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A new middle Permian waagenophyllid rugose coral species, *Ipciphyllum dilatum* sp. nov. from the Shan Plateau, Myanmar

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Abstract: A new rugose coral, *Ipciphyllum dilatum* sp. nov. is described and illustrated from the Thitsipin Limestone of the Plateau Limestone Group of middle Permian (Roadian-Wordian) substages of the Shan Plateau, Myanmar. This new taxon is distinct from all other previously described species by having all septa in the tabularium being dilated, smaller corallite diameter, and lack of the medial plate in the axial column. It is palaeogeographically significant that it co-occurs with other middle Permian rugose coral species, *Yatsengia hangchowensis*, *Iranophyllum* sp. cf. *caracinophylloides*, *Ipciphyllum subelegans*, *Pavastehphyllum* sp., *Pavastehphyllum* (*Thomasiphyllum*) sp. in the Linwe area of the Shan Plateau region. This fossil assemblage is correlated with that of China, Thailand, Iran, and Malaysia. The similarities of middle Permian rugose corals between Myanmar and Malaysia clearly indicate that both were at a close paleogeographic position likely in the Cathaysian paleogeographic provinciality during the middle Permian. The new species demonstrates variability within five parameters: number of sides of corallite wall, nature of septa, number of septa, development of dissepiments, and variation of axial structure. From this work, it should be noted that, intraspecific variability is one of the basic criteria for identification of the rugose coral species.

Keywords: Middle Permian, rugose coral, new species, Myanmar

INTRODUCTION

The Permian limestone sequences of the Shan Plateau region, Shan State have yielded rich fossil coral, brachiopod, bryozoan, fusuline, and crinoid faunas that have significantly aided in the development of a biostratigraphic framework for the Shan Plateau. Initially, these faunas greatly assisted the geological mapping of the area. Stratigraphic correlations of the Permian strata throughout the region have been based on common stratigraphic position, lithology and totally identical fossil assemblages. Nevertheless, little has been published partly or wholly of the Permian coral faunas. Smith (1941) described seven species of rugose coral from five genera and three tabulate species collected by V. P. Sondhi from the "Plateau Limestone" of the southern Shan State. His coral faunas were obtained from five localities: Htam Sang, Pangtara (Pindaya), Poila (Pwehla), Alegyaung and Pon. Some unpublished reports on the Permian corals include, Myint Thein (1982) and in the frame of Master of Research and Master of Science studies on the corals which were carried out in the areas of the southern Shan State, Taung-ni (Soe Moe Lwin, 2003) and Thayetpya (Thandar Tun, 2010). The considerable numbers of coral specimens were collected by Aye Ko Aung, staff and students of Taunggyi and Dagon universities. He documented Permian rugose corals collected from 19 localities in southern Shan State: Thitsipin, Kyaukkupyin, Ye-U, Nwabangyi, Kazet, Linwe, Pegin, Kyauktaw, Hsinsapya, Kyauknget, Shwepahtoe, Konlon, Thayetpya, Yechanzin, Pwehla, Taungni, Hopong, Htamsang, and Banyin (Aye Ko Aung, 2011). Aung Myo Zaw (2014) first described five coral species belonging to four genera *Yatsengia hangchowensis*, *Iranophyllum* sp. cf. *caracinophylloides*, *Ipciphyllum subelegans*, *Pavastehphyllum* sp., and *Pavastehphyllum* (*Thomasiphyllum*) sp., from the Thitsipin Limestone of the Pegin-Linwe area, Ye-ngan Township, southern Shan State. The study area (Pegin-Linwe) is located about 13 km (8 miles) NE of Ye-U, Ye-ngan Township, southern Shan State (Figure 1). Documenting intragroup variation is necessary for differentiating fossil species especially for rugose corals because of the high variation well observed in, phylum Cnidaria, which includes Rugosa and Tabulata. Variation is noted in length and width, degree of curvature, number and relative position of dilated skeletal elements. It is necessary to consider the following criteria during identification; diagnostic characters of mature specimens,

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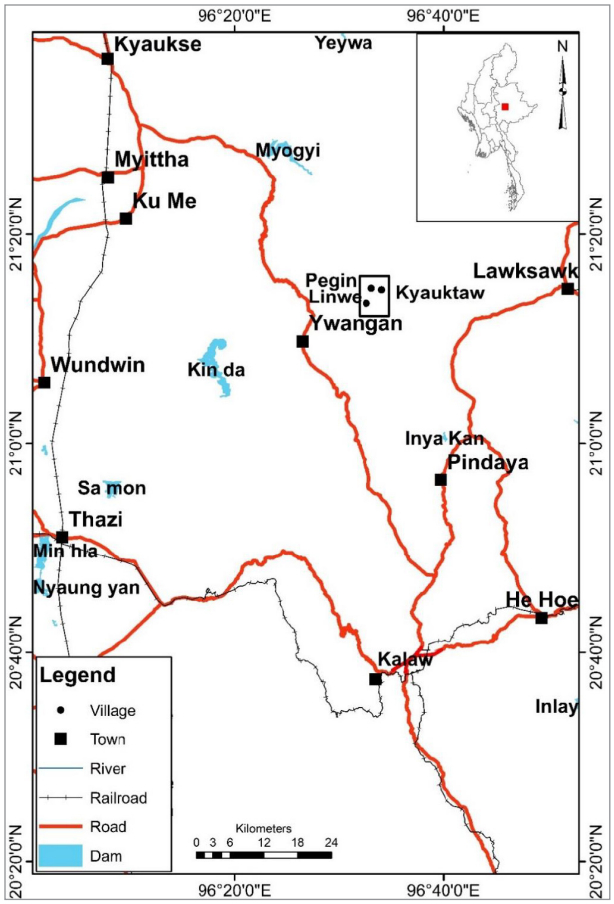

Figure 1: Locality map of the Pegin-Kyauktaw area.

ontogenetic development, and microstructure, which are morphological characteristics seen in the rugose corals are important in generic classifications. Intraspecific variability is a characteristic feature of many rugose corals but few examples have been well documented. The following papers on variation in rugose corals were submitted in the Fifth International Symposium on Fossil Cnidaria in 1988, Brisbane. Oliver (1989) described intraspecific variation in Pre-Carboniferous rugose corals. Fedorowski (1989) pointed out the intraspecific variation in Carboniferous and Permian rugose corals. Sutherland (1989) showed intraspecific variability in rugose coral *Stelechophyllum? mclareni* from the Carboniferous (Visean) of northeastern British Columbia. Sorauf & Mackey (1989) studied variation and biometrics in rugose corals.

Similarly, variation can be observed in other kinds of invertebrate fossils from Myanmar Permian strata, such as Bivalvia, Gastropoda, Trilobita, Cnidaria and Bryozoa. In the present work, the phylum Cnidaria is chosen by the authors for the study of intraspecific variation. The Permian corals are found in various localities in Myanmar, occurring at several horizons and are rather sporadically distributed in the Permian sequence of the southern Shan State. In this paper, we study the intraspecific variability in the rugose coral *Ipciphyllum dilatum* sp. nov. from the Permian Thitsipin Formation, near Phaya Cave, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State (Figure 1). This collection was made by the first author, a second year Honours student, Department of Geology, Dagon University in 2007.

Stratigraphic setting

The thick carbonate sequence of the Plateau Limestone Group (Brown & Sondhi, 1933) extensively outcrops in the southern Shan State. This paper follows the formation division described by Amos (1975) and Garson *et al*. (1976): the Thitsipin Limestone Formation (Permian), the Nwabangyi Dolomite Formation (late Permian-early Triassic), and the Natteik Limestone Formation (middle Triassic). The type section of the Thitsipin Limestone Formation is at the Thitsipin village, north of Ye-ngan Township and it is widely distributed northeast and southeast of Ye-ngan. It is also exposed in other regions: Taungni area, Taunggyi Township; Banyin, Naung Kha and Htam Sang, Hopong Township; Mong Pawn Township; Konlon Taung, Pindaya, Thayetpya, Yechanzin and Pwehla, Pindaya Township; and Nyaung-che-dauk, Heho Township. It consists of light to dark gray colored bedded to massive limestone and wackestone. Locally the limestone has been dolomitized, and it is extensively brecciated. Garson *et al.* (1976) divided the Thitsipin Limestone into three main facies: the massive limestone facies, massive cherty limestone facies, and the well-bedded calcarenite facies. The Thitsipin Limestone Formation contains fairly abundant fossils including corals, brachiopod, bryozoa, and fusulinids. The Thitsipin Limestone unconformably overlies the older Paleozoic rocks and it is conformally overlain by the Nwabangyi Dolomite Formation of late Permian to early Triassic age.

MATERIALS AND METHODS

Specimens were studied using light microscopy of the transverse and longitudinal thin-sections of the rugose corals. The rugose coral terminology and supergeneric classification follows that of Hill (1981). The abbreviations used are: N = number of septa; D = diameter of corallite in mm.

Repository

The coral fossil specimens are housed in the Dagon University Geology Museum and are prefixed by DUGM (Table 1).

Systematic palaeontology

Class ANTHOZOA Ehrenberg, 1834
Subclass RUGOSA Milne Edwards & Haime, 1850
Order METRIOPHYLLINA Spassky, 1965
Suborder PLEROPHYLLINA Sokolov, 1960

Family WAAGENOPHYLLIDAE Wang, 1950
Genus *Ipciphyllum* Hudson, 1958
Type species Ipciphyllum ipci Hudson, 1958

Diagnosis: Cerioid, axial column with thin, irregular persistent medial plate, radial lamellae and prominent conical axial tabellae, septa thin or somewhat thickened particularly in tabularium, and crestal in lonsdaleoid parts of wide dissepiment with normal concentric or anguloconcentric dissepiment tabularium occupies greater part of corallite, formed of wide outer zone of elongate almost vertical cytose clinotabullae and of narrow periaxial zone of horizontal tabulae (Hill, 1981).

Geological range and distribution: Upper Permian (*Parafusulina-Yabeina Z.*), Asia (Turkey, Iraq, Iran, Laos, Vietnam, China, Timor, Japan and Myanmar).

Ipciphyllum dilatum sp. nov. Figure (2 A&B)

Holotype: DUGM-(3005a-b) from middle Permian Thitsipin Limestone, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, Myanmar.

Etymology: Composed of dilated septa.

Material studied: A single corallum (DUGM 3005), Middle part of the Permian Thitsipin Limestone, Plateau Limestone Group, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, Myanmar.

Description: The corallum is compound, massive, and cerioid. In transverse section corallite are regularly polygonal, having five to seven sides, approximately 7 to 11.5 mm in diameter in the mature stages. They are circular to triangular in shape in the earlier stages. Corallite walls are thin and slightly undulating. Two orders of septa are radially arranged and are sometimes made discontinuous by the presence of small, lonsdaleoid dissepiments at the corallite corners. As many as 19 to 25 major septa, alternating with the same number of minor septa, are present in the mature corallites. Major septa nearly reach the axial column, but ordinarily do not touch; it even in the earlier stages. They are somewhat axially curved.

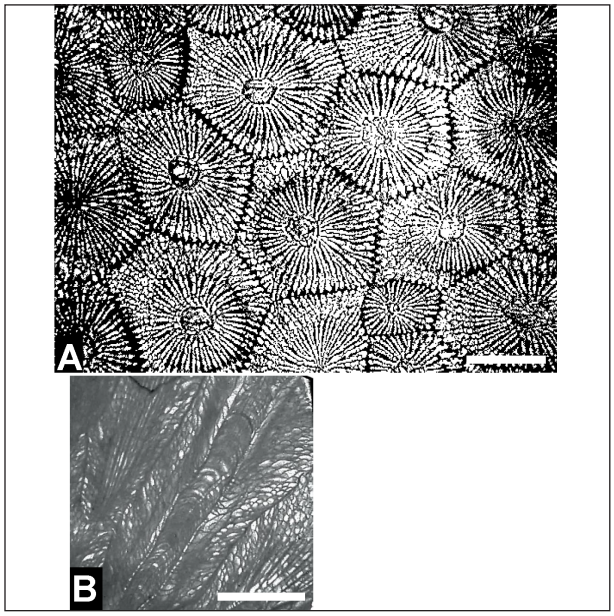

Figure 2: *I. subtimoricum dilatum* sp. nov. A) DUGM 3005, Holotype, transverse section of the cerioid corallum; B) DUGM 3005, Holotype, longitudinal section; from Phaya Cave, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, showing general characters of the morphologic variation (scale bar = 2.5 mm).

Minor septa are a little shorter and thinner than major septa. Somewhat thickened septa in the tabularium coupled with slight dilation of the innermost series of dissepiment from a faint inner wall. The axial column is circular to sub elliptical in outline and ranges from 1.0 to 2.5 mm in diameter, occupying about one-fifth to one-fourth of the diameter of corallite. It is free from the axial ends of major septa and consists of radially disposed septal lamellae, sometimes showing a prominent medial plate; and several rows of axial tabellae. The tabularium is narrow and annular 0.6 to 1 mm in width. The dissepimentarium is wide and is filled with several rows of small dissepiments of concentric to angulo-concentric arrangement. At the corallite corners small and irregularly formed lonsdaleoid dissepiments are present. In longitudinal section, corallite walls are thin, tabulae are complate, 1 to 2 mm in width, the tabularium is composed of almost upwardly convex transverse tabulae, six to twelve transverse tabulae occur in a vertical distance of 5 mm; dissepimentarium is comparatively wide; dissepiments irregular in size and shape, three to eight rows of globose and steeply to gently inclined elongated dissepiments are present.

Comparison and remarks: The Myanmar specimen is compared with those of the previously described species, *Ipciphyllum subtimoricum* (Huang, 1932) from Nesan Formation, Abadeh, Iran (Ezaki, 1991). The present species is distinguished from the later by having highly dilated major septa, smaller corallite diameter, and greater number of septa. The axial column in Myanmar form is circular to sub-elliptical in outline. It has no prominent medial plate in the axial column like Iran form. The new species is closely allied to *Ipciphyllum stabilis* Zhao, described and illustrated by Ezaki, 1991, but it is distinguished from the latter in having a larger axial column and a wider tabularium. The new species falls in the group of *Ipciphyllum*, however, it is differing from other *Ipciphyllum* species by comparison of their morphological characters, such as: *I. subelegans* Minato & Kato, 1965 from Central Thailand (Fontaine *et al*., 1994); from Bukit Kepayang, Pahang State (Fontaine & Suteethorn, 1988); from Bukit Biwa, Terengganu state, Malaysia (Kato & Ezaki, 1986); from the Thitsipin Limestone, Pegin-Linwe area, Ye-ngan Township, southern Shan State, Myanmar (Aye Ko Aung, 1994; Aung Myo Zaw, 2014; 2024); from the Taungni area, Taunggyi Township, southern Shan State (Soe Moe Lwin, 2003); Thayetpya area, Pindaya Township, southern

Table 1: *Ipciphyllum dilatum* sp. nov.: Some dimensional characters of representative corallites (mm) housed in the Dagon University Geology Museum.

DUGM Cat. No	Dc	Dt	Dt/Dc	N	Preparation
3005	1.5	5.5	0.3	19	transverse section, longitudinal section
3006	4	2.5	0.6	32	transverse section
3007	5	3	0.6	32	transverse section
3008	4.5	3	0.67	30	transverse section
3009	6.5	5	0.77	34	transverse section
3010	6	4	0.67	38	transverse section
3011	7	6.5	1.0	25	transverse section

Dc = corallite diameter, Dt = tabularium diameter, N = number of septa

Shan State (Thandar Tun, 2010) (Table 2). At a glance, the present form appeared to the authors as representing a new subspecies of *Ipciphyllum subtimoricum dilatum* sub sp. nov. However, following the kind comments of the reviewer (1), we made taxonomic reinvestigation, and it suggests the taxon a new species.

ANALYSIS OF VARIABILITY

To show variation of specific characters within single a corallum, five serial transverse thin sections were prepared for this study. One transverse section contains 25 corallites; of these, 14 corallites are selected for the detailed study of variation. As the new subspecies is typical for previously studied Permian corals, morphological variability within this single corallum is high (Figure 2). The present species is varied in the following characteristics:

1. Number of sides of corallite wall
2. Nature of septa
3. Number of septa
4. Development of dissepiments
5. Variation of axial structure

Number of sides of corallite wall

This species has a corallite diameter that varies from 4 to 9.5 mm within an individual corallite. The number of corallites walls also varies in a mature specimen. Almost all corallites contain six to seven-sided walls but a few corallites composed of four (or) five sided (Figure 3).

Nature of septa

Figure 4 shows the septa from three areas: the dissepimentarium, the tabularium, and the axial area. In the dissepimentarium, most of the corallites comprises tapering septa (Figure 4A), some have sinuous septa (Figure 4B), and a few corallites show thickened septa (Figure 4C) in mature corallum. All septa in the middle part of tabularium area (Figure 4).

Number of septa

The numbers of septa are different between larger and smaller corallites within a single corallum. Larger

Table 2: Comparison of *Ipciphyllum dilatum* sp. nov. of the Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State and *Ipciphyllum* species from other areas (mm).

	Dc	Dt	Dt/Dc	N	Ad
1	1.5-7	2.5-6.5	0.3-1	0.3-1	1.0-2.5
2	7-10.5	5.5-6.5	0.4-1.3	17-22	1.4-2.1
3	6.3-7.8	1.0-1.6	0.2-0.21	18- ?	1.2-1.6
4	6.0-8.5	-	-	16-20	1.2-1.8
5	10.5	0.7-1.2	0.06	15-17	1.4-2
6	6-7	2.5-3.5	0.4-0.5	20	1.5-1.6
7	5	3	0.6	32	2-1
8	4-6.5	2.5-5	0.5-0.77	32-44	16-20
9	5-6	3-3.5	0.6-0.58	52	-
10	5-7.5	3-5	0.5-0.77	32-44	16-20

1. *Ipciphyllum dilatum* sp. nov. Pegin-Kyauktaw area (Thitsipin Limestone), southern Shan state, Myanmar (This study).
2. *I. subtimoricum* (Huang, 1932) (Nesen Formation), Iran (Ezaki, 1991).
3. *I. huangi* Minato & Kato, 1965 (Surmaq Formation), Iran (Ezaki, 1991).
4. *I. subelegans* Minato & Kato, 1965 (Surmaq Formation), Iran (Ezaki, 1991).
5. *I. guangdongense* Xu, 1984, (Surmaq Formation), Iran (Ezaki, 1991).
6. *I. subelegans* Minato & Kato, 1965, Kampong Awah quarry, Pahang, Malaysia (Kato & Ezaki, 1986).
7. *I. subelegans* Minato & Kato, 1965, Taungni area, Taunggyi Township, southern shan State (Soe Moe Lwin, 2003).
8. *I. subelegans* Minato & Kato, 1965, Thayetpya area, Pindaya Township, southern Shan state (Thandar Tun, 2010).
9. *I. subelegans* Minato & Kato, 1965, Pegin-Linwe area, Ye-ngan Township, southern Shan state (Aung Myo Zaw, 2014).

Dc = corallite diameter, Dt = tabularium diameter, N = number of septa, Ad = axial diameter.

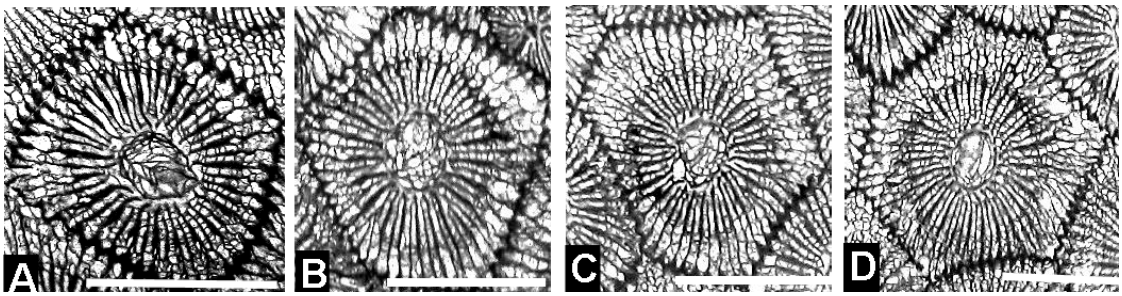

Figure 3 A-D: Variation in the number of corallite walls, A) refer to four sided, B) five sided, C) six sided, and D) seven sided (scale bar = 1.5 mm).

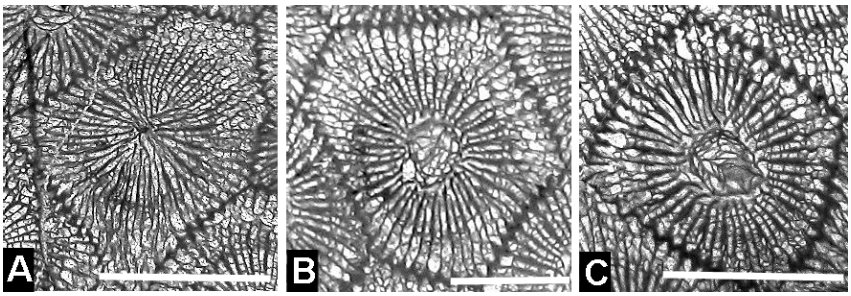

Figure 4 A-C: Variation in the nature of septa in single corallum (scale bar = 1.5 mm).

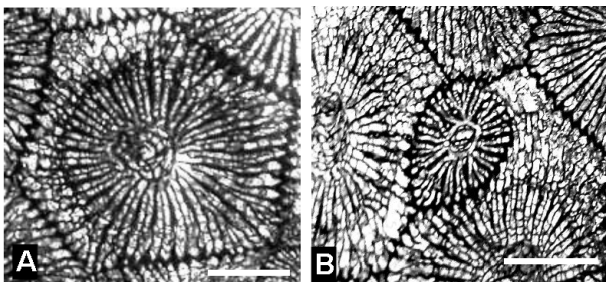

Figure 5 A, B: Variation in the number of septa (scale bar = 1.5 mm).

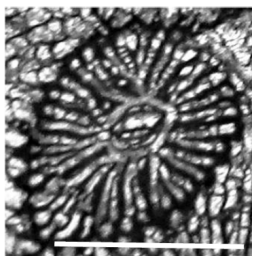

Figure 6: Smaller corallite showing poorly developed dissepiments (scale bar = 1.5 mm).

corallite (9 mm) contains 50-56 septa, while a smaller corallite may have 34 septa. The number of septa is directly proportional to corallite diameter (Figure 5).

Development of dissepiments

During growth of individual corallites, lateral dissepiments are well developed but some corallites have poor development of Lonsdaleoid dissepiments. No dissepiments developed in smaller corallite during mature stages (Figure 6).

Variation of axial structure

Axial structures varies in the corallum described. Three kinds of axial structure occur in this species, which are non-axial structure, simple axial structure and septal lamellae axial structure. Some corallites have a confluence of septa rather than the axial structure (Figure 7). Almost all corallites have a simple axial structure, but a few have septal lamellae in the axial area.

CONCLUSION

This paper has introduced a new waagenophyllid rugose coral species *Ipciphyllum dilatum* sp. nov., from the Thitsipin Limestone of the "Plateau Limestone Group". The occurrence of this coral genus is reported for the first time from the Linwe area, Ye-ngan Township, southern Shan State. The present fossil finding is significant because in the Linwe area, the genus co-occurs with other Middle Permian rugose corals; *Yatsengia hanchowensis* Huang, 1932, *Iranophyllum* sp. cf. *carcinophloides* Douglas, 1936, *Ipciphyllum subelegans* Minato & Kato, 1965, and *Pavastehphyllum* (*Thomasiphyllum*) Minato & Kato, 1965. Nowhere is found such an important paleogeographic clues on basis of the Permian rugose corals in one area. Some

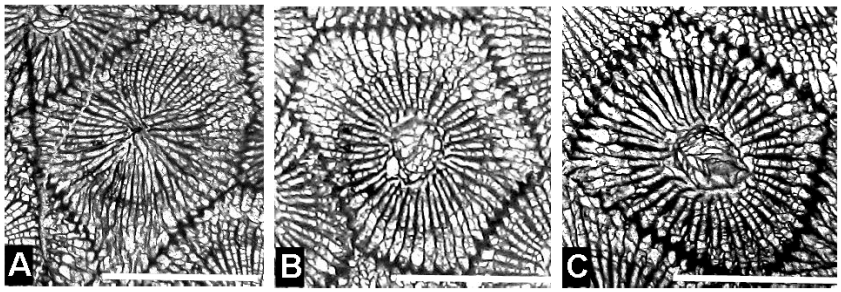

Figure 7 A-C: Variability of axial structure, A) lack of axial structure, B) subcircular axial structure, C) typical waagenophyllid axial structure (scale bar = 1.5 mm).

Middle Permian rugose corals from the Sibumasu Block in Myanmar *(Waagenophyllum yini* Fontaine *et al*., 1988; *Multimurinus fontaini* Kato & Ezaki, 1986 `*Ipciphyllum subelegans* Minato & Kato, 1965) also resemble those from Bukit Kapayang, Pahang State (Fontaine *et al*., 1988) and Bukit Biwah, Terengganu State (Kato & Ezaki, 1986), both are located in the East Peninsular Malaysia. The similarities between the Middle Permian rugose corals *Waagenophyllum yini* Fontaine, *Multimurinus fontainei* Kato & Ezaki and *Ipciphyllum subelegans* Minato & Kato from Sibumasu Block in Myanmar and that of the East Peninsular Malaysia Indochina Block suggest that both were at a close paleogeographic position likely in the Cathaysian paleogeographic provinciality during the Middle Permian.

The new species was first thought as a new subspecies, *Ipciphyllum subtimoricum dilatum*, closely similar to *Ipciphyllum subtimoricum* (Huang, 1932) in all aspects, however, it is characterized by the presence of dilated septa in the tabularium. Serial sectioning in *Ipciphyllum dilatum* sp. nov. shows that variation between corallites within most single thin sections reflects not changes in a specific direction. The main aspects are 1, different in number of sides of corallite wall, 2, variably dilated septa and their numbers in each corallite, 3, the dissepiments are well developed only when the corallites are large or matured, 4, the axial structures in individual corallites are varied possibly in all ontogenic stages.

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AUTHORS CONTRIBUTION

AMZ: Conceptualization, data curation, funding acquisition, investigation, methodology, writing original draft; AKA: Investigation, methodology, writing original draft, project administration, writing review and editing.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

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Structural analysis using 3D digital outcrop model: A case study in Kebun 500 outcrop, Kedah, Peninsular Malaysia

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Abstract: Photogrammetry and digital outcrop modelling are the latest techniques used by various geoscience groups for Earth visualisation and research. This study showcases the structural analysis of a digital outcrop model in the Kebun 500 area, Kedah, involving drone photo collection, digital model construction, structural data extraction, and geological interpretation. The outcrop represents folded and fractured sedimentary rocks of the Permian-Triassic Semanggol Formation, situated adjacent to a major fault, the Bok Bak Fault. The digital model revealed a N-S strike direction and steep dips to the east in the sedimentary beds at the Kebun 500 outcrop. The rocks experienced flexural slipping on the bedding planes and locally folded into close-to-open folds. They can also be further classified into gently plunging-upright folds, gently plunging and moderately inclined folds, and moderately plunging and steeply inclined folds. The beds/folds are cross-cut by N-S striking, steeply dipping fractures, and NNW-SSE striking, inclined dipping reverse faults. The folds that occurred in the Kebun 500 outcrop are interpreted as parasitic folds. The identified fractures are also potentially associated with the Bok Bak fault system.

Keywords: Digital outcrop model, fold, fracture, photogrammetry, Semanggol Formation

Abstrak: Fotogrametri dan pemodelan singkapan digital adalah teknik terbaru yang telah banyak digunakan oleh pelbagai bidang geosains untuk visualisasi dan penyelidikan bumi. Kajian ini mempamerkan penganalisaan struktur geologi secara digital di kawasan Kebun 500, Kedah melalui pengambilan foto udara, pembinaan model singkapan digital, pengekstrakan data struktur, dan tafsiran geologi. Kawasan ini mewakili batuan sedimen berlipat dan berretak Formasi Semanggol yang berusia Perm - Trias, dan ia terletak bersebelahan dengan Sesar Bok Bak. Batuan sedimen dalam model singkapan digital berjurus utara-selatan dengan kemiringan curam ke arah timur. Lapisan sedimen ditafsirkan mengalami *flexural slipping* dan terlipat secara tempatan, kemudian membentuk lipatan jenis *close-to-open*. Lipatan ini juga dapat dikelaskan sebagai *gently plunging-upright fold*, *gently plunging and moderately inclined*, dan *moderately plunging and steeply inclined*. Lapisan/lipatan sedimen juga dipotong oleh retakan berjurus utara-selatan dan sesar berjurus NNW-SSE. Maka, lipatan di singkapan Kebun 500 boleh ditafsirkan sebagai lipatan parasit dan pembentukan retakan berpotensi berkait dengan sistem sesar Bok Bak.

Kata kunci: Model singkapan digital, lipatan, sesar, fotogrametri, Formasi Semanggol

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INTRODUCTION

The application of digital outcrop models (DOMs) has become increasingly popular in Earth Science. The advancement in Earth visualisation technology has improved geological research in terms of data gathering and interpretation. Geological studies are shifting from traditional field-based and 2D visualisation (map or photo) work to more computer-based and 3D visualisation (digital model) output. Satellite imagery and photogrammetry are two remote techniques that are widely used for geological studies, especially in areas that are inaccessible or challenging to reach. They are beneficial when field data acquisition time is limited, allowing for the geological study and analysis to start immediately. Previous studies in NW Peninsular Malaysia (Salmanfarsi, 2017; Azman *et al*., 2018) have proved that remote sensing techniques can be used to extract higher accuracy lineament/ structural information and reconstruct deformation history.

This study aims to present capability of drone-based photogrammetry can improve structural analysis by extracting precise and sufficient digital geological data on a high-relief and steep rocky slope at Kebun 500, Kedah (Figure 1). This abandoned quarry exposes an extensive folded and fractured outcrop of the Semanggol Formation, providing the opportunity to demonstrate the workflow for structural analysis.

GEOLOGICAL SETTING OF NORTH KEDAH

Major rock formations

Geologically, the north Kedah region is mainly covered by the Paleozoic - Early Mesozoic sedimentary sequences of the Sibumasu Block. The oldest sequences comprise clastic rocks of the Lower Silurian Sungai Patani Formation and the Mahang Formation (Lower Ordovician-Upper Devonian), which are overlain conformably by the Carboniferous to Lower Permian Kubang Pasu Formation. The Kubang Pasu Formation conformably overlies the Permian to Triassic carbonates of Kodiang Formations and Chuping Formation at different locations in central and north Kedah (Jones, 1981; Shashida *et al*., 1995), as well as the Semanggol Formation clastic rock, which are later locally intruded by Triassic granite.

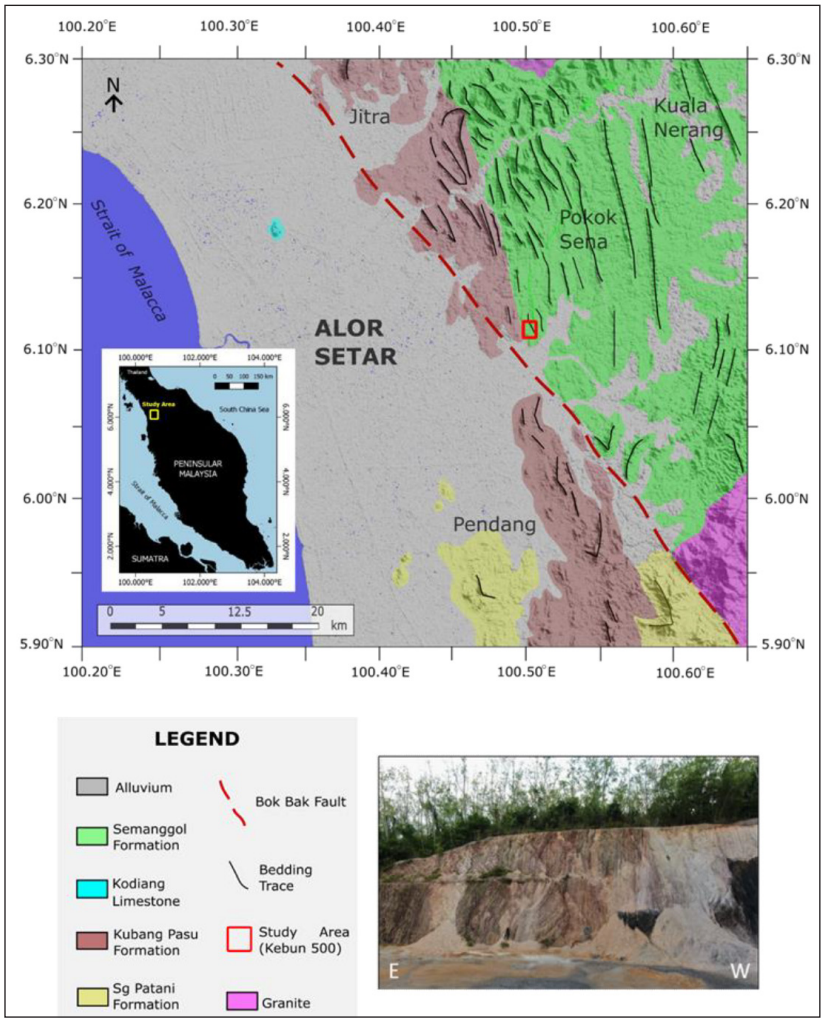

Figure 1: The Kebun 500 outcrop is located east of Alor Setar, Kedah, northwest of Peninsular Malaysia. [Top] Geological map of north Kedah. [Inset] Location of study area (Kebun 500 outcrop) in Peninsular Malaysia. [Bottom Right] Photograph of part of the rocky cliff at Kebun 500. The overall exposed outcrop is roughly 120 m long with an average height of 20 m.

The Sungai Patani Formation is mainly distributed further south in Kedah, consisting of argillaceous rock (Hassan, 1989) with Llandovery (Lower Silurian) graptolites (Courtier, 1974), which was later identified as Lower Devonian in age (Jones, 1973b). The formation was initially correlated to the Mahang Formation (Lower Ordovician-Upper Devonian) and separated by a granite body (Courtier, 1974). However, the name was no longer used and was included in the Mahang Formation by Burton (1988). Meanwhile, Burton (1967) identified the Kubang Pasu Formation as the Kampong Sena Formation, which is equivalent to the Singa Formation on Langkawi Island (Jones, 1973a). It comprises thick-bedded quartz and feldspathic grey, red or purple sandstone interbedded with subordinate varicoloured mudstone. The red mudstone near the base is where most Carboniferous fossils from the Kubang Pasu Formation are reported (Jones, 1973a). Numerous isolated limestone hills to the northwest of Kedah, known as Triassic limestone, were formally established by de Coo & Smit (1975). They were named Kodiang Limestone prior to the formalisation (Jones *et al*., 1966). The limestone hills are believed to be localised in the Kodiang area and are lithologically different from the other limestone overlying the Kubang Pasu Formation, i.e., Chuping Limestone in Bukit Barak, Pokok Sena (Shashida *et al*., 1995). de Coo & Smit (1975) reported that the Kodiang Limestone consists of repetitive units of thickly- and thinly-bedded limestone with several horizons of limestone conglomerate and breccia. The thickly-bedded limestone is composed of algal laminate and skeletal wackestone-packstone, while the thinly-bedded limestone comprises shell fragments, sponge spicules, ostracods, and foraminifers wackestone or mudstone. Semanggol Formation was named after Gunong Semanggol (Alexander, 1959) for the Triassic clastic rocks that extend from the northern border of Kedah southward to northwest Perak (Courtier, 1974). Sandstone, shale, and mudstone with turbiditic characteristics are the most abundant rocks in the Semanggol Formation. The sediments were also reported to contain a wide distribution of chert clasts in the turbidites and conglomerate, where some clasts are radiolarian-bearing (Hutchison & Tan, 2009).

Semanggol Formation

The Semanggol Formation stretches from the northern border of Kedah southwards to north Perak (Alexander, 1959). The chert unit of this formation is widely exposed in Kedah, while its contacts are either faulted or unexposed (Hutchison & Tan, 2009). Burton (1973a) initially subdivided the Semanggol Formation into chert, rhythmite, and conglomerate members, which Teoh (1992) later referred to as a unit. Jasin (1997) interpreted the three units as having a lateral and interfingering contact, representing lateral facies variation. The chert unit was described as alternations of black, carbonaceous mudstone with chert, siltstone, and greywacke (Burton, 1973a). The age of the siliceous rocks of the Semanggol Formation was interpreted to be Permian-Triassic based on the radiolarian assemblage in the chert unit (Shashida *et al*., 1992; Jasin, 1997, 2008; Jasin & Harun, 2007).

The sedimentary rocks of the Semanggol Formation were deposited in a post-collision basin, corresponding to the collision between Sibumasu and Sukhothai Arc during the Triassic (Metcalfe, 2013). The Semanggol Formation mapped in the NW Peninsular was suggested to initially be a continuous basin that was later truncated by wrench faults and separated into three sedimentary accumulations (Burton, 1973a; Ahmad Jantan *et al*., 1989). Burton (1973a) reported that the beds exhibited repeated and tight folds. Mustaffa (1994a) interpreted a single deformation phase resulting in regional N-S trending, slightly asymmetric drag folds that were superimposed by the E-W trending folds and strike-slip related structures at the southern part of the formation in north Kedah. This complexity is believed to have been created by reverse fault drags along the N-S striking steeply dipping faults due to granite intrusions and movement along the Bok-Bak fault. In the adjacent area of Pokok Sena, Harun & Jasin (1999b) also reported evidence of combined movements of lateral faults with reverse components on the moderate to steeply dipping NW-NNE striking beds, which resulted in the development of fault-related gentle, open folds, tight folds, and a positive flower structure. Overall, the Semanggol Formation of Pokok Sena has N-S striking chert beds with distinct folding and faulted structures (Jasin, 1997).

METHODOLOGY

The study was divided into three stages: (1) data acquisition, (2) digital outcrop model (DOM) generation, and (3) interpretation and analysis using DOM. The main workflow for this study is summarised in Figure 2.

Data acquisition

High-resolution digital aerial photographs of the outcrop were acquired in 2022 using a DJI Mavic 2

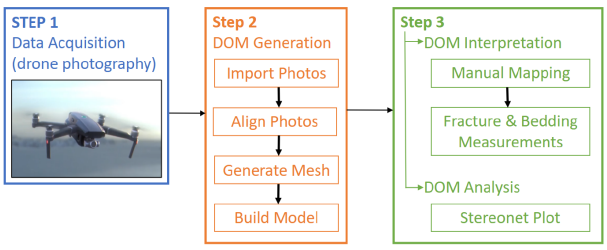

Figure 2: Basic workflow diagram showing the three main steps of the study: Step 1 - data acquisition using a drone, Step 2 - DOM building in photogrammetry software, and Step 3 - structural data extraction and analysis.

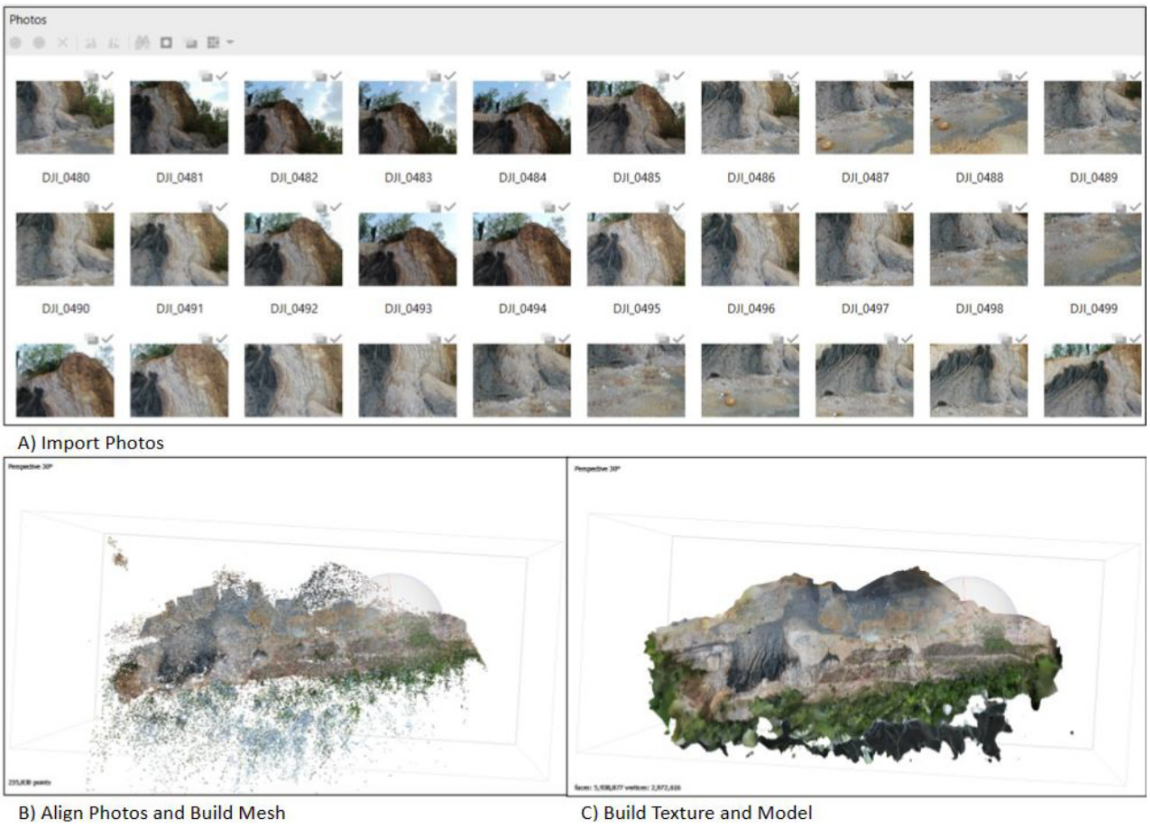

Figure 3: DOM photogrammetry processing steps. The workflow in sequential order: [A] Import outcrop's aerial photos, [B] Matching mutual points in photos and estimating photo's locations, then build depth map and mesh, [C] Texture atlas parameterization, blend textures and tiled model building.

Zoom drone camera (camera model FC2204). The drone camera was fitted with a 1/ 2.3-inch 12MP CMOS sensor which shot up to two-times optical zoom (24–48 mm) photos. The aircraft flew back and forth from a position perpendicular and at an angle to the strike of the rock layer to cover the full extent of the outcrop at an altitude of 23–56 m. The aircraft was equipped with a positioning algorithm using signals from GPS and GLONASS satellite positioning systems to precisely geo-reference the images taken. Each digital photograph has 4000 × 3000 pixels and was taken at slightly different angles from each other in overlapping series around the outcrop to capture all the detailed geometry of the outcrop for a precise DOM generation (Figure 3A).

Digital outcrop model (DOM) building

A 3D outcrop model was constructed using the Agisoft Metashape Professional 2.0.1 photogrammetry software. The photogrammetry processing steps from importing photos to model building are shown in Figure 3. A total of 235,830 tie points in different dimensions were created from 354 aligned images. A point cloud was used to define the faces and shapes which make up the depth maps and mesh. Lastly, model texturing was applied to give colour and detail to the 3D model after applying the mesh via the mosaic blending model.

DOM validation

The quality of the photogrammetric product was assessed following the guidelines outlined in the accuracy standards set by the American Society for Photogrammetry and Remote Sensing (2023) (Table 1). Notably, results obtained from a few checkpoints (both from field and Google Maps) are considered photogrammetrically accurate, falling within the defined accuracy window for the x, y, and z coordinates.

Table 1: Aerial triangulation and ground control accuracy requirements, orthoimagery and/or planimetric data and elevation data. (*RMSE: root-mean-square error)*

Product Accuracy ($RMSE_x$, $RMSE_y$) (cm)	A/T Accuracy		Ground Control Accuracy	
	$RMSE_x$ and $RMSE_y$ (cm)	RMSEz (cm)	$RMSE_x$ and $RMSE_y$ (cm)	RMSEz (cm)
50	25	25	12.5	12.5

Interpretation and analysis using DOM

The generated DOM was analysed in the Lidar Interpretation and Manipulation Environment (LIME) software of Virtual Outcrop Geology Group that allows 3D visualisation of outcrop models, manual mapping, and digital measurements (Buckley, 2019). Lines and planes representing structural features were mapped manually by point-picking the intersection of the selected structural features and the 3D model's surface (Figure 4). The best-fit planes representing each bedding and fracture plane were calculated from three picked points, and their orientations, positions, and lengths were recorded. Then, the extracted structural readings were plotted in the Stereonet software version 11.5.1 (Cardozo & Allmendinger, 2013) for illustration and further analysis.

RESULTS AND DISCUSSION

This study focused on the observation and interpretation of structural elements, particularly on folds and fractures on the Kebun 500 outcrop DOM.

General geology of Kebun 500 outcrop

The Kebun 500 outcrop is an exposed sedimentary sequence of the Semanggol Formation. The outcrop extends 120 m in the east-west direction. Earlier studies have reported the nearly vertical dip of chert beds interbedded with shale and mudstone, as well as the occurrence of radiolaria in the chert unit. A large section of a black-coloured sequence at the western end of the Kebun 500 outcrop is interpreted to be related to a post-deposit thermal process (Mohammad, 2016) (Figure 5).

Geological structures of the Kebun 500 DOM

Bedding

Eight representative bedding planes were sampled at a distance away from the highly folded zones. The interpreted bedding planes generally recorded a N-S strike direction, predominantly dipping at 65°–87° towards the east (average: 011/76) (Figure 5 and Table 2).

Table 2: Readings of bedding planes extracted from Kebun 500 DOM.

Bedding	
Number of readings	8
Strike	002 - 019 182 - 195
Dip	65 - 87°

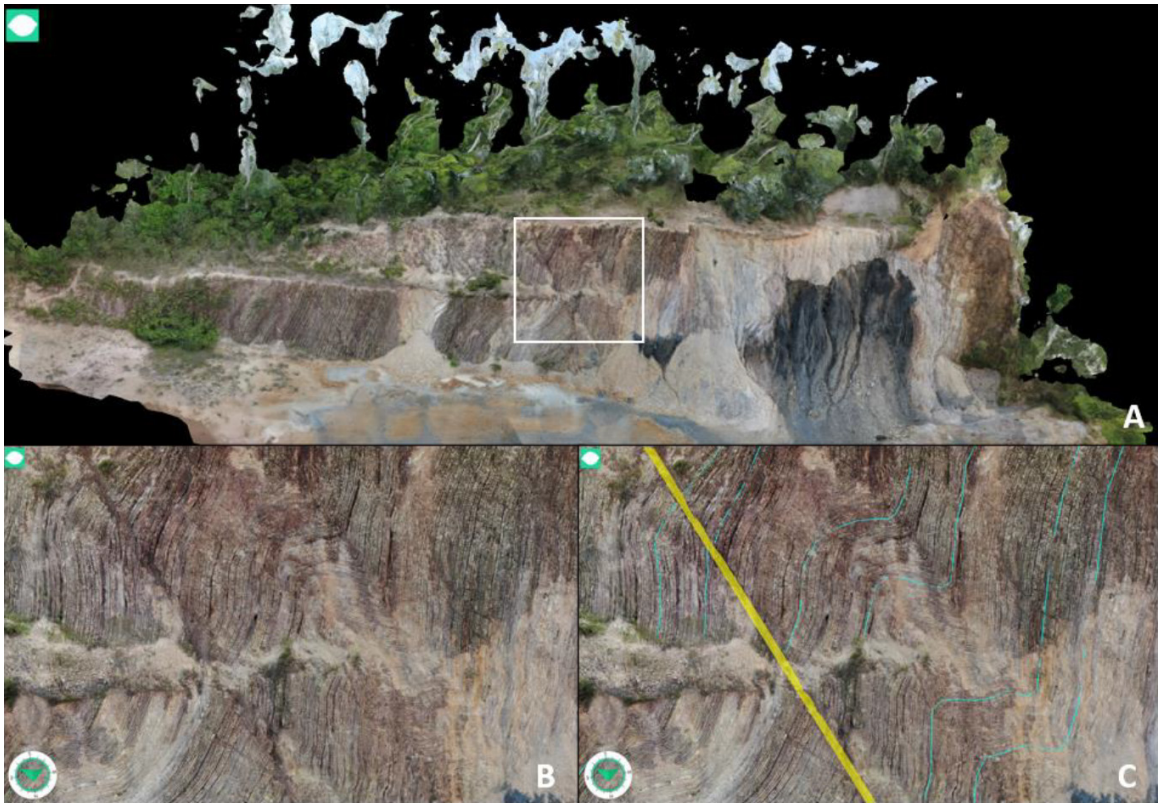

Figure 4: 3D DOM of Kebun 500 outcrop. [A] Model visualisation in LIME software. The white box indicates the location shown in "B" and "C". [B] High-resolution outcrop model illustrates the distinct beddings and structural features. [C] Interpretation of lines (cyan) and planes (yellow) in LIME software environment.

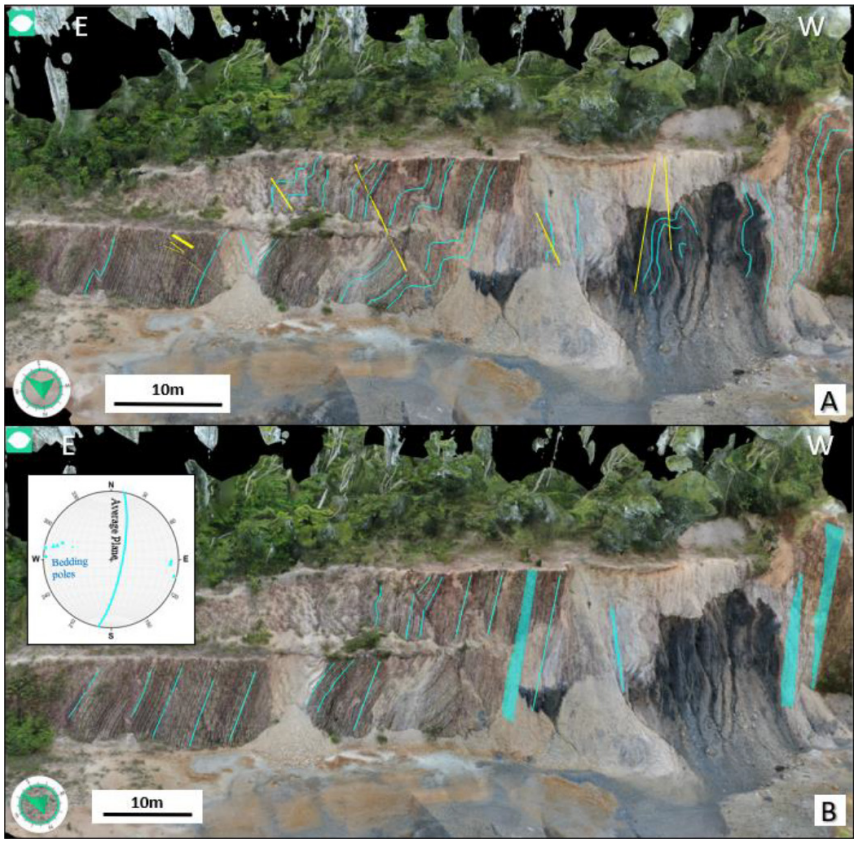

Figure 5: [A] Key geological structures observed on the Kebun 500 DOM. Bedding (cyan) and fracture/fault planes (yellow) were interpreted in LIME. [B] The beds generally strike in a N-S direction and steeply dip eastward. The readings of the bedding planes (cyan) are plotted on a stereonet.

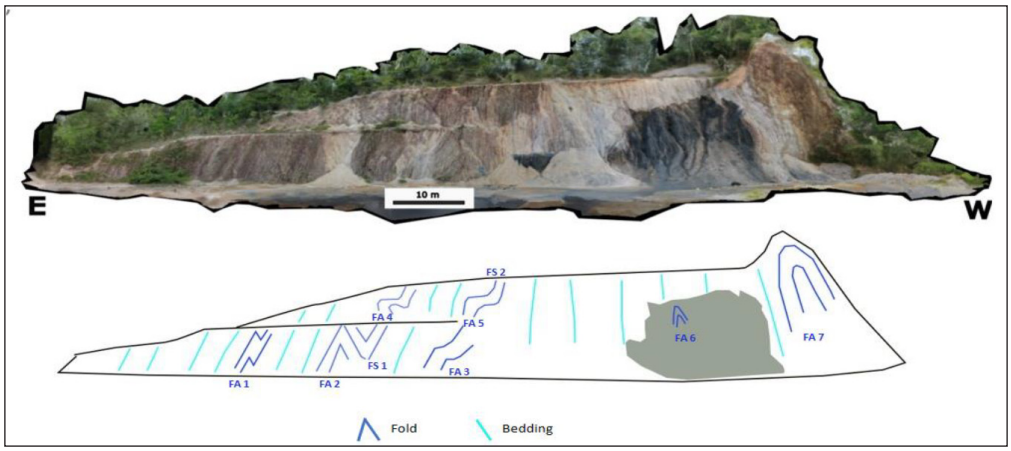

Figure 6: [Top] DOM of the Kebun 500 outcrop. [Bottom] Sketch of interpreted bedding (cyan) and folds (dark blue) in outcrop. There were seven anticlines and two synclines identified. [FA: anticline; FS: syncline]

Folds

Folds are prominent secondary structures at the Kebun 500 outcrop. A total of nine folds (seven anticlines and two synclines) were mapped and analysed via visual interpretation on the DOM (Figure 6 and Table 3). Three bedding planes were sampled on each fold limb to obtain the mean reading of each limb. The mean bedding plane (dip, strike) of each fold limb allows the calculation of the orientation of the fold axial plane and hinge line.

The mapped folds were further classified based on their different geometric features. Based on the interlimb angle, these folds can be classified into two types: close

Table 3: Information of the studied folds in Kebun 500 outcrop.

Folds	Average Limbs (Strike/ Dip)	Hinge Line (Trend/ Plunge)	Axial Plane (Strike/Dip)	Interlimb Angle		Fold Classification	
				Range	Average	Interlimb Angle	Hinge Line-Axial Plane
FA1	007/71° 172/64°	181/18°	180/87°	32-67°	56°	Close fold	Gently plunging, upright fold
FA2	172/59° 001/70°	178/10°	177/85°	44-63°	58°	Close fold	Gently plunging, upright fold
FS1	172/59° 020/65°	188/24°	186/87°	48-77°	65°	Close fold	Gently plunging, upright fold
FA3	005/74° 061/25°	178/23°	159/52°	109-120°	119°	Open fold	Gently plunging, mod. inclined fold
FA4	095/37° 185/76°	196/37°	037/64°	73-87°	79°	Open fold	Mod. plunging, steeply inclined fold
FA5	003/86° 103/27°	181/27°	160/55°	73-91°	89°	Open fold	Gently plunging, mod. inclined fold
FA6	005/68° 117/50°	164/41°	154/80°	70-86°	75°	Open fold	Mod. plunging, steeply inclined fold
FA7	179/63° 081/32°	197/30 °	028/71°	75-83°	79°	Open fold	Mod. plunging, steeply inclined fold
FS2	359/85° 104/28°	177/27°	157/56°	79-92°	87°	Open fold	Gently plunging, mod. inclined fold

folds (30°–70°) at the eastern side of the outcrop and open folds (70°–120°) on the western cliff (Figure 7). Additionally, the fold classification based on the plunge of the hinge line and dip of the axial plane (Fleuty, 1964) has grouped the observed folds into (Figure 8): gently plunging-upright folds (FA1, FA2, and FS1), gently plunging and moderately inclined folds (FA3, FA5, and FS2), and moderately plunging and steeply inclined folds (FA6, FA7, and FA4). The folds at the eastern part of the outcrop had a vertical axial plane and gently plunging fold axis geometric position. Towards the central and west sections, the axial planes became more inclined, possibly indicating plunging folds. In general, the folds at Kebun 500 outcrop have an acute interlimb angle with axial planes striking nearly in the N-S direction. In addition, these folds changed from symmetrical folds on the eastern side to asymmetrical folds towards the west.

Fractures / faults

Eleven major fracture planes were mapped and measured on the Kebun 500 DOM. The identified fractures can be subdivided into two sets (Figure 9 and Table 4). Three fractures were non-displaced with a nearly vertical fracture plane (dip angle 67°–88°), while the remaining eight were reverse faults with measured slip ranging from 6 cm to 32 cm and moderately steeply dipping (30°–58°) (Figure 9).

The reverse faults strike from the SSE to S direction and dip towards SW. Most of the fracture planes are sub-parallel to the fold axial planes and the bedding planes. The rocks were displaced discretely without any significant changes to the bed thickness under faulting. (Figure 9B).

Discussion

Structural geology of Kebun 500 area

Generally, the bedding, folds, and fractures interpreted on the Kebun 500 DOM are ~N-S directed. The rocks strike N-S and dip steeply toward the E or W. Most of the folds in the study area are asymmetrical and trend N-S. The folds are mainly classified into close to open folds based on interlimb angles and grouped into gently plunging-upright, gently plunging and moderately inclined, and moderately plunging and steeply inclined folds, based on the plunge of the hinge line and dip of the axial surface. There are two groups of fractures observed on the DOM. The first group represents non-displacement fractures that strike in the N-S direction and dip steeply towards E or W. The second group is the reverse faults with strikes ranging from SSE to S and inclined dips (30º–58º) toward the W. These fractures and faults have orientations parallel to sub-parallel with the axial planes and outcrop bedding, as well as the major morphological features in the NW Peninsular Malaysia region. Besides, the study area is located next to the NW striking sinistral Bok Bak Fault Zone. The ~N-S folds of

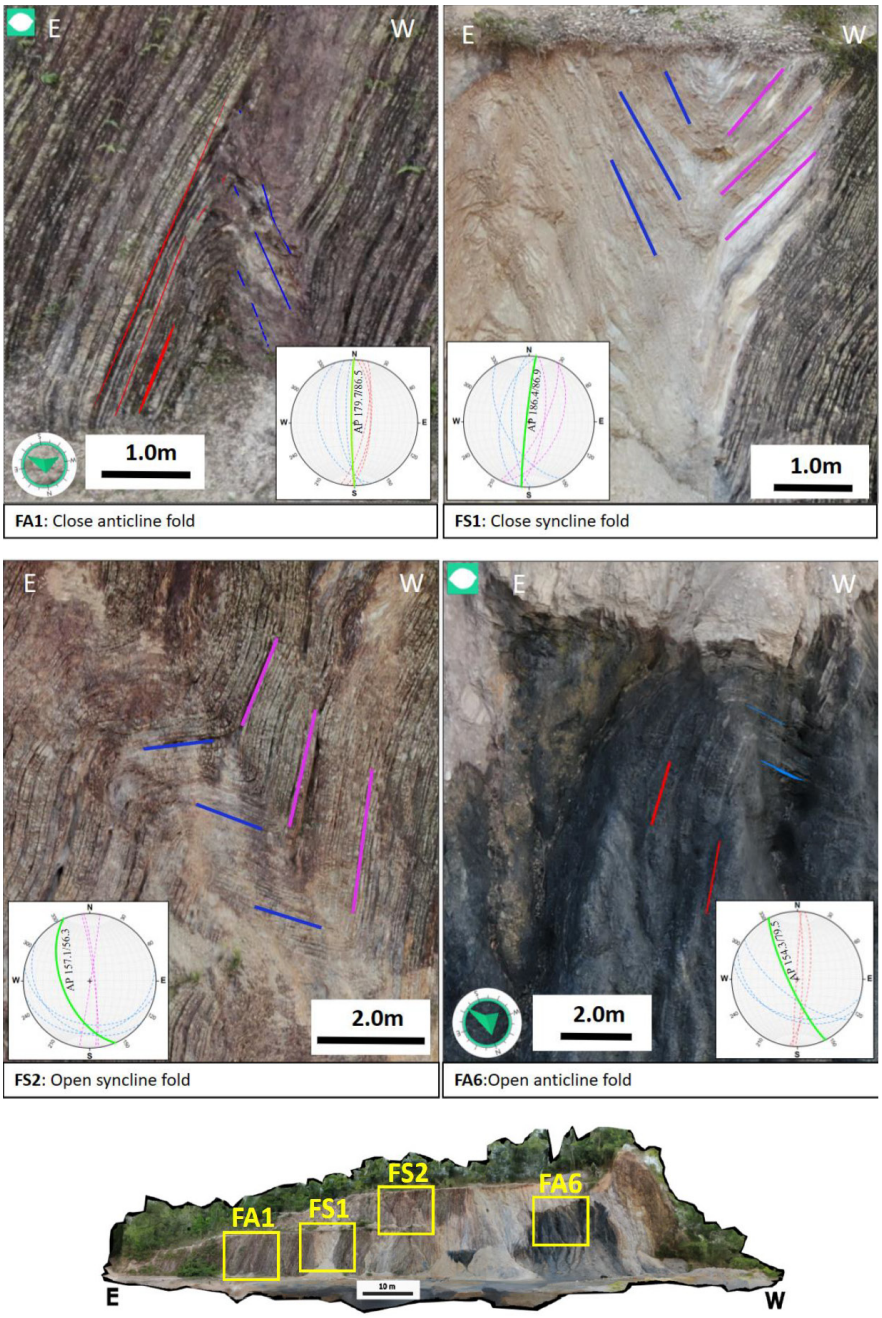

Figure 7: Folds on the Kebun 500 DOM are classified based on the interlimb angle: close folds (30°–70°) and open folds (70°–120°). FA1: close fold. FS1: close fold. FS2: open fold. FA6: open fold.

the Semanggol Formation and NW sinistral movement of the Bok Bak Fault both deduce an ~E-W compressional event, which suggests that the structures in Kebun 500 and Bok Bak Fault activity were likely formed during the same deformation episode, which was also reported in the nearby outcrops of Bukit Jabi and Cheong Chong Kaw estate (Harun & Jasin, 1999b; 2000).

The sedimentary layers of the Semanggol Formation (chert and mudstone) with contrasting mechanical properties were folded when flexural slip occurred at the boundary during a shortening or compressional event. It can be observed that the local outcrop folds appear like parasitic structures relative to the regional-scale fold. Minor folds parasitic to the major fold usually have S and Z asymmetrical profiles on the limbs of the major fold and M profiles in the hinge region (Figure 10 [Top]). The western outcrop with an M fold-profile is interpreted as the core of the fold and fracture/fault system. In contrast,

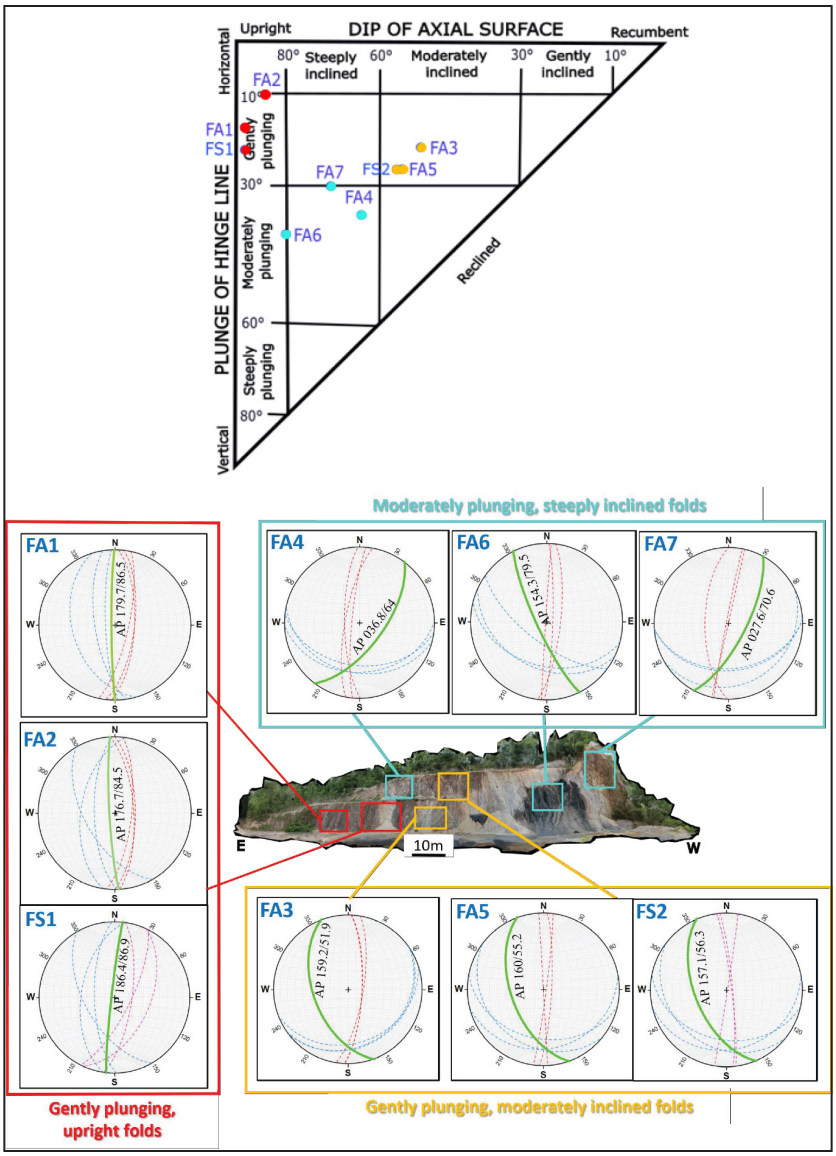

Figure 8: Fold classification (Fleuty, 1964) based on the axial plane dip and the plunge of the hinge line. Three types of fold were identified in the Kebun 500 DOM: (1) gently plunging-upright; (2) gently plunging-moderately inclined; (3) moderately plunging-steeply inclined.

the fractures in the western outcrop did not display any displacement, possibly due to the lack of marker beds. The fractures branch out from the core of the fracture/fault system to the east with lower dip angles and cross-cut the earlier formed folds. The deformation in the Kebun 500 outcrop is explained with a structural model in Figure 10 [Bottom].

Usage of digital outcrop model as study material

The integration of digital inspection within 3D models has revolutionized the tracing and interpretation of structural planes, offering several key advantages. Firstly, it has markedly reduced the time required for data collection in the field, streamlining the process and enhancing efficiency. Moreover, this technology enables the extraction of geological insights, such as precise structural orientations, with unprecedented levels of accuracy. Additionally, digital inspection facilitates the collection of data from inaccessible or remote areas, expanding the scope of geological studies. Lastly, it accelerates the interpretation and analysis phase, allowing geoscientists to quickly derive meaningful conclusions and make informed decisions.

The results from this study align with the existing knowledge regarding the structural geology of the Kebun 500 area. The general strike trends north-south and compression forces are believed to originate from the east-west direction (Ahmad, 2016). Additionally, unique features such as folds have been reported (Ahmad, 2016). However, this study, utilising DOM reveals additional

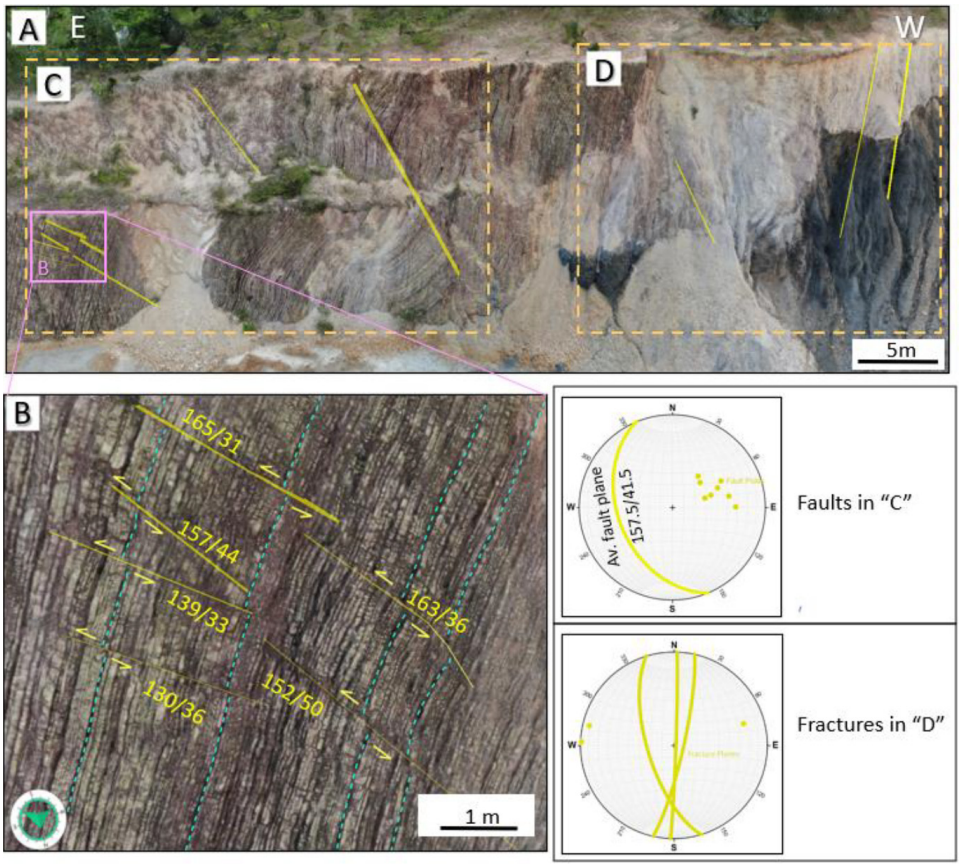

Figure 9: Fracture interpretation on the Kebun 500 DOM. [A] Eleven distinct fractures were identified, of which three had no displacement, and eight were reverse faults. Stereonets show the faults that occurred in area "C" and the fractures that occurred in area "D". [B] Local fractures observed at the eastern part of the Kebun 500 digital outcrop. The bed displacements showed a fault system with consistent reverse motion.

Table 4: Fracture information of Kebun 500 outcrop.

	Fracture	
Displacement	no	yes
Number of readings	3	8
Strike	002-013; 163	130-180
Dip	67°-88°	30°-58°
Mapped Length (m)	7-14	2-14
Displacement (cm)	-	6-32
Motion	-	Reverse

insights. Compared to traditional field study, DOM provides a broader view of fold features, allowing us to zoom in, zoom out and explore different angles. This enhanced perspective aids in understanding the direction, connections between bends and the overall formation of this geological structure. Furthermore, other case studies in different regions have also demonstrated that UAV-based photogrammetry approaches enable precise detection of geological features, enhancing fieldwork and advancing in the field of structural geology (Colica *et al*., 2021; Peace & Jess, 2023).

CONCLUSION

A 3D digital outcrop model (DOM) of the Semanggol Formation in the Kebun 500 area of Kedah was constructed to collect high-accuracy geological data and analyse its structural style and deformation. The rocks of the Semanggol Formation in Kebun 500 are observed to

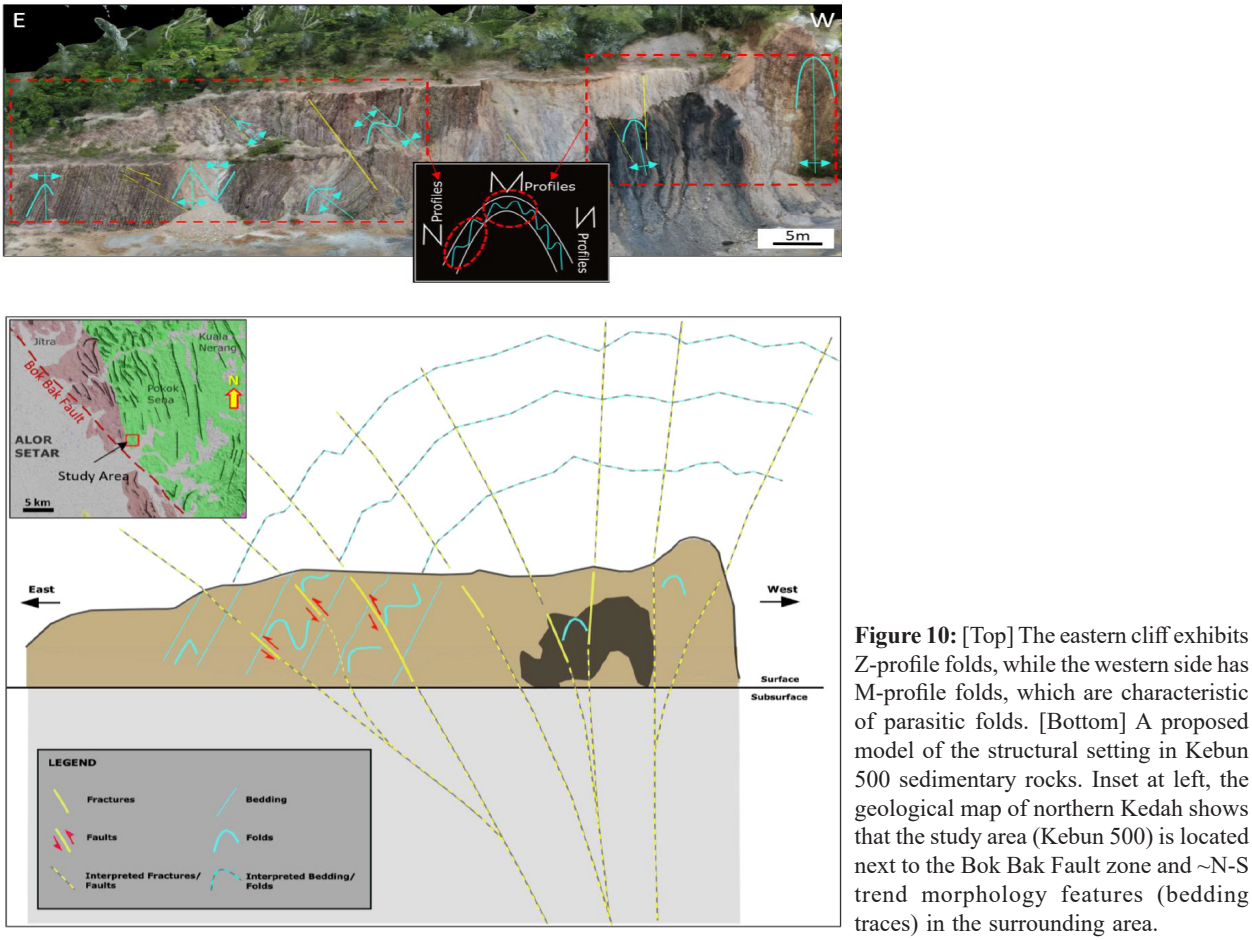

Figure 10: [Top] The eastern cliff exhibits Z-profile folds, while the western side has M-profile folds, which are characteristic of parasitic folds. [Bottom] A proposed model of the structural setting in Kebun 500 sedimentary rocks. Inset at left, the geological map of northern Kedah shows that the study area (Kebun 500) is located next to the Bok Bak Fault zone and ~N-S trend morphology features (bedding traces) in the surrounding area.

be folded and fractured. Based on the interlimb angles, the folds are classified as close to open folds and can also be grouped into gently plunging-upright folds, gently plunging and moderately inclined folds, and moderately plunging and steeply inclined folds. These folds are part of a series of minor/parasitic folds that form when flexural slip occurs in sedimentary layers with contrasting mechanical properties during a shortening or compressional event. The N-S striking beds and folds of the Kebun 500 sedimentary rocks are cross-cut by N-S striking, steeply dipping fractures and NNW-SSE striking, inclined dipping reverse faults. These fractures could be associated with the adjacent NW striking Bok Bak fault.

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AUTHORS CONTRIBUTION

TYE performed interpretation, analysis, drafted and wrote the manuscript with input from the other authors. NHMJ conducted field data collection using drone. CCM, MAMY, and NHMJ provided technical oversight. CCM, NHMJ and MAMY reviewed the writing.

CONFLICT OF INTEREST

This paper has never been published and is not in the process of being published by any journal. The authors declare that there are no competing interests or conflicts of interest associated with this work.

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Moisture retention characteristics of weathered graphitic-quartz-muscovite schist

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Abstract: Slope cuts in weathered graphitic-quartz-muscovite schist expose an upper pedological soil (3-4 m thick) of silty to sandy clays with lateritic concretions, and a lower saprock (>10 m thick) of alternating bands of variously colored, firm to stiff and hard, clayey silts and silts with indistinct to distinct relict bedrock minerals, textures and structures. Moderately sloping (<60°), low cuts (<15 m high) in unsaturated, weathered schist are unaffected by failures, though small slips and falls have sometimes occurred at steeper cuts during rainfall events. To validate the role of negative pore water pressures in influencing the stability of slope cuts, laboratory pressure plate tests were carried out on weathered graphitic-quartz-muscovite schist collected at depths of 5.83 m (A), 6.71 m (B) and 8.95 m (C) at a weathering profile in the Kajang Schist. Samples A, B, and C, with dry unit weights of 12.76, 14.73, and 13.23, kN/m^3, and porosities of 51%, 44%, and 49%, are overwhelmingly fine gained with silt contents of 53.6%, 73.7%, and 76.6%, and clay contents of 35.0%, 14.0%, and 23.0%, respectively. Increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1500 kPa resulted in volumetric moisture retentions of 49.9% through 48.9% and 36.7% to 33.0% and 7.2% in sample A, from 51.8% through 48.6% and 41.1% to 34.3% and 4.5% in sample B, and from 55.5% through 53.2% and 47.6% to 30.2% and 8.6% in sample C. Best fit lines drawn with the van Genuchten (1980) parametric model indicate rapidly decreasing moisture contents with increasing suction due to large porosities. It is concluded that negative pore water pressures in unsaturated, weathered graphitic-quartz-muscovite schist give rise to an enhanced shear strength and stability of slope cuts, though rapid infiltration of rainwater results in saturation and failure.

Keywords: Weathered graphitic-quartz-muscovite schist, moisture retention, suction, negative pore water pressures, slope cut stability

INTRODUCTION

Weathering profiles of considerable thickness are found in Peninsular Malaysia as a result of favorable tectonic and environmental factors that have permitted pervasive weathering of bedrock during a larger part of the Cenozoic era (Raj, 2009). The weathered materials are characterized by indistinct to distinct preservation of the minerals, textures and structures of the original bedrock and are classified as residual soils for they can removed by commonly accepted excavating methods (USBR, 1974; JKR, 2007). In undulating to hilly terrain in the Peninsula, residual soils are considered to be unsaturated for unconfined groundwater tables are only found at great depths (Bujang *et al*., 2005; Raj, 2009).

Unsaturated soils are characterized by negative pore water pressures or suction; the relationship between moisture content and suction best described by the soil water characteristic curve (Agus *et al*., 2001). In Agronomy, the soil water characteristic curve is known as the soil moisture retention curve and is important for developing effective irrigation and plant stress management techniques as the yield and quality of crops is influenced by suction/water relationships (Scherer *et al*., 1996).

In a study to characterize the fertility of saprolite layers (C soil horizon) as agricultural substrates, Hamdan *et al*. (1998) investigated three weathered rock-saprolite-soil sequences over basalt, granite and schist in Peninsular Malaysia. The three sequences were differentiated into several horizons, morphologically described and sampled for determination of various physical and chemical properties, including granulometry, porosity and moisture retention characteristics as well as pH, organic carbon contents and cation exchange capacity. The study concluded that the saprolites were of poor fertility and could pose a serious limitation to crop production in upland soil areas (Hamdan *et al*., 1998).

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Noguchi *et al*. (2003) determined the depths, saturated hydraulic conductivity and moisture retention curves of soils developed over meta-sedimentary bedrock at a site in tropical rain forest, and at a site in a nearby rubber plantation. Total soil depths at the forest site were between 118 and 140 cm, and those in the rubber estate, between 106 and 162 cm, whilst the macro-porosity varied from 3.0% to 13.9% at the forest site, and from 2.7% to 7.7% at the rubber plantation. Noguchi *et al*. (2003) concluded that the study allowed a better understanding of the influence of land-use on water conservation.

Hamdan *et al*. (2006) employed the pressure plate method to determine the soil moisture retention curves of granite, basalt, schist and shale saprolites in Peninsular Malaysia as part of a study to evaluate their hydraulic conductivity. In the case of the schist saprolite, increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1500 kPa resulted in volumetric moisture retentions of 78% through 47% and 45% to 39% and 19%.

Soil water characteristic curves of a red laterite soil compacted at three different moisture contents, i.e., dry of optimum, optimum, and wet of optimum, were determined with the pressure plate method by Yamusa *et al*. (2019). After applying different parametric models to obtain curve fitting parameters, Yamusa *et al*. (2019) concluded that the van Genuchten (1980) as well as Fredlund & Xing (1994) models could fit most of the curves, though the Brooks & Corey (1964) model represented the curves better when the soil had a distinct air entry suction.

In an earlier study, it was reported that moderately sloping (<60°), low cuts (<15 m high) in weathered graphitic-quartz-muscovite schist in the Kajang area were unaffected by failure where they were located above unconfined groundwater tables (Raj, 2001). Where the low cuts were excavated at steeper angles (>60°), however, there had sometimes occurred small earth falls and shallow slips during, or following, periods of continuous rainfall (Raj, 2001). As the cuts involved unsaturated earth materials, it was considered that negative pore water pressures (or suction) contributed to their stability through enhanced shear strengths, though infiltration of rainwater led to saturation and loss of the enhanced strength (Raj, 2001).

The role of negative pore water pressures (or suction) in enhancing the stability of slope cuts in the residual soils of humid tropical areas and the occurrence of failures during periods of rainfall have been high-lighted by several workers, in particular Wesley (2009; 2010; 2011). Yusof *et al*. (2016) furthermore, have concluded that it is the infiltration of rainfall in Malaysia that results in slope failures due to loss of the negative pore water pressures (or suction) that provides an additional shear strength to unsaturated soils. The soil water retention (or soil water characteristic) curve was thus considered to be the key to implementation of unsaturated soil mechanics in engineering practice in Malaysia (Yusof *et al*., 2016).

In this geological short note, are discussed the results of laboratory pressure plate tests that were carried out to validate the presence of negative pore water pressures (or suction) in unsaturated, weathered graphitic-quartz-muscovite schist, and their influence on the stability of slope cuts.

GEOLOGICAL SETTING

In the Kajang area are found dark grey to black, graphitic-quartz-muscovite schists inter-layered with thin bands and lenses of orange to buff, quartz-muscovite schists (Figure 1). These schists, mapped as the Kajang Schist, are of a probable Silurian to Devonian age and strongly folded with many quartz veins and pods (Yin, 1976; Lee, 2009). Thin-section and binocular microscope descriptions of these graphitic-quartz-muscovite schists have been earlier published (Raj, 1995).

The Kajang Schist is deeply weathered with slope cut exposures showing two broad weathering zones; i.e. an upper pedological soil and a lower saprock (Raj, 1995). The pedological soil, which comprises silty to

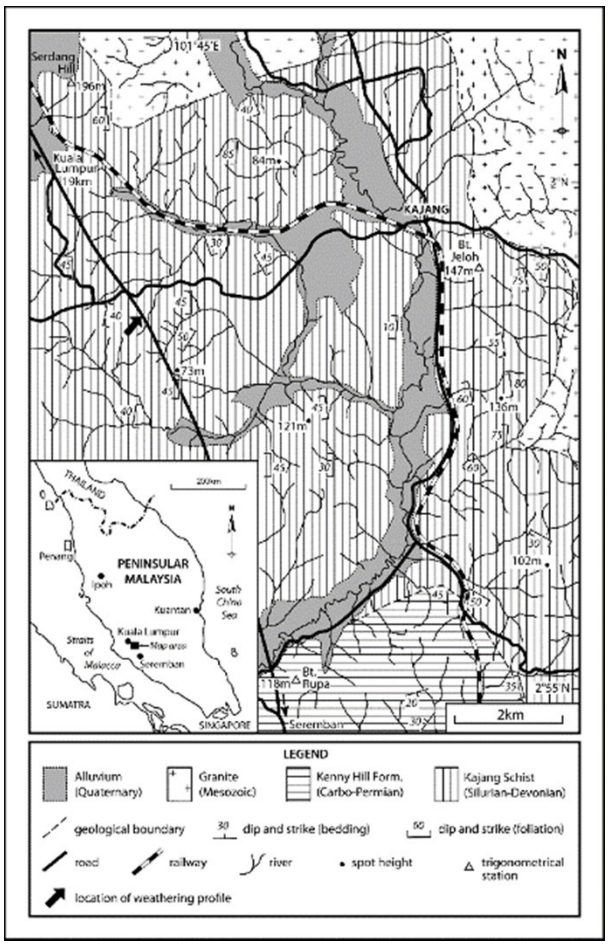

Figure 1: Geology map of the Kajang area (main roads in 1985) showing location of sampled weathering profile. (After Yin, 1976).

sandy clays with abundant lateritic concretions, is some 3 to 4 m thick and can be separated into B and C soil horizons. The saprock is more than 10 m thick and consists of alternating bands of variously colored, firm to stiff and hard, clayey silts and silts with indistinct to distinct preservation of the original bedrock minerals, textures and structures (Raj, 1995).

A field survey of slope cuts in the Kajang Schist has shown that failures have not occurred at moderately sloping (<60°), low cuts (<15 m high), located above unconfined groundwater tables (Raj, 2001). These cuts were considered to be excavated in unsaturated earth materials that are characterized by negative pore water pressures (or suction); a feature that gives rise to the enhanced shear strength of residual soils in humid tropical areas (Wesley, 2009; Wesley, 2010; Wesley, 2011).

Where the low cuts were excavated at steeper angles (>60°), however, there have sometimes occurred, during or following periods of rainfall, failures that are best classified as earth falls and shallow slips (Raj, 2001). The earth falls, which involved small volumes (<2 m^3) of pedological soil, only occurred at very steep cuts (>80°) and were preceded by the development of tension cracks. Infiltration of rainwater through the tension cracks was considered to result in the loss of negative pore water pressures and down-slope movement of a small saturated soil mass backed by the tension crack (Raj, 2001). The shallow slips involved small volumes (<3 m^3) of pedological soil and/or highly to completely weathered schist (saprock), and were preceded by the development of desiccation (or shrinkage) cracks (Raj, 2001). Infiltration of rainwater through the cracks thus led to saturation, and loss of negative pore water pressures, which then led to sliding of a small, saturated soil mass along an approximately cylindrical surface (Raj, 2001).

METHODOLOGY

In order to validate the presence of negative pore water pressures in unsaturated, weathered graphitic-quartz-muscovite schist, samples were collected for determination of their moisture retention characteristics through laboratory pressure plate tests. The samples were collected at the weathering profile in Kajang Schist exposed at the slope cut at Km 298.30 (south bound) of the N-S Expressway (Figure 1).

The slope cut is located in undulating terrain with several low hills and ridges (rising to some 160 m above sea-level) separated by narrow to broad, flat-bottomed valleys (some 15 m above sea-level). The cut itself is excavated where the N-S trending Expressway crosses a low ridge rising to 65 m above sea-level. The cut with a vertical height of 10 m and overall angle of 45° is benched; the 2.50 m and 3.75 m high benches with 55° face angles, separated by 1.56 m, and 1.88 m, wide horizontal berms (Figure 2).

Brass rings of 4 cm length and 7.6 cm internal diameter were used to collect the samples at vertical depths of 5.83 m (sample A), 6.71 m (sample B) and 8.95 m (sample C) at the selected profile (Figures 2 & 3). Two constant volume samples were collected at each sampling point; one for determination of physical and soil index properties, and the other for determination of the water retention characteristics. Details on the method of sampling have been described in earlier publications (Raj, 2010; 2021).

Subsequent treatment of the undisturbed samples for determination of their physical and soil index properties according to standard procedures (ASTM, 1970) has also been described in earlier publications (Raj, 2021; 2023). Laboratory determinations of the moisture retention characteristics of the weathered graphitic-quartz-muscovite schist were carried out according to standard

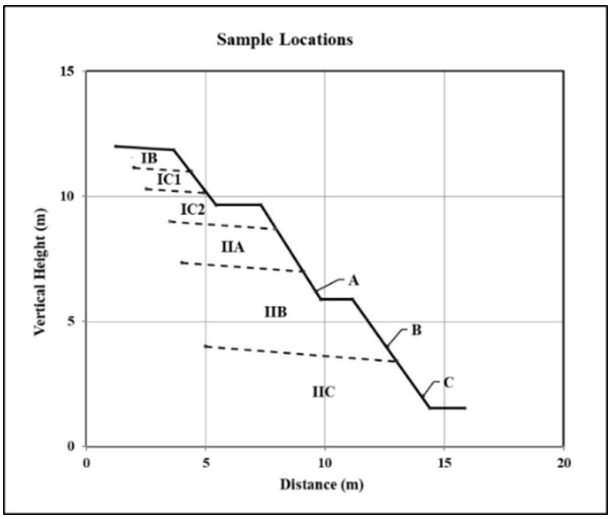

Figure 2: Sample locations and lateral extensions of weathering sub-zones.
(Note: IB refers to soil horizon B, IC1 and IC2 refer to soil horizon C, and IIA, IIB and IIC refer to weathering sub-zones within saprock).

Figure 3: View of slope cut with sampling locations.

procedure described in earlier publications (Raj, 2021; 2023). Results of these laboratory determinations were used to plot volumetric moisture retention curves (or water characteristic curves) and best-fit lines drawn with the van Genuchten (1980) parametric function.

RESULTS

Descriptions of weathered graphitic-quartz-muscovite samples

As earth materials in weathering profiles preserve to different extents, the minerals, textures and structures of the original bedrock material and mass, it is important that samples for field or laboratory tests be described in as much detail as possible (Raj, 1983; Raj, 2009). In the case of the present samples, some minor differences in color, texture and mineral composition are seen as they were collected at different depths (Table 1).

Relict foliation planes resulting from the alignment of silt and clay sized particles are present in all three samples; the shallower samples (A and B) being lighter colored than the deeper sample (C). The coarse fractions of samples A and B consist of sericite flakes and some quartz grains, though sample C only comprises sericite flakes. The clay fractions of all samples are similar in composition; the clay minerals present being kaolinite and illite (Raj, 1995).

Physical and soil index properties of weathered graphitic-quartz-muscovite schist

The three samples show minor differences in physical properties; samples A, B, and C, having dry unit weights of 12.76, 14.73, and 13.25, kN/m^3, and dry densities of 1301, 1502, and 1349 kg/m^3, respectively (Table 2). Samples A, B, and C, have field moisture contents of 33.1%, 26.7%, and 34.0%, respectively, whilst the specific gravity of their soil particles is closely similar (2.67-2.68) due to fairly similar mineral compositions (Table 1). Samples A, B and C also have porosities of 51%, 44% and 49%, and void ratios of 1.05, 0.79, and 0.98, respectively (Table 2). Plastic limits of samples A, B and C are some 37%, 33% and 35%, whilst liquid limits are 50%, 43% and 50%, respectively.

Some variations in soil texture result from differences in sampling depths; samples B and C with an absence of gravel fractions and sample A with a very small gravel fraction (2.2%) (Table 2). Sample C has a very minor sand content (0.4%), whilst samples A, and B, have contents of 10.2%, and 12.3%, respectively. Fine grained fractions are very variable; samples A, B and C with silt contents of 52.6%, 73.7%, and 76.6%, and clay contents of 35.0%, 14.0% and 23.0%, respectively. Relatively large silt contents thus characterize the deeper samples (B and C), whilst relatively large clay contents characterize the shallower sample A (Table 2).

Pressure plate tests on weathered graphitic-quartz-muscovite schist samples

Volumetric moisture contents are seen to decrease with increasing suctions in the laboratory pressure plate tests (m). In sample A, volumetric moisture contents decrease from 49.9% through 48.9% and 36.7% to 33.9% and 7.2% under increasing suctions from 0 kPa through

Table 1: Descriptions of weathered schist samples.

Sample	Sub-zone	Vertical Depth	Description
A	IIB	5.83 m	Light grey, firm, clayey silt with distinct relict foliation. Coarse fraction of quartz grains & sericite flakes. Clay fraction of kaolinite & illite. Highly weathered graphitic-quartz- muscovite schist.
B	IIB	6.71 m	Light grey, firm, silt with distinct relict foliation. Coarse fraction of quartz grains & sericite flakes. Clay fraction of kaolinite & illite. Highly weathered graphitic-quartz-muscovite schist.
C	IIC	8.95 m	Dark grey, stiff, clayey silt with distinct relict foliation. Coarse fraction of sericite flakes. Clay fraction of kaolinite & illite. Moderately weathered graphitic-quartz-muscovite schist.

Table 2: Physical and soil index properties of weathered schist samples.

Sample	Depth (m)	Dry Density (kg/m^3)	Mineral Grain SG	Porosity (%)	Void Ratio	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
A	5.83	1301	2.67	51	1.05	2.2	10.2	52.6	35.0
B	6.71	1501	2.68	44	0.79	0.0	12.3	73.7	14.0
C	8.95	1349	2.67	49	0.98	0.0	0.4	76.6	23.0

Note: SG refers to Specific Gravity

0.98 kPa and 9.8 kPa to 33 kPa and 1500 kPa, respectively (Table 3). Exactly similar increasing suctions furthermore, give rise to decreasing volumetric moisture contents from 51.8% through 48.6% and 41.1% to 34.3% and 4.5% in sample B, and from 55.5% through 53.2% and 47.6% to 30.2% and 8.6% in sample C (Table 3).

Plots of volumetric moisture content versus suction pressure for samples A, B and C are shown in Figures 4, 5 and 6 together with the best fit lines calculated with the van Genuchten (1980) parametric function. The best fit-lines are bilinear in nature with an initially horizontal segment followed by a steeply sloping segment.

Available water storage capacity of weathered graphitic-quartz-muscovite schist

Laboratory pressure plate tests yield four levels of moisture content that reflect the availability of water in soil to plants, i.e., a) saturation, b) field capacity, c) wilting point, and d) oven dry (Scherer *et al*., 1996). The moisture content when all pores in the soil are filled with water is known as saturation, whilst the field capacity refers to the moisture content left in a soil after drainage of gravitational water (Scherer *et al*., 1996). The wilting point is defined as the moisture content where most plants cannot exert enough force to remove water from small pores in the soil. When soil is dried in an oven nearly all water is removed; this "oven dry" moisture content providing a reference for measuring the other three moisture contents (Scherer *et al*., 1996).

At saturation, there is a soil moisture tension of about 0.001 bar (0.1 kPa) or less, whilst at field capacity, most soils have a soil moisture tension between 0.05 and 0.33 bars (5 and 33 kPa) (Scherer *et al*., 1996). The wilting

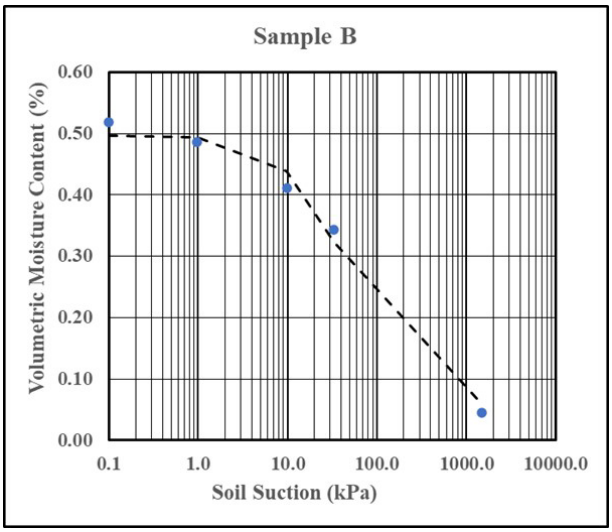

Figure 5: Moisture retention curve of sample B with best fit line based on van Genuchten (1980) parametric model.

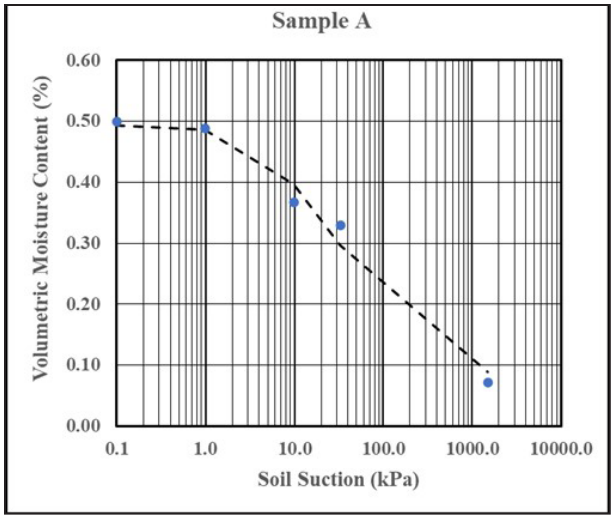

Figure 4: Moisture retention curve of sample A with best fit line based on van Genuchten (1980) parametric model.

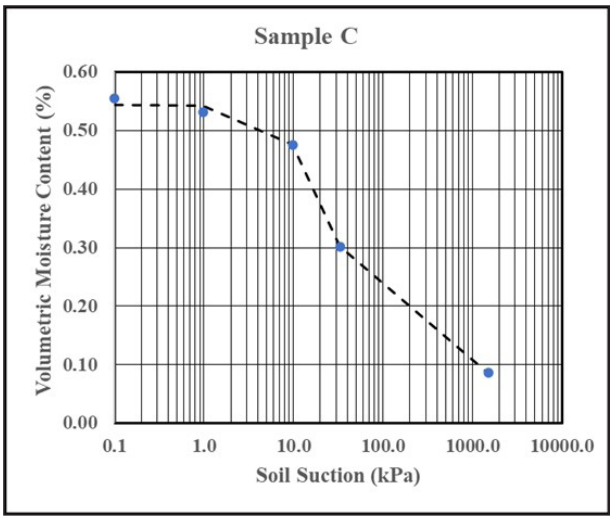

Figure 6: Moisture retention curve of sample C with best fit line based on van Genuchten (1980) parametric model.

Table 3: Volumetric moisture contents retained under different suctions.

Sample	Vertical depth	Volumetric moisture content (%)				
		0 kPa	0.98 kPa	9.8 kPa	33 kPa	1500 kPa
A	5.83	49.9	48.9	36.7	33.0	7.2
B	6.71	51.8	48.6	41.1	34.3	4.5
C	8.95	55.5	53.2	47.6	30.2	8.6

point for most agricultural crops furthermore, is at about 15 bars (1,500 kPa) of soil moisture tension (Scherer *et al*., 1996). The difference between the amount of water in the soil at field capacity and the amount at the permanent wilting point is referred to as available soil moisture or available water storage capacity (Weiler & McDonnell, 2004). Based on these definitions, the weathered graphitic-quartz-muscovite schist has the water storage capacities shown in Table 4.

DISCUSSION

Published data on physical and soil index properties of weathered schist

Published data of direct relevance to physical and soil index properties of the present samples are those cited in the study to characterize the fertility of saprolites in the Peninsula (Hamdan *et al*., 1998). Relevant results (Table 5) show the present samples (Table 2) to have fairly similar physical and soil index properties as those from the lower saprolite and saprock of a weathering profile over schist. Details of the type of schist are not known, though the sampling location at a road cut in Selangor or Pahang suggests a quartz-mica schist.

The physical and soil index properties of the present samples are also comparable with those reported for a schist saprolite which had a bulk density of 1300 kg/m^3, particle density of 2300 kg/m^3, moisture content of 15.6% and total porosity of 42% (Hamdan *et al*., 2006).

Published data on pressure plate tests of weathered schist

Published data of direct relevance to the present tests are those cited in the study to characterize the fertility of saprolites in the Peninsula (Hamdan *et al*., 1998). Relevant results (Table 5) show the volumetric moisture retentions of a schist saprock to be relatively similar to those determined in the present study (Table 3). Somewhat similar volumetric moisture retentions are also reported in the study to evaluate the hydraulic conductivity of a schist saprolite (Hamdan *et al*., 2006) where increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1500 kPa resulted in volumetric moisture contents of 78% through 47% and 45% to 39% and 19%. The results are not exactly similar with those of the present study (Table 3) as there are differences in texture between samples from saprolite, and those from saprock.

The plots of moisture retention curves with best fit lines of the present study should ideally be compared with those involving similar earth materials as the study by Noguchi *et al*. (2003). In the study of Noguchi *et al*. (2003), pressure plate tests were carried out on soils over meta-sedimentary bedrock at a site in tropical rain forest, and at a site in a nearby rubber plantation. Two types of best fit lines were obtained with the van Genuchten (1980) parametric model; both with an initially horizonal segment, but followed by a steeply sloping segment in the first type, and a gently sloping segment in the second type. These differences, which indicate rapid, or gradual, decreases in moisture content with increasing suction, were considered to reflect differences in the volumes of mesopores and macropores (Noguchi *et al*., 2003). Best fit lines plotted in the present study (Figures 4, 5 and 6) are similar to those of the first type of Noguchi *et al*. (2003) and indicate a rapid decrease in moisture content with increasing suction due to a large volume of mesopores and macropores. The rapid decrease in moisture content with increasing suction also reflects the inherent alignment of silt-sized particles in the present samples as they were collected from saprock where indistinct to distinct relict foliation planes are present.

Table 4: Available water storage capacity of weathered schist samples.

Sample	Depth (m)	Saturation (%)	Field Capacity (%)	Wilting Point (%)	Available Water Storage Capacity (%)
A	5.83	49.9	33.0	7.2	25.8
B	6.71	51.8	34.3	4.5	29.8
C	8.95	55.5	30.2	8.6	21.6

Table 5: Soil index properties and moisture retention contents under different suctions of a schist saprolite and saprock (From Tables 1 & 2 in Hamdan *et al*., 1998).

Horizon	Depth (m)	Bulk Density (kg/m^3)	Porosity (%)	Granulometry			Volumetric moisture content (%)				
				Clay (%)	Silt (%)	Sand (%)	0 kPa	0.98 kPa	9.8 kPa	33 kPa	1500 kPa
Upper Saprolite	1.5 – 6	1590	44.8	39.4	43.2	17.5	72.0	66.5	45.9	42.1	12.4
Lower Saprolite	6 – 9	1850	49.3	10.9	79.1	11.0	88.7	60.2	57.1	42.2	10.3
Saprock	9 – 10	1950	45.8	7.4	81.7	10.9	52.9	51.2	40.6	23.2	11.1

The best fit lines of the present study (Figures 4, 5 and 6) are also very similar to those shown in the study by Yamusa *et al*. (2019) where pressure plate tests were carried out on three specimens of a red laterite soil moulded at 2% dry of optimum, at optimum, and 2% wet of optimum, water content. The similarity in shape of the best fit lines again points to the rapid decrease in moisture content with increasing suction due to a relatively large volume of mesopores and macropores.

Published data on available water storage capacity of weathered schist

Available water storage capacities (21.6% to 29.8%) of the present samples (Table 4) are best correlated with the average values of 20% and 21% for loam and silt loam soils cited by Easton & Bock (2016). The values of field capacity (30.2% to 34.3%) (Table 4) can also be correlated with the average values of 36% and 39% for loam and silt loam soils noted by Easton & Bock (2016). The moisture contents at wilting point (4.5% to 8.6%), however, are much lower than the average values of 16% and 18% cited for loam and silt loam soils, and are probably best correlated with the average value of 9% cited for a sandy loam (Easton & Bock, 2016).

Locally published data of direct relevance to the available water storage capacities (21.6% to 29.8%) of the present samples are those cited for samples from lower saprolite (42.2%), and from saprock (23.2%), at a profile over schist (Hamdan *et al*., 1998). The moisture contents at wilting point for these samples from lower saprolite (10.3%), and saprock (11.1%), however, are larger than those determined in the present study. This difference may be attributed to differences in texture as well as the extent of preservation of relict foliation planes.

Significance of study

The role of negative pore water pressures in enhancing the stability of slope cuts in the residual soils of humid tropical areas and the occurrence of failures during periods of rainfall has been high-lighted by several workers, including Wesley (2009), Wesley (2010), Rahardjo *et al*. (2010) and Wesley (2011). Yusof *et al*. (2016) have also concluded that in Malaysia, it is the infiltration of rainfall that results in slope failures due to the loss of the negative pore water pressures or soil suction that provide an additional shear strength in unsaturated soils. This additional shear strength is best described as being the contractile skin or air–water interface (Fredlund & Morgenstern, 1977) that acts like an elastic membrane and influences the mechanical behavior of soil by pulling the soil particles together through surface tension (Rahardjo *et al*., 2019).

In the present study, it has been shown that decreasing moisture contents in weathered graphitic-quartz-muscovite schist are reflected by increasing suctions (or negative pore water pressures). These negative pore water pressures thus account for the absence of failures at moderately sloping, low cuts in unsaturated, weathered graphitic-quartz-muscovite schist as they give rise to enhanced (or additional) shear strengths.

Best fit lines plotted with the van Genuchten (1980) parametric model in the present study furthermore, show initially horizontal segments followed by steeply sloping segments that indicate rapid decreases in moisture contents with increasing suction (or negative pore water pressures). Infiltration of rainwater will thus give rise to a rapid decrease of negative pore water pressures and loss of the additional shear strength. This feature thus accounts for the earth falls and shallow slips that have occurred at steeply sloping, low cuts in unsaturated, weathered graphitic-quartz-muscovite schist; infiltration of rainwater aided by the tension and desiccation cracks that were earlier formed.

CONCLUSIONS

Samples, collected at depths of 5.83 m (A), 6.71 m (B) and 8.95 m (C) at a weathering profile in weathered graphitic-quartz-muscovite schist, have dry unit weights of 12.76, 14.73, and 13.23, kN/m^3, and dry densities of 1301, 1501, and 1349, kg/m^3, respectively. Samples A, B and C have porosities of 51%, 44%, and 49%, and void ratios of 1.05, 0.79 and 0.98, respectively whilst their constituent mineral grains have a specific gravity between 2.67 and 2.68. Grain size analyses show samples A, B and C to be overwhelmingly fine-grained with silt contents of 53.6%, 73.7%, and 76.6%, and clay contents of 35.0%, 14.0%, and 23.0%, respectively.

Laboratory determinations employing the pressure plate method show increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1,500 kPa, to result in volumetric moisture retentions of 49.9% through 48.9% and 36.7% to 33.0% and 7.2% in sample A, from 51.8% through 48.6% and 41.1% to 34.3% and 4.5% in sample B, and from 55.5% through 53.2% and 47.6% to 30.2% and 8.6% in sample C.

Decreasing moisture contents with increasing suctions indicate the presence of negative pore water pressures; a feature that gives rise to enhanced shear strengths and accounts for the absence of failures at moderately sloping (<60°), low (<15 m height) cuts in unsaturated, weathered graphitic-quartz-muscovite schist.

Best fit lines plotted with the van Genuchten (1980) parametric model for the moisture retention (or water characteristic) curves show an initial horizontal segment followed by a steeply sloping segment indicating a rapid decrease in moisture content with increasing suction due to large porosities. Infiltration of rainwater thus results in a rapid decrease in negative pore water pressures and the loss of enhanced shear strength which gives rise to the earth falls and shallow slips at steeply sloping, low cuts in unsaturated, weathered graphitic-quartz-muscovite schists.

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CONFLICTS OF INTEREST

The author has no conflicts of interest to declare that are relevant to the contents of this article.

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National Geoscience Conference (NGC) 2024

The National Geoscience Conference (NGC) 2024 took place from October 1–3, 2024, at the Wyndham Grand Bangsar, Kuala Lumpur. This 37th edition of the annual conference had the theme "Geoscience for a Sustainable Future." A post-conference fieldwork session was held on October 3, 2024. The event was hosted by the Geological Society of Malaysia (GSM) and the Department of Geology at Universiti Malaya (UM), in collaboration with the Department of Mineral and Geoscience Malaysia (JMG), the Board of Geologists (BoG), and the Institute of Geology Malaysia (IGM). It also celebrated the 65th Anniversary (Sapphire Jubilee) of the Faculty of Science at Universiti Malaya.

The organizing committee was chaired by P. Geol. Assoc. Prof. Dr. Meor Hakif Amir Hassan, Vice President of GSM, and co-chaired by P. Geol. Tuan Yusari bin Basiran, Director of Mineral Economics at JMG, along with P. Geol. Abd Rasid Jaapar, President of IGM. The conference was officially opened by Datuk P. Geol. Zamri bin Ramli, Director-General of JMG.

The conference attracted more than 200 participants, including technical committee members, students, academics, geoscience researchers, and practitioners from various organizations, such as universities, government institutes, the private sector, and NGOs. The post-conference fieldwork had 20 participants, including committee members.

Four keynote papers were presented. Associate Professor Dr. Hasrizal (UMT), P. Geol. Professor Joy Jacqueline Pereira (UKM), Associate Professor Dr. Masatoshi Sone (UM), and P. Geol. Dr. Zuhar Zahir Tuan Harith (Beicip-Franlab Asia) shared their insights on emerging trends and the critical role of geoscience in shaping the future.

There were 72 oral presentations, divided between 18 technical sessions, with three sessions being run at a time in parallel. In addition, 40 posters were presented. Figures 3-10 summarize all the activities during NGC2024.

Plenary keynote session

Table 1: List of the four plenary keynote speakers during NGC 2024.

No.	Speaker	Affiliation	Title
1	Assoc. Prof. Dr. Hasrizal bin Shaari	Palaeoceanography Research Group, Universiti Malaysia Terengganu (UMT)	Marine Geoarchaeology – Unveil the history of Bidong Shipwreck
2	P. Geol. Prof. Dr. Joy Jacqueline Pereira	Southeast Asia Disaster Prevention Research Initiative, Universiti Kebangsaan Malaysia (UKM)	Climate change and disaster resilience in cities – The role of geoscience
3	Assoc. Prof. Dr. Masatoshi Sone	Sedimentary Geology and Paleontology Research Group, Universiti Malaya (UM)	Malaysian dinosaurs
4	P. Geol. Dr. Zuhar Zahir Tuan Harith	Technical Advisor, Beicip-Franlab Asia	Role of geoscience in the energy transition

Oral Presentations

Oral presentations were held throughout the two-day conference, covering a wide range of disciplines, including Disaster Risk Reduction, Climate Hazards, Climate Change and Engineering Geology, Energy and Mineral Resources, Groundwater Resources, Conservation Geology and Geo-tourism, Quaternary, Coastal and Marine Geology, Tectonics and Structural Geology, Stratigraphy, Sedimentology and Palaeontology, Karst, Geochemistry, Geophysics, Geospatial Applications and Geotechnology, and Policies, Ethics and Professional Practice (Figure 1). Each presentation was evaluated by the session chairperson, an expert in their respective field. A list and chart of the presented papers follows (Figure 1, Table 2). The best oral presentation was awarded to Farid Najmi Rosli from USM, Muhammad Rafi

from UTP and Ery Arifullah from Universitas Muhammadiyah Kalimantan Timur, Indonesia. Details are presented in Table 3. In addition to the papers presented by academics, students and professional practitioners, three sponsored talks were given by conference sponsors (talks 70, 71 and 72 in Table 3).

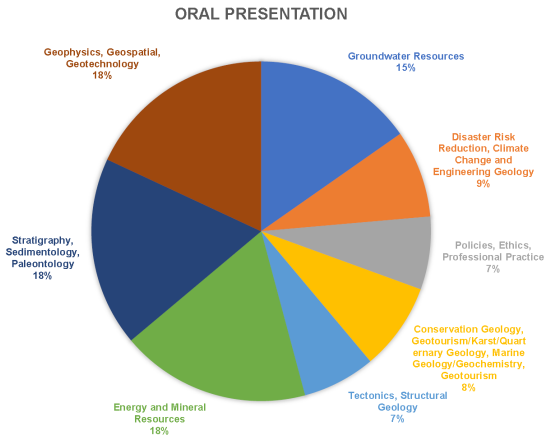


Figure 1: Pie-chart showing the discipline of oral presentation during NGC 2024.

Table 2: Details of the oral participants during NGC 2024.

No.	Speaker	Title
1	John Kuna Raj	Late Quaternary denudational chronology of the Kg. Air Jernih area, Terengganu, Malaysia
2	Josiah Nuhu Jabbo	Groundwater potential zone controlling source and flow using Multi-Criteria Decision-Making Analysis (MCDMA) based on Analytical Hierarchical Process (AHP) of Yankari Game Reserve and its environs, Northeast Nigeria
3	Meor Hakif Amir Hassan	A chronostratigraphic chart for the Palaezoic of NW Peninsular Malaysia: Reconciling local stratigraphy with regional and global geologic events
4	Alya Batrisyia Binti Maghrib	Assessment of karst as potential carbon storage through virtual reality environment
5	Mohd Talha Anees	Landslide risk assessment controlled by geological and triggering factors at regional scale using remote sensing and GIS
6	Nor Shahidah Mohd Nazer	Internal and surface erosion mechanism of residual soil based on detachment and dispersion control
7	Mohammed Abubakar Mohammed	Source rock potential of Agbada Formation Shales: Case study, DRM Field
8	Muhammad Hanif Haziq Mohammad	Distribution of planktonic foraminifera species in deepwater offshore Sarawak
9	Kuganeswaraan A/L Narayanasamy	Role of temperature, magnesium and strontium ions in the polymorphism of calcium carbonates in water
10	Noorzamzarina Sulaiman	Investigation of landslide potential using Electrical Resistivity Imaging (ERI) method in Hutan Lipur Bukit Bakar, Machang, Kelantan
11	Mazlan Madon	Continental margins according to UNCLOS 1982: A review based on CLCS recommendations on the outer limits of the continental shelf
12	Askury Abd Kadir	Chronology of pseudo-karst formation in Kampar, Perak: A preliminary assumption
13	Sohag Ali	Investigation of hydrochemistry, origin and suitability of drainage water: A case study in Barapukuria Coal Mine, Bangladesh

14	Nur Amirah Azman	Hard sand or soft sand? Looking from a rock physics lens – A case study from a shallow clastic reservoir
15	Syaiful Alam	Paleoclimate, calcareous nannofossil distribution, and astronomical forcing of the late Miocene Halang Formation, West Java, Indonesia
16	Habibah Hanan Mat Yusoff	Late Quaternary fluvial to deltaic depositional systems within a source-to-sink framework of Central Sarawak, Malaysia
17	Nur Fadzlina Aini M. Lehan	Linking geospatial applications and business continuity to MSMEs: Implications for disastrous events
18	Nur Alya Sabrina Mohd Saharom	Investigation of sedimentary outcrops using geophysical methods in Langkawi, Kedah, Malaysia
19	Prasanna Mohan Viswanathan	Assessment of groundwater quality in Miri – A baseline study
20	Mazlan Madon	Gravity inversion of Moho depth beneath Sabah using seismic-derived density model
21	K.M. Leong	Impact of affirmation of Sabah tonalites Triassic and Jurassic biotite K:Ar ages by U-Pb zircon ages
22	Muhammad Rafi	Developing a surface Distributed Acoustic Sensing (DAS) response with different type of seismic source for shallow survey
23	Bashir Agha-Musa	Groundwater potential assessment of Penang mainland, Malaysia, through integration of remote sensing and GIS
24	Mohd Khairul Nizar Shamsuddin	Assesment of integrated surface water-groundwater: A case study at Perlis River Basin, Malaysia
25	Maryam Sofia Mohd Rasdi	Paleoecology of Northwest Peninsular Malaysia based on Ordovician – Silurian graptolites
26	Ahmad Hasnulhadi bin Che Kamaruddin	Geostatistical analysis of Geographic Information System (GIS) using Inverse Distance Weighting (IDW) mapping technique
27	Khaira Ismail	Geological and jurisdictional aspects of deep-sea mining
28	Satapat Kumpitak	Plio-Pleistocene mosaic environments of northern Peninsular Malaysia: Evidence from Murid Rodent Fossils from Semadong Cave (Perlis)
29	Mohamed Rouai	Geophysical prospecting of groundwater in the Middle Atlas of Morocco: Study case
30	B. Venkateshwaran	Synthetic gamma-ray log reconstruction based on the depositional facies in Malay Basin for CO_2 storage using machine learning
31	Lim Tze Tshen	Characterization of Peninsular Malaysian Quaternary large mammal fauna, with special focus on fossil orangutan (Pongo sp.)
32	Rezal Rahmat	Zircon U-Pb ages and geochemical characteristics of Cretaceous ophiolitic rocks from Kudat and Marudu Bay ophiolite, Northern Sabah (Borneo), Malaysia
33	Sirajo Abubakar	Investigation of the debris and alluvium deposit thickness using the 2D-resistivity and soil moisture index analysis along Sungai Kupang tributary, Kampung Iboi, Muda River Basin
34	Ismail Abd Rahim	Simplified mode of failure approach, critical zone and safe slope angle determination in stereographic projection
35	Abdull Halim Bin Abdul	Measurement of the thermal conductivity of Quaternary deposit soils using Single Probes Method
36	Kribagiry Thamilarasan	Effectiveness of sieving and grinding in measuring the concentration of rare earth element from ion adsorption clay in Lumut, Perak
37	Farid Najmi Rosli	Optimization of pole-dipole array in subsurface investigation
38	Robert C Shoup	Ethics in science; Application of the scientific method
39	Nor Najiha Binti Nasrudin	Evaluating slope failure risks using 2D Electrical Resistivity Imaging (ERI) and Induced Polarization (IP) at Berjaya Hills Resort, Bukit Tinggi, Pahang Darul Makmur

40	Muhammad Afiq Ariff Hellmy	Digital preservation and 3D documentation of geological heritage sites in Malaysia: Technologies and applications
41	Nur Muhammad Asyraf Mansor	National offshore sand resources survey phase 3B: Sediment sampling survey in offshore of Kelantan and Terengganu
42	Nur Anati Azmi	A closer look at Lebuhraya Karak and Lebuhraya Pantai Timur 1 (LPT1): Kinematic analysis reveals surprising results
43	Okmen Sümer	The largest sinistral doublet earthquakes of the world during the instrumental period; February 06, 2023 Kahramanmaraş earthquakes, Türkiye
44	Low Keng Lok	Critical parameters for feasibility in mining projects
45	Daulip DD Lakkui	Sustainable development of Sabah coal resources
46	Yi Ning Fong	Palynological insights from the Tukau Formation, northwest Sarawak, Malaysia
47	Najiatun Najla Mohamad	Facies and stratigraphic associations of the Pedawan Formation (Jurassic-Cretaceous) in Kuching area, Sarawak: Paleoenvironment, paleogeographic and paleotectonic significance
48	Peter Lunt	The Rajang Unconformity of Sarawak, re-considered
49	Peter Lunt	The changing role of stratigraphy; SE Asia as a leader
50	Thivineshvaren Elanggovan	Correlation of lineament analysis and satellite gravity data processing to study surface and subsurface deformation trends in Northwest Sabah
51	Azrul Normi Idris	Resistivity survey for determining the subsurface structures of Lake Bed in Linggi, Negeri Sembilan, Malaysia
52	Siti Fariza Abdul Hamid	Pembangunan aspiring Melaka Geopark: Status dan perkembangan semasa
53	Zakiyah Ainul Kamal	Appraisal of groundwater quality for drinking and irrigation purposes in Northeastern Kelantan
54	Maybelline Kueh Siu Cheng	Estimating karst volume as potential CO_2 storage site in F23 carbonate buildup, Central Luconia Province, offshore Sarawak
55	Ery Arifullah	Ichnofabric and Principal Component Analysis: Unveiling paleobiological rhythms in the Kutai Basin's Sediments, Indonesia
56	Amirah Wardah Binti Mohd Azmir	Artificial intelligence prediction of porosity utilising well-log and seismic data of the Maui Gas Field, Taranaki Basin, New Zealand
57	Alya Batrisya Mohd Zeffry	Salt water intrusion and groundwater quality using geochemical methods in Bachok District, Kelantan
58	Ibrahim Danial Maarof	Visiting south of Taiping Pluton for possible enrichment of rare earth elements
59	Ismail Tawnie	R&D and strategy for groundwater sustainability through managed aquifer recharge
60	Anuar Sefie	Characterizing geochemistry and groundwater age using Carbon-14 dating techniques in Lower Kelantan Basin
61	Nazrin Rahman	Concrete slab and beam scanning using high frequency ground penetrating radar
62	Allan Filipov	Facies mapping in the Kenny Hill Formation, Selangor, Malaysia
63	Naqib Ullah	Source rock evaluation in the Kohat Basin, Pakistan: A comprehensive analysis of Early Eocene evaporite-interbedded shales using geochemical and petrographic techniques
64	Belinda Clare Bonny	Potential rare earth element from Bujang Melaka-Chenderoh Pluton within the Main Range province in Perak, Peninsular Malaysia
65	Nur Mujeera Chaudhry	Petrographic assessment and diagenetic history of Oligocene-Miocene Gomantong Limestone, East Sabah

66	Abdulsalam Bello	Integrated geological and petrophysical modelling for caprock and reservoir characterization for carbon storage in FX field, central Luconia province
67	Sudirman Dawing	Sediment fairway controlling factor in deep water fold thrust belt
68	Muhammad Anasrullah Abd Rahim	Geophysical survey of Pulau Sembilan, Perak
69	Ros Fatihah Muhammad	Karst-like morphology of Bujang Melaka granite boulders in Kampar, Perak, West Malaysia
70	Leonardo Salazar	Recent advancements in automated mineralogy and SEM-EDS for geological applications
71	Catrina Ng, Swee Leng	Overcoming challenges in REE analysis
72	Kenneze Santic	The mine geo-hazard digital Insights Platform

Table 3: Recipient of the best oral presentations award in NGC2024.

ORAL		
1	Farid Najmi Rosli- USM	Optimization of pole-dipole array in subsurface investigation
2	Muhammad Rafi- UTP	Developing a surface Distributed Acoustic Sensing (DAS) response with different type of seismic source for shallow survey
3	Ery Arifullah- Universitas Muhammadiyah Kalimantan Timur, Indonesia	Ichnofabric and Principal Component Analysis: Unveiling paleobiological rhythms in the Kutai Basin's sediments, Indonesia

Poster presentations

A total of 40 abstracts were selected for poster presentations. The posters were evaluated by Dr. Mohd Hariri, Dr. Muhammad Hatta and Ms. Azianti. A list and chart of the presented papers are as follows (Figure 2, Table 4): The best poster was won by Amir Hakim Amiruddin, Muhammad Aiman Syafeeq Azly, and Lim Tze Shen. Details are presented in Table 5.

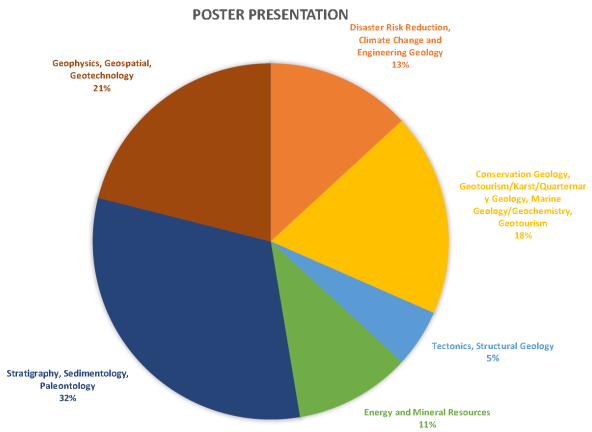


Figure 2: Pie-chart showing the discipline of poster presentation during NGC 2024.

Table 4: Details of the poster participants during NGC 2024.

No	Speaker	Title
1	Amir Hakim Amiruddin	Discovery of Quaternary proboscidean fossils in karst caves of Peninsular Malaysia
2	Muhammad Amri Mahadir	Integration of electrical resistivity and induced polarization methods for near surface characterization
3	Siti Amirah Rosmi	Investigation of seepage in subsurface profile using Electrical Resistivity Imaging (ERI) method on route D219 Temangan - Kuala Hau, Kelantan
4	Ivy Vun Jin Ying	Shallow subsurface analysis through Distributed Acoustic Sensing (DAS) and Seismic Equivalent Signal
5	Nur Al Maidah Che Mod	Geomechanics characterisation and correlation between geometry and stability of granite boulders at Kampar, Perak
6	Nurul Jannah Adnan	Geomechanics characterization and boulder stability evaluation using photogrammetric analysis for granite boulders in Kampar, Perak
7	Puteri Amirah Nabilah Azman	Estimation of landslide volume from 2D-landslide model
8	Muhammad Aidil Hakimi Mohd Noor	Geomechanics characterisation and influence of surface roughness on stability of granitic boulders in Kampar, Perak
9	Muhammad Said Harfiandri	Reservoir analogue of legendary Talang Akar Formation, South Sumatra Basin, Indonesia: Implication to carbon capture storage
10	Nuriffa Syahira Mohd Najib	Influence of pH and salinity on metal mobility in clay and peat soil: A column leaching approach
11	Hijaz Kamal Hasnan	Pre-Carbonation analysis of Kuantan Basalt, Pahang, Malaysia: Insights from mineralogical studies
12	Nur Amal Rumaisha Ek Noorza	The petrography and general geology of Kampung Durian Badak, Dabong, Kelantan.
13	Nurul Syafiah Mat Jusof	The petrography and general geology of Kampung Kemubu, Dabong, Kelantan
14	Muhamad Qarin Johari	The geology and petrography of igneous rocks in Kampung Biak, Dabong, Kelantan
15	Siti Nurassila Anang	Geotourism potential evaluation of Lata Turbo, Jeli, Kelantan using M-GAM method
16	Mohammad Syahmi A Rahim Musly	Facies analysis of the Kayan Formation, Tembawang area, Sarawak
17	Azaleya Nurfatin Najwa A Karim	Facies analysis of the Kayan Formation in the Lundu-Matang area, Sarawak
18	Lim Tze Tshen	Description of a re-discovered elephant fossil from Perlis, and a critical review of Palaeoloxodon evidence in Peninsular Malaysia and Borneo
19	Muhammad Afiq Ariff Hellmy	Karst cliff stability analysis at Batu Caves, Selangor: Utilizing Terrestrial Laser Scanning (TLS) techniques
20	Nur Aisyah Mohd Norhusairi	General geology of Kampong Paloh Road (km 6.5-7), Kelantan with emphasis on sedimentology
21	Liew Mon Long	Seismic interpretation and structural analysis of Maari field using enhanced machine learning techniques
22	Nurul Afiqah Mohammad Zahir	Metals mobility in coastal peatland environment, south Selangor, Malaysia.
23	Elanni Md Affandi	A geospatial approach towards disaster resilience and strategic development planning in Kuala Lumpur

24	Mohammad Aiman Syafeeq Azly	Crocker Formation potential as hydrocarbon reservoir
25	Muhd Fauzi Azmi	Outcrop analogues potential as hydrocarbon reservoirs: Semantan Formation case study (Middle to Late Triassic, Central Belt of Peninsular Malaysia)
26	Yang Zhengrui	Geochemical characteristics of coal-measure source rock, Arang Bed, Tertiary Basin, Peninsular Malaysia
27	Muhammad Amiruddin Amran	New insights into the structural framework of the Kenny Hill Formation, Western Peninsular Malaysia
28	Nur Syahirah Rosmadi	Late Oligocene to Early Miocene calcareous nannofossil assemblages of Temburong Formation in Batu Luang, Klias Peninsula, Sabah
29	Ery Arifullah	Ichnofossil records and paleoecological frameworks: A case study from the Kutai Basin, Indonesia
30	Abdul Hadi Abd Rahman	A river-dominated, tide-influenced delta plain succession, Kayan Formation (uppermost Cretaceous to Lower Eocene Kayan), Lundu, Sarawak
31	Leong Mun Cong	The use of 4'6-diamino-2'phenylindole (DAPI) and propidium iodide (PI) epifluorescence approach for cell quantification in biogeochemical incubation experiment
32	Harry Linang	Seismic structure of Sulawesi: Crustal thickness model from receiver function analysis
33	Shereen Farisha Azlan Shah	Preliminary source rock evaluation of Miocene sedimentary succession in the Northern North Malay Basin.
34	Ida Bagus Suananda Yogi	1D controlled-source electromagnetic resolution enhancement using Seismic Joint Conjugate Gradient Inversion algorithm
35	Siti Aida Nasuha Binti Mahmud Fauzi	Microplastics in the marine environment of Penang Island: Implications for human health
36	Nopporn Khongphakdee	Evaluation of microplastics in beach sediments along the West Coast of Peninsular Malaysia
37	Muhammad Fayyadh	Microplastic as vectors of heavy metal contamination in mangrove sediments of Western Peninsular Malaysia
38	Muhammad Zaim Azraf Mohamed Saidi	Eocene-Oligocene diatom biostratigraphy and palaeoclimatic condition from Site U1553, IODP Expedition 378, Southwest Pacific Ocean
39	Maisarah Alaudin	Exploration of gold deposit potentials using integrated geophysical methods at Ulu Cheka, Pahang
40	Muhammad Zarif bin Amdan	Ground penetrating radar and soil analysis in characterization of soil subsidence in USM main campus

Table 5: Recipients of the best poster award for NGC 2024.

POSTER		
1	Amir Hakim Amiruddin	Discovery of Quaternary proboscidean fossils in karst caves of Peninsular Malaysia
2	Muhammad Aiman Syafeeq Azly	Crocker Formation potential as hydrocarbon reservoir
3	Lim Tze Shen	Description of a re-discovered elephant fossil from Perlis, and a critical review of Palaeolodoxon evidence in Peninsular Malaysia and Borneo

Exhibitors and the C.S. Hutchison Best Student award 2024

There were 10 exhibitors from various industries, including mining, marine exploration, and oil and gas. Each exhibitor showcased their expertise and specialties within their respective industries. A list of exhibitors for NGC 2024 are shown in Table 6:

Table 6: List of exhibitors for NGC2024.

1	Geo Technology Resources Sdn. Bhd.
2	RD-Palmer/LR Teknik Geo
3	MCRE Resources Sdn Bhd
4	IT-Tech Sdn. Bhd.
5	Kumpulan Semesta Sdn. Bhd.
6	Board of Geologists (BOG) Malaysia
7	Thermo-Fisher Scientific
8	Perkin Elmer Malaysia
9	GPS Lands (M) Sdn. Bhd.
10	Mawea Industries Sdn. Bhd.

This year, a total of seven students from geology programs of Malaysian universities were awarded the C.S. Hutchison Best Student award. The list of the recipients is given in Table 7:

Table 7: GSM Huchison best student award 2024.

No	Name	University
1	Muhammad Amri bin Mahadir	USM
2	Nur Adliyana bt Hasriman	UKM
3	Hannah Christabel Phua Wen Xuan	UM
4	Lim Yan Ying	UMS
5	Kaz Nezhan bin Khalib	UMK
6	Maybelline Kueh Siu Cheng	UTP
7	Mohamad Aqil Azmi Bin Mohd Rasedi	UMT

The event concluded with an official closing ceremony, presided over by the chairman of NGC 2024, P. Geol. Assoc. Prof. Dr. Meor Hakif Amir Hassan. The GSM President formally passed GSM's Ceremonial Hammer to P. Geol. Assoc. Prof. Dr. Ismail Abd Rahim, representative from Universiti Malaysia Sabah (UMS), as UMS and JMG Sabah will host next year's NGC in Tawau, Sabah. Tawau, renowned for its stunning and diverse geological heritage, promises to be an exciting host. Among its most remarkable features are striking columnar basalt formations and geothermal hot-springs, a testament to recent volcanic activity, and the historical gold mining sites that once flourished in the area. Attendees will have the opportunity to explore remnants of dormant volcanoes. Not far from Tawau lies the majestic Maliau Basin, often referred to as Malaysia's "Lost World," due to its unique and untouched biodiversity, while the nearby Semporna archipelago boasts spectacular coral islands that are of both geological and ecological significance. These natural wonders make Tawau a perfect backdrop for the 38th NGC, blending scientific exploration with the extraordinary beauty of Sabah's geological treasures.

As a conclusion, the organising committee would like to thank all conference and fieldwork sponsors, Board of Geologists Malaysia, Kumpulan Semesta Sdn. Bhd. Thermo Fisher Scientific, Geo-Technology Resources Sdn. Bhd., Mawea Industries Sdn. Bhd., Selinsing Gold Mine Manager Sdn. Bhd. We are also thankful to JMG and IGM for their cooperation and support in making this event successful.

Photos taken during the event

Figure 3: The conference was officially declared open by Datuk P. Geol. Zamri bin Ramli, Director-General, Department of Mineral and Geoscience Malaysia (JMG).

Figure 4: Participants attended during the opening ceremony.

Figure 5: VIPs during the official opening ceremony.

Figure 6: Souvenir presentation during the Opening Ceremony.

Figure 7: Plenary keynote presentations by P. Geol. Prof. Dr. Joy Jacqueline Pereira, Assoc. Prof. Dr. Hasrizal bin Shaari, Assoc. Prof. Dr. Masatoshi Sone, and Dr. Zuhar Zahir Tuan Harith.

Figure 8: Booth visits by the Director-General of JMG, Datuk P. Geol. Zamri bin Ramli.

Figure 8: Continued.

Figure 8: Continued.

Figure 9: Photographs taken during oral presentations.

Figure 9: Continued.

Figure 10: Group photo of the organizing committee after the closing ceremony.

Post-conference fieldwork

The conference fieldtrip titled "Introduction to Karst" was conducted at Bukit Takun, Rawang Selangor. It was facilitated by Dr Ros Fatihah, Dr Elanni Md Affandi, and Dr Arindam Chakraborty and 17 participants from various agencies joined the excursion. The group departed from the department at 8.30 am and returned at 4.00 pm. The fieldtrip covered an introduction to Kuala Lumpur Limestone, karst hills distribution in Selangor, hypothesis evolution of karst development and the origin of Bukit Takun (Figure 11). Participants were encouraged to look for the limestone-granite contact along the foot of the hill. Preservation of Quaternary fossil-bearing sediment in a shelter cave was also shown to the participants.

Figure 11: Some photos of the post-conference fieldwork to Bukit Takun, Rawang.

Prepared by:
Dr. Lin Chin Yik
Secretary
National Geoscience Conference (NGC) 2024

CERAMAH TEKNIK TECHNICAL TALK

Geologist career prospects in the engineering and construction industry

Fauziah Hanis Hood
Geomag Engineering Sdn Bhd
Date: 12 June 2024
Venue: Bilik Mesyuarat Geologi, Bangunan Geologi, Fakulti Sains dan Teknologi, UKM, Bangi

Program Geologi UKM, Jabatan Sains Bumi dan Alam Sekitar (JSBAS) telah meneruskan sesi ceramah teknik geologi siri ke 5 bagi tahun 2024. Ceramah teknik kali ini disampaikan oleh Cik Fauziah Hanis Hood yang merupakan seorang Ahli Geologi Profesional berdaftar dengan Lembaga Ahli Geologi Malaysia. Ceramah beliau bertajuk *Geologist career Prospects in the Engineering and Construction Industry* telah disampaikan pada 12 Jun 2024 bertempat di Bilik Mesyuarat Geologi, Bangunan Geologi, Fakulti Sains dan Teknologi, Universiti Kebangsaan Malaysia, Bangi. Ceramah ini telah dihadiri oleh pelajar dan kakitangan akademik Program Geologi dan dijalankan secara bersemuka.

Ceramah ini menyentuh tentang bagaimana seseorang ahli geologi boleh memulakan kerjaya dalam industri kejuruteraan dan pembinaan. Beberapa kemahiran profesional asas yang menjadi kelebihan individu sekiranya dikuasai turut dikongsi sebagai persiapan diri sekiranya ingin menceburi bidang ini. Selain itu, beliau turut memperkenalkan beberapa syarikat terkenal serta kewajaran bagi ahli geologi muda menceburi bidang ini. Slide pembentangan beliau telah dikongsi dan boleh diperolehi dengan menghubungi ashahadi@ukm.edu.my .

Upacara penyampaian cenderamata telah disampaikan oleh Prof. Madya Dr. Mohd Hariri Arifin, Timbalan Dekan HEJIM, FST. Pihak Program Geologi UKM merakamkan ucapan jutaan terima kasih kepada Cik Fauziah Hanis Hood atas perkongsian pengalaman. Penghargaan juga dipanjangkan kepada Institut Geologi Malaysia (IGM) dan Persatuan Geologi Malaysia (GSM) atas kerjasama penganjuran sesi ceramah teknik ini. *Geology to the Fore!!*

Penceramah semasa menyampaikan perkongsian berkaitan geologis dan industri kejuruteraan dan pembinaan.

Disediakan oleh,
Dr. Muhammad Ashahadi Bin Dzulkafli P.Geol.
Pensyarah Geologi, JSBAS
Universiti Kebangsaan Malaysia

CERAMAH TEKNIK TECHNICAL TALK

Satellite geodesy applications on tectonic deformation

Jeng Hang, Chong
Department of Earth and Planetary Sciences, University of New Mexico (USA)
Date: 26 July 2024
Venue / Platform: Department of Geology, Universiti Malaya / Zoom

On 26th July, 2024, Department of Geology, Universiti Malaya in partnership with Geological Society of Malaysia hosted a technical talk titled "Satellite Geodesy Applications on Tectonic Deformation". The talk was delivered by Chong Jeng Hann in hybrid mode from the meeting room of Department of Geology, Universiti Malaya, Kuala Lumpur. Around 45 members participated online through Zoom and others viewed through GSM Facebook live. There were 10 participants present at the venue to listen to the talk and interact with him.

Facebook Link: (https://www.facebook.com/share/v/gyaYirqrHU5znWqc/?mibextid=WC7FNe)

Abstract of the talk:

Satellite geodesy such as Interferometric Synthetic Aperture Radar (InSAR) has revolutionized the study of tectonic deformation. The high precision and wide coverage of InSAR and ground-based geodetic measurements such as the Global Navigation Satellite System (GNSS) allow us to study and monitor ground deformation due to tectonic, volcanic, and anthropogenic activities. In this seminar, I will present my work studying different earthquake cycles along convergent boundaries using different geodetic methods and modeling to improve our seismic hazard assessment.

We thank Mr Chong Jeng Hann for his support and contribution to the Society's activity.

Prepared by,
Dr. Harry Telajan Anak Linang
GSM Member
Senior Lecturer
Department of Geology, Universiti Malaya
30th July 2024

CERAMAH TEKNIK TECHNICAL TALK

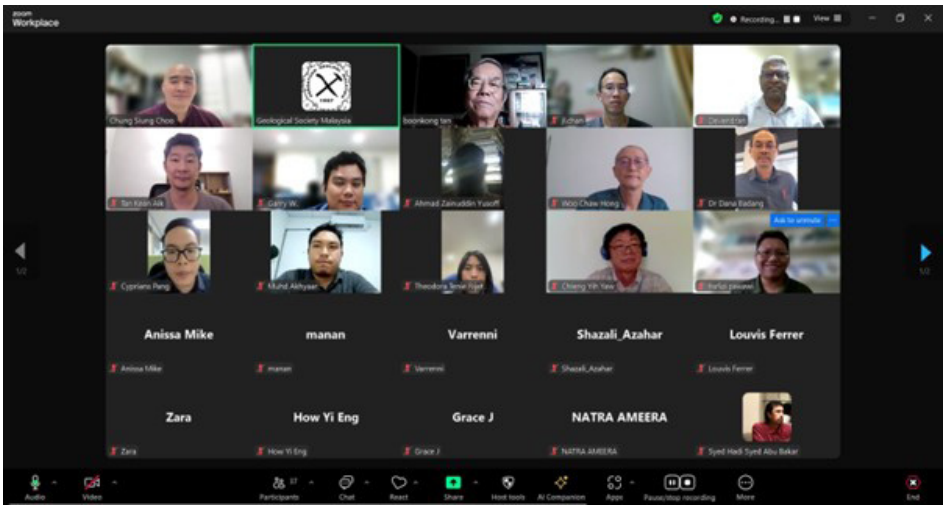
The influence of lithology on pipe jacking through the Tuang Formation in Kuching

Choo Chung Siung
Swinburne University of Technology, Kuching
Date: 21 August 2024
Platform: Zoom

The above talk was delivered by Ir. Dr. Choo Chung Siung (Swinburne University of Technology, Kuching) on 21st August, 2024 via Zoom. Some 60 members participated. An abstract of the talk is given below:

Abstract: During the construction of the trunk sewer line for the Kuching Wastewater Management System, the gravity-fed system meant that the trunk sewer pipeline would be installed at depths of up to 35 m. This implied that the pipelines would be constructed well within the highly weathered lithology of the Tuang Formation. Due to the highly weathered and highly fractured nature of the various rock masses within the Tuang Formation, it was challenging to extract intact rock cores. The absence of intact rock cores meant that it was not possible to perform conventional laboratory rock strength tests. From this presentation, various innovations will be shared, including laboratory testing of tunnelling spoil, in situ methods for rock mass characterisation, and the use of deep learning techniques to visualise the influence of geology on pipe jacking.

We thank Sdr Choo for his support and contribution to the Society's activities.



Prepared by,
Tan Boon Kong
Chairman, Working Group on Engineering Geology & Environmental Geology
22nd August 2024

CERAMAH TEKNIK TECHNICAL TALK

Advancing mining practices through innovative solutions

GSM, Mawea Industries, Dassault Systèmes, and University of Malaya
Date: 11 September 2024
Venue: Department of Geology, Universiti Malaya

On 11th September 2024, the GSM Technical Talk 2024 brought together over 70 mining professionals and academics at the University of Malaya. The event provided a vital platform for geologists, engineers, planners, surveyors, lecturers, and students to dive into the most critical advancements shaping the future of mining.

A Focus on What Matters Now

The theme for this year's event, Advancing Mining Practices through Innovative Solutions, highlighted how next-generation technologies are transforming the extraction and management of rare earth elements, bauxite, and gold. As the mining industry faces rising pressure for efficiency, sustainability, and precision, adopting these solutions has become vital for maintaining a competitive edge.

Key Insights Shaping the Industry

The discussions at GSM Technical Talk 2024 provided participants with more than just updates - they offered actionable strategies that are already reshaping mining operations today. Key takeaways included:

1. **Game-Changing Technologies in Use Today**

Detailed case studies showcased how advanced tools are being applied in real-world mining environments, especially in areas like survey controls, parametric mine design, and material tracking. These proven methods are streamlining operations, improving accuracy, and reducing inefficiencies - delivering results that can be implemented now.

Organiser: Geological Society of Malaysia, Co-organisers: Mawea Industries, Dassault Systèmes, and University of Malaya.

Industry expert delivering insights on parametric approaches in mine design.

2. **Digitalisation: A Must for the Future of Mining**

Industry experts emphasised the growing importance of digitalisation and data-driven decision-making. These technologies are enabling mining companies to integrate planning and operational data more efficiently, unlocking new levels of precision and productivity. Staying ahead in the mining sector will require embracing this digital transformation.

3. **Practical Solutions for Immediate Implementation**

Attendees gained real, hands-on solutions to some of the most pressing challenges in mining today. From optimising mine planning processes to improving resource tracking, the event provided participants with tools they can immediately put into practice to enhance operational success.



Building Connections for the Future

In addition to the technical sessions, the event created an excellent platform for networking and collaboration. Professionals, educators, and students came together to exchange ideas and forge new partnerships, fostering a collaborative atmosphere that will drive the next generation of mining innovation.

The Time to Act is Now

The GSM Technical Talk 2024 was more than just a gathering - it was a critical moment for the mining industry. As technological advancements reshape how we approach mining, adopting these innovations has become essential, not just for operational efficiency but also for addressing some of the industry's most pressing challenges, including sustainability, safety, and cost management. Attendees left the event with practical strategies and knowledge to enhance their operations in an evolving landscape.

The integration of new technologies - such as automation, data analytics, and digital twin solutions - enables mining companies to operate more efficiently, reduce risks, and meet growing environmental and social expectations. In a world where mining is becoming more complex, from lower ore grades to deeper deposits and harsher environments, the ability to leverage these technologies is key to long-term resilience and success.

Looking Forward

The mining industry is at a pivotal juncture. As the sector faces increasing demands for efficiency, safety, and sustainability, staying informed about the latest technological advancements is critical. The time to act is now - embracing these changes today will ensure the industry's future viability and success.

Join Us and Drive Change

The landscape of mining is evolving rapidly. Join us at our next event to explore cutting-edge innovations, engage with industry leaders, and learn how these advancements can directly improve your operations. This is your opportunity to be part of the transformation that will shape the future of mining.

For more details or to register, contact us at marketing@mawea.com.my.

Prepared by,
Sabrine Hoh
MAWEA Industries Sdn. Bhd.
16th October 2024

CERAMAH TEKNIK TECHNICAL TALK

Pelan Induk Cerun Negara / *National Slope Master Plan*

Nursalbiah Binti Hamidun
Cawangan Kejuruteraan Cerun, JKR
Date: 11 September 2024
Platform: Zoom

The above talk was delivered by Ir. Nursalbiah Binti Hamidun (Cawangan Kejuruteraan Cerun, JKR) on 11th September, 2024 via Zoom. Some 100 members participated. An abstract of the talk is given below:

Abstrak: Pelan Induk Cerun Negara (PICN) adalah satu dasar nasional yang komprehensif dan sistematik merangkumi strategi dan pelan tindakan untuk mengurus dan mengawal risiko tanah runtuh serta meningkatkan keselamatan cerun di seluruh negara. Matlamat utama PICN adalah untuk mengurangkan risiko dan kerugian akibat tanah runtuh. Ia bertujuan untuk membimbing pengurusan cerun dan risiko bencana di semua peringkat serta dalam dan merentasi semua sektor, swasta dan awam.

PICN dibangunkan pada tahun 2009, dan kajian semula PICN telah dijalankan pada tahun 2016, selaras dengan Rangka Kerja Sendai UNDRR untuk Pengurangan Risiko Bencana (2015-2030). Strategi dan pelan tindakan PICN yang disemak semula dikelompokkan mengikut keutamaan atau teras. Teras ini diilhamkan melalui Rangka Kerja Sendai, yang memfokuskan kepada tindakan yang perlu diambil untuk mengurangkan risiko bencana termasuk menilai risiko tanah runtuh, melabur dalam pengurangan risiko, mempromosikan tadbir urus yang baik, bersiap siaga untuk tindak balas dan pemulihan, serta merangsang inovasi. Komponen utama dalam PICN merangkumi Rangka Kerja Dasar dan Institusi, Penilaian dan Pemetaan Bahaya, Langkah-langkah Pencegahan Tanah Runtuh, Kesedaran Awam dan Pendidikan, Pengumpulan, Tafsiran, Penyebaran dan Penyimpanan Maklumat, Kesiapsiagaan, Tindak Balas Kecemasan dan Pemulihan, serta Penyelidikan dan Pembangunan (R&D).

Jawatankuasa Antara Kerajaan Mengenai Pengurusan Cerun (ICSM) telah ditubuhkan pada tahun 2011 untuk membolehkan pelbagai agensi kerajaan dan pihak berkepentingan membincangkan isu-isu cerun. ICSM menangani isu-isu berkaitan penyelarasan yang lebih baik dalam pengurusan cerun dan bencana tanah runtuh termasuk langkah-langkah keselamatan dan pencegahan, kesedaran awam, pembangunan perancangan, piawaian, dasar dan garis panduan.

PICN telah dibangunkan dan dilaksanakan selama 15 tahun (2009-2023), dengan pelbagai inisiatif dan pencapaian yang telah dilaksanakan melalui pendekatan bersepadu. Pendekatan ini mengambil kira elemen ekonomi, struktur, rangka kerja undang-undang, aspek sosial, pendidikan, kebimbangan alam sekitar, teknologi, dan langkah-langkah institusi yang menghalang dan mengurangkan pendedahan kepada bahaya dan kerentanan kepada tanah runtuh, meningkatkan kesiapsiagaan untuk tindak balas dan pemulihan, meningkatkan kemampanan dan seterusnya memperkukuhkan daya tahan setempat.

Ia merupakan pelan induk pertama yang mencetuskan perubahan di kalangan pembuat dasar, perancang, pelaksana dan orang awam, terutamanya bagi mereka yang tinggal di kawasan bukit dan kawasan yang terdedah kepada tanah runtuh.

Abstract: *The National Slope Master Plan (NSMP) is a comprehensive and systematic national policy that includes strategies and action plans to manage and control landslide risks and enhance slope safety nationwide. The primary goal of PICN is to reduce the risks and losses due to landslides. It aims to guide the slope management and disaster risk at all levels as well as within and across all sectors, private and public.*

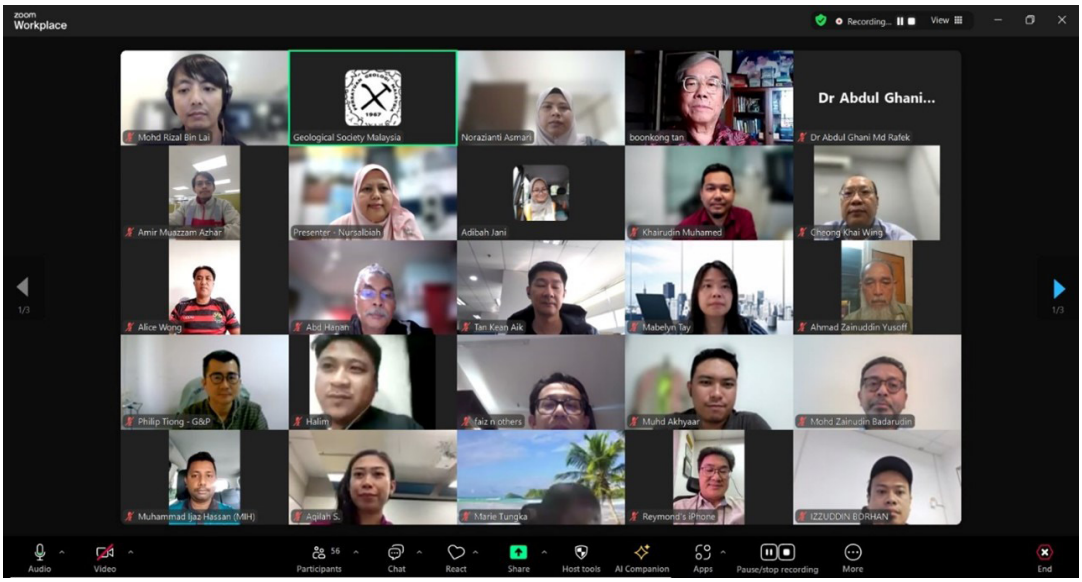
The NSMP was developed in 2009, and a review was conducted in 2016, in line with the UNDRR Sendai Framework for Disaster Risk Reduction (2015-2030). The strategies and action plans of the revised NSMP are grouped by priority or thrust. These thrusts were inspired by the Sendai Framework, which focuses on actions to reduce disaster risk, including assessing landslide risk, investing in risk reduction, promoting good governance, preparing for response and recovery, and spurring innovation. The components covered in the NSMP include the Policy and Institutional Framework, Hazard Assessment and Mapping, Landslide Prevention Measures, Public Awareness and Education, Information Collection, Interpretation, Dissemination and Archiving (ICIDA), Preparedness, Emergency Response and Recovery, as well as Research and Development (R&D).

The Inter-Governmental Committee on Slope Management (ICSM) was established in 2011 to facilitate discussions among various government agencies and stakeholders on slope matters. The ICSM addresses issues related to better coordination in slope management and landslide disasters, including safety and preventive measures, public awareness, planning development, standards, policies, and guidelines.

The NSMP has been developed and implemented over the past 15 years (2009-2023), with various initiatives and achievements carried out through an integrated approach. This approach considers economic, structural, legal, social, educational, environmental, technological, and institutional measures to prevent and reduce hazard exposure and vulnerability to landslides, increase preparedness for response and recovery, enhance sustainability, and further strengthen local resilience.

It was the first master plan to drive changes among policy makers, planners, implementers and the general public, particularly for those living in hillsides and landslide-prone areas.

We thank Sdri Salbiah for her support and contribution to the Society's activities.



Prepared by,
Tan Boon Kong
Chairman, Working Group on Engineering Geology & Environmental Geology
14th September 2024

CERAMAH TEKNIK TECHNICAL TALK

Fenomena *sinkhole*

Wan Jemizan W. Deraman, Ahmad Fariman Yunus & Mohd. Hariri Arifin
Takaful IKHLAS & UKM
Date: 12 September 2024
Platform: Facebook/Youtube

Satu webinar bertajuk Fenomena Sinkhole telah diadakan pada 12 September 2024 secara maya. Webinar tersebut merupakan kerjasama antara pihak Takaful IKHLAS dengan Persatuan Geologi Malaysia serta Universiti Kebangsaan Malaysia. Program tersebut telah berlangsung dari jam 9.00 malam sehingga 10.00 malam.

Idea webinar ini diadakan adalah sempena isu hangat yang berlaku iaitu kejadian seorang pelancong yang telah jatuh ke dalam lubang di Jalan Masjid India. Banyak kupasan dan liputan berita telah menarik minat orang awam dan tidak kurang juga yang mempunyai perasaan takut untuk ke Kuala Lumpur kerana bimbang ada lubang besar di bawah ibu kota tersebut.

Kupasan menarik dan pelbagai soalan yang dilontarkan semasa ceramah ini boleh dilihat kembali dalam rakaman pihak Takaful IKHLAS menggunakan pautan berikut: https://fb.watch/vc6yioXfvt/.

A webinar titled The Sinkhole Phenomenon was held on September 12, 2024, virtually. The webinar was a collaboration between Takaful IKHLAS, the Geological Society of Malaysia, and Universiti Kebangsaan Malaysia. The program took place from 9:00 PM to 10:00 PM.

The idea for the webinar came in light of a recent hot issue involving an incident where a tourist fell into a hole on Jalan Masjid India. Extensive discussions and media coverage have attracted public interest, with some even expressing fear of visiting Kuala Lumpur, worried about the presence of large sinkholes beneath the capital city.

The insightful discussion and the various questions posed during the talk can be revisited through the recording provided by Takaful IKHLAS via the following link: https://fb.watch/vc6yioXfvt/.

Foto 1: Poster ceramah yang cuba mengetengahkan kejadian lubang benam dan kupasan peri pentingnya mempunyai perlindungan.

Disediakan oleh,
Prof. Madya Ts. Dr. Mohd Hariri Arifin; P.Geol
Presiden Persatuan Geologi Malaysia
14 Oktober 2024

CERAMAH TEKNIK TECHNICAL TALK

Taklimat kepentingan berdaftar dengan Lembaga Ahli Geologi Malaysia (BoG) dan aktif dalam Persatuan Geologi Malaysia (GSM) dan Institut Geologi Malaysia (IGM)

Mohd. Badzran bin Mat Taib, Mohd. Hariri bin Arifin & Adam bin Hashim
BoG, GSM & IGM
Date: 18 September 2024
Platform: Zoom

Tiga organisasi telah berusaha untuk mempromosikan bidang geologi melalui usaha meningkatkan promosi kepada ahli geologi terutama pelajar universiti dan graduan muda. Wakil Lembaga Ahli Geologi atau lebih dikenali sebagai Board of Geologist (BoG) memulakan sesi dalam talian yang disertai dalam 30 orang. Beberapa persoalan yang sering timbul berjaya diulas oleh Pendaftar BoG seperti syarat dan kelayakan untuk menjadi ahli PG dan GG. Apa itu PG dan GG? Berikut adalah pautan laman sesawang BoG untuk anda semua dapatkan info dengan lebih lanjut: https://www.bog.gov.my/

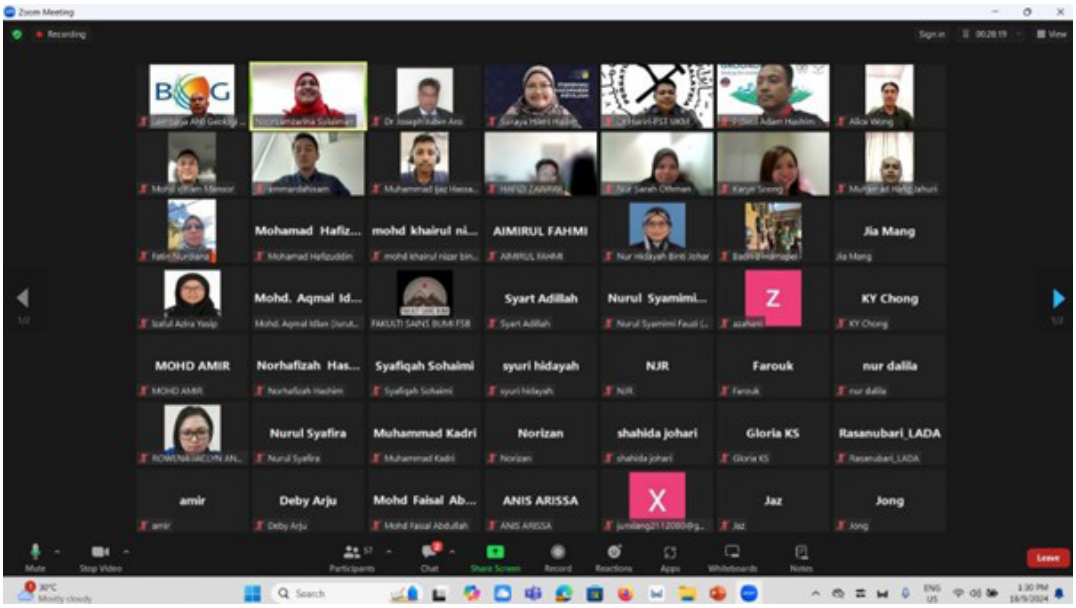
Panel kedua pula diteruskan oleh Presiden Persatuan Geologi Malaysia atau lebih dikenali sebagai GSM. Beliau berkongsi manfaat dan kelebihan menjadi ahli Persatuan Geologi Malaysia dengan menggunakan menu-menu yang ada di dalam laman sesawang GSM. Walaupun sering ditanya oleh komuniti geologi terutama pelajar baru, sebenarnya ramai yang tidak tahu banyak artikel dan penulisan dapat dibaca dan dirujuk dengan percuma. Malah ada yang tidak tahu jika menjadi ahli GSM, mereka akan mendapat harga istimewa dalam membeli buku terbitan GSM dan menyertai acara anjuran GSM juga dengan kadar istimewa. Oleh itu, berikut disediakan pautan laman sesawang untuk rujukan pembaca Warta Geologi: https://gsm.org.my/

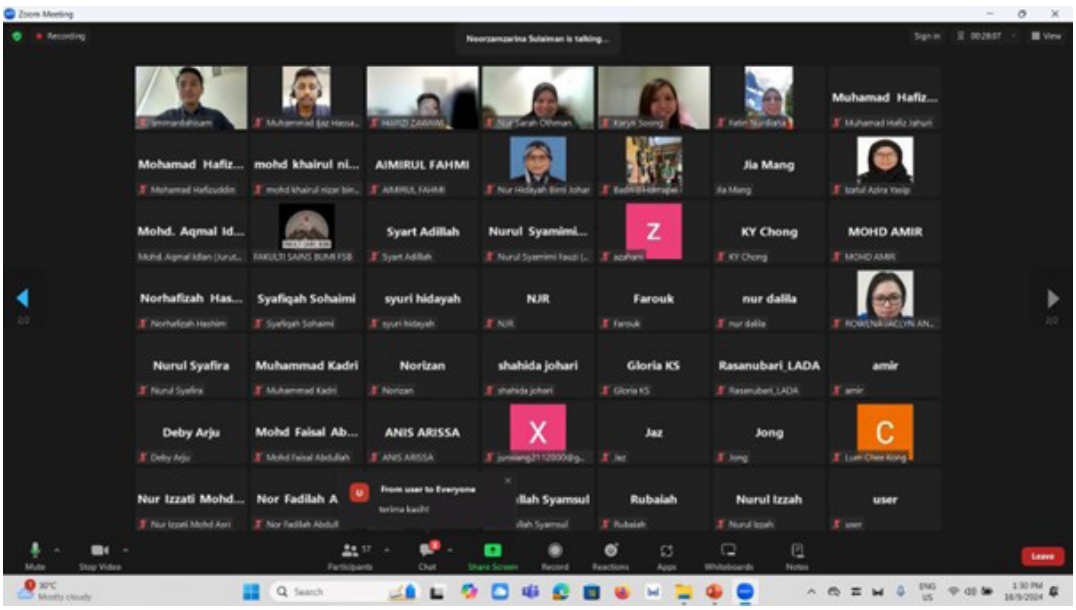
Panel terakhir adalah wakil daripada Institut Geologi Malaysia (IGM) yang diwakili oleh Timbalan Presiden (En. Adam). Beliau mengulas perbezaan antara IGM dengan GSM dan bertekad untuk memastikan IGM kekal relevan di dalam komuniti ahli geologi. Hasrat beliau adalah untuk menjadikan IGM sebagai platform untuk menghubungkan pihak industri-kerajaan-ahli akademik. Perkara ini penting sepertimana usaha pihak IGM yang baru-baru ini telah berjaya menjadi pihak yang menguruskan kerjasama beberapa pihak dalam bidang air bawah tanah khasnya perkembangan ilmu dalam bidang geoterma. Maklumat lanjut tentang IGM bolehlah didapati pada pautan berikut https://www.igm.org.my/.

Three organizations have been working to promote the field of geology by increasing outreach to geologists, particularly university students and young graduates. A representative from the Board of Geologists (BoG) began the online session, attended by about 30 people. Several common questions were successfully addressed by the BoG Registrar, such as the requirements and qualifications to become a Professional Geologist (PG) and Graduate Geologist (GG). What are PG and GG? Here is the link to BoG's website for more information: https://www.bog.gov.my/

The second panel was continued by the President of the Geological Society of Malaysia (GSM). He shared the benefits and advantages of becoming a member of the Geological Society of Malaysia by navigating through the menus available on the GSM website. Although frequently asked by the geological community, especially new students, many are unaware that numerous articles and writings are available for free reference. Moreover, some do not know that by becoming a GSM member, they can receive special prices on purchasing GSM publications and participate in GSM-organized events at discounted rates. Therefore, the following is the website link for readers of Warta Geologi to refer to: https://gsm.org.my/

The final panelist was a representative from the Institute of Geology Malaysia (IGM), represented by the Deputy President (Mr. Adam). He explained the differences between IGM and GSM and is determined to ensure that IGM remains relevant within the geologist community. His aim is to make IGM a platform to connect the industry, government, and academics. This is important, as IGM recently succeeded in managing the collaboration of several parties in the field of groundwater, particularly the development of knowledge in the geothermal sector. More information about IGM can be found at the following link: https://www.igm.org.my/.





Disediakan oleh,
Prof. Madya Ts. Dr. Mohd Hariri Arifin; P.Geol
Presiden Persatuan Geologi Malaysia
14 Oktober 2024

CERAMAH TEKNIK TECHNICAL TALK

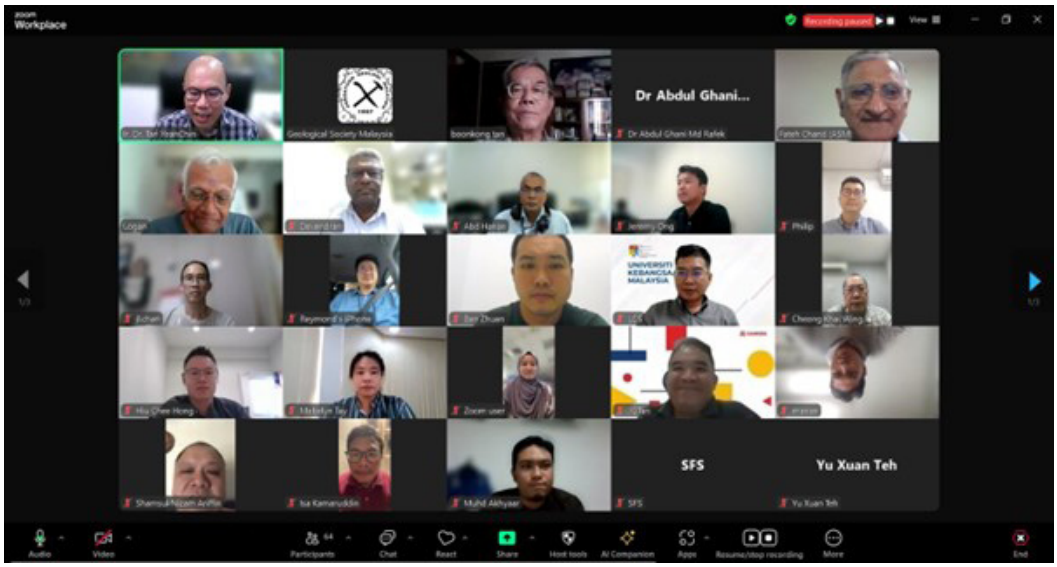
Challenges in design and construction of MRT underground stations in Kuala Lumpur Limestone

Tan Yean Chin
G&P Professionals Sdn Bhd
Date: 9 October 2024
Platform: Zoom

The above talk was delivered by Ir. Dr. Tan Yean Chin (G&P Professionals Sdn Bhd) on 9th October, 2024 via Zoom. Some 100 members (maximum limit) participated. An abstract of the talk is given below:

Abstract: Due to scarcity of land, especially in urban areas, the need for underground structures to optimise the use of land has resulted in the construction of deep excavation works. Deep excavation works pose great challenges to geotechnical engineers, particularly in complex ground conditions such as in limestone, which exhibits notorious karstic features with irregular bedrock profiles, variable weathering condition, cavities and slime zones. With proper geotechnical input, costly failures and delays associated with underground works such as excessive groundwater lowering, occurrences of sinkholes, excessive ground settling, etc. can be prevented. Suitable temporary earth retaining system and rock strengthening works have to be properly designed to prevent such failures. This paper presents design principles of temporary earth retaining systems together with vertical rock excavation, as well as three case studies from Mass Rapid Transport (MRT) projects, featuring various challenging geological formations found within the Klang Valley of Malaysia - Limestone, the Kenny Hill formation and alluvium with high ground water table.

We thank Sdr Tan YC for his support and contribution to the Society's activities.



Prepared by,
Tan Boon Kong
Chairman, Working Group on Engineering Geology & Environmental Geology
10th October 2024

CERAMAH TEKNIK TECHNICAL TALK

Current issues on geomorphology in Malaysia and Indonesia: IAG – Malaysia webinar recap

Rodeano Roslee, Universiti Malaysia Sabah (UMS)
Ros Fatihah Muhammad, Universiti Malaya (UM)
Alfend Rudyawan, Institut Teknologi Bandung (ITB)
Elvaene James, Universiti Malaysia Kelantan (UMK)
Edlic Sathiamurthy, Universiti Malaysia Terengganu (UMT)
Date: 20 October 2024
Platform: Zoom

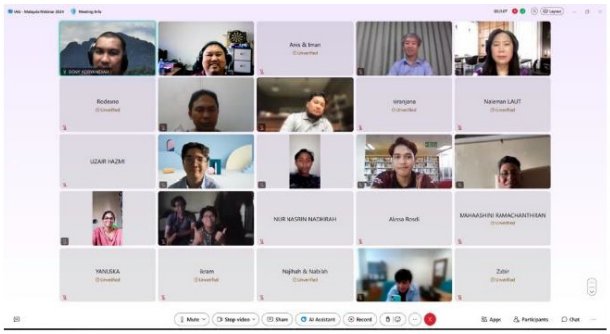
A recent webinar on "Current Issues on Geomorphology in Malaysia and Indonesia" has been organized on 20 October 2024 by the International Association of Geomorphologists (IAG) – National Scientific Member (NSM) for Malaysia in collaboration with the Marine Geoscience Program, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu (UMT) and the Geological Society of Malaysia (GSM). The webinar has brought together leading experts and researchers to present key topics and current trends on geomorphological studies in Malaysia and Indonesia. The event has attracted a diverse audience, such as lecturers, researchers, and students, who were keen to explore hot topics on geomorphology in both countries. During the webinar, attendees had a great opportunity to pose questions directly to the experts during the Q&A sessions.

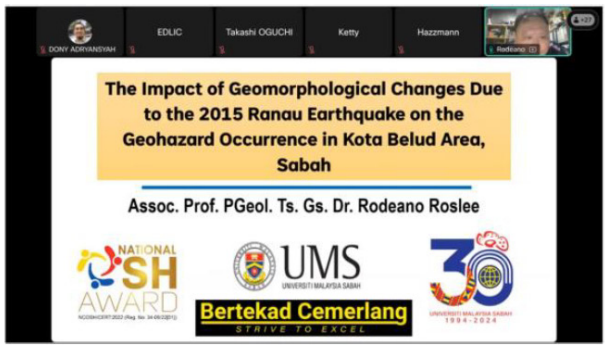
This webinar was attended by the Vice President of IAG, Prof. Takashi Oguchi. He had the opportunity to deliver his welcome speech before the speaker session began. He highly appreciated such an activity since it can bring us to understand the highly diverse geomorphology in the world, such as in Malaysia and Indonesia. In another opening remark, Assoc. Prof. Dr. Edlic Sathiamurthy, as PIC IAG-Malaysia, has welcomed and thanked all participants in this first event organized by IAG-Malaysia and expected many more activities will be organized, not only within Malaysia but also within the broader region of Southeast Asia.

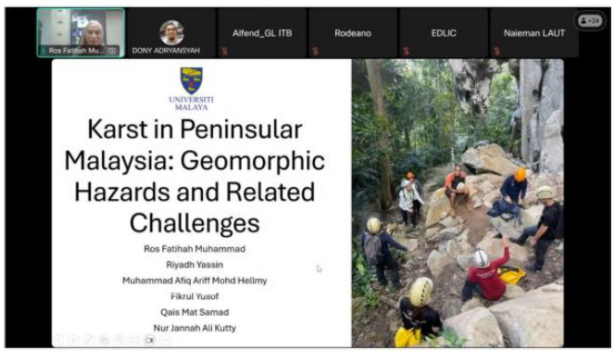
Moderator of the webinar, Dr. Dony Adryansyah Nazaruddin (from the Marine Geoscience Program UMT), introduced five prominent invited speakers from different universities in Malaysia and Indonesia who shared their expertise on a range of geomorphological issues, as follows:

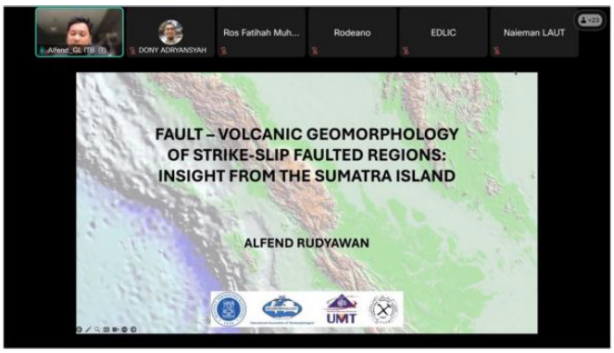
1. Assoc. Prof. Ts. Gs. Dr. Rodeano Roslee, P.Geol., Natural Disaster Research Centre and Faculty of Science and Natural Resources, Universiti Malaysia Sabah (UMS) – "The Impact of Geomorphological Changes due to the 2015 Ranau Earthquake on the Occurrence of Geohazards in Kota Belud Area, Sabah".
2. Dr. Ros Fatihah Muhammad, P.Geol., Department of Geology, Faculty of Science, Universiti Malaya (UM) – "Karst of Peninsular Malaysia: Geomorphic Hazards and Related Challenges".
3. Ir. Alfend Rudyawan, S.T, M.Sc., M.T., Ph.D., Program of Geological Engineering, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung (ITB) – "Fault-Volcanic Geomorphology of Strike-Slip Faulted Regions: Insight from Sumatra Island".
4. Dr. Elvaene James, Geoscience Program, Faculty of Earth Sciences, Universiti Malaysia Kelantan (UMK) – "Characteristics and Geomorphological of Quartz Ridge on igneous rocks: The example of Johor and Pahang, Malaysia".
5. Assoc. Prof. Dr. Edlic Sathiamurthy, Marine Geoscience Program, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu (UMT) – "Kelantan Delta and Strand Plains: Lidar's view"

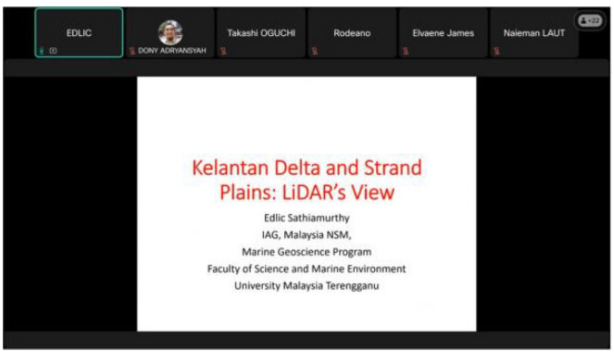
The webinar on "Current Issues on Geomorphology in Malaysia and Indonesia" provided some key issues and challenges in geomorphological research in both countries. It also underscored the importance of regional collaboration in addressing current geomorphological trends. Participants left with a deeper understanding of the necessity for sustainable solutions to preserve the geomorphological integrity of Malaysia and Indonesia in the face of ongoing environmental challenges.











Prepared by,
Dony Adryansyah Nazaruddin & Edlic Sathiamurthy (Contact Persons, IAG Malaysia)
Marine Geoscience Program, Faculty of Science and Marine Environment, UMT
11th November 2024

CERAMAH TEKNIK TECHNICAL TALK

Graptolite research in Malaysia: From its uses in biostratigraphy to the paleoenvironment and thermal maturities studies

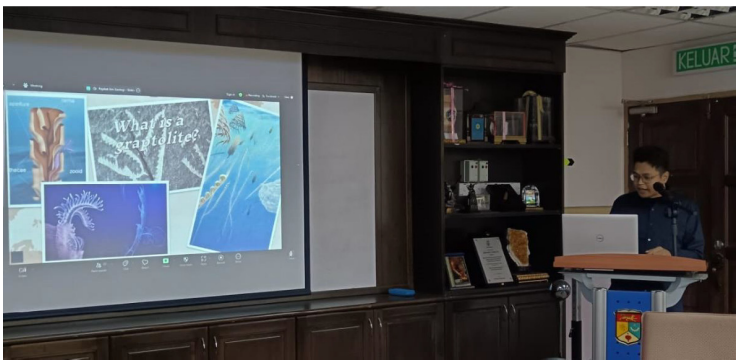
Muhammad Aqqid Saparin
Nanjing Institute of Geology and Palaeontology,
Chinese Academy of Sciences (NIGPAS), Xuanwu, Nanjing, Jiangsu, China
Date: 6 November 2024
Venue: Bilik Mesyuarat Geologi, Universiti Kebangsaan Malaysia (UKM)

Program Geologi UKM, Jabatan Sains Bumi dan Alam Sekitar (JSBAS) berasa sangat bertuah kerana telah berpeluang mendengar sesi perkongsian penyelidikan berkenaan fosil yang sangat jarang dan sukar ditemui di Malaysia iaitu fosil Graptolite. Perkongsian ini telah disampaikan oleh Dr. Muhammad Aqqid Saparin pada 6hb November 2024 di Bilik Mesyuarat Geologi, UKM. Beliau kini sedang berkhidmat sebagai Penyelidik Posdoktoral di Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS), Xuanwu, Nanjing, Jiangsu, China.

Dr. Muhammad Aqqid telah membentangkan hasil kajian graptolitnya di barat laut Semenanjung Malaysia yang merupakan topik penyelidikan bagi tesis Doktor Falsafah yang beliau peroleh daripada Universiti Teknologi Petronas (UTP). Hasil kajian beliau telah diterbitkan dalam beberapa jurnal dan memperbaharui stratigrafi batuan Paleozoik Awal di Semenanjung Malaysia.

Para hadirin dan pelajar turut mengambil peluang bertanyakan tentang pengalaman kerjaya di China, proses dan peluang yang ada di tempat yang sama. Selain itu, beliau turut menunjukkan sampel tangan batuan yang mengandungi fosil graptolit yang telah beliau temui.

Upacara penyampaian cenderamata telah disampaikan oleh Prof. Madya Dr. Habibah binti Hj. Jamil selaku Timbalan Pengerusi bagi Jabatan Sains Bumi dan Alam Sekitar (JSBAS), FST UKM. Geologi UKM merakamkan ucapan jutaan terima kasih kepada Dr. Muhammad Aqqid Saparin atas perkongsian pengalaman yang sangat menarik dan bermanfaat. Penghargaan juga dipanjangkan kepada Institut Geologi Malaysia (IGM) dan Persatuan Geologi Malaysia (GSM) di bawah Kumpulan Kerja Warisan Geologi atas kerjasama penganjuran sesi ceramah teknik ini. *Geology to the Fore!!*



Dr. Aqqid berkongsi maklumat asas berkenaan Graptolit bersama hadirin.


Penyerahan cenderamata kepada penceramah.

Disediakan oleh,
Dr. Muhammad Ashahadi Bin Dzulkafli P.Geol.
Pensyarah Geologi, Jabatan Sains Bumi dan Alam Sekitar, UKM
29 November 2024

CERAMAH TEKNIK TECHNICAL TALK

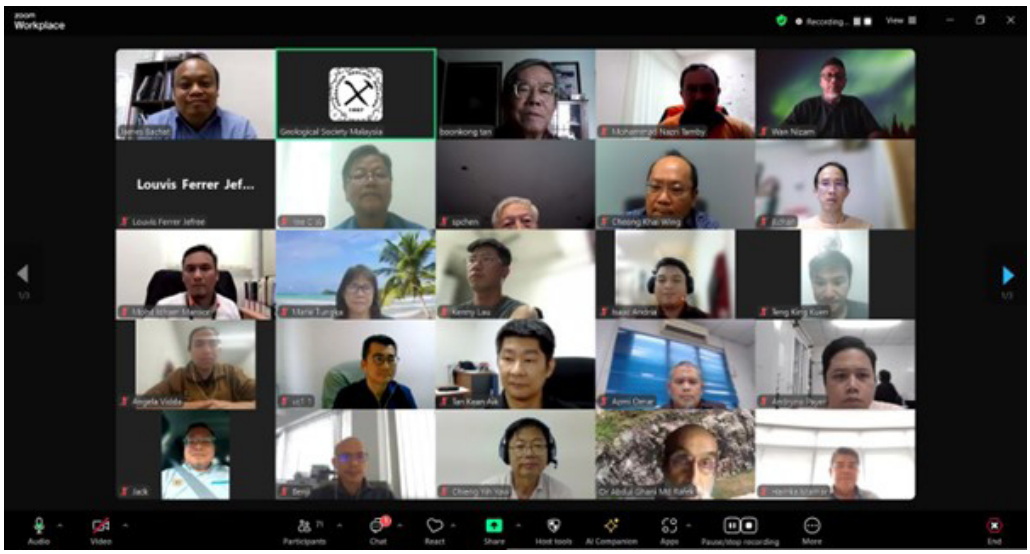
Geological and geotechnical problems in construction in Sarawak

James anak Bachat
Borneo Geoscience Sdn Bhd
Date: 20 November 2024
Platform: Zoom

The above talk was delivered by P. Geol. James anak Bachat (Borneo Geoscience Sdn Bhd) on 20th November, 2024 via Zoom. Some 100 members participated. An abstract of the talk is given below:

Abstract: This paper presents the construction problems issues related to geological and geotechnical related problems in relation to the unfavourable geological composition and materials in Sarawak. The geological setting of Malaysia has generally gotten younger stratigraphically towards the East. This has a direct impact on the engineering properties of the geological materials in Sarawak, particularly with regard to constructability, slope protection schemes, and foundation concerns. Younger geological elements are typically breakable and quickly separable when exposed, and argillaceous rocks crumble easily into soft clay. Excavation procedures revealed the poor geological aspects, which affected the construction process. With poor geological conditions, temporary protection works are essential when constructing slopes, foundations, roads, and buildings. The majority of the construction projects in Sarawak have been influenced by major geotechnical constraints related to weak geological materials. Massive colluvium, weak and brittle arkose, weak interbedded impermeable mudstone/shale, highly permeable sandstone/arkose layers, and argillaceous rocks that are frequently calcareous and which alter into all conceivable gradations between shale and clay are a few of materials encountered. In this research, four pertinent case studies have been chosen, which are pertinent to the unfavourable geological state that was previously discussed.

We thank Sdr James Bachat for his support and contribution to the Society's activities.



Prepared by,
Tan Boon Kong
Chairman, Working Group on Engineering Geology & Environmental Geology
22nd November 2024

CERAMAH TEKNIK TECHNICAL TALK

Carbon sequestration in conventional and unconventional hydrocarbon fields

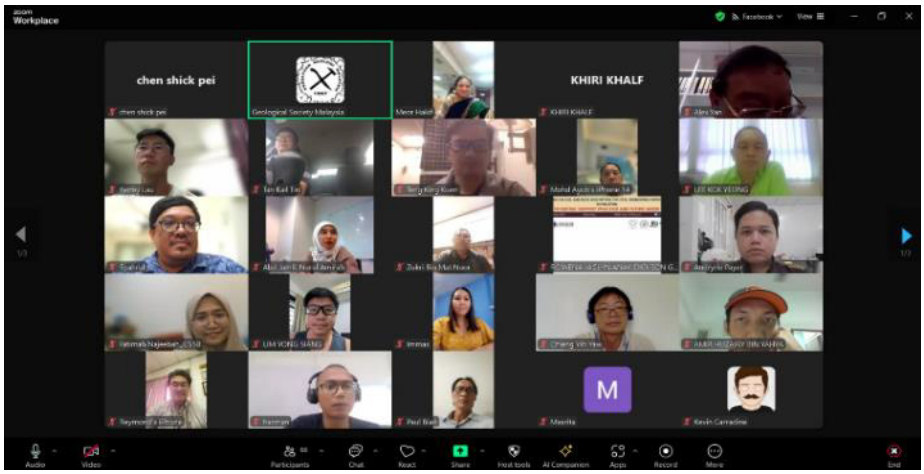
Nimisha Vedanti
Senior Principal Scientist & In-Charge Shallow Seismic Group
CSIR-National Geophysical Research Institute (NGRI), Hyderabad (India)
Date: 22 November 2024
Venue: Department of Geology, Universiti Malaya and Zoom

Moderator: Dr. Arindam Chakraborty, Senior Lecturer, Department of Geology, UM

On 22nd November, 2024, Department of Geology, Universiti Malaya in partnership with Geological Society of Malaysia hosted a technical talk titled "Carbon sequestration in conventional and unconventional hydrocarbon field". The talk was delivered by Dr Nimisha Vedanti (CSIR-NGRI) in hybrid mode from the DKG, Department of Geology, Universiti Malaya, Kuala Lumpur. Around 10 members participated offline and 107 online through zoom and others viewed through GSM Facebook live (https://fb.watch/w46AMbaWR9/). Both the online and offline participants interacted with her.

Abstract of the talk: Carbon storage in geological formations is an essential strategy for reducing atmospheric CO_2 emissions, and it involves injecting CO_2 into deep underground reservoirs. These reservoirs can be classified into conventional, unconventional, and basalt formations, each with its own storage mechanisms and potential for CO_2 sequestration. Geophysical data plays a critical role in evaluating and ensuring the efficiency and security of these storage processes. Additionally, unconventional reservoirs offer the added benefit of enhanced recovery of cleaner energy sources such as coal bed methane (CBM) and shale gas while simultaneously storing CO_2. In conventional reservoirs, such as sandstones and carbonates, CO_2 is injected into porous and permeable rocks that are sealed by impermeable caprocks, like shales, ensuring the CO_2 remains trapped. The primary storage mechanisms are structural trapping, where CO_2 accumulates under the caprock, residual trapping, where CO_2 is immobilized in pore spaces, and solubility trapping, where CO_2 dissolves in formation water. Theoretical storage capacity in conventional reservoirs is determined by the total pore volume available for CO_2 injection, but practical storage capacity is typically lower due to operational constraints such as heterogeneity of the reservoir and injection limitations. Geophysical data, including seismic surveys and well logs, are essential for accurately mapping the geometry of the reservoir, assessing the integrity of the caprock, and ensuring the CO_2 is securely stored in the target formation. In unconventional reservoirs, such as coal beds and shale formations, CO_2 is stored in addition to facilitating the recovery of cleaner gas resources. In coal bed methane (CBM) reservoirs, CO_2 injection enhances methane recovery by adsorbing onto coal surfaces, displacing methane in a process known as CO_2-Enhanced Coal Bed Methane Recovery (CO_2-ECBM). This results in a cleaner, higher-quality methane product. In shale gas reservoirs, CO_2 is injected to improve methane production by adsorbing onto organic-rich materials in the shale and by fracturing the formation to enhance permeability. In these reservoirs, theoretical capacity refers to the total adsorptive capacity of the coal or shale, while practical capacity accounts for factors like gas extraction efficiency, fracture performance, and the ability of the formation to retain CO_2. Geophysical techniques like microseismic monitoring and fracture mapping are critical for optimizing gas recovery and ensuring CO_2 remains securely trapped in the formation. Basalt formations present a unique opportunity for permanent CO_2 sequestration through the process of mineral carbonation, where CO_2 reacts with minerals like calcium and magnesium to form stable carbonates, such as calcite and magnesite. This process locks CO_2 in a solid form, effectively immobilizing it for thousands of years. Theoretical capacity in basalts is based on the mineralogical potential of the formation to react with CO_2, but practical capacity is influenced by factors like injection efficiency, reaction rates, and the permeability of the formation. Geophysical data plays a crucial role in selecting suitable basalt sites by mapping the fracture networks and determining the best areas for CO_2 injection, which ensures the process proceeds effectively. Geophysical data is essential throughout all stages of carbon storage. It helps characterize reservoir properties like porosity and permeability, defines potential storage capacities, and monitors the CO_2 plume once injected. Techniques. However, while making recommendations uncertainties associated with the estimates must be considered.

We thank Dr Nimisha for her support and contribution to the Society's activity.



Online participants.

Dr Nimisha presenting.

Felicitating the speaker by Assoc. Prof. Dr. Meor Hakif Bin Amir Hassan.

Prepared by,
Dr. Arindam Chakraborty
Life Member, GSM
Senior Lecturer and Supervisor, Geology Museum
Department of Geology, Universiti Malaya
22nd November 2024

WORKSHOP

GSM-UTP-SC training on seismic reflection data acquisition and processing 2024

On 10th of July 2024, the Geological Society of Malaysia Universiti Teknologi PETRONAS Student Chapter organized a Training on Seismic Reflection Data Acquisition and Processing. This event was organized in collaboration with the Centre of Seismic Imaging, Universiti Teknologi PETRONAS and the Geophysics Working Group within the Geological Society of Malaysia (GSM). Titled "Training on Seismic Reflection Data Acquisition and Processing," the event was designed to enhance the practical and theoretical knowledge of professionals and students in the geoscience domain, focusing on seismic reflection methodologies. Participants gained a deeper understanding of the steps involved in seismic data acquisition, helping them tackle challenges and apply the right methods in real-life projects. Hands-on training allowed participants to use seismic equipment themselves, boosting their skills in operating, calibrating, and maintaining the equipment. They also learned how to plan effective data acquisition surveys by considering geological and environmental factors. The event encouraged networking and collaboration among participants from different backgrounds, helping them build connections and share ideas through discussions and interactions.

The poster for the training session.

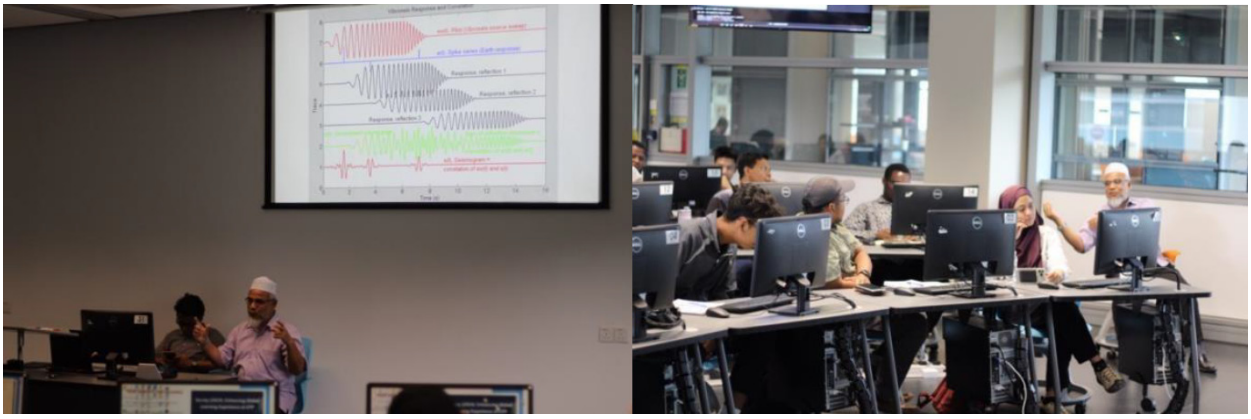
The event was divided into morning and afternoon sessions, each dedicated to different aspects of seismic reflection. The training took place at the Integrated Lab of Universiti Teknologi Petronas Malaysia and was attended by 35 participants, including geologists, lecturers, and students from various parts of Malaysia.

In the morning session, the focus was on seismic acquisition, where participants received hands-on training in acquiring seismic data, primarily using vibroseis technology. The session included practical demonstrations on the use of

The morning session where participants were able to experience a simulation on seismic data acquisition.

outdoor weight drop simulations for seismic data acquisition. The trainer emphasized the importance of understanding the fundamentals of seismic reflection and its various applications.

The afternoon session was dedicated to seismic data processing. Participants learned about the methodologies and best practices for processing seismic data using built-in applications. The trainer demonstrated how to handle data from initial acquisition to final interpretation, highlighting key techniques and tools essential for effective seismic data analysis.



The afternoon session where participants get to know the fundamental of processing seismic data

The event concluded with a dynamic Q&A session, where participants engaged with the trainer on various topics related to seismic processing, practical challenges in data acquisition, and advanced seismic interpretation techniques. The trainer provided detailed responses, ensuring that attendees gained a comprehensive understanding of the subject matter.

The training session was highly interactive and provided valuable insights and practical knowledge to the participants. The collaboration between Geophysics Working Group of GSM, CSI, UTP and GSM-UTP-SC highlighted the importance of industry-academia partnerships in fostering skill development and knowledge sharing within the geophysical community in Malaysia.

Prepared by,
Noor Amirah Syahirah Noor Aizam
Event Program Director

IN MEMORIAM

A distinguished geologist and passionate educator

Peter Mark Lloyd, a renowned geologist with a distinguished career spanning over four decades, passed away peacefully in early August 2024.

Peter's passion for geology led him to pursue a degree in the subject at the University of Cambridge, UK, graduating in 1974. His academic journey laid a strong foundation for a successful career in the field.

Peter's professional experience was marked by his significant contributions to various organizations. He dedicated 20 years to NExT Training, sharing his expertise and knowledge with aspiring geologists. His 23-year tenure at Schlumberger took him across the globe, working in Europe, Asia, Latin America, Australia, and the Middle East. Prior to that, he served BP & Deminex for 7 years.

Peter's commitment to the geological community was unwavering. He was a dedicated member of the American Association of Petroleum Geologists (AAPG), serving as Vice President twice (2002-2003 and 2015-2017) and heading various committees. His passion for education led him to visit over 150 universities worldwide. He was also a member of the AAPG Foundation, an Advisory Council member for the Asia Pacific Region, and a recipient of a special commendation award, a Certificate of Merit, and Honorary Membership in 2008.

Peter was equally active in the Geological Society of Malaysia, where he was a Life Member. He served on the Student Affairs Committee of the European Association of Geoscientists and Engineers (EAGE) in 2010, chaired the Student Committee from 2011 to 2015, and served as a Distinguished Lecturer, VP Elect in 2018, and President from 2020-2021.

Peter is survived by his loving wife, Christiane Margarete, who passed away in 2022 from an unexpected, but painless illness. They shared a joyous marriage for over 37 years. Christiane worked as a cartographer and contributed significantly to geological mapping and engineering drafting.

In May 2024, Peter was diagnosed with cancer and underwent treatment. Despite his illness, he maintained his positive spirit and dedication to the field. His passing will be deeply felt by his family, friends, and colleagues. Peter Mark Lloyd's legacy as a distinguished geologist and passionate educator will continue to inspire generations to come.

Prepared by,
Herman Darman
September 2024

Biodata

Name: Peter Mark Lloyd
Address: Portugal and Indonesia (Bali)
Experiences: NExT Training – 20 years
Schlumberger – 23 years (worked in Europe, Asia, Latin America, Australia, Middle East)
BP & Deminex – 7 years

Education: Geology Department in University of Cambridge, UK, 1971-1974

Organizational activity:
AAPG: Joined in 1979
1. twice served as Vice President, in 2002-2003 & 2015-2017
2. heading various committees
3. visiting about 150 universities world wide
4. joined the AAPG Foundation
5. Advisory council for Asia Pacific Region
6. Received a special commendation award
7. Certificate of Merit and Honorary Member in 2008
8. Honorary member of the house of delegates.

Geological Society of Malaysia
1. Life member

EAGE:
1. Student Affairs Committee in 2010
2. Student Committee chair from 2011 to 2015
3. Distinguished lecturer
4. VP Elect in 2018
5. President from 2020-2021

SPE

Wife: Christiane Margarete (1953 to 2022), Germany, more than 37 years of marriage, passed away from an unexpected, but painless illness. She worked as a cartographer and done geologic maps, as well as engineering drafting

Health: In May 2024 was quite ill and he received cancer treatment. He passed away in August 2024

Peter Lloyd, third from right, visiting young professionals in the Netherlands in 2012, together with Herman Darman (author) on the left.

- *RIP Peter, from Anna.*

NEW MEMBERSHIP

Student Membership

1. Ahmad Aqil Ahmad Aznan
2. Ahmad Sheeqal Shah Abdul Samad
3. Ainaa Zahirah Mohamad Isa
4. Ainin Sofia Mohamad Daud
5. Alia Nur Abyana Rizainizam
6. Al-Jubouri Baraa Ali Mahdi
7. Amir Hakim Amiruddin
8. Amirul Aniq Jamaluddin
9. Aqil Irfan Alim Hakim
10. Athalla Nera Ntalagewang Koyu
11. Dania Qistina Hanif @ Umar Hanif
12. Danish Aneeqaiman Yusri
13. Dayana Batrisya Nor Hamedi
14. Dayang Adriana Amani Abang Azahari
15. Fang Hehan
16. Fatin Damia Faidzal
17. Hanum Nabilah Rashid
18. Ida Bagus Suananda Yogi
19. Irdina Wani Fatini Abd Zaini
20. Liew Mon Long
21. Madihah Amran
22. Maisarah Khan Ahmad Zairini
23. Muammar Naim Mohamad Farouk
24. Muhamad Waqiyuddin Zun
25. Muhammad Danish Amri
26. Muhammad Danish Roslan
27. Muhammad Firdaus Hassan
28. Muhammad Haikal Mohd Farid
29. Muhammad Hasif Md Kamal
30. Muhammad Haziq Fahmi Jamsari @ Ridzuan
31. Muhammad Nur Haziq Abd Hadi
32. Muhammad Said Harfiandri
33. Naqib Ullah
34. Noraini Mohamad Hadi
35. Norul Aisyah Mohamad Ali Napiah
36. Nur Asyhura Sorffina Mohd Razak
37. Nur Farah Izzati Abd Aziz
38. Nur Hani Sofia Azhar
39. Nur Hanisah Azman
40. Nur Izzatul Rizwa Rizuwan
41. Nurul Izzah Mustafa
42. Nurul Nabilah Ridzuan
43. Ridho Pranata
44. Roshaan A/L Mohan
45. Satapat Kumpitak
46. Saveetraa A/P Tangavelu
47. Sazrie Shahril Rezza Mohd Jali
48. Sofiah Zazali
49. Syamimi Farhani Che Salan @ Mohd Saiful
50. Thivineshvaren Elanggovan
51. Vikna Raj Gobu
52. Wan Aimie Sufiah Wan Abdul Rahim
53. Yang Zhengrui
54. Yasmin Naziha Suzaimi

Full Membership

1. Amin Noorasid Abdul Jalil
2. Amir Muazzam Azhar
3. Azrin Azmi
4. Calvin Patrick @ Dayu
5. How Yi Eng
6. Iskandar Shah Abd. Rahman
7. Kamilia Sharir
8. Kuan Siew Fung
9. Lam Wan Hwa, Jacqueline
10. Mohamad Hisham Mazlan
11. Mohamad Zakwan Khair Khalil
12. Mohd Ezwan Syah Yusoff
13. Mohd Najmi Afifi Mohd Nasir
14. Muhamad Nurfirdaus Sapawie
15. Muhammad Nazrin A Rahman
16. Muhammad Shafiq Izuwan Ramli
17. Noran Alwakhir Shaarani
18. Nur Muhammad Asyraf Mansor
19. Peter Justin Lunt
20. Rosni Lokmannul Hakim
21. Sharafuddin Mohamed
22. Sim Sze Yuan
23. Zurfarahin Zulkarnain

From Full To Life Membership

1. Mohd Suhaili Ismail
2. Muhammad Taqiuddin Zakaria
3. Nur Amelya Mohammed Jamal

Associate Membership

1. Chee Poi Kee, Reymond
2. Lee Hwan King

Board Of Geologists Malaysia

Board of Geologists Malaysia (BoG) is now in its 11th year of existence. As a regulatory body, the Board by the end of November 2024 registered 1,439 geologists comprising 897 Registered Professional Geologists, 101 Registered Foreign Geologists, 438 Registered Graduate Geologists and 3 Registered Practitioners. Registration certificate renewal for year 2025 has been opened from 15th November 2024 until 31st January 2025 and it is the responsibility of registered geologists to renew with BoG to continue the practice of geological work in Malaysia.

Renewal of registration can be made through an application using Form F with payment of renewal fee, and notification of CPD credit points using Form C. In addition, the hardcopy submission of Registration Certificates has been abolished, all registration certificates will be submitted to members in softcopy form which can be downloaded in the "Resources > Download Certificates" section.

Starting in January 2020, BoG has implemented the registration of geological consulting firms (under physical consulting services, non-engineering fields) for firms and local/foreign individuals who wish to be registered with the Ministry of Finance under the code 330211- Geology. Currently, there are 33 geological firms that have been registered with BoG, 12 Sole Proprietor, 1 Partnership and 20 Body Corporate.

BoG is also in the process of implementing activities and programs to contribute to the professional development and strengthen the profession of geologist. Among the activities that are being worked on are the Continuing Professional Development Program (CPD), professional assessment exams, accreditation of geological profession qualifications, fee scale standards for geoscience services and enforcement matters in accordance with the requirements of the Geologists Act.

The mandate to implement CPD requirement is under Section 4. (1)(k); to hold or cause to be held professional development programmes for registered geologists and registered practitioners to further enhance their knowledge in the latest developments relating to the geological profession. The Professional Development Programme Committee (JPPP) is a committee of BoG led by Prof. P.Geol. Dr. Joy Jacqueline Pereira with 4 members and is responsible for developing this CPD programme. The members are:

i. Prof Madya P.Geol. Dr. Mohd Rozi bin Umor
ii. Datuk P.Geol. Mior Sallehhuddin bin Mior Jadid
iii. P.Geol. Askury bin Abd Kadir
iv. P.Geol. Suhaileen binti Shahar

Finally, BoG successfully conducted 2 sessions of Professional Assessment Examination for this year. BoG extends its congratulations to the newly Registered Professional Geologists as follows:

1. P.Geol. Siti Norhidayah Binti Abd Hamid (PG 1555)
2. P.Geol. Amier Bin Khalid (PG 1556)
3. P.Geol. Jacqueline Lam Wan Hwa (PG 1557)
4. P.Geol. Paul Bian (PG 1558)
5. P.Geol. Nurul Syafida Binti Abu Bakar. (PG 1559)

6. P.Geol. Susan Sana Paran (PG 1560)
7. P.Geol. Oh Hwee Theng (PG 1561)
8. P.Geol. Muhammad Nursafwan Bin Mustafa (PG 1562)
9. P.Geol. Barman Bin Omoi (PG 1601)
10. P.Geol. Istor Bin Ahsan (PG 1602)
11. P.Geol. Muhammad Amirul Bahri Bin Mohd Ridzwan Rajarendra (PG 1603)
12. P.Geol. Syaukat Bin Salim (PG 1604)
13. P.Geol. Mohammad Zakwan Khair Bin Khalil (PG 1605)
14. P.Geol. Shernie Binti Ashri (PG 1607)
15. P.Geol. Muhammad Akhyaar Kok Bin Mohammad Firdaus Kok (PG 1608)
16. P.Geol. Nurul Nisya Binti Amran (PG 1610)
17. P.Geol. Eric Teng Jing Hang (PG 1613)
18. P.Geol. Mohd Syakir Bin Sulaiman (PG 1614)

Prepared by,
Shahiratul Nida Shaharudin
CPD Executive BoG
25th November 2024

UPCOMING EVENTS

February 5-7, 2025: 2025 NAPE Summit; Houston, TX. More details at https://napeexpo.com/.

February 18-20, 2025: International Petroleum Technology Conference (IPTC); Kuala Lumpur, Malaysia. More details at https://www.iptcnet.org/2025.

March 2-5, 2025: PDAC 2025 World's Premier Mineral Exploration & Mining Convention; Toronto, Canada. Website: https://www.pdac.ca/convention.

March 3-5, 2025: Carbon Capture, Utilization, and Storage (CCUS); George R. Brown Convention Center in Houston, Texas. More details at https://ccusevent.org/2025/about/about-ccus-2025.

March 20-21, 2025: GEMS 2025 - International Conference on Geology Engineering and Marine Sciences; Wuhan, China. Website: https://gems.isgcpi.com/.

April 6-8, 2025: GeoGulf 2025; Nacogdoches. More details at https://geogulf2025.org/.

April 15-16, 2025: Unlocking Hidden Potential: Unveiling Off- Structure Prospects and Re-Evaluating Borderline Discoveries; Kuwait City, Kuwait. More details at https://www.aapg.org/global/middleeast/events/workshop/articleid/67306#details

April 27 - May 2, 2025: EGU 2025 - European Geosciences Union General Assembly; Vienna, Austria. Website: https://www.egu25.eu/

May 5-8, 2025: Offshore Technology Conference (OTC); Houstan, Texas, USA. More details at https://2025.otcnet.org/

May 13-14, 2025: AAPG Europe Regional Conference; Pau, France. More details at https://erc.aapg.org/2025/

May 13-15, 2025: 7th edition of Asia Pacific Meeting on Near Surface Geoscience and Engineering (NSGE); Xi'an, China. Visit https://eage.eventsair.com/7th-asia-pacific-meeting-on-near-surface-geoscience-and-engineering/ for more information.

May 21-23, 2025: IUGS - Initiative on Forensic Geology conference; Rome, Italy. Website: https://www.iugs-ifg2025.com/

May 28-29, 2025: Carbon Capture, Utilization, and Storage (CCUS) Latin America; Cartagena, Columbia. More details at https://ccusevent.org/latinamerica/2025/

June 9-11, 2025: Unconventional Resources Technology Conference (URTeC); George R. Brown Convention Center, in Houston, Texas. More details at https://urtec.org/2025/

August 25-28, 2025: SEG/ AAPG International Meeting for Applied Geoscience & Energy (IMAGE) 2025; Houstan, Texas, US. More details at https://www.aapg.org/events/conferences/ace/announcement/articleid/64036.

September 16-18, 2025: The Middle East Oil, Gas and Geoscience Show (MEOS GEO); Bahrain. More details at https://www.meos-geo.com/en/home.html.

September 30- October 3, 2025: International Conference and Exhibition (ICE); Rio de Janeiro. More details at https://rio2025.iceevent.org/

November 3-5, 2025: EAGE/ AAPG Workshop on Tectonostratigraphy of the Arabian Plate; Riyad, Saudi Arabia. More details at https://eage.eventsair.com/eageaapg-workshop-on-tectonostratigraphy-of-the-arabian-plate-structural-evolution-of-the-arabian-basins/

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