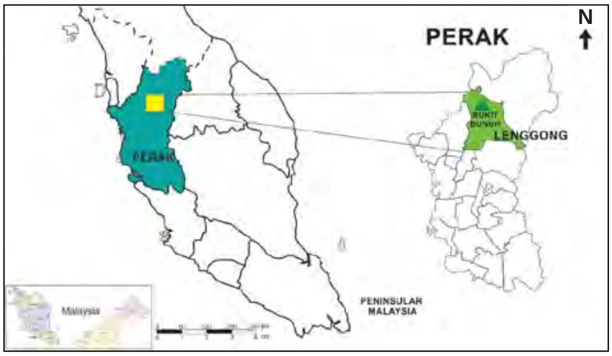

Figure 1: Location of Bukit Bunuh.

METHODOLOGY

Samples were collected from Bukit Bunuh streams and its vicinity, corresponding to the area of Bukit Bunuh impact crater. The samples taken in this research are heavy minerals. Heavy minerals is a class of mineral deposits with a density more than 2.8 g/cm^3 (Stendal & Theobald, 1994). The samples was obtained by panning process in the field using the standard gold pan and heavy minerals separation using Bromoform in the laboratory. The minerals are present in small quantities in sediments, especially sand, but they represent the variety of mineral classes from different geology units (Morton, 1985). Most of these minerals are very specific, limited and have their own paragenesis where some information cannot be provided by other methods. By using the geochemical data, we can determine the origin of minerals using mineral composition, structure and crystal morphology as an indicator of petrogenesis (Lihou & Mange-Rajetzky, 1996; Mange & Maure, 1992; Mertie, 1954; Morton, 1991; Morton & Hallworth, 1999; Morton *et al*., 2002). In geochemical exploration, the use of heavy minerals has a crucial role in detecting anomalous halos around mineralization (Gandhi & Sarkar, 2016). Thus, XRD analysis was made to identify the presence of polymorph minerals in the heavy minerals, which is based on the chemical composition of minerals. The analysis was carried out using an automatic horizontal diffractometer, rotating anode generator, with CuK*a* radiation operating at 40 kV and 40mA at the Earth Material Characterization Laboratory, Centre for Global Archaeological Research. These samples were analyzed by XRD on D8 Advance Bruker machine. We conducted XRD analysis by using full and slow scanning technique. The slow scanning technique was adopted to give more exposure of the X-ray to the samples with small angles. The step size of 0.008° and scan range from 28-32° 2Θ/sec was used as the parameter for slow scan.

RESULTS AND DISCUSSION

The number of samples for the heavy mineral separation and XRD analysis are 51 out of the 95 samples collected. Some of the samples were too small to be analyzed. After heavy mineral separation, these samples were ground before the XRD analysis. Based on the XRD analysis, Bukit Bunuh and its vicinity is shown to be dominated by zircon, quartz, ilmenite, rutile, anatase and schorl minerals. These minerals are also representing or indicator of a class of high polymorph minerals. The analysis also showed the presence of high pressure polymorph minerals, which is coesite (Figure 2), stishovite (Figure 3), akimotoite, ringwoodite, wadsleyite (Figure

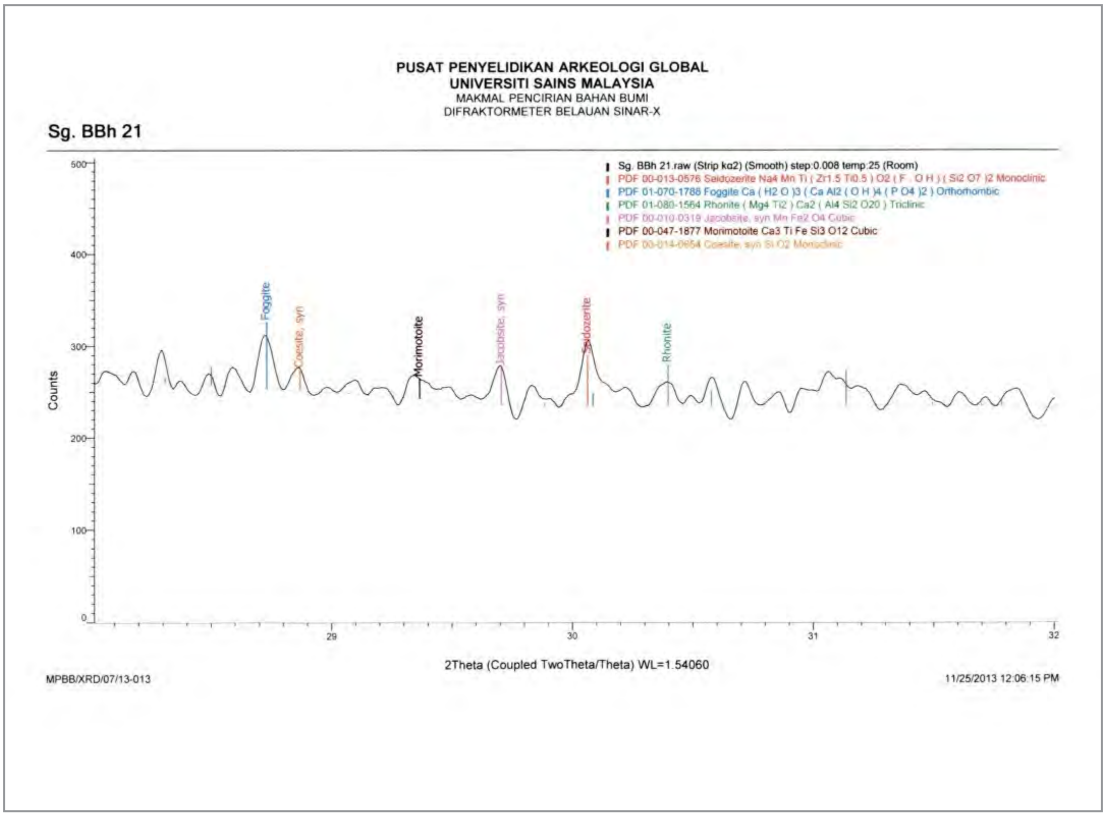

Figure 2: XRD pattern shows the occurrence of coesite mineral in Sg. BBh 21 sample.

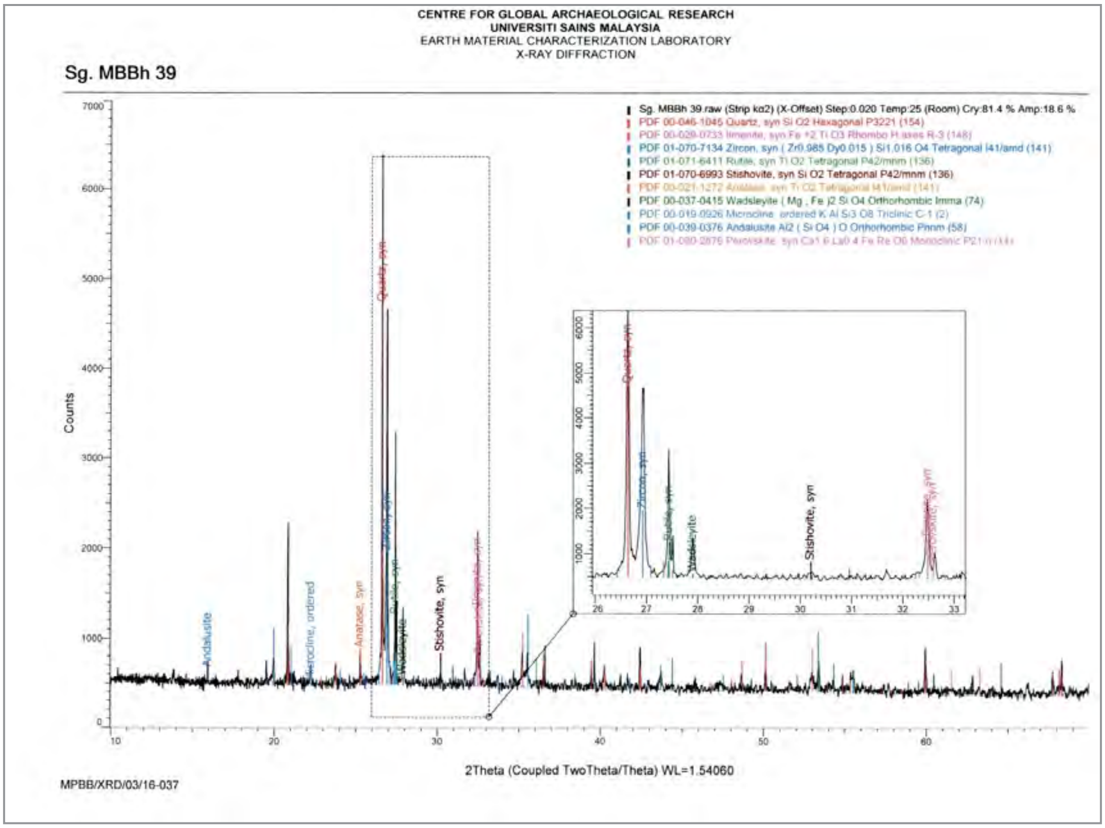

Figure 3: XRD pattern shows the occurrence of stishovite and wadsleyite minerals in Sg. MBBh 39 sample.

3) and reidite. Coesite and stishovite are the polymorphs of silica (SiO_2) group and these minerals have high Mohs scale with conchoidal fracture (Akhavan, 2014; Chao *et al*., 1960; Chao *et al*., 1962; Stishov & Popova, 1961).

Akimotoite is a polymorph mineral from the ilmenite group (Tomioka & Fujino, 1999) while ringwoodite and wadsleyite are polymorphs of olivine that formed during high pressure and temperature (Binns *et al*., 1969; Katsura *et al*., 2004; Kiefer *et al*., 1999). Reidite is zircon high pressure polymorph (Glass & Liu, 2001; Reid & Ringwood, 1969). The presence of these high pressure polymorph minerals proves that Bukit Bunuh is a meteorite impact site because these minerals are normally found in naturally occurring impact structures (astroblemes) and synthesized in experiments (Fel'dman *et al*., 2007). Most of these high pressure polymorph minerals have high density and Mohs hardness. Despite having the same chemical formula of SiO_2, their structural arrangement is different (Figure 4). Minerals with high hardness provide the rocks with more strength and toughness thus making it one of the important quality for stone tools production. The hardness property of the rocks and its fine texture were formed as the result of recrystallization of the regional rocks. Due to these advantages, this may be the main reason why the edges of most of the stone tools, especially the flake tool and chunk tool had not been retouched. This made the edge of the stone tools to be very sharp (Figure 5).

Thousands of artifacts such as pebble tools and flake tools were discovered on the surface of Bukit Bunuh site and during the excavation. More surprising is that some of these artifacts found were made using suevite as the raw material. Suevite is a rock that formed after an impact event, due to the high pressure and temperature. From excavation records, most of the stone tools found at Bukit Bunuh used quartzite, cherty metasediment, suevite and quartz as the raw materials (Table 1), compared to the other sites at Lenggong valley such as Kota Tampan, Lawin, Bukit Jawa and Temelong. Within these areas, quartz and quartzite are the main raw materials. The Bukit Bunuh site also revealed the different method to use the raw materials because the early humans here used rock cobbles from rock quarries. The other Paleolithic sites in the Lenggong valley however used pebbles directly from the rivers and streams.

CONCLUSION

The presence of high polymorph minerals at Bukit Bunuh has strengthened the evidence of Bukit Bunuh as an impact meteorite site. Based on the characterization

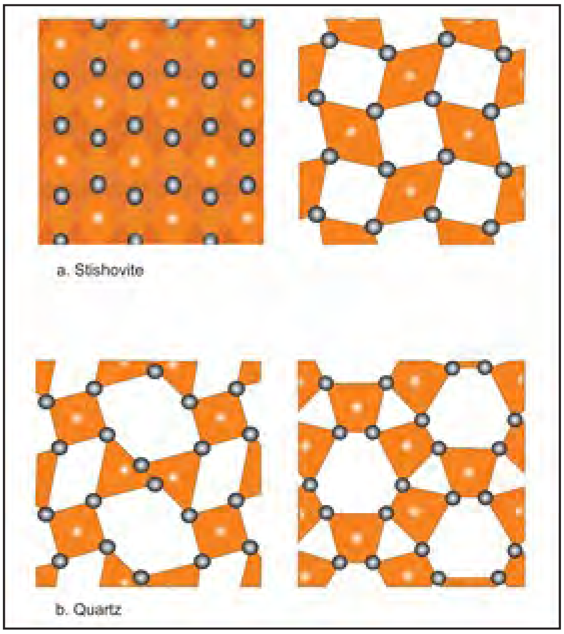

Figure 4: Crystal structures of stishovite compared to quartz (After Funamori *et al.*, 2015).

Figure 5: Edge of a flake tool that has not been retouched.

Table 1: Statistics of Bukit Bunuh raw materials. (Nor Khairunissa *et al*., 2016).

Raw Materials	Anvil	Core	Hammerstone	Flake tools	Pebble tools	Chunk tools
Quartz	2	229	37	21	9	133
Suevite	28	105	37	76	6	64
Quartzite	1	72	27	298	12	134
Cherty Metasediment	0	139	9	447	10	215

of these high polymorph minerals with high density and hardness indirectly give the advantage toward the raw materials at Bukit Bunuh. Hence, it has been advantageous to the selection of raw materials in terms of durability, compression and strength as well as describing the Paleolithic society of Bukit Bunuh were using the finest materials and knowing the appropriate materials in their vicinity to be used in the stone tools industry. Thus, this reveals that the Bukit Bunuh Paleolithic society acknowledged the best raw materials and shows that their technology was advancing.

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Mineralogical analyses of Belata Black Shale, Perak, Peninsular Malaysia

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Abstract: Although Peninsular Malaysia comprises of 25% Paleozoic black shales, these shales have very little published literatures on their mineralogical content. This study employs the use of X-ray diffraction analyses to characterize the mineralogical composition of the Belata Black shales. The findings of the study indicate that the black shales of Belata Formation are dominated by felsic minerals such as quartz and feldspars. Minerals such as muscovite, calcite, pyrite, kaolinite and chlorite are also present, and this may indicate a felsic source rock for the shales. The study of the source of sediments helps in revealing the processes they have gone through and may together be used with the weathering, transport, deposition and burial history of the sediment to analyze their thermal maturity.

Keywords: Mineralogy, black shales, Belata Formation, Xray diffraction

INTRODUCTION

Shale is by far the most abundant type of sedimentary rocks mostly formed in marine environments close to continents at places where the seafloor falls beneath the storm wave base. Shale is a sedimentary rock formed at quiet parts of rivers, lagoons, lakes, tidal flats, deltas, and open seas (Tourtelot, 1979). Organic shales have been classified as argillaceous, siliceous or calcareous based on their mineralogical content.

Black shales are basically composed of mixtures of non-clay minerals such as microcrystalline quartz, feldspars, pyrite, carbonates and clay minerals of smectites, kaolinite, chlorites, illites and mixed layers of the mentioned clay types.

Sedimentary rocks are composed of both detrital and authigenic minerals. Shales rich in organic matter could be classified as argillaceous, siliceous or calcareous depending on their mineralogical content (Chermak & Schreiber, 2014). Organic shales are mostly referred to as black shales due to their black color incorporated during their deposition and the organic matter present in them. Black shales primarily have a mixed composition of non-clay minerals such as fine-grained quartz, feldspars, pyrite, carbonates and clay minerals of smectites, kaolinite, chlorites, illites and mixed layers of the mentioned clay minerals.

With the rise in the exploration and production of shale gas globally due to the decline in conventional resources, it has become a necessity to explore shale around the globe. Researchers have placed current interest in the study of organic rich shales due to their hydrocarbon potential and their metal concentrations especially in countries with shale deposits such as Argentina, China and the United States of America (Masters *et al*., 1987; Wang *et al*., 2014). Thus, understanding the mineralogy of shales is one of the fundamental information required. Studies into the type of mineral together with other geochemical parameters are useful for the study of the source rock, depositional environment and burial diagenesis of sediments (Niu *et al.,* 2018).

Peninsula Malaysia is made up of 25% scattered Paleozoic black shales from various formations of which the Belata Formation forms a part (Figure 1). Various authors have published the existence of these shales. Burton (1970), Jones (1970), Foo (1983, 1990) extensively studied the shales in the Peninsular for their stratigraphy and geology. Baioumy *et al.* (2016) worked on a wide selection of shales from all over Peninsular Malaysia excluding the Belata Formation amongst a few. Using age, he grouped all the black shale lithology into seven main categories ranging from Cambrian through to Permian and worked on their mineralogy. He discussed the shales to be in the late stage of maturity but recommended other analysis to be conducted to confirm his claim. However, the black shales in the Belata Formation unlike the other shales worked on by Baioumy *et al.* (2016) has been described by Gan (1992) to not have been affected by contact metamorphism and may be found to be economically important due to their distance further away from the granitic intrusion.

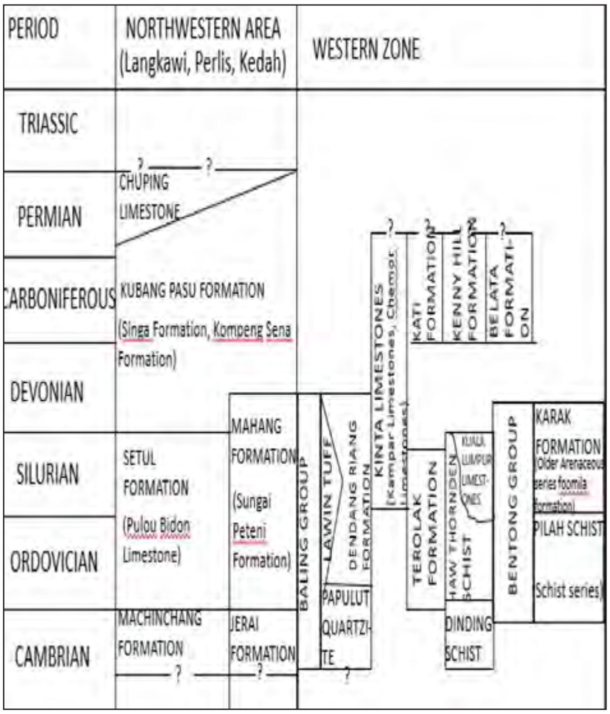

Figure 1: Formations found within Peninsula Malaysia, modified after Foo (1983).

In the study of shale as a reservoir, it is necessary to understand the geologic processes by which the sediments in the rock have been through. This begins with the type of source rocks from which the sediments originated from weathering, then transportation to deposition and finally burial. Although it has been recognized that black shales are by far an economic and important rock type for reasons in and beyond geological studies, about twenty five percent of Paleozoic black shales scattered in Peninsular Malaysia have little or no work done on them in terms of their mineralogical characteristics.

In this work, the mineralogy of the black shale of Belata Formation is studied for the first time. The mineralogical composition of the carboniferous black shales of the Belata Formation which lies to the southern part of Tanjung Malim on the borders of Perak state and Selangor state of Peninsular Malaysia is studied to interpret their source rock type (Figure 2). Apart from the interpretation of the source rock of these shales, mineralogy together with a study of the elemental and oxide analysis of the black shales could aid in the determination of the maturity of these shales which could further assist in their shale gas prediction.

MATERIAL AND METHOD

Representative fresh samples from different outcrops and localities of the black shales were taken from the field using geologic instrument such as the geologic hammer. The samples after being ripped of the weathered portion were crushed in an electronic pulverizing machine and then subjected to detail mineralogical analysis at the Centralized Analytical Laboratory (CAL) in Universiti Teknologi PETRONAS. Twenty-two black shale samples

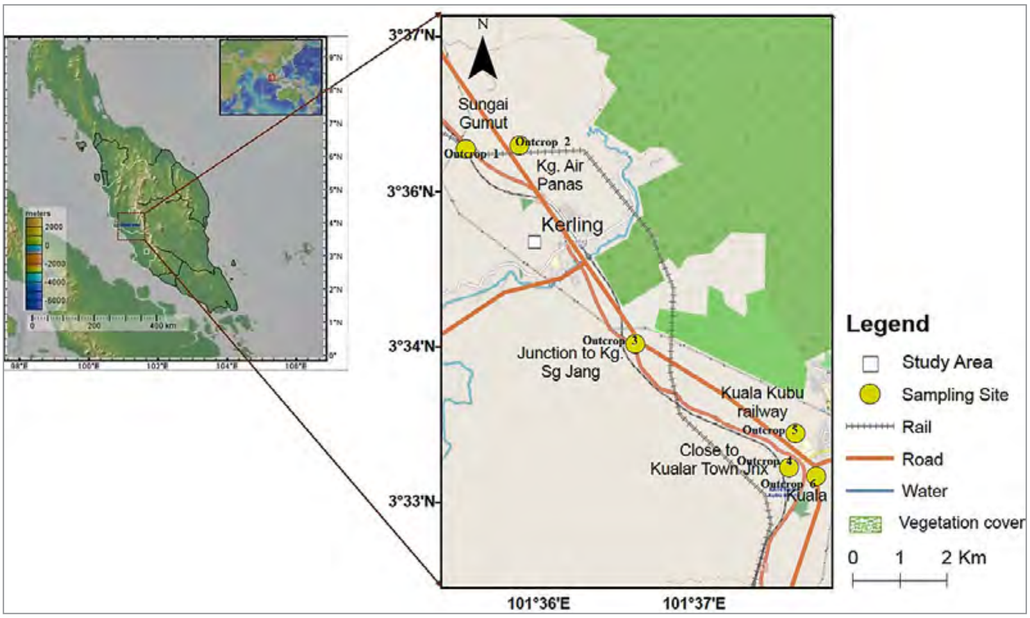

Figure 2: Geology Map of the peninsular showing the study area (Peng *et al.*, 2004).

picked from the field were analyzed for their clay and non-clay fraction using powder X-ray Diffraction (XRD) method.

Powder XRD is a robust method for identifying and characterizing crystalline minerals (such as quartz, clays, carbonates and pyrite). A bulk analysis was done by mounting the powdered samples into the X-ray holder for analyzing of mineral peaks. Clay fraction involved 10 g of powdered shale samples mixed with 1 M acetic acid and shook in the beaker till it was completely disaggregated. This procedure removes carbonates (if any) present in the samples and the residue was washed several times with distilled water. After that, the residue was treated with 30% H_2O_2 to get rid of organic matter in the samples and then the residue was rinsed several times to remove the acid before drying. Finally, the suspended clay fraction was pipetted onto glass slides and the water allowed to drain out of it. For each sample, three oriented mounts were prepared. The first slide was dried by air. The second was saturated with ethylene glycol and kept in an oven for an hour at 60°C. The third slide was heated for three hours at 550°C. The analysis determined both the bulk and clay fraction with scans limited to the range from 2 to 80° 2θ for the bulk samples and from 2 to 40° 2θ for the clay fractions. Minerals identification was based on the data produced by International Center for Diffraction Data (ICDD).

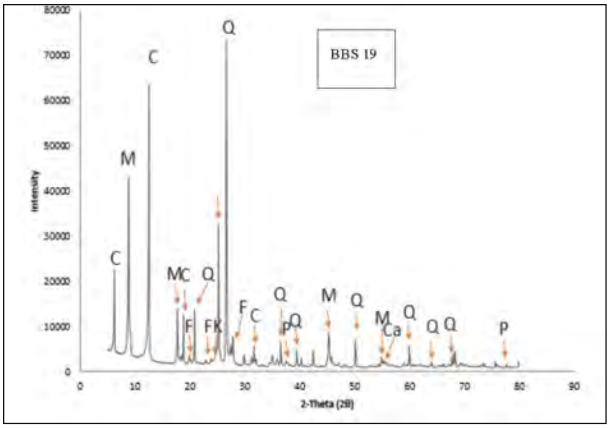

Figure 3: XRD pattern of the various mineral phases. C- Chlorite, M- muscovite mica, K- Kaolinite, Ca- Calcite, Q- Quartz, F- Feldspar (Albite) and P- Pyrite.

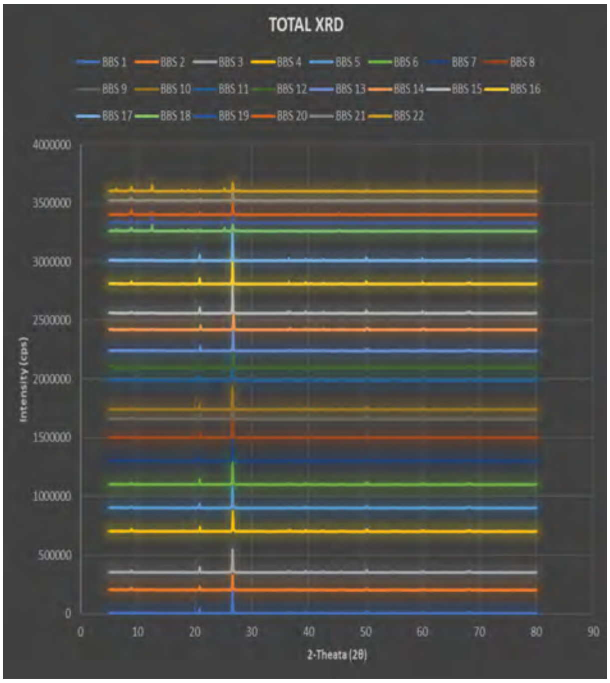

Figure 4: Total XRD patterns for all twenty two black shale samples of the Belata Formation.

RESULT AND DISCUSSION

Minerals present in the Belata black shale includes non-clay minerals (quartz, feldspars and muscovite with traces of calcite and pyrite) and clay minerals (kaolinite and chlorites) as shown in Figure 3.

While minerals such as quartz, feldspars and chlorite are products of detrital components of the Belata black shales, minerals such as carbonates and sulfides may have formed in the shales during burial or most probably as cementing or replacing materials similar to what was described by Boggs (2006).

The minerals present within the shales from all the outcrops are same, represented by the similar trends shown in Figure 4. Also, the shales are dominated by felsic or silicic minerals such as quartz and feldspars and hence could be interpreted as coming from a felsic provenance which is not too distant away from the place of deposition. Thus, feldspars are generally low resistant minerals to weathering as compared to quartz which has high resistance. The K-feldspar presence in the mineralogy indicates a short time exposure to weathering and/or diagenesis. The absence of mafic and ultramafic minerals such as olivine, pyroxenes and amphiboles support the felsic nature of the sediments which formed the black shales. However, for future work and recommendations, the use of higher magnification microscope such as the scanning electron microscope (SEM) and the use of other geochemical parameters such as major and minor element proxies would be employed to aid in the source rock as well as the depositional environment description of the shales. This is necessary because the minerals present in the shales may have been affected by other conditions such as weathering and burial diagenesis at variable conditions and these methods have been used by various authors (e.g. Morton, 1985; Fralick & Kronberg, 1997; Garzanti *et al.*, 2013; Newport *et al.*, 2016) to tell the conditions. The black shales of the Belata Formation probably originated from the hidden felsic igneous basement rock of Peninsular Malaysia, similar to what was described by Baioumy *et al.* (2016) for the other shales in the Peninsular.

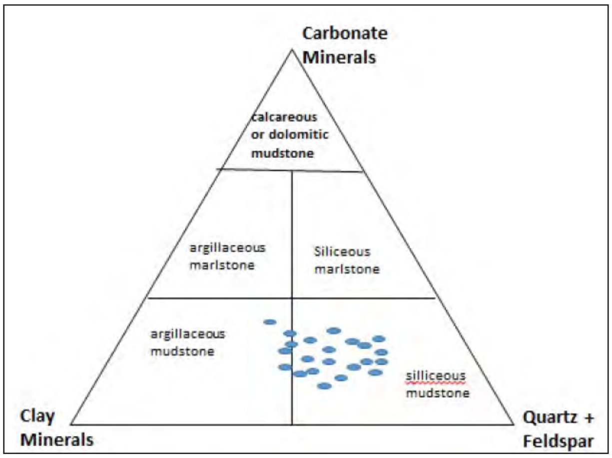

Figure 5: Classification of Belata black shales (after Allix *et al*., 2010).

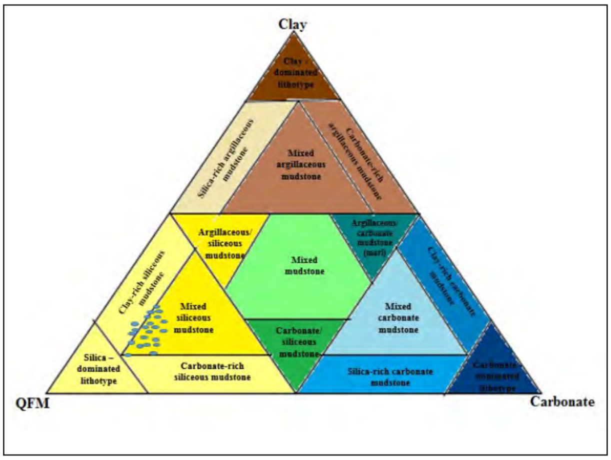

Figure 7: Ternary plot of the black shales of Belata Formation. Q- quartz, F- feldspar, M- muscovite (after Gamero *et al*., 2012).

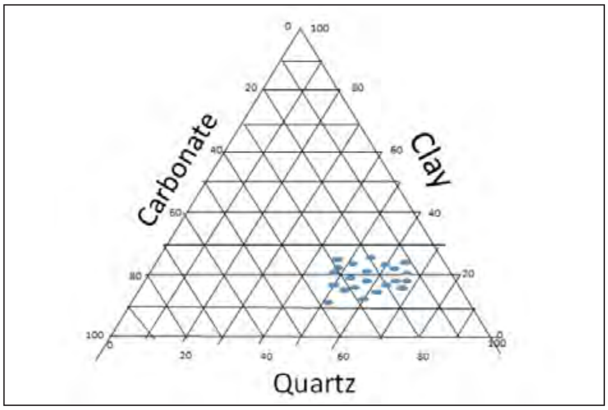

Figure 6: Simple classification of organic mudstone using ternary plot from Dunn *et al.* (2012).

Ternary diagrams have been proposed by various authors and used to describe the mineralogy and source rock of fine organic rich mudstones like shales. From the diagrams introduced by Allix *et al.* (2010); Dunn *et al.* (2012); Gamero *et al.* (2012) as seen in Figures 5, 6 and 7, the Belata black shales are dominant in quartz compared to the carbonates and clays hence are siliceous mudstones as they are plotted in the Mixed siliceous mudstone quadrant.

CONCLUSION

The Belata black shales are rich in felsic minerals such as quartz and feldspars. Minerals such as muscovite, calcite, pyrite, kaolinite and chlorite are also present, and this may indicate a felsic source of sediment. Therefore, it could be concluded that the Belata black shales have siliceous source of sediment. However, other analyses such as the use of the energy dispersive X-ray scanning electron microscopy (EDX/SEM) and other geochemical studies can aid in this study.

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Assessment of supporting system of Hulu Terengganu hydroelectric surge chamber cavern in Malaysia

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Abstract: When rocks are excavated, the in-situ stress is disturbed and thereby causes a state of instability due to the deformation caused by the creation of space in the in-situ rocks. This research assessed the supporting system used in a surge chamber cavern excavated for Hulu Terengganu hydroelectricity project in the northeast of Peninsular Malaysia. The results obtained were compared with the installed supports. Geological mapping of the excavated region was carried out to outline the discontinuity parameters of the rock. The rock mass quality (Q), the rock mass rating (RMR), the geological strength index (GSI) and the uniaxial compressive strength were evaluated using standard methods and procedures. The strength and rock mass properties were further used to classify the rock and establish the required standard supports for the surge chamber cavern. The wall height is approximately 40 m. It requires systematic bolting with 7 to 11 m length of rock bolt at a maximum wall spacing of 1.5 m. The required reinforce shotcrete falls within a thickness of 50-90 mm. The currently installed shotcrete is within the minimum of 50 mm thickness and has a spacing of 3.0 m along the wall which is too large for reliable safety. The cavity of the crown is critical and to consider unforeseen geological weaknesses in rock mass, maximum safety must be ensured by increasing the current thickness of the shotcrete and reducing the spacing to a maximum of 1.5 m as evaluated using the rock mass properties.

Keyword: Rock mass rating, geological strength index, deformation, shotcrete, cavern

INTRODUCTION

Large underground caverns are excavated for a variety of purposes in civil and mechanical engineering. They can be used for housing turbines, electrical generators and transformers in hydroelectric projects. Caverns are also used for storing liquid or gaseous fuels and underground sports facilities. Because of the capital-intensive nature of the project and the risks associated with public access to these facilities, adequate care must be taken in providing appropriate supports for the caverns to minimize potential risks while at the same time providing cost effective and practical engineering solutions.

As the rock mass is excavated, redistribution of the in-situ stresses occurs resulting in deformation and instability of the rock. Deformation is defined as relaxation of rock mass after the opening that caused changing in shape or size of the tunnel (Li *et al*., 2012; Xing *et al*., 2018). The deformation in a hard rock mass may be manifested as creep or displacement of the intact material along the discontinuities. In intact crystalline rocks, creeping depends on the temperature; time; shear strain and volumetric strain; effective pressure and confining pressure; moisture content and discontinuity geometry (Lacroix & Amitrano, 2013; Riva *et al*., 2018). Creeps in rock joints occur as normal compression and shear movements along the discontinuities (Mutlu & Bobet, 2006) . The movements will arise along the joint system with most unfavourable conditions and direction with respect to the excavation. This is due to the fact that the shear strength of a fracture is generally less than that of intact rock (Cowie & Scholz, 1992).

However, if appropriate supports are constantly installed at the tunnel face immediately after its excavation, the pressure increases with progress of the tunnel face and thus reducing its potential risk factors (Wu *et al*., 2015). (Barton, 2002) emphasized the necessity and increasing use of steel fiber and reinforced shotcrete in underground excavation supports. They submitted that the needed supports are related to the rock mass parameters – Geological Strength Index (GSI), Rock Mass Rating (RMR) and Rock Mass Quality (Q). The use of the Q classification system can be considerably beneficial at the preliminary design stage when less detail information on the rock mass, its state of stress and hydrologic characteristics are available (Barton, 2002).

The studied Surge Chamber Cavern (SCC) is part of the underground power station structure of Hulu Terengganu Hydroelectric Project located on northeast Peninsular in the state of Terengganu, Malaysia. It is on the upper rich of Sg. Terengganu, upper of Kenyir Lake reservoir and 100 km away from Kuala Terengganu. The Surge Chamber Cavern (SCC) is provided to protect the tailrace tunnel from water hammer effect due to fluctuation in load, it is located downstream of the draft tube and discharges into a single inclined long tailrace tunnel under pressure. The SCC has a dimension of 65 m length, 14 m width and 46 m height, constructed 200 m under surface in volcanic jointed rock. It was excavated using drilling and blasting technique from top elevation of 167.7 m to a bottom elevation of 121.5 m.

METHODOLOGY

The main objective of this study is to provide the deformation assessment of engineering geological characteristics of rock masses in the Surge Chamber Cavern (SCC) during excavation and construction until operation of power generation. For this aim, a detailed engineering geological study was carried out in the project area including field investigations, drillings and in-situ and laboratory testing; excavation monitoring comprises of geological mapping; geological over break and supporting system. Empirical and numerical analysis were also carried out.

A total of 14 hydraulic fracture tests were conducted on drill hole UT14-1D at various depths. The discontinuities intersected were analyzed and quantified. The mechanical properties of the rocks were also evaluated to obtain input parameters for the assessment of rock mass quality. The results were modeled to create approximate solutions for major principal stress, displacement of the surge chamber cavern boundary before and after installation supports.

The rock mass was classified based on the Rock Mass Quality (Q), Rock Mass Rating (RMR) and Geological Strength Index (GSI) (Hoek & Brown, 1997; Lin *et al.*, 2011; Palmstrom & Broch, 2006). Core drilling was performed to collect information about the rock mass conditions and the composition of possible weakness zones. Based on the results from the field investigations, the expected ground conditions were evaluated, and the major weakness zones localized and applied for the selection of the final tunnel (cavern) alignment. RocLab was used to evaluate the rock mass and deformation parameters based on Hoek-Brown *failure criterion* (Hoek & Brown, 1997). The strength and rock mass properties were further used to classify the rock and establish the required standard supports for the surge chamber cavern.

The discontinuities intersected were evaluated in terms of orientation, persistence, joint sets number, spacing, aperture, filling and roughness. Stereographic projection was done using Dip 6.0 from Rocscience. Laboratory tests were carried out to determine the unit weight, Young's modulus, Poisson's ratio and uniaxial compressive strength. Rock core samples were collected from borehole drilling investigations. All laboratory tests were conducted in accordance with the relevant ASTM and ISRM standards.

The Rock Mass Quality (Q) was evaluated as suggested by (Barton, 2002) using equation (1).

$$Q = (RQD/Jn).(Jr/Ja).(Jw/SRF) \quad (1)$$

Where RQD = Rock Quality Designation
Jn = Number joint sets
Jr = Joint roughness
Ja = Joint alteration
Jw = Joint water reduction
SRF = Stress Reduction Factor

To meet this end, (Hoek & Brown, 1997) produced the tables used to estimate values for these parameters. The RQD was estimated as suggested by Deere (1989). The support category was chosen based on the chart published by Barton (2002).

The following empirical relationships (Barton & Choubey, 1977) were used to evaluate bolt length as shown in equations (2) and (3):

$$L = 2+(0.15H/ESR) \text{ (For wall)} \quad (2)$$
$$L = 2+(0.15B/ESR) \text{ (For roof)} \quad (3)$$

Where, B = tunnel width, H = tunnel height and ERS = Excavation Ratio Support

RESULTS AND DISCUSSION

Tables 1, 2 and 3 show the summarized average values of rock mass quality (Q), Rock Mass Rating (RMR) and Geological Strength Index (GSI) respectively for nine various positions tested.

The rock strength and deformation parameters as obtained using RocLab is presented in Table 4.

Table 5 compares the installed supports at the site and the one evaluated in this research.

The result has summarized that SCC condition is a good rock with UCS of 50 to100 MPa, good RQD, joint spacing 60 cm to 2 m, slightly rough surfaces, low filling, dry and fair in orientation.

The support category based on Q assessment summaries the SCC has value 12 with rock class is good. The SCC has a crown 12 m of height, as required support

Table 1: Average Q value at 9 various positions in the SCC.

Description/ Rating	RQD %	Joint Set, Jn	Joint Roughness, Jr	Joint Alteration, Ja	Joint Water, Jw	SRF	Q
Description	75 - 90	2-3 Joint set + random	Rough to smth, undulating, slickenside	Slightly alter., little filling	Dry (minor inflow <5l/min)	Med. stress, favourable	Good
Rating	79	6.8	1.4	1.1	1	1.7	Good 12

Table 2: Averages RMR rating at 9 various positions in the SCC.

Description / Rating	UCS MPA	RQD %	Joint Spacing, m	Condition of Discontinuities	Ground Water	Orientation	RMR	Cohesion Mpa	Friction Angle, °
Description	50-100	75-90	0.6 - 20, some less 0.6	Slightly rough, low fill, slickenside	Dry	Fair	Good rock	0.339	39
Rating	7	17	14	19	15	-5	66		

Table 3: Average GSI rating at 9 various positions in the SCC.

Description / Rating	Roughness Rating (Rr)	Weathering Rating (Rw)	Infilling Rating (Rf)	SCR= $R_r+R_w+R_f$	Structure Rating (SR)	GSI	Rock Condition	Classification
Description	Smooth to slighty rough	Fresh to slighty rough	Hard > 5mm	Good, smooth slight w.	Blocky, less joint	60	Blocky	Good
Rating	2.0	5.8	4.7	12.4	62.5			

Table 4: Summary Rock Mass Strength and deformation parameters.

Rock Type	Deformation Modulus, Mpa	Friction Angle (deg.)	Cohesion, Mpa	UCS (Mpa)	Tensile Strength, Mpa
Undisturbed	33,800	55	1.7	8.026	0.267
Disturbed	11,106	48	1.1	3.561	0.086

Table 5: Supporting applied on site and calculation based on Q-value.

Position	Length of rockbolt, m	Spacing, m	Thickness of shotcrete, mm	Remark
Crown	6	2	100 reinforce (SRF)	Applied on site
Wall	6	3	50 reinforce (SRF)	
Crown	3 - 5	systematic	Un-reinforce 40 - 100	Evaluated Q-value, (Borton's)
Wall	7 - 11	1.3 - 1.5 m	Reinforce 50-90	

in crown are 4.0 m long and systematic rock bolts with unreinforced shotcrete 40-100 mm of thickness. The crown of the cavity is critical and to consider unforeseen geological weaknesses in rock mass. 100 mm thick SFR-40 shotcrete and rock bolts Type R4, 6.0 m long at 2.0 m spacing were currently applied on site.

The height of the wall is 40 m. The systematic support system requires a rock bolt of length 7 to 11 m to be installed at a maximum of 1.5 m wall spacing. The required reinforce shotcrete falls within a thickness of 50-90 mm as shown in Table 5. The currently installed shotcrete is within the minimum of 50 mm thickness and has a spacing of 3.0 m along the wall which is considerably too large for dependable safety. The cavity of the crown is dangerous and to consider unforeseen geological weaknesses in rock mass, maximum safety must be ensured by increasing the current thickness of the shotcrete and reducing the spacing to a maximum of 1.5 m as evaluated using the rock mass properties.

CONCLUSION

The rock mass has been classified based on the Q, RMR, and GSI classification systems as good rock. The strength and deformation parameters of rock mass from empirical correlation have varying results. The orientations of the discontinuities and the state of the in-situ stresses of the surge chamber is significantly affecting its stability. The supporting system requires more reinforcement at smaller spacing to ensure the stability of the wall and roof of the excavated Surge Chamber Cavern for enhanced safety.

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CERAMAH TEKNIK TECHNICAL TALK

Perkongsian pengalaman menyambung pelajaran di dalam dan luar negara

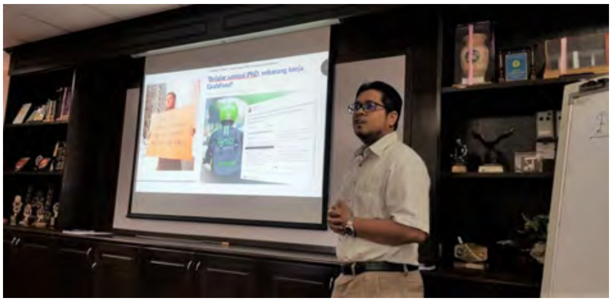
Nor Shahidah Mohd Nazer, Mohd Hariri Arifin,
Norasiah Sulaiman & Muhammad Ashahadi Dzulkafli

Date: 19 February 2020
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Persatuan Geologi Malaysia dengan kerjasama Institut Geologi Malaysia dan Program Geologi Universiti Kebangsaan Malaysia telah mengadakan satu ceramah perkongsian pengalaman menyambung pelajaran di dalam dan luar negara. Ceramah ini telah diadakan pada 19 Febuari 2020. Sesi perkongsian ini disampaikan oleh Dr. Nor Shahidah Mohd Nazer, Dr. Mohd Hariri Arifin, Dr. Norasiah Sulaiman dan En. Muhammad Ashahadi Dzulkafli. Pensyarah muda Program Geologi UKM ini telah berkongsi pengalaman dan langkah-langkah dalam mencari tempat untuk menyambung pengajian.

Berikut adalah antara foto-foto yang dirakam semasa sesi tersebut berlangsung di Bilik Mesyuarat, Program Geologi UKM.

Dr. Shahidah menyampaikan pengalaman beliau dan berkongsi langkah-langkah yang perlu diambil oleh bakal pelajar yang ingin menyambung pengajian di peringkat yang lebih tinggi.



En. Ashahadi turut mengulas isu pengangguran di kalangan graduan dan langkah untuk mengurangkan isu pengangguran di kalangan graduan.

Antara tetamu yang datang dan sempat bergambar kenangan bersama pembentang. Dari kiri: Dr. Hariri, En. Kamal, Cik Lisa, En. Ashahadi, Dr. Norasiah dan Dr. Shahidah.

Pelajar sedang mendengar taklimat yang sedang disampaikan. Program ini turut disokong oleh pensyarah kanan di Program Geologi UKM.

*****Laporan disediakan oleh Dr. Mohd Hariri Arifin dan Dr. Nor Shahidah Mohd Nazer. Jika perlukan bahan pembentangan tersebut, boleh emel kepada hariri@ukm.edu.my atau shahidahnazer@ukm.edu.my.*

CERAMAH TEKNIK TECHNICAL TALK

Studying in the US: A Malaysian geologist's experience

Lisa NurMarini binti Mohd Kamal (Lisa Kamal)
Date: 4 March 2020
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Lisa Kamal shares her experience obtaining her undergraduate degree in the United States of America. Under the sponsorship of PETRONAS, she was given the opportunity to study geology at the University of Wisconsin-Madison. She will share her journey from an ambitious SPM leaver obtaining a scholarship to becoming the student speaker at her graduation ceremony. As surviving university was not easy, Lisa will share how she managed her responsibilities and tips to excel as a college student. On top of that, she will share her experience as a student in the Department of Geoscience at UW-Madison, along with information regarding her geology coursework and field trips.

Lisa Kamal received her Bachelor of Science degree in Geology from the University of Wisconsin-Madison, the largest public research university in the state of Wisconsin. As an undergraduate, she started working at the Wisconsin Geological & Natural History Survey in data preservation projects and bedrock mapping projects. She has also gained research experience in microanalysis through her senior year project studying electron beam damage on carbonates using electron microprobe analyzer and scanning electron microscope, supported by the Hilldale Undergraduate Research Fellowship. During her undergraduate, she was an active student member of the Geological Society of America (GSA) and has been sponsored to attend the annual GSA meeting in 2017 under the On to The Future (OTF) travel award from GSA and in 2018 under a travel award from the National Science Foundation (NSF). Her academic achievements were recognized by the Department of Geoscience with the Lowell R. Laudon Outstanding Junior award in 2019.

CERAMAH TEKNIK TECHNICAL TALK

Cabaran kebolehpasaran geologis dalam industri – Survival for the fittest

Ahmad Nizam Hasan (Geosolution Resources)
Date: 4 March 2020
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Encik Ahmad Nizam merupakan antara 'orang lama' dalam bidang geosains. Beliau telah membentangkan ceramahnya berkenaan cabaran kebolehpasaran geologist dalam industri. Sebagai orang lama, beliau telah berkongsi naik bangun beliau dalam menguruskan syarikat beliau dan peri penting geosaintis melibatkan diri dalam persatuan.

Abstrak: Saban tahun menunjukkan peningkatan yang begitu ketara jumlah graduan geologi daripada universiti awam dan swasta. Namun begitu kebolehpasaran graduan-graduan tersebut juga menunjukkan kadar penggangguran yang semakin meningkat. Trend tersebut adalah disebabkan kekangan di pihak industri di mana semenjak tahun 2017, mengalami kesan kegawatan ekonomi yang kian menghimpit dan meruncing. Keadaan ini menyebabkan peluang bilangan geologis diambil semakin berkurangan dalam pelbagai sektor, malah ada yang terpaksa diberhentikan bagi pengurangan kos operasi atau syarikat gulung tikar.

Bagi pemain industri yang masih bertahan, peluang ini diambil manfaat dengan mengenakan lebih tekanan dari sudut pemilihan calon-calon geologis muda bukan sahaja dari aspek nilai penggajian malah lebih penting memilih bakat-bakat yang mempunyai ciri-ciri yang lebih meyakinkan. Akan tetapi keterampilan dan kecemerlangan akademik bukanlah tiket terpenting dalam kriteria pemilihan pemain industri kini tetapi ciri-ciri tambah nilai berbentuk `soft skill' seperti komunikasi, disiplin, pengurusan, dinamik, daya tahan, skil teknologi IT dan kreatif dalam aplikasi pengetahuan asas geologi yang mantap dan kukuh dalam `problem solving' merupakan faktor yang paling penting diambilkira. Justeru itu; apa, di mana dan bagaimana persiapan bakal graduan geologi menjurus kepada cabaran ini. `Survival for the fittest' adalah ungkapan yang bukan lagi retorik! Hanya yang awal bertindak meningkatkan kebolehupayaan pasaran diri akan lebih selesa dalam menongkat arus cabaran kelak.

Bersama-sama saya berkongsi pengalaman dalam memecah kepompong `inferiority complex' sebagai persiapan awal mental dalam merentas onak-duri alam industri.

CERAMAH TEKNIK TECHNICAL TALK

Bidang tugas ahli petrofizik dalam evaluasi batu takungan

Fadzlin Hasani Bin Kasim (PETRONAS)
Date: 11 March 2020
Venue: Bilik Mesyuarat, Program Geologi, Bangunan Geologi, FST, Universiti Kebangsaan Malaysia

Encik Fadzlin menyampaikan tajuk pembentanganya berkisar tentang peranan ahli petrofizik dalam menilai batuan takungan. Selain itu, pada akhir sesi pembentangan beliau turut berkongsi tips untuk pelajar dan pendengar yang hadir menceburi dalam bidang petrofizik. Sesi ceramah beliau juga turut dimeriahkan dengan beberapa sesi perkongsian pendek dari alumni geologi UKM yang lain.

Abstrak: Evaluasi batu takungan merupakan proses yang penting untuk menentukan potensi ekonomi sesuatu *field*. Setiap ahli kumpulan *subsurface* menggunakan kepakaran tersendiri untuk perkara tersebut yang kemudiannya digabungkan menjadi satu. Untuk penentuan jumlah isipadu hidrokarbon, terdapat tiga input dari ahli petrofizik iaitu purata keliangan *(average porosity*), nisbah potensi kepada keseluruhan (*net to gross*) dan ketepuan hidrokarbon (*average hydrocarbon saturation*). Manakala untuk penentuan kadar pengeluaran hidrokarbon dari sesuatu batu takungan, nilai kebolehtelapan (*permeability*) perlu dihitung menggunakan kaedah yang telah ditentukan. Semua parameter di atas di kira berdasarkan data mentah dari lapangan seperti; *Gamma ray, resistivity, bulk density,* dan *neutrón porosity* Antara tugas lain ahli petrofizik adalah penentuan jenis batuan, pengelasan dari lithofasies kepada elektrofasies dan menentukan jenis cecair; gas, minyak atau air. Contoh evaluasi petrofizik untuk *field* XY *Malay Basin* dilampirkan.

Laporan Aktiviti Kerja Lapangan

Satu trip kerja lapangan anjuran Persatuan Geologi Malaysia telah diadakan pada 16 dan 17 November 2019. Seramai 22 orang peserta terdiri daripada geosaintis dan ahli akademik, pelajar geologi serta saintis cilik. Trip kali ini bertemakan mata air panas dan pinakel batu kapur. Lawatan ke Kg. Ulu Slim dan FELDA Sungai Klah adalah bertujuan untuk melihat contoh pembentukkan mata air panas yang paling panas di Semenanjung Malaysia. Manakala lawatan ke bandar baru Kampar, Perak adalah bertujuan melihat pembentukkan pinakel batu kapur yang sangat menarik untuk dijadikan geotapak.

Berikut adalah antara foto-foto yang dirakam semasa kerja lapangan tersebut berlangsung.

Antara peserta terawal sampai di tempat berkumpul di stesen Petronas pekan Slim River. Dari kiri: Timbalan Presiden Persatuan Geologi Malaysia (En. Askury Abd Kadir), wakil dari Jabatan Mineral dan Geosains (En. Noor Akhmar Kamarudin dan En. Tuan Rusli Tuan Mohamad) dan ahli majlis Persatuan Geologi Malaysia (Cik Norazianti Asmari).

Rakaman imej FLIR di lokaliti pertama iaitu di Kg. Ulu Slim. Suhu tertinggi yang direkodkan oleh bacaan termometer adalah 92°C.

Pemandangan di sekitar telaga air panas(40°C) Sime Darby yang terletak sekitar 5 km dari lokasi mata air panas Kg. Ulu Slim.

Peserta singgah makan tengahari di Restoran Nasi Bamboo, Sungkai.

Peserta menginap di FELDA Resident Hot Spring, Sungkai.

Lokasi yang wajib dilawati untuk merebus telur di kawasan FELDA Resident Hot Spring. Lokasi ini merupakan antara spot mata air panas terpanas dengan suhu yang direkodkan adalah sekitar 99°C.

Pemandangan pinakel batu kapur pada bahagian hadapan dan granit Gunung Bujang Melaka pada bahagian belakang.

Rakaman sebahagian peserta di pinakel batu kapur bandar Baru Kampar, Perak.

**Laporan disediakan oleh Dr. Mohd Hariri Arifin dan Norazianti Asmari. Jika perlukan maklumat lanjut berkenaan aktiviti ini, boleh emel kepada hariri@ukm.edu.my; noraziantiasmari@gmail.com.*

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THANK YOU

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Program Geoscience@school dianjurkan oleh Jabatan Geosains, Fakulti Sains Bumi UMK dengan kerjasama Persatuan Geologi Malaysia (GSM). Tujuan program ini dijalankan adalah untuk memupuk minat pelajar terhadap bidang sains di samping mempromosikan program Geosains UMK. Program ini dianjurkankan pada 22 September 2019 di SK Jeli (1) dan 23 Oktober 2019 di SMK Ayer Lanas, Kelantan. Seramai 7 orang pensyarah dan 70 orang pelajar dari Program Geosains telah terlibat secara langsung dalam program ini. Antara aktiviti yang dijalankan dalam program ini adalah seperti pameran batuan dan mineral, pembentangan poster serta permainan interaktif bersama pelajar sekolah.

Selain daripada itu, beberapa pameran turut diadakan yang merangkumi beberapa topik berkenaan geologi, di mana pelajar di perkenalkan dengan jenis-jenis batuan dan mineral yang terdapat di sekitar Kelantan dan Malaysia. Selain daripada itu, beberapa model proses geologi turut disediakan seperti model kitaran air. Album-album yang mempamerkan aktiviti-aktiviti dan program-program yang dianjurkan oleh Geosains UMK seperti International Geomapping Gua Musang (IGGM), Geo Exploration de Langkawi dan Geo Tour de Malaysia turut dipamerkan bagi menarik perhatian pelajar.

Disediakan oleh:
Mohammad Muqtada Ali Khan, Ahmad Shafie & Khairul Hakim

Marine Fossil Hunting, Terengganu

The wonder of palaeontology was being shared with students and communities through Marine Fossil Hunting @ Terengganu that was organised by the Marine Geoscience Program of Universiti Malaysia Terengganu (UMT) in collaboration with the Mineral and Geoscience Department and the Geological Society of Malaysia. The event was held on the 20th to 22nd of January 2020 at Bukit Buchu, Bukit Keruak and Bukit Keluang of Terengganu. The event was facilitated by four geological experts, Prof. Dr. Mohd Shafea Leman (Langkawi Research Center), Prof. Dr. Che Aziz Ali (Universiti Kebangsaan Malaysia), Mr. Ahmad Rosli Othman and Mrs. Azrah Atan (Mineral and Geoscience Department, Malaysia).

Approximately 70 participants were actively involved in this event. The participants are from public universities such as Universiti Malaya (UM), Universiti Teknologi Petronas (UTP) and Universiti Malaysia Terengganu, and other private industries. The 3-day event started off with a talk by Prof. Dr Mohd Shafeea Leman entitled "Fossil Wonderlands : Nature's Hidden Treasure" that touched on the fossil understanding regarding the extinction of species and plate tectonic movements. The session was continued by Prof. Dr Che Aziz Ali with an interesting talk on "A Rock Reveals the Story of the Ocean" which unfolds the story of rock formations of which 90% were formed in the ocean. The session was ended by Mr. Ahmad Rosli Othman with a talk on "The Flora Fossil of Bukit Keruak" which explained about the carboniferous era in Malaysia.

Later in the afternoon, the first exploration was kicked off in Bukit Buchu where the type of fossils found here is Carboniferous, aged between 354 to 290 million years ago. Among the fossils found here are brachiopods, bryozoans, crinoids, ammonites and trilobites, which are all marine fossils. This evidence shows that the area was once a shallow marine environment. On the second day, the exploration continued at Bukit Keruak which is famously presumed as an untouchable area. Fossils found at Bukit Keruak are aged between 298 and 251 million years ago, and younger, compared to the fossils at Bukit Buchu. Fossils found include *Neuropteris* sp. and species from the Unionidae family which are known as freshwater organisms. The area is concluded to be once a freshwater area with the evidence from the fossil found.

The participants also had a chance to present their experience throughout the event and the knowledge they had gained, as well as provide some feedback for the event organiser.

On the last day, the participants were also able to hunt for trace fossils which are abundantly distributed along the coast of Bukit Keluang. This event was successfully held in Terengganu with the support from the participants and all collaborators. Similar event is also planned to be held annually with more enjoyable activities for the participants.

Prepared by:
Syazana Md Shubri
Secretary, Marine Fossil Hunting @ Terengganu,
Marine Geoscience Program,
Universiti Malaysia Terengganu

Excited fossil hunters of the Marine Fossil Hunting@Terengganu event.

Registration Day for Marine Fossil Hunting@Terengganu.

Talk by Mr. Ahmad Rosli Othman from the Department of Mineral and Geoscience Malaysia (JMG).

Talk by Prof Dr Mohd Shafeea Leman from Langkawi Research Centre.

Talk by Prof. Dr Che Aziz Ali from Universiti Kebangsaan Malaysia (UKM).

The backbone of the Marine Fossil Hunting @Terengganu event with some of the participants.

Some of the committee members involved in the successful three-day event.

Rain did not stop all the fossil hunters from continuing the second day exploration at Bukit Keruak.

Fossils found at Bukit Buchu.

UPCOMING EVENTS*

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

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

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

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

September 14-17, 2020: 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.

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

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

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

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

November 23-26, 2020: National Geoscience Conference, Bangi, Selangor, Malaysia. For further information, please visit https://www.igm.org.my/component/rseventspro/event/78-33rd-national-geoscience-conference-and-exhibition.

November 25-26, 2020: International Conference on Earth Sciences and Environment (ICEMEN 2020), Langkawi Island, Kedah, Malaysia. For more details on the conference, please visit: http://www.icemen2020.com.

* Subject to re-evaluation by the organizers due to the unprecedented disruptions brought about by the COVID-19 pandemic.

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Book:

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Chapter of book and Symposium volume:

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

Article in Malay:

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

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