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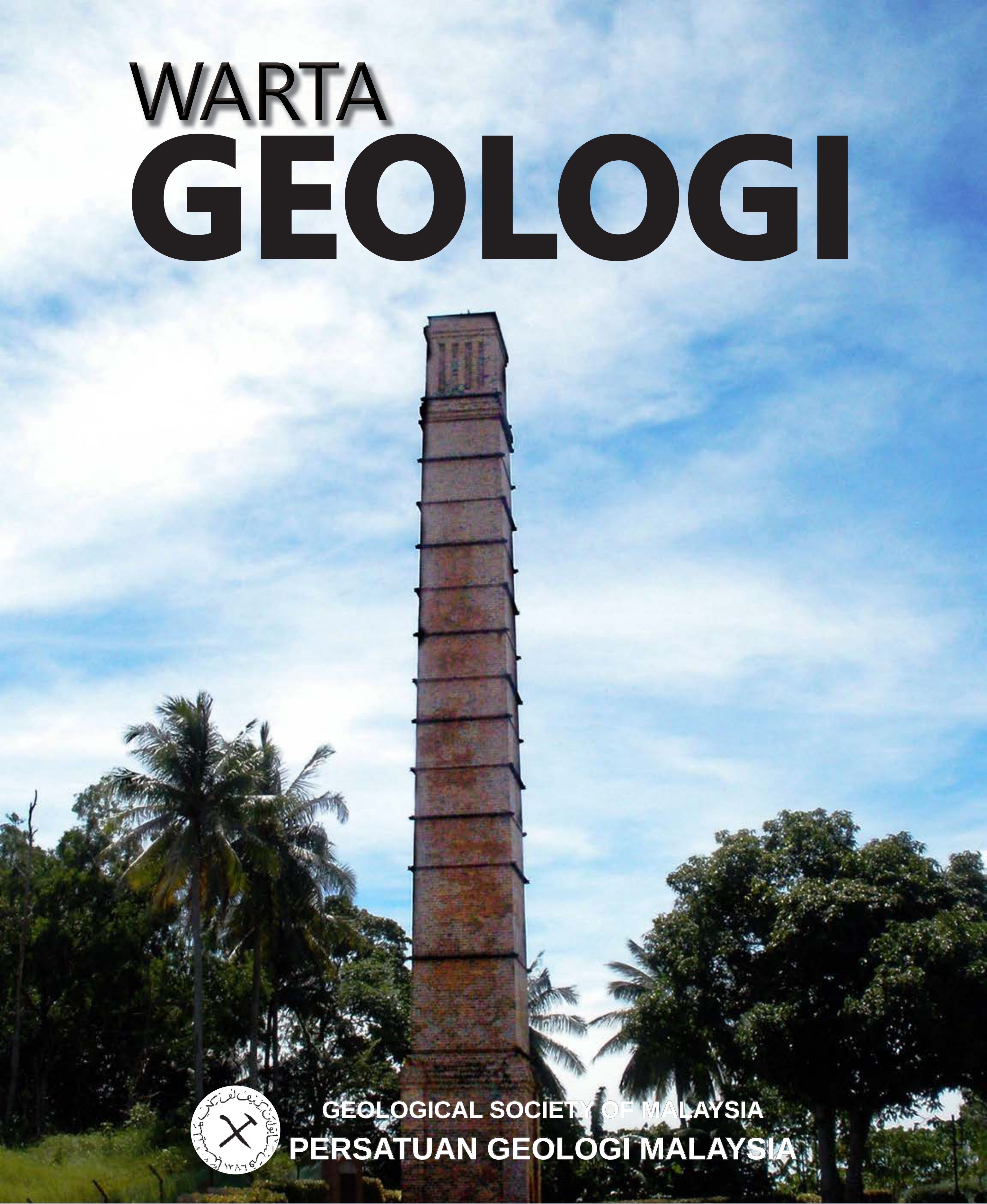

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Warta Geologi

Cover photo: The Chimney, at Tanjong Kubong, Labuan: the enigmatic 32-m tall brick-walled structure built in 1900 is the subject of an article in the current issue. Photograph by Mazlan Madon (2008).

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Peranan geofizik dalam pembinaan dan penilaian kestabilan terowong

(The role of geophysics in the construction and stability assessment of tunnels)

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Abstrak: Bidang geofizik memainkan peranan yang penting dalam pembinaan mana-mana struktur utama di dunia. Salah satu daripada struktur buatan manusia ialah terowong. Pelbagai maklumat dan kaedah geofizik perlu difahami secara mendalam sebelum merangka sebuah projek pembinaan terowong. Penyiasatan menyeluruh terhadap keadaan bumi perlu dilakukan terlebih dahulu sebelum kajian persediaan lapangan yang akan menentukan tempoh masa bertahan tanpa sokongan dan keadaan air bawah tanah yang mungkin menyukarkan pembinaan terowong. Bagi menilai kestabilan terowong pula, integrasi pelbagai kaedah diperlukan untuk mendapatkan hasil kajian yang lebih tepat. Tafsiran imej satelit menekankan kepada surihan struktur lineamen negatif manakala pemetaan lapangan menekankan kepada lokasi resapan air bawah tanah dan struktur tektonik utama seperti sesar, kekar dan zon ricih. Survei tomografi keberintangan geoelektrik dapat mengenalpasti keberintangan bahan yang berbeza di mana ia dapat menentukan kandungan air di dalam bahan bumi. Pemilihan langkah-langkah pemulihan akan ditentukan berdasarkan dapatan hasil kajian tersebut.

Kata kunci: Terowong, penggalian, penilaian kestabilan, pemulihan

Abstract: Geophysics play a vital role in the constructions of any major manmade structures in the world. One of those being the tunnels. In depth understanding of geophysical methods and a lot of information are needed in order to design a tunnel construction project. Comprehensive investigation on the ground condition has to be done before the field preparation study that will determine the stand-up time and the groundwater condition that may disrupt the tunnel construction. For tunnel stability assessment, an integration of geophysical methods is a must in order to obtain the most accurate results. Satellite imaging interpretation emphasizes on the structural tracing of negative lineament while field mapping emphasizes on location of underground seepage and major tectonic structures such as faults, joints and shear zones. Geoelectrical resistivity tomography survey is able to identify the differences in resistivity of Earth's materials based on the water content inside of them. The best course of remediation could only be chosen once the output from all these studies are made available.

Keywords: Tunnel, drilling, stability assessment, remediation

PENGENALAN

Terowong ialah sebuah lorong bawah tanah, digali melalui bahan bumi sama ada tanah atau batuan sekitarnya dan tertutup kecuali di pintu masuk dan keluar di setiap penghujungnya. Terowong umumnya agak panjang dan sempit di mana panjangnya adalah lebih jika dibandingkan dengan diameternya. Kegunaan terowong mungkin berbeza, sama ada sebagai laluan pejalan kaki, laluan lalu lintas kenderaan, laluan keretapi ataupun sebagai terusan. Sesetengah terowong bertindak sebagai akueduk untuk membekalkan air untuk diminum ataupun untuk kegunaan stesen janaelektrik (Rajah 1) dan pembentungan. Terowong kemudahan awam digunakan untuk penghalaan stim, air sejuk, bekalan elektrik ataupun kabel telekomunikasi serta menghubungkan bangunan-bangunan dengan laluan bagi manusia dan peralatan. Terowong rahsia pula dibina untuk kegunaan ketenteraan atau oleh orang tertentu bagi tujuan penyeludupan senjata haram, kontraban ataupun manusia. Terowong khas seperti lintasan haiwan liar dibina semata-mata untuk membolehkan binatang menyeberangi mana-mana halangan buatan manusia. Terowong boleh dihubungkan bersama melalui rangkaian terowong yang meluas. Tidak kira apa jenis terowong sekalipun, pembinaan dan penyelenggaraan kesemuanya adalah lebih kurang sama. Di antara semua bidang kepakaran yang sama terlibat, bidang geofizik merupakan antara

Rajah 1: Terowong Janakuasa Hidroelektrik TNB Pergau, Jeli, Kelantan. Sumber: Mohd Hariri Arifin.

yang paling penting apabila melibatkan pembinaan dan kestabilan terowong.

PEMBINAAN TEROWONG

Sebuah projek terowong utama mesti bermula dengan penyiasatan keadaan bumi yang menyeluruh dengan memperolehi sampel-sampel dari lubang gerudi dan juga menerusi teknik-teknik geoteknikal yang lain. Pilihan jentera dan kaedah yang tepat kemudiannya dapat dibuat bagi penggalian dan sokongan tanah di mana ianya akan dapat mengurangkan risiko menghadapi masalah keadaan bumi yang tak terduga. Di dalam perancangan laluan terowong, penjajaran menegak dan melintang perlu diambil kira untuk menentukan keadaan bumi dan air yang terbaik. Adalah menjadi amalan biasa untuk merancang terowong yang lebih dalam dari yang diperlukan supaya dapat menggali batuan pejal dan bahan-bahan lain yang lebih mudah untuk ditampung semasa pembinaan.

Kajian persediaan lapangan mungkin memberikan maklumat yang tidak mencukupi untuk menilai faktor-faktor seperti sifat bongkah batuan, kedudukan tepat zon-zon sesar ataupun tempoh masa bertahan tanpa sokongan (*stand-up time*) bahan bumi yang lembut. Ini adalah kebimbangan yang utama di dalam terowong yang berdiameter besar. Untuk mendapat maklumat yang lebih, kebiasaannya sebuah terowong rintis akan dibuat terlebih dahulu sebelum penggalian utama. Terowong yang lebih kecil adalah berkemungkinan rendah untuk roboh dengan teruk sekiranya syarat-syarat tertentu dipatuhi dan ianya boleh dimasukkan ke dalam terowong akhir atau digunakan sebagai sandaran atau laluan pelepasan kecemasan. Sebagai langkah alternatif, lubang gerudi melintang boleh dibuat sebelum memajukan muka terowong.

Faktor-faktor geoteknikal yang lain:

- Tempoh masa bertahan tanpa sokongan ialah jumlah masa sesuatu rongga yang baru digali dapat menampung secara sendirian tanpa bantuan struktur tambahan. Dengan mengetahui parameter ini, ia membolehkan jurutera untuk menentukan sejauh mana penggalian dapat dilakukan sebelum system sokongan diperlukan, di mana ianya akan turut mempengaruhi kelajuan, keberkesanan dan juga kos pembinaan. Secara dasarnya, sesetengah konfigurasi batuan dan lempung mempunyai tempoh masa bertahan tanpa sokongan paling lama manakala pasir dan tanah halus mempunyai tempoh masa bertahan tanpa sokongan yang jauh lagi pendek (Sutcliffe, 2004).
- Pengawalan air bawah tanah adalah sangat penting dalam pembinaan terowong. Kebocoran air ke dalam terowong atau syaf menegak akan mengurangkan tempoh masa bertahan tanpa sokongan dengan ketara. Ini akan mengakibatkan penggalian untuk menjadi tidak stabil dan berisiko untuk runtuh. Cara yang paling biasa digunakan untuk mengawal air bawah tanah ialah dengan memasang paip penyahairan ke dalam bumi dan mengepam keluar air (Powers *et al*., 2007).
- Bentuk keratan rentas terowong juga amat penting dalam menentukan tempoh masa bertahan tanpa sokongan. Jika penggalian terowong adalah lebih lebar berbanding tinggi, ia akan lebih susah untuk menampung dengan sendiri, justeru, mengurangkan tempoh masa bertahan tanpa sokongan. Penggalian secara segi empat sama atau segi empat tepat adalah lebih susah untuk dibuat sokongan kendiri disebabkan oleh penumpuan tekanan di penjuru (United States Army Corps of Engineers, 2007).

Terowong digali pada bahan bumi yang berlainan, dari lempung yang lembut kepada batuan yang keras. Kaedah pembinaan terowong bergantung kepada faktor-faktor seperti keadaan bumi, keadaan air bawah tanah, panjang dan diameter terowong pandu, kedalaman terowong, logistik yang membantu penggalian terowong, kegunaan akhir dan bentuk terowong serta pengurusan risiko yang mencukupi.

Ada tiga jenis asas pembinaan terowong yang menjadi kebiasaan untuk digunakan. Terowong potong-dan-tutup (*cut-and-cover*) dibina di parit cetek dan seterusnya ditutupi. Terowong gerudi dibina *in situ* tanpa mengalihkan tanah di atasnya. Akhir sekali, sebuah tiub ditenggelamkan ke dalam sesuatu badan air, yang mana terowong ini dipanggil sebagai terowong tenggelam. Contoh pembinaan terowong menerusi kaedah penggerudian ialah seperti di dalam Rajah 2.

PENILAIAN KESTABILAN TEROWONG

Setelah penggunaan selama beberapa dekad, setiap terowong harus menjalani penilaian kestabilan yang menyeluruh di samping penyenggaraan berkala agar dapat dipastikan tahap kesesuaian dan keselamatannya untuk terus digunakan. Jika didapati tidak selamat, langkah-langkah pemulihan boleh dilakukan untuk mengelak daripada berlakunya kemalangan.

Pencirian jasad batuan penting bagi mengenalpasti keadaan jasad batuan terutamanya jika melibatkan binaan struktur utama seperti terowong. Pencirian jasad batuan boleh dilakukan samada sebelum, semasa atau selepas pembinaan (Rajah 3). Pendekatan integrasi melibatkan pelbagai kaedah seperti pemetaan lapangan, tafsiran imej satelit, survei tomografi keberintangan geolektrik dan yang sepertinya boleh digunakan.

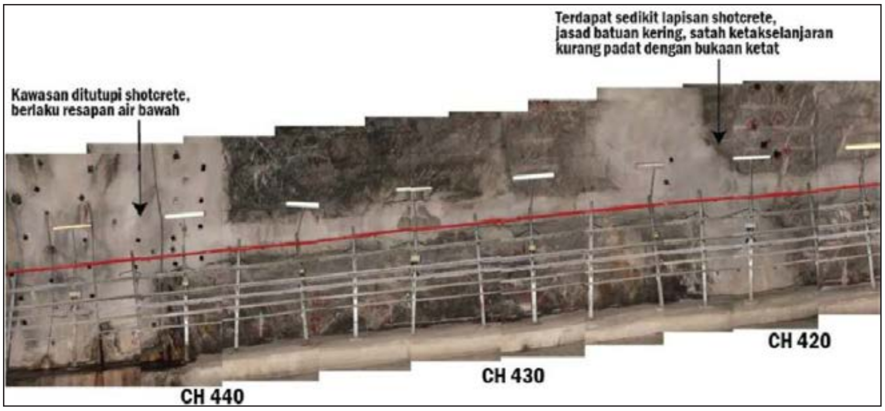
Penggunaan imej satelit semakin berkembang dan digunakan secara meluas dalam bidang geologi. Imej satelit yang berkualiti dan beresolusi tinggi boleh memberi maklumat penting seperti kehadiran lineamen. Tafsiran lineamen bertujuan untuk mendapatkan maklumat rantau taburan, orientasi dan ketumpatan struktur dalam kawasan kajian (Rajah 4).

Rajah 2: Pembinaan terowong Kuantan sepanjang 2.86 km oleh Syarikat China Communications Construction Sdn Bhd (CCC) untuk projek Laluan Rel Pantai Timur (ECRL).
Sumber: Foto Arkib NSTP.

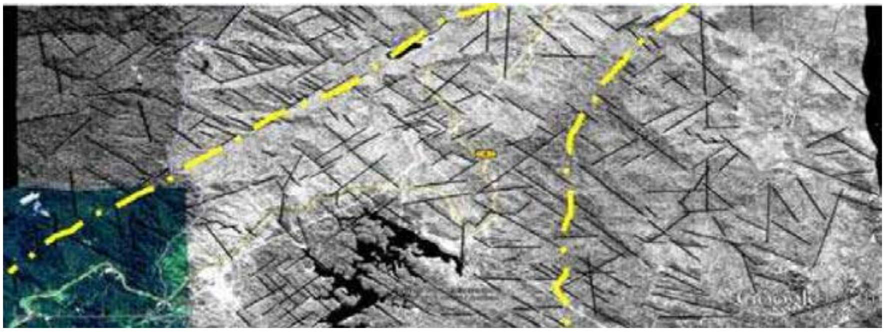
Pemetaan lapangan pula menekankan kepada lokasi resapan air bawah tanah dan struktur tektonik utama seperti sesar, kekar dan zon ricih. Sepanjang garis survei, catatan lapangan pada bahagian dinding terowong dilakukan untuk melihat sebarang fitur atau maklumat penting yang boleh membantu dalam proses tafsiran (Rajah 5).

Keberintangan geoelektrik merupakan satu kaedah yang berdasarkan pengukuran perbezaan keupayaan antara dua titik di atas permukaan bumi hasil daripada pengaliran arus elektrik yang bergerak di bawah subpermukaan bumi. Survei tomogafi keberintangan geoelektrik dijalankan pada bahagian dinding terowong (Rajah 6). Analisis data akan menunjukkan kehadiran tiga nilai keberintangan bahan yang berbeza iaitu berkeberintangan tinggi (> 1500 Ωm), sederhana (100 – 500 Ωm) dan rendah (< 25 Ωm). Dapatan daripada pemetaan lapangan dan tafsiran lineamen digunakan dalam tafsiran keratan rentas pseudo. Ketiga-tiga nilai ini ditafsirkan sebagai zon tinggi kandungan air (berkeberintangan rendah), jasad batuan terkesan lineamen dan terkekar kuat (berkeberintangan sederhana) dan batuan granit kurang terkekar (berkeberintangan tinggi). Zon mengandungi air adalah zon kelemahan yang menyumbang kepada ketidakstabilan sesebuah terowong.

Bagi kawasan-kawasan yang mempunyai aliran air, sistem saluran air perlu dipasang di bahagian tepi bukaan

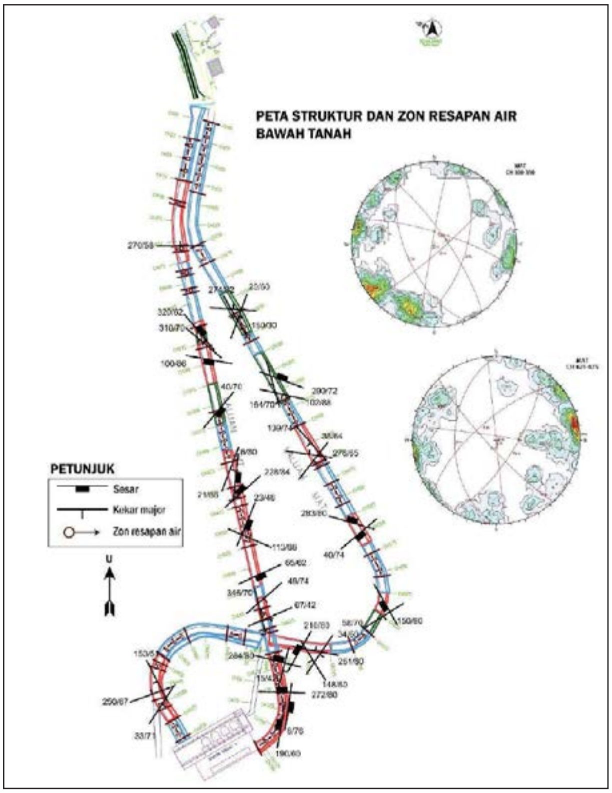


Rajah 3: Keadaan jasad batuan di lapangan (selepas pembinaan) menunjukkan keadaan jasad batuan granit yang mempunyai nilai keberintangan tinggi.
Sumber: Hussin *et al.*, 2020.



Rajah 4: Peta surihan lineamen yang ditafsirkan daripada imej satelit Google Earth.
Sumber: Arifin *et al.*, 2016.

untuk menyalurkan air ke luar daripada belakang sistem sokongan, iaitu di antara jasad batuan dan sistem sokongan. Bagi kawasan-kawasan di mana runtuhan berskala kecil telah berlaku, pengisian semula (*back filling*) perlu dilaksanakan semasa kerja pemulihan supaya keratan bukaan adalah seragam.



Rajah 5: Ringkasan struktur sesar dan kekar major serta lokasi resapan air di sepanjang dinding-dinding terowong. Sumber: Hussin *et al.*, 2020.

Kawasan di mana runtuhan besar telah berlaku memerlukan pemasangan kerangka konkrit berterusan (*continuous cast concrete lining*) bersama dengan sistem saluran air, selepas pengisian semula dilaksanakan.

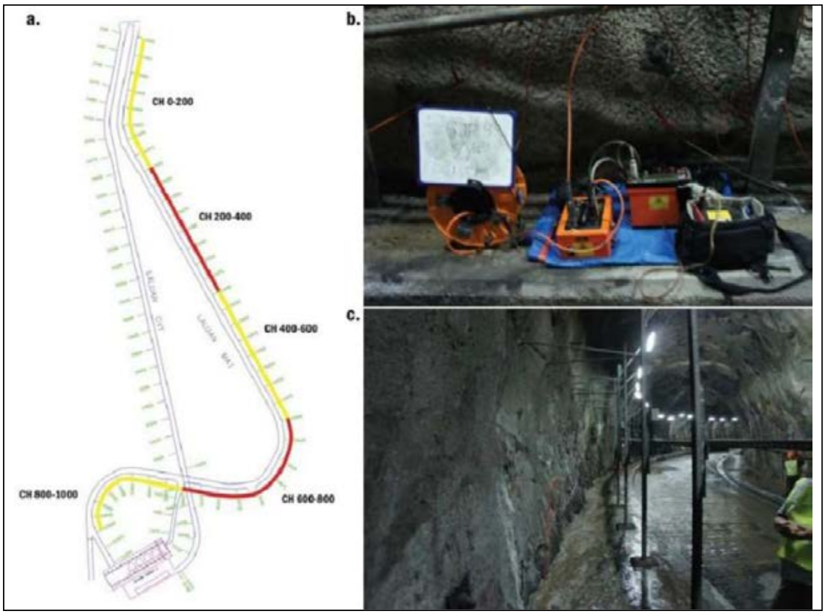
Semasa kerja-kerja pembaikan dijalankan, penggunaan bahan letupan perlu dielakkan sama sekali. Penggunaan alat pemotong dan kerja pembersihan perlu dijalankan menggunakan mesin dengan tahap gegaran yang minima untuk mengelak dari berlaku runtuhan akibat daripada gegaran.

PENUTUP

Dapat dilihat daripada penjelasan di atas bahawa bidang geofizik amat penting dalam projek terowong. Ahli geofizik bertanggungjawab dalam penyiasatan keadaan bumi dan air bawah tanah, penyeliaan lubang gerudi, perancangan reka bentuk terowong, penentuan tempoh masa bertahan tanpa sokongan, pengurusan risiko dan penilaian kestabilan terowong. Pendek kata, ahli geofizik akan memainkan peranan daripada mula peringkat perancangan dan berterusan sehinggalah ke peringkat pemulihan.

PENGHARGAAN

Pengarang ingin memberikan sekalung penghargaan kepada pengarang-pengarang terdahulu yang menjadi sumber rujukan kepada penulisan ini. Segala maklumat-maklumat penting dan terkini di dalam artikel ini datangnya daripada hasil kajian mereka. Pengarang juga ingin menyatakan penghargaan kepada para pewasit diatas semakan dan cadangan tambah baik artikel. Turut dizahirkan penghargaan kepada penyunting dan penerbit artikel ini di atas bantuan dalam membentuk dan menerbitkan artikel ini.



Rajah 6: a) Peta lokasi survei tomografi keberintangan geoelektrik dilakukan (garisan warna kuning); b) sistem ABEM SAS 4000 dalam kajian; c) Pengukuran data di lapangan.

REFERENCES / RUJUKAN

Arifin, M.H., Rafek, A.G., Abdullah, I. & Umor, M.R., 2010. Geologi pemeliharaan dan pemuliharaan bekas terowong Sungai Lembing, Kuantan, Pahang sebagai tapak warisan geologi. Bulletin of the Geological Society of Malaysia, 56, 61 – 66.

Arifin, M.H., Jamaluddin, T.A., Husin, H., Ismail, A., Abbas, A. A., Nordin, M.N.M. & Othman, N.A., 2016. Comparison of geological mapping with electrical resistivity and ground penetration radar methods for rock fractured system study. Chiang Mai Journal of Science, 43(6), 1346 – 1357.

Hussin, H., Arifin, M.H., Jamaluddin, T.A., Fahmi, A.G.M., Ismail, N. & Manan, A.A., 2020. Integrasi pemetaan lapangan, tafsiran lineamen dan survei tomografi keberintangan geoelektrik dalam pencirian jasad batuan granit terlindung shotcrete. Bulletin of the Geological Society of Malaysia, 69, 39 – 51.

https://www.hmetro.com.my/mutakhir/2021/01/666929/tahap-kemajuan-ecrl-seksyen-b-melepasi-sasaran

Powers, J.P., Corwin, A.B., Schmall, P.C. & Kaeck, W.E., 2007. Construction dewatering and groundwater control. John Wiley & Sons Inc., Hoboken, NJ. 623 p.

Sutcliffe, H., 2004. Tunnel Boring Machines. In: John O. Bickel, Thomas R. Kuesel & Elwyn H. King, (Eds.), Tunnel Engineering Handbook (2nd ed.). Kluwer Academic Publishers, Boston, Dordrecht, London. 210 p.

United States Army Corps of Engineers, 1978. Tunnels and shafts in rock. Department of the Army, Washington DC.

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On the supposed onshore extension of the Penyu Basin, Peninsular Malaysia

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Abstract: The Penyu Basin is a Tertiary sedimentary basin located offshore Peninsular Malaysia. The basin is assumed to continue westwards beneath the Pahang River delta where as much as 115 m of Quaternary sediments overlie a bedrock of pre-Tertiary granites and metamorphic rocks. No Pliocene or older sediments beneath the delta have been reported. If the Quaternary sediments are considered as part of the Cenozoic Penyu Basin, the basin's western limit may be delineated at the foothills of the coastal plain where those sediments onlap onto pre-Tertiary rocks. Therefore, any sedimentary rock of Tertiary age that may occur to the west of that limit most probably represents a separate basin.

Keywords: Penyu Basin, Quaternary, Tertiary, gravity, basement

INTRODUCTION

The Penyu Basin is an east-west oriented Tertiary sedimentary basin lying offshore Peninsular Malaysia (Figure 1). It is approximately 150 km long and only 90 km wide at the western end, which is considered small compared to the adjacent West Natuna and Malay basins. Up to 7-8 km of sediments occur in its deepest parts, where Late Eocene to Oligocene syn-rift deposits accumulated in isolated fault-bounded depocentres. Due to its relatively small size, the basin has been extensively explored, even though not yet commercially productive. Through seismic data acquisition and exploratory drilling, the basin had been relatively well studied by the mid-1990s and its structural geometry is fairly well established. This was achieved through detailed mapping based on an almost complete coverage by seismic and gravity data, as well as information from 18 exploration wells in the basin. Some of those wells penetrate the pre-Tertiary basement of igneous and metamorphic rocks (Figure 2A), which represent a continuation of the onshore geology of the Malay Peninsula. The top of the pre-Tertiary basement represents the Late Mesozoic to Early Tertiary erosional unconformity surface upon which Tertiary basins developed. Although the seismic line spacing on the western side is rather coarse, both the seismic and gravity data clearly indicate shallowing of the basement westwards as the basin-bounding faults die out towards the peninsular coastline (Figure 2B). A recent review of the geology and exploration history was given by Madon *et al*. (2019).

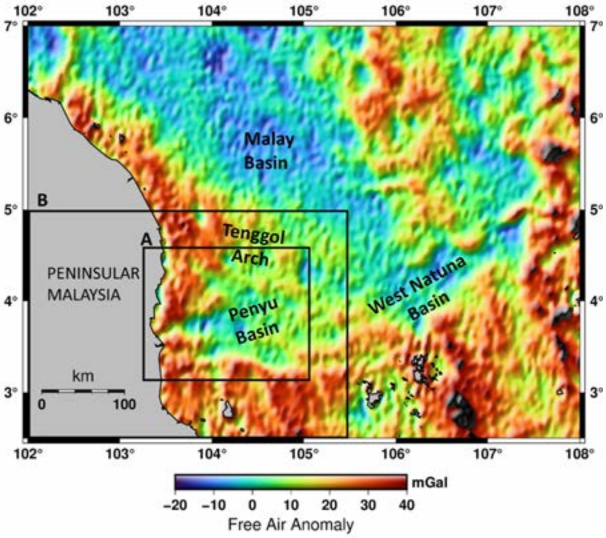

Figure 1: Free-air gravity anomaly map of offshore Peninsular Malaysia, based on satellite-derived gravity grid of Sandwell *et al.* (2014). Colours were applied to accentuate the outline of Tertiary basins which are characterised by low anomalies of <10 mGal. Small rectangle A refers to map area in Figure 2. Larger rectangle B refers to map area in Figures 3 and 5.

Some authors considered the West Natuna Basin as the eastward continuation of the Penyu Basin (Haribowo *et al*., 2013). This is a reasonable assumption since there is no known structural discontinuity between the two basins and the fault trends appear to continue seamlessly

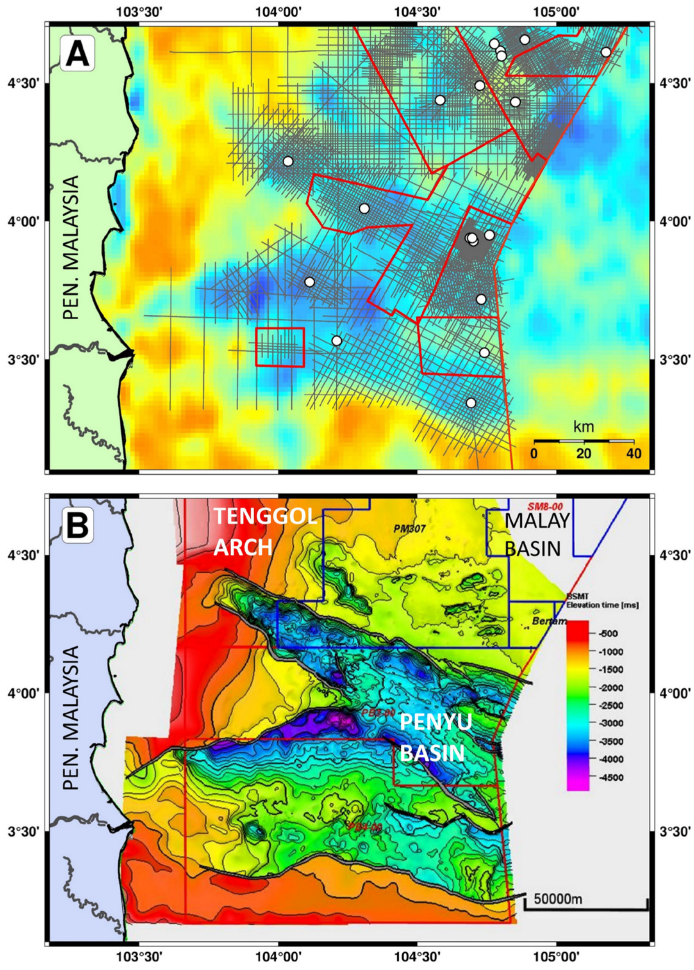

Figure 2: Extensive seismic and gravity data enable the structure of the Penyu Basin to be mapped in detail. (A) Dense coverage of 2D seismic data (grey lines) and 3D data (red polygons), supplemented with wells that penetrate the pre-Tertiary basement (white dots). Plotted with data from Madon (2021). Coloured background in offshore area is gravity anomaly map as in Figure 1; warm colours indicate shallow basement areas, cool colours indicate basin areas. (B) Pre-Tertiary basement elevation map of the Penyu Basin, showing the major faults that define the half-graben depocentres (from Madon *et al*., 2019). Basement elevation in milliseconds (ms).

across the Malaysia-Indonesia maritime boundary. The southern and northern boundaries of the Penyu Basin are generally well-defined by major E-W trending and NW-SE trending faults, which were mapped at the top of the pre-Tertiary basement unconformity (Figure 2B). There is no evidence to support the suggestion that those E-W faults at the northern and southern boundaries of the basin extend all the way to the coastline in the manner shown on the map by Tate *et al*. (2008). The seismic evidence suggests that the normal faults die out before reaching the coastline, indicating proximity to the basin edge (Figure 2B). This brief note further examines the nature of the western edge of the Penyu Basin.

BASIN EDGE

The western edge of the Penyu Basin is not distinct, as there are no known faults that could represent that boundary. The top of the pre-Tertiary basement, which is essentially the basal boundary of the basin, becomes shallower towards the present-day coastline. It is fair to assume that the basement extends beneath the modern Pahang River delta until it reaches the surface further landward. Hence, Hutchison (1989; 2007, p. 118) wrote: the Penyu Basin "is a westwards continuation of the West Natuna basin, and is an east-west directed graben-like structure which extends onshore to include the flat alluvial plain of the Pekan area of Pahang". This is a valid assumption since Hutchison (1989, 2007) considered the Penyu Basin as a Cenozoic basin and therefore includes both Tertiary (i.e., Paleogene and Neogene) and Quaternary sediments.

Figure 3 shows a map of the depth (z) to the pre-Tertiary basement in the offshore (z<0) and land elevation (z>0) in the adjacent onshore area of the Malay Peninsula. This surface represents a continuous surface of eroded pre-Tertiary Sundaland landmass which was probably elevated above sea level before the Penyu Basin formed during the Late Eocene by extensional faulting and subsidence. We can see that the Penyu Basin is a relatively isolated and confined system of grabens and half-grabens, of Late Eocene to Oligocene age (Madon *et al*., 2019). Its outline can be represented by the 2000 m basement depth contour, as is the boundary between the Tenggol Arch and the Malay Basin to the northeast.

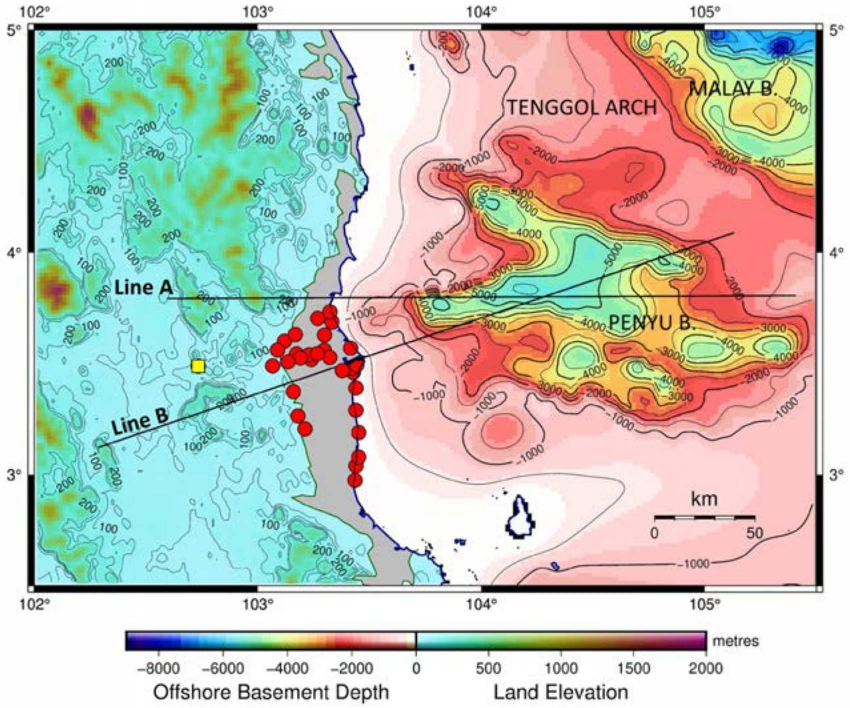

Figure 3: Map of land elevation and pre-Tertiary basement depth (converted from ms to m) in the offshore generated from the data digitised from Figure 2 for the offshore and digital elevation model from GMRT for the onshore (Ryan *et al.*, 2009). For offshore map, time-to-depth conversion was based on velocity data obtained from Madon (1996). Lines A and B represent profiles in Figures 4 and 5. Grey shaded area landward of the coastline represents Quaternary deposits on the coastal plain (Raj *et al.*, 2009). Red circles are the locations of groundwater boreholes from Yoong *et al*. (2018). Yellow square is the location of East Chenor outcrops studied by Makeen *et al*. (2019a, b), as mentioned in the text.

The top-of-basement surface in the Penyu Basin gradually becomes shallower towards the margins to the north, south and west. It probably reaches sea level (depth z=0 m) at some distance landward of the coastline (within the grey shaded area in Figure 3) beneath the coastal plain, which is elevated to more than 30 m above sea level. Figure 4A shows a W-E profile (Line A) extracted from the map in Figure 3 representing the basement surface from land to sea. We can see the great depth of the Penyu Basin relative to the land elevation onshore. At the foothills, landward of the coastal plain, a line may be drawn where the basement reaches the surface and the thickness of Quaternary sediment is zero. This line, which is also above sea level, may be taken as the landward limit of the basin (Figure 4B).

Yoong *et al*. (2018) reported groundwater boreholes that were drilled through the Quaternary sediments in the Pekan area (red dots in Figure 3). The boreholes penetrated as much as 115 m of Quaternary sediments before reaching the bedrock of pre-Tertiary geology comprising weathered granites and metasediments. Similar rocks have been found in the offshore wells on the margins and intrabasinal highs of the Penyu and Malay basins (e.g., Madon *et al*., 2019, 2020). Similarly, since the pre-Tertiary basement is the offshore continuation of the onshore pre-Tertiary geology, the basin boundary may be drawn where Quaternary sediments onlap and pinch out onto the pre-Tertiary bedrock at the foothills (Figure 4B).

As mentioned, the northern and southern boundaries of the basin are defined by syn-rift graben-bounding faults, even though Tertiary post-rift sediments extend further onto the basement highs well beyond those faults (Figure 2B). In contrast, the western edge of the basin, as determined above, is at some distance landward of the coastline where Quaternary sediments pinch out to a feather edge. It should be noted that defining the basin limits this way creates a problem. Since Quaternary sediments also occur continuously on the coastal plains of around the entire peninsula (Figure 3), where would the southern and northern limits of the "onshore Penyu Basin" be? Clearly, they would also extend beyond the onshore projections of the fault-bounded limits defined in the offshore. If Quaternary sediments are included, then all basins should be considered as one single basin, which is not helpful for the purpose of basin analysis and the understanding of sedimentary basins. Unfortunately, the Quaternary is of little interest to oil companies which are generally concerned with Pliocene and older sediments. As a result, the Pliocene-Pleistocene (or Tertiary-Quaternary) transition or boundary is rarely investigated and the total thickness of the Quaternary section in the offshore is generally unknown. Images from CHIRP sub-bottom

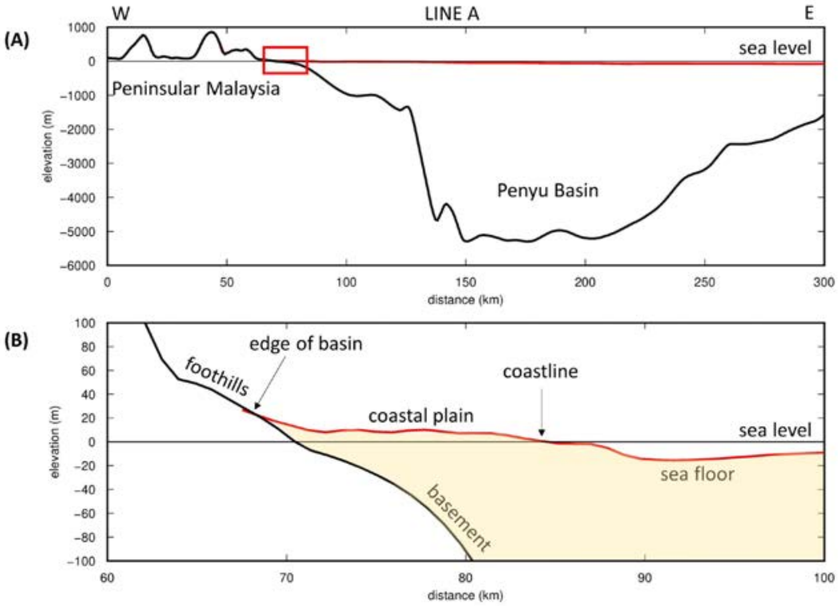

Figure 4: Profile along Line A in Figure 3 which shows (A) the top-of-basement surface in the Penyu Basin continuing onshore as the pre-Tertiary bedrock forming the landscape of Malay Peninsula. (B) Close-up of coastline area marked by red rectangle in A, showing the basement surface rising beneath Quaternary coastal plain sediments and pinching out and onlapping onto the foothills. Note the exaggerated vertical scale to emphasise the elevation of the coastal plain. Technically, where the sediment thickness is 0 represents the edge of the basin.

profiles in the Upper Pleistocene-Holocene section of the basin have revealed some interesting sedimentary features, such as palaeo-fluvial channels and incised valleys (Rahman *et al.*, 2016). The lower Pleistocene and its basal transition with the Upper Pliocene section would be worth investigating in the future.

Whether the Penyu Basin extends onshore and include the Quaternary sediments of the Pahang coastal plains is "academic". It really depends on whether one considers Penyu Basin as a Cenozoic basin (cf. Hutchison, 1989) or, as most petroleum geologists would, a Tertiary basin (cf. Doust & Sumner, 2007). I suggest that it serves no purpose to "prove" that Penyu Basin extends onshore based on the presence of Quaternary sediment, as attempted by some authors (e.g., Yoong *et al.*, 2018). For practical purposes, where direct structural evidence (e.g., faults) is lacking, other practical means may be used to define the approximate limits of sedimentary basins, such as sediment thickness, basement depth, or gravity anomalies. For example, steep gradients in gravity anomalies are usually related to underlying structural discontinuities (faults), as is the case for Penyu Basin (comparing Figures 1 and 2), and would be a useful indicator of basin boundaries.

CHENOR OUTCROPS

In recent years, there have been references made with regard to the "onshore extension" of the Penyu Basin located further inland, as far as Chenor, a sub-district in central Pahang (Makeen *et al.*, 2019a, b, yellow square in Figure 3). It is my view that this is taking the "onshore extension" idea too far. Unfortunately, the authors of the paper did not provide the basis for the Oligocene age of the sediments or the reasons why the outcrops were considered part of the Penyu Basin. The authors, however, cited the work of Ahmad Munif *et al.* (2012) who, based on palynomorphs from those outcrops, had determined that the age was Late Miocene and younger, but not Oligocene as quoted. The presence of Tertiary sediments at this location does not necessarily mean that the outcrops represent an "onshore extension" of the Penyu Basin. The outcrop is located ~45 km landward from the basin edge determined above and more than 120 km from the nearest Oligocene syn-rift half-graben in the Penyu Basin. This distance is even wider than the Tenggol Arch which separates Penyu from the Malay Basin (Figures 1, 2). It is more likely that the Chenor outcrops represent a separate, previously unknown, onshore Tertiary basin which is an important addition to the existing list of onshore Tertiary basins described by Raj *et al.* (2009).

Figure 5 is a gravity anomaly map covering the same region shown in Figure 3. It clearly shows free-air anomaly lows corresponding to the grabens of the Penyu Basin (cf. Figure 1). Note that due to the gentle gradient of the Sunda Shelf and shallow water depths (<70 m) in this area, Bouguer anomalies at sea would look similar, reflecting the subsurface density variations due to the presence of a sedimentary basin. On land, the Bouguer gravity anomalies also reflect the subsurface density variations across the Malay Peninsula which are directly related to the underlying geology. In particular, there are two anomaly highs separated by a large negative anomaly. Figure 6 is a profile of the Bouguer gravity anomaly extracted from the map along line B in Figure 5. The profile shows a large negative anomaly with an amplitude of >40 mGal, which is greater than the free-air anomalies associated with the Penyu Basin offshore. It is clear that that negative anomaly is due to sedimentary rocks of lower density compared to the surrounding rocks of the Central Belt in the Malay Peninsula.

Based on the Geological Map of Peninsular Malaysia (JMG, 2021), the abovementioned N-S trending large negative anomaly on land corresponds with an area mapped as Jurassic-Cretaceous formations (Figure 7). The sedimentary formations at the Chenor outcrop locality studied by Ahmad Munif *et al*. (2012) and Makeen *et al*. (2019a, b) are also within this area (yellow square on the map). More importantly, the gravity profile indicates that the Tertiary outcrops at Chenor clearly lie in a basin that is separated from the Penyu Basin by a regional basement high composed of a mixture of Palaeozoic metamorphic and Mesozoic plutonic rocks. This is confirmed by the groundwater boreholes in Figure 7 which penetrated pre-Tertiary basement comprising mainly weathered granites north of Pahang River and mainly metamorphic rocks south of it (Yoong *et al*., 2018).

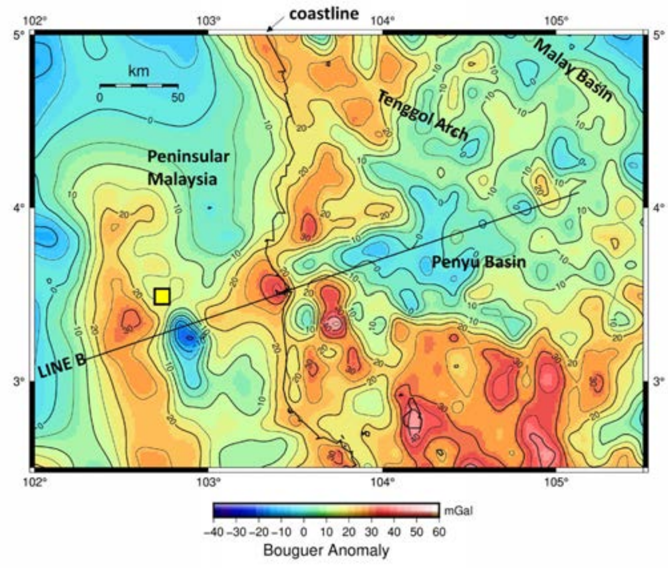

Figure 5: Gravity anomalies over the same map area in Figure 3; Bouguer anomaly on land, free-air anomaly at sea. As in Figure 1, the low negative anomalies in the Penyu Basin are apparent. Note the three distinct anomalies on land crossed by Line B, along which the gravity anomalies are extracted and plotted in Figure 6. Chenor outcrop locality is marked by a yellow square.

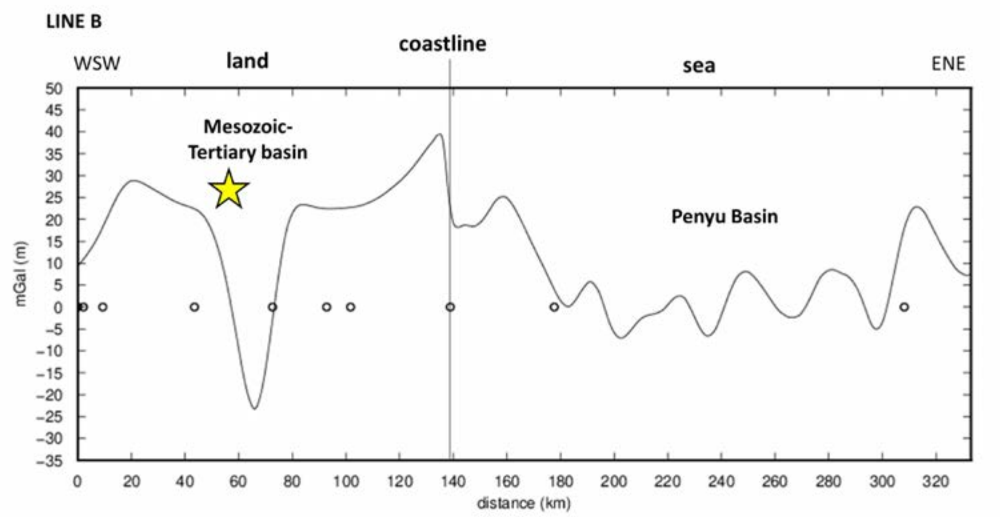

Figure 6: Gravity anomalies along Line B in Figure 5 from land to sea. Note the two main areas of negative anomalies representing sedimentary basins. A single negative peak on land coincides with Jurassic-Cretaceous outcrops (which include the Tertiary outcrop mentioned in the text, marked with a yellow star). The rugged and broad negative anomaly at sea reflects the faulted graben morphology of the Penyu Basin. The small circles at 0 mGal represents the lithological/formation boundaries identified from the geological map of Peninsular Malaysia (see Figure 7).

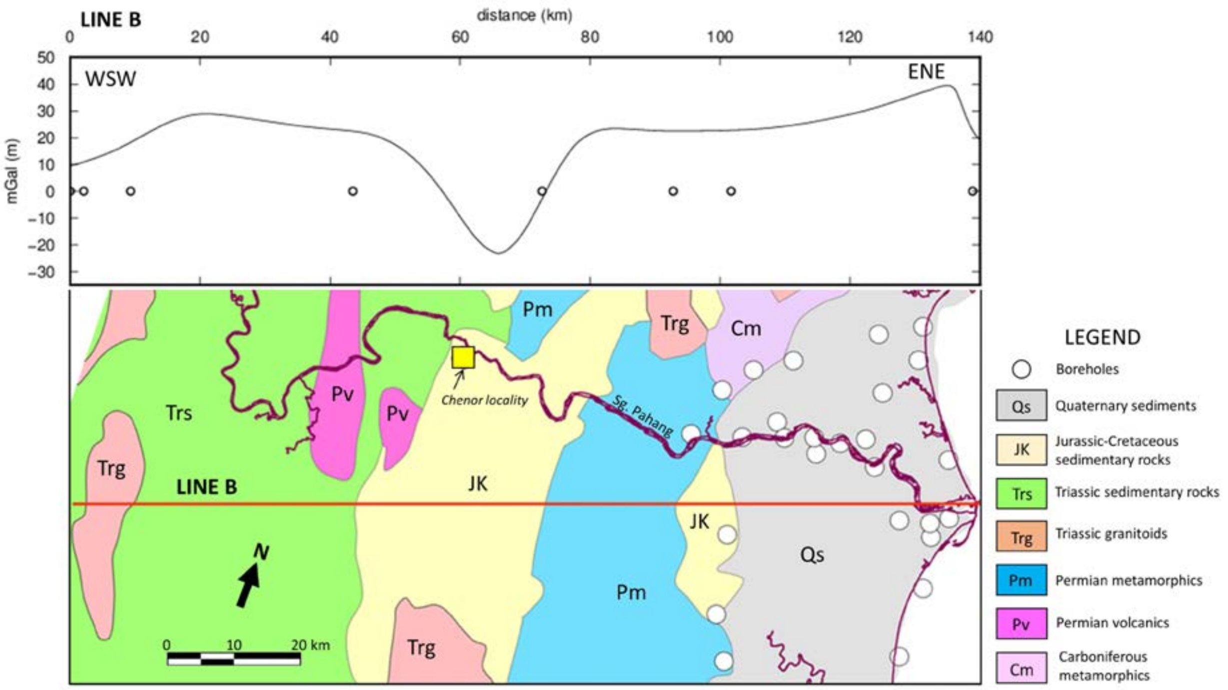

Figure 7: Bouguer gravity anomalies (upper panel) along the onshore portion of Line B in Figure 5 showing the correlation with pre-Tertiary outcrop geology (lower panel). The geological map (modified from JMG, 2021) is slightly rotated clockwise and plotted at the same horizontal scale as the gravity profile. The small circles at 0 mGal on the gravity plot correspond to the boundaries between the lithological groupings shown on the map below. Note the location of the Chenor outcrops (yellow square) within an area mapped as Jurassic-Cretaceous sedimentary rocks (JK). Groundwater borehole locations (large white circles on map) are from Yoong *et al*. (2018).

CONCLUDING REMARKS

For all intents and purposes, the Tertiary Penyu Basin is located entirely offshore. Its supposed western extension onshore seems to comprise mainly Quaternary deposits that underlie the coastal plains of the Pahang River delta. Tertiary sedimentary rocks are not known from the coastal plains of the Malay Peninsula but are well known to occur as isolated pockets or outliers in the interior of the peninsula (Raj *et al*., 2009). If the outcrops at Chenor are indeed Tertiary in age, further work should be done to delineate the extent of the Tertiary basin.

Within the general vicinity of the supposed Tertiary outcrops at Chenor, there have been studies on fluvial sediments that were assumed to be of Jurassic-Cretaceous age (Madon *et al*., 2010; Baioumy *et al*., 2020), since this region of the Central Belt has been mapped as Jurassic-Cretaceous (Figure 7). The discovery of Tertiary deposits in the area casts doubt on the age of these undated “Jurassic-Cretaceous” sediments, and should be further investigated.

Indeed, the Chenor outcrops were initially thought to be Jurassic-Cretaceous (Zainey *et al*., 2007) but later found to be no older than Late Miocene (Ahmad Munif *et al*., 2012). Unlike the Mesozoic deposits of the Central Belt, the moderately dipping (~30°) to flat-lying strata at Chenor do not appear to have been highly deformed. Furthermore, the paleocurrent data indicate west and north-westerly transport directions (Zainey *et al*., 2007), opposite to that in the main Penyu Basin. In any case, the Chenor outcrops represent an entirely separate basin located within the Central Belt of the Malay Peninsula and not an “onshore extension” of the Penyu Basin.

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REFERENCES

Ahmad Munif, K., Zainey Konjing & Maharizal Malihan, 2012. Tertiary palynomorph assemblage from eastern Chenor Pahang. Bulletin of the Geological Society of Malaysia, 58, 37−42.

Baioumy, H., Ting, J., Farouk, S. & Al-Kahtany, K., 2020. Facies architecture of fluviatile deposits of the Jurassic-Cretaceous Bertangga Formation, Peninsular Malaysia. Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen, 298 (2), 177 – 195. http://dx.doi.org/10.1127/njgpa/2020/0943.

Doust, H. & Sumner, H. S., 2007. Petroleum systems in rift basins – a collective approach in Southeast Asian basins. Petroleum Geoscience, 13, 127-144. http://dx.doi.org/10.1144/1354-079307-746.

Haribowo, N., S. Carmody & J. Cherdasa, 2013. Active petroleum system in the Penyu Basin: exploration potential syn rift and basement-drape plays. Proceedings 37th Annual Convention Indonesian Petroleum Association (IPA), Jakarta, IPA13-G-041, 1-16.

Hutchison, C.S., 1989. Geological Evolution of South-East Asia. 1st Edition, Oxford Univ. Press. 368 p.

Hutchison, C.S., 2007. Geological Evolution of South-East Asia. 2nd Edition, Geological Society of Malaysia. 433 p.

JMG (Jabatan Mineral dan Geosains), 2021. Peta Geologi Semenanjung Malaysia. Web display, https://www.jmg.gov.my/add_on/mt/smnjg/tiles/. Last accessed 24 November 2021.

Madon, M., 1996. Tectonic evolution of the Malay and Penyu basins, offshore Peninsular Malaysia. D.Phil. thesis, Oxford University.

Madon, M., 2021. Five decades of petroleum exploration and discovery in the Malay Basin (1968-2018) and remaining potential. Bulletin of the Geological Society of Malaysia, 72, 63-88. https://doi.org/10.7186/bgsm72202106.

Madon, M., Jong, J., Kessler, F.L., M. Hafiz Damanhuri & Mohd Khairil Azrafy Amin, 2020. Pre-Tertiary basement subcrops beneath the Malay and Penyu basins, offshore Peninsular Malaysia: their recognition and hydrocarbon potential. Bulletin of the Geological Society of Malaysia, 70, 163 - 193. https://doi.org/10.7186/bgsm70202014.

Madon, M., Jong, J., Kessler, F.L., Murphy, C., Your, L., Mursyidah A. Hamid & Nurfadhila M. Sharef, 2019. Overview of the structural framework and hydrocarbon plays in the Penyu Basin, offshore Peninsular Malaysia. Bulletin of the Geological Society of Malaysia, 68, 1-23. https://doi.org/10.7186/bgsm68201901.

Madon, M., Zainol Affendi Abu Bakar & Hasnol Hady Ismail, 2010. Jurassic-Cretaceous fluvial channel and floodplain deposits along the Karak-Kuantan Highway, central Pahang (Peninsular Malaysia). Bulletin of the Geological Society of Malaysia, 56, 9-14. https://doi.org/10.7186/bgsm56201002.

Makeen, Y.M., Abdullah, W.H., Abdul Ghofur, M.N., Ayinla, H.A., Hakimi, M.H., Shan, X., Mustapha, K.A., Shuib, M.K., Liang, Y.& Zainal Abidin, N.S., 2019a. Hydrocarbon generation potential of Oligocene oil shale deposit at onshore Penyu Basin, Chenor, Pahang, Malaysia. Energy Fuels 2019, 33, 89−105. https://doi.org/10.1021/acs.energyfuels.8b03164.

Makeen, Y.M., Abdullah, W.H., Ayinla, H.A., Shan, X., Liang, Y., Su, S., Mohd Noor, N., Hasnan, H.K. & Asiwaju, L., 2019b. Organic geochemical characteristics and depositional setting of Paleogene oil shale, mudstone and sandstone from onshore Penyu Basin, Chenor, Pahang, Malaysia, International Journal of Coal Geology, 207, 2019, 52-72, https://doi.org/10.1016/j.coal.2019.03.012.

Rahman, M.M., Shathiamurthy, E., Zhong, G., Geng, J. & Liu, Z., 2016. CHIRP acoustic characterization of paleo fluvial system of Late-Pleistocene to Holocene in Penyu Basin, Sunda Shelf. Bulletin of the Geological Society of Malaysia, 62, 47–56. https://doi.org/10.7186/bgsm62201607.

Raj, J.K., Tan, D.N.K. & Wan Hasiah Abdullah, 2009. Cenozoic stratigraphy. In: Hutchison, C.S. & Tan, D.N.K., (Eds.), Geology of Peninsular Malaysia. Universiti Malaya & Geological Society of Malaysia, Kuala Lumpur, 134-173.

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

Sandwell, D.T., Muller, R.D., Smith, W.H.F., Garcia, E. & Francis, R., 2014. New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure. Science, 346 (6205), 65-67. https://doi.org/10.1126/science.1258213.

Tate, R.B., Tan, D.N.K. & Ng, T.F., 2008. Geological Map of Peninsular Malaysia. Scale 1:1,000,000. Geological Society of Malaysia & University Malaya.

Wessel, P., Luis, J. F., Uieda, L., Scharroo, R., Wobbe, F., Smith, W.H.F., & Tian, D., 2019. The Generic Mapping Tools version 6. Geochemistry, Geophysics, Geosystems, 20, 5556–5564. https://doi.org/10.1029/2019GC008515.

Yoong, A.A., Abdul Ghani Md Rafek, Khairul Arifin Mohd Noh & Radziamir Mazlan, 2018.The reconstruction of 3D geo-lithological model of Pekan, Pahang: A possible onshore extension of Penyu Basin. Bulletin of the Geological Society of Malaysia, 65, 63-67. https://doi.org/10.7186/bgsm65201807.

Zainey, K., Maharizal Malihan & Uyop Said, 2007. Jurassic-Cretaceous continental deposits from Eastern Chenor Pahang. Bulletin of the Geological Society of Malaysia, 53,7−10. https://doi.org/10.7186/bgsm53200702.

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Lenggong Valley – Revisit our national treasure

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Abstract: Lenggong Valley was incepted as UNESCO World Heritage Site in 2012 for its marvellous cultural value. However, the status will be in peril if the valley is left neglected and nothing is done. The area is renowned for the discovery of prehistoric human settlement. Numerous studies and researches have been conducted at Lenggong Valley to increase the scientific knowledge of the surrounding areas for further conservation and development. Toba ash deposit from volcanic eruption in Sumatra, Indonesia and possible meteorite impact were also discovered within the valley. Geoelectrical resistivity survey have been conducted to determine the thickness of Toba ash. The results were correlated with borehole log from the Department of Mineral and Geoscience Malaysia (JMG), that shows the Toba ash layer is around 10 m in depth and presents low resistivity range of values (<100 Ωm). Water geochemical analysis at one of the known water spring shows the surface temperature is 27.6 °C, with a pH value of 7.47. Truth be told, Lenggong Valley has a diversity of archaeological sites and geosites that can be established as a geopark and a group of committee will be materializing it in year 2021 or 2022.

Keyword: Lenggong, archaeology, Toba, meteorite impact, cool spring, geopark

INTRODUCTION

Malaysia has always been considered as an international tourist destination for its precious heritage and fascinating natural wonders. Lenggong Valley has been named as Malaysia's fourth and most recent UNESCO World Heritage Site for its outstanding cultural value, yet this amazing site has still not received great attention from the public compared to the other sites such as Malacca and George Town Historic Cities, Gunung Mulu National Park and Kinabalu Park. Over the unprecedented year where the COVID-19 pandemic had limited the movement of citizens, this article is hoped to promote our country heritage. The subtopics below will describe Lenggong Valley through few scientific aspects.

Geological setting

Generally, the Lenggong Valley consists of several lithologies such as alluvium, granite and limestone (Nordiana *et al*., 2014). The granitic rock is from Jurassic end - Carbonaceous low era and form the basement rock of the whole valley. Most of the alluvium units are quaternary sediments and situated along the Perak River area. Toba ash studies had been conducted by earlier researchers and the ashes are believed to be scattered around 70 km square in Lenggong Valley (Rapidah *et al.,* 2018). Figure 1 shows the general geological map of Lenggong Valley, Perak.

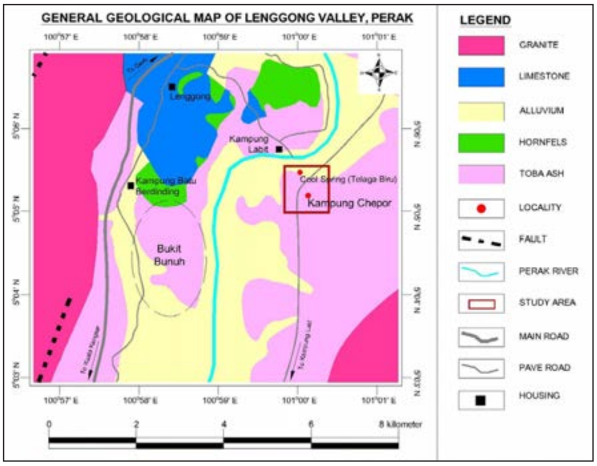

Figure 1: General geology of Lenggong Valley showing the area is covered with alluvium and Toba ash. Source: Modified from Nur Asikin, 2013.

Archaeological site

The Lenggong Valley World Heritage Site is located in an ancient, narrow valley in Perak State, northern part of Peninsular Malaysia, and it is the oldest known place of human activity. The valley is an important archaeological site where evidences of human settlement throughout the prehistoric periods (Palaeolithic, Neolithic and Metal) were found.

Lenggong Archaeological Museum was built at Kota Tampan to exhibit the archaeological findings of the area. Most discoveries found in Lenggong have been associated with caves. Artefacts, stone tools and skeletal remains from the archaeological excavations are displayed in the museum to provide informative prehistoric knowledge in Peninsular Malaysia. One of the most significant archaeological discoveries is the Perak Man or "Orang Perak", an 11,000 years old human skeletal remains at Gunung Runtuh Cave, Lenggong. Even though human skulls had also been found at Niah Cave in Sarawak which is said to be older in terms of age, Perak Man by far is the best preserved entire human skeleton found in the South East Asia region.

Toba ash

74,000 years ago, Toba super-volcano erupted and formed Lake Toba in Northern Sumatra, Indonesia. Over thousands cubic kilometres of scalding hot ash (Youngest Toba Tuff, YTT) belched out from the volcano into the Earth's atmosphere, travelled far and wide then descending upon vast areas in the southern and south eastern Asia, the South China Sea, and the central Indian Ocean Basin (Gatti & Oppenheimer, 2012). Several sites of terrestrial tephra fall deposits from the Toba eruption have been identified in Indian Peninsula and Malaysia, including Lenggong Valley as shown in Figure 2.

The first reported Toba ash sediment in Malaysia was found near Sungai Perak in 1932 by Scrivenor. Since then, these volcanic ashes were discovered in the western part of Pahang, Selangor and Kedah (Stauffer & Batchelor, 1978; Debaveye *et al.*, 1986). The evidence of Toba ash in Lenggong Valley was found during an archaeological expedition which noticed a thick layer of volcanic ash above a Palaeolithic stone tool workshop in Kota Tampan, Lenggong. This finding suggests that the Toba volcanic eruption had a direct impact on life at that period of time.

Subsequently, more study on the Toba ash has been carried out in the Lenggong Valley that has contributed to scientific knowledge until present time. Geophysical study had been carried out by the author in order to determine the thickness of the Toba ash. Figure 3 shows the study location nearby Masjid Lama Kampung Chepor, Lenggong with coordinate 5°5'14.13" N, 100°59'55.02" E. Figure 4 and Figure 5 show an example of exposed Toba ash deposit at Masjid Lama Kampung Chepor, Lenggong and the geophysical survey results, respectively.

Two geological layers were interpreted from the obtained geoelectrical resistivity results. The top layer is characterised by lower resistivity values ranging < 100 Ωm.

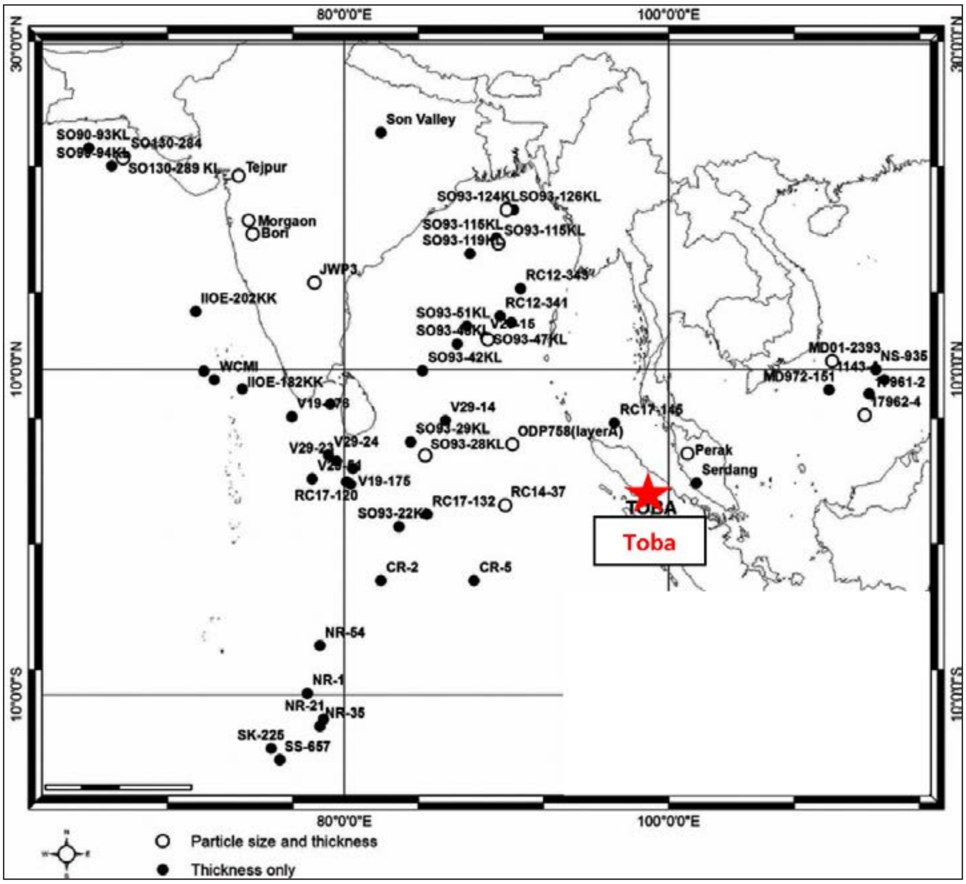

Figure 2: Youngest Toba Tuff (YTT) tephra distribution in Asia. Source: Gatti & Oppenheimer, 2012.

This layer is about 7 m to 10 m in thickness that might consist of alluvium, which is believed to be Toba ash with mixture of sand and clay. The second layer has higher resistivity range of above 300 Ωm which probably represents weathered granite bedrock. The resistivity results correlated well with the previous study by USM and JMG borehole where the Toba ash distribution in the Lenggong Valley is found to be around 10 m thick (Rapidah *et al*., 2018).

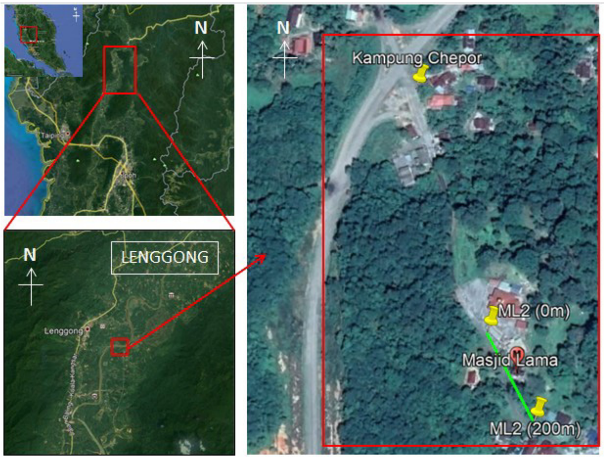

Figure 3: Google Earth Satellite photo showing the study area (red box) and geoelectrical resistivity survey line (green line) where Toba ash can be observed around the Masjid Lama at Kampung Chepor, Lenggong.

Meteorite impact

Little do people know that Lenggong Valley is the only place in Malaysia that has the evidence of meteorite impact that had taken place around 1.83 million years ago. The unanticipated discovery is due to the land redevelopment to change rubber estate into oil palm estate that revealed a huge amount of boulders at Bukit Bunuh. Since then, various researchers in Malaysia notably from Universiti Sains Malaysia (USM) and Universiti Kebangsaan Malaysia (UKM) started to discover the evidence around the possible meteor impact site through geological and geophysical studies. Figure 6 shows the result of gravity survey to model the possible meteorite impact crater. More interestingly, stone tools embedded in the suevite rock (a type of rock which formed due to meteorite impact) were found at the site during archaeological studies (Saidin,

Figure 4: Exposed Toba ash as basement of Masjid Lama at Kampung Chepor, Lenggong.

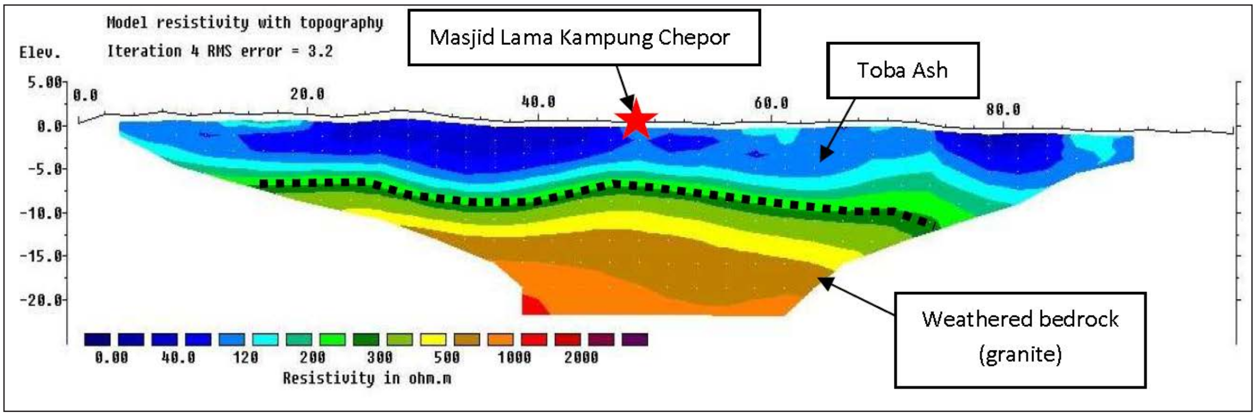

Figure 5: Geoelectrical resistivity result for Toba ash thickness (average: 10 m) study at Masjid Lama, Kampung Chepor, Lenggong.

Table 1: Geoelectric resistivity survey details.

Survey Line	Survey Length (m)	Maximum Penetratration (m)	Start of Line		End of Line	
			Latitude	Longitude	Latitude	Longitude
ML2	100	21.5	5°5’15.45”U	100°59’54.07”T	5°5’12.54”U	100°59’55.54”T

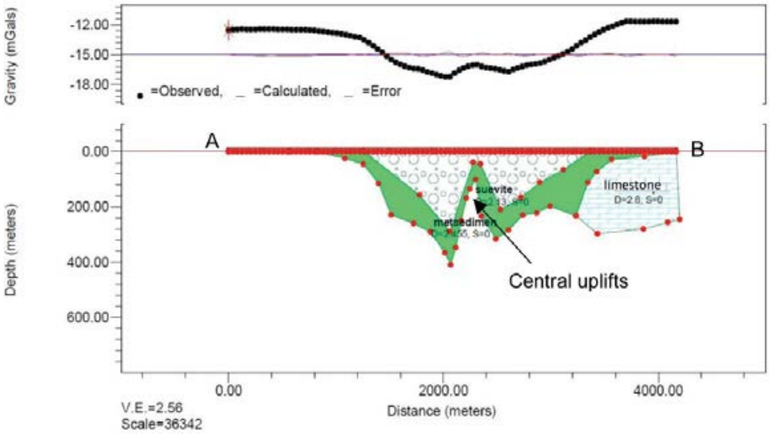

Figure 6: 2D gravity model of the possible meteorite impact crater at Bukit Bunuh, Lenggong. Source : Samsudin *et al*., 2012.

2021). These discoveries mark the presence of earliest hominid in South-East Asia outside of Africa continent.

Cool spring (Telaga Biru Lenggong)

A water spring is a natural occurrence where cold or hot groundwater issues from the earth on a regular basis. The groundwater flows through the interconnected pores within the aquifer or crack system such as faults and fracture planes in the subsurface. When the groundwater is heated and circulates upwards to the surface through buoyancy or pressure by the shallow intrusions of magma in volcanic area, or cooling magma and geothermal gradient at non-volcanic area such as Peninsular Malaysia, hot spring is occurred (Baioumy *et al*., 2014).

One of the known water spring, name Telaga Biru by local villagers has existed in Kampung Chepor, Lenggong for about 200 years (Rashidi, 2020). The coordinate of this spring is 5°5’31.34” N, 100°59’52.54” E and the spring is shown in Figure 7. Geophysical and water geochemical study had been conducted at the water spring by the author to understand the geological structure present in the subsurface and to study the characteristics of the water.

Generally, the mineral content in groundwater increases as it moves along through the pores and fracture openings in rocks. Table 2 below shows the result of water geochemical analysis with selected parameter. The in-situ test of water sample is recorded using Thermo Fisher Eutech 5+, showing the surface temperature is about 27.6 °C and pH value of 7.47. The obtained water geochemical analysis results have been shared in this article. The geophysical results are still in progress as more surrounding geological information are needed for correlation and interpretation. Through this additional research, the origin of the water spring can be identified and the potential usage of this water spring can be evaluated.

Figure 7: Cool spring (Telaga Biru Lenggong) situated at Kampung Chepor, Lenggong.

The water sample from the spring has been compared to the World Health Organisation (WHO) and Malaysia Ministry of Health (MOH) standard on raw and drinking water quality. The result shows that the sample is within the acceptable value for usage. However, more detailed geochemical analysis such as biological aspect for bacteria test should be conducted to make sure the water from spring is suitable for domestic usage.

Geopark

Geopark is a unified geographical area where geoheritage sites are part of a holistic concept of protection,

Table 2: Geochemical analysis result of water from the spring compare with Water Quality Standard from World Health Organisation (WHO) and Malaysia Ministry of Health (MOH).

No	Parameter / Element	Unit	Result	Recommended Raw Water Quality (Acceptable Value)		Drinking Water Quality Standards (Maximum Acceptable Value)	
				WHO	MOH	WHO	MOH
1	pH	-	7.47	6.5-8.5	5.5-9.0	-	6.5 – 9.0
2	Temperature	°C	27.6				
3	Total Silica, SiO_2	mg/l	44	-	-	-	-
4	Calcium, Ca	mg/l	8.97	200	-	200	-
5	Magnesium, Mg	mg/l	3.28	150	150	200	150
6	Potassium, K	mg/l	8.07	-	-	-	-
7	Sodium, Na	mg/l	13.4	200	200	200	200
8	Iron, Fe	mg/l	0.004	1	1	2	0.3
9	Bicarbonate, HCO^{3-}	mg/l	7.47	-	-	-	-
10	Sulphate, SO_4	mg/l	27.6	250	250	500	250
11	Chloride, Cl	mg/l	44	250	250	200	250
12	Fluoride, F	mg/l	8.97	1.5	1.5	1.5	0.4-0.6

Source: Malaysia Ministry of Health 2016 & WHO 2017

education and sustainable development (Komoo, 2014). Malaysia comprises of 5 geoparks to date, which includes Langkawi UNESCO Global Geopark, Jerai National Geopark, Lembah Kinta National Geopark, Kinabalu National Geopark and Mersing National Geopark.

In terms of landscape, Lenggong Valley possesses beautiful geological landforms and unique geological phenomena such as hills, caves and rivers. With its myriad and fascinating archaeological and geological values, Lenggong Valley can be known as a national treasure that is a pride of the nation. Although the area has the coveted UNESCO heritage status, sustainable developments are needed to sustain the status. Therefore, the academic researchers in Malaysia are currently working on promoting Lenggong Valley to be the next geopark that is yet to be established in the coming years (National Geoparks Malaysia, 2020). The purpose of geopark establishment is to emphasize the importance of improving the socio-economic status of local communities by taking into account the advantages that exist both naturally and heritage.

Tourism industry is a way to help citizens to rediscover the treasures around the country and visit it's rich heritage. Continuous promotions on ecotourism will not only sustain and expand the tourism industry, but will also provide growth for other supporting industries such as accommodation services, transportation and local businesses. Apart from that, active conservation and preservation values of the geopark are needed through more research and developments to maintain the cultural heritage. By involving the local communities in the conservation program of geoparks, unemployment rate can be reduced as this can create many job opportunities.

Another goal for the geopark establishment will be to work on the science education in order to draw visitors' interest and to raise awareness of its fragility. It is hoped that the localized scientific study conducted by the author at Kampung Chepor, Lenggong will be able to contribute more facts and information to the committee who will be working on materializing the Lenggong Geopark.

CONCLUSION

Potential threats such as change of land use and building constructions while developing the UNESCO World Heritage Site needed to be addressed through specific measures. The appropriate protection measures can be done with the collaboration among ministries and government agency such as the Department of Mineral and Geoscience Malaysia (JMG), local universities, research centers as well as local communities to preserve the existing value. The Lenggong Valley treasure trove of history should not be forgotten by the public and it will be a great loss if we cannot preserve and manage well the historic values that have been on our home soil for millennia.

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REFERENCES

Baioumy, H.M., Wagner, K., Nawawi, M.N. & Arifin, M.H., 2014. Geological Setting And Origin Of Non-volcanic Hot Springs In West Malaysia. 3rd Annual International Conference on Geological & Earth Science (GEOS2014).

Debaveye, J., De Dapper, M., De Paepe, J. & Gijbels, R., 1986. Quartemary volcanic ash deposits in the Padang Terap deposits, Kedah, Peninsular Malaysia. Bulletin of the Geological Society of Malaysia, 19, 533-549.

Gatti, E. & Oppenheimer, C., 2012. Utilization of Distal Tephra Records for Understanding Climatic and Environmental Consequences of the Youngest Toba Tuff. Geophysical Monograph Series, 198, 63-75.

Komoo, I., 2014. Geopark in Malaysia: The Front Door of Our Geological Treasures. Slide.

National Geoparks Malaysia, 2020. Dosier Permohonan sebagai Geopark Kebangsaan: Lenggong Geopark. Malaysia, 28 May.

Nordiana, M.M., Saad, R., Saidin,M., Azwin, N.I. & Jinmin, M., 2014. The Resistivity Topography in Delineating Crater Rim of Meteorite Impact at Bukit Bunuh, Lenggong, Perak (Malaysia). Electronic Journal of Geotechnical Engineering, 19, 377-388.

Nur Asikin, R., 2013. Pemilihan Jenis Batuan oleh Masyarakat Prasejarah di Kawasan Impak Meteorit Bukit Bunuh, Lenggong, Perak dan Sumbangannya kepada Teknologi Paleolitik. Tesis Sarjana, Universiti Sains Malaysia.

Rapidah, M.S., Mohamed, K.R., Ali, C.A., Leman, M.S. & Saidin M., 2018. A Geotouristic Itinerary: A Proposal for Geotourism and Archaeotourism Development of Lenggong Valley, Perak, Malaysia. GeoJournal of Tourism and Geosites, 22(2), 597–624.

Rashidi, M.Y., 2020. Telaga belerang tertua di Perak. Berita Harian, 14 June, 37.

Saidin, M., 2021. Pelajaran dari Mega-Bencana. Benturan Meteorit dan Debu Letusan Toba di Lenggong, Perak, Malaysia. Slide. DKM Al-Hidayah Badan Geologi.

Samsudin, A.R., Harun, A.R., Hariri, M.A., Hamzah, U., Saidin, M. & Karamah, M.S.S., 2012. Gravity Investigation of the Bukit Bunuh Impact Crater at Lenggong, Perak, Malaysia. Sains Malaysiana, 41(12), 1629-1634.

Scrivenor, J.B., 1932. The Geology of Malaya. Nature, 129, 352.

Stauffer, P.H. & Batchelor, B., 1978. Quaternary volcanic ash and associated sediments at Serdang, Selangor. Warta Geologi, 4, 7-11.

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Soil moisture retention characteristics of saprock from the weathering profile over a biotite-muscovite granite in Peninsular Malaysia

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Abstract: The weathering profile at the slope cut near Km 16 of the Kuala Lumpur - Ipoh trunk road can be differentiated into an upper, 11.8 m thick pedological soil (zone I) and a lower, 31.9 m thick saprock (zone II) comprising silty sandy gravels that distinctly preserve the minerals, textures and structures of the original granite. In order to investigate the influence of particle size distributions on soil moisture retention characteristics, saprock samples were collected at depths of 26.53 m (Sample A), 31.29 m (Sample B) and 41.93 m (Sample C). Samples A and B, with porosities of 37%, comprise 33% gravel, 27% sand, 22% silt and 18% clay, and 31% gravel, 24% sand, 25% silt and 22% clay, respectively. Sample C with a porosity of 44% consists of 24% gravel, 28% sand, 38% silt and 10% clay. Tests with 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 gravimetric soil moisture retentions of 31.9% through 28.6% and 23.3% to 16.9% and 6.8% in sample A, of 32.1% through 24.9% and 21.5% to 17.8% and 7.4% in sample B, and of 31.5% through 30.3% and 27.30% to 23.5% and 9.5% in sample C. Regression analyses of gravel, sand and clay contents plotted against moisture contents retained at high suctions (33 kPa and 1,500 kPa) yield negative trends with variable correlation coefficients (R^2), though plots involving silt contents yield positive trends with large correlation coefficients (R^2 >0.9966). It is concluded that adsorption of water on surfaces of silt sized particles (of mainly sericite derived from weathering of feldspars) that gives rise to the retention of soil moisture in saprock.

Keywords: Biotite-muscovite granite, saprock, soil moisture retention, silt content

INTRODUCTION

Deep weathering profiles (several tens of meters thick) are found in Peninsular Malaysia as a result of favorable tectonic and environmental factors that have facilitated pervasive chemical weathering during a larger part of the Cenozoic era (Raj, 2009). The profiles are found over a variety of bedrock and characterized by the indistinct to distinct preservation of the minerals, textures and structures of the original bedrock material and mass. As the earth materials of the profiles are "able to be removed by commonly accepted excavating methods", they are known as residual soils in geotechnical literature in the Peninsula (USBR, 1974; JKR, 2007). These residual soils are considered to be unsaturated soils as they are located above unconfined groundwater tables that are only found at the base of weathering profiles in the hilly to mountainous terrain of the Peninsula (Faisal *et al*., 2005; Bujang *et al*., 2005a; Raj, 2009).

Unsaturated soils are characterized by the presence of negative pore water pressures; the relationship between negative pore pressures and moisture content expressed by the soil water characteristic curve (Agus *et al*., 2001). The soil water characteristic curve or soil moisture retention curve is considered to be a fundamental relationship that should be determined in investigations of unsaturated soils (Vanapalli *et al*., 1996). The soil moisture retention curve is also of importance in agriculture where it is essential to the development of effective irrigation and plant stress management techniques as suction/water relationships directly affect the yield and quality of crops (Scherer *et al*., 1996).

In Peninsular Malaysia, there is limited published data on the soil moisture retention characteristics of its unsaturated residual soils, especially those over granitic bedrock. In a study to evaluate the hydraulic conductivity of saprolite (IC soil horizon), samples were collected from 16 locations in the Peninsula and their soil moisture retention curves determined with the pressure plate method (Hamdan *et al*., 2006). Increasing suctions from 0 kPa to 1,500 kPa resulted in decreasing volumetric soil moisture retentions from 60% to 11% in the case of a granite saprolite, from 47% to 19% in the case of a schist saprolite, from 82% to 30% in the case of a shale saprolite, and from 94% to 35% in the case of a basalt saprolite (Hamdan *et al*., 2006).

Another study, also involving the pressure plate method, showed saprolite (IC soil horizon) of a weathering profile over porphyritic biotite granite to experience decreasing gravimetric moisture contents from 34.5% to 18.0% with increasing suctions from 0 kPa to 1,500 kPa (Raj, 2010). Saprock samples from sub-zones IIB and IID at this weathering profile also experienced decreasing moisture contents from 34% to 6.4%, and from 26.8% to 3.9%, respectively, with increasing suctions from 0 kPa to 1,500 kPa (Raj, 2010). In the study, it was noted that the earth materials present varied with depth in not only texture and mineral compositions, but also in the extent of preservation of the original bedrock minerals, textures and structures. It was thus emphasized that discussions on the physical and soil index properties of earth materials in weathering profiles (and residual soils), as well as their soil moisture retention characteristics, be carried out with reference to the locations of samples (Raj, 2010).

There is also limited published data on the soil moisture retention characteristics of earth materials in neighboring, humid tropical areas. A study involving residual soils over the sedimentary Jurong Formation and the Bukit Timah Granite in Singapore Island concluded that the depth of weathering did not have a consistent effect on their soil water characteristic curves, though soils over the granite had a wider range of pore sizes (Agus *et al.*, 2001). Several multi-variate empirical equations using a number of basic soil properties were also proposed in this study to estimate the soil water characteristic curves of Singapore residual soils (Agus *et al.*, 2001).

Published literature on topics related to soil moisture retention characteristics in Malaysia include a paper that discusses modifications to the standard shear box that allowed testing of samples under unsaturated conditions (Bujang *et al.*, 2005a). Results of a series of direct shear tests with fixed suction on samples of saprolite (soil horizon IC) from a weathering profile over porphyritic biotite granite led to the conclusion that suction played a role in increasing the shear strength of unsaturated soil, though there was a non-linear failure envelope due to the non-linear soil water characteristic curve (Bujang *et al.*, 2005b; Thamer *et al.*, 2006).

As a part of a study to characterize weathering profiles in Peninsular Malaysia was investigated the profile developed over biotite-muscovite granite that outcrops in the north-west of Kuala Lumpur (Raj, 1983). In this paper are presented the results of laboratory tests carried out to investigate the influence of particle size distributions on soil moisture retention characteristics of saprock at the profile.

GEOLOGICAL SETTING OF INVESTIGATED WEATHERING PROFILE

The investigated profile is located at the slope cut close to milestone 10 (Km 16) of the Kuala Lumpur - Ipoh trunk road (Federal Route 1) and was exposed during earthworks for widening of the road. The cut, at an elevation of 120 m above sea-level, is found in a fluvially dissected hilly terrain of moderate to steep ground slopes with narrow to broad, flat-bottomed valleys, some 3.5 km to the northwest of Batu Caves in Kuala Lumpur (Figure 1). Granitic and meta-sedimentary rocks are present in the general area; the meta-sediments mapped as the Dinding Schist, Hawthornden Schist, and Kuala Lumpur Limestone (Gobbett, 1965). The granites are part of the Kuala Lumpur Pluton which is a large body of irregular shape comprising two lobes located on the western side of the Main Range of Peninsular Malaysia (Cobbing *et al.*, 1992).

Core-boulders at the cut and nearby outcrops show the bedrock to be a biotite-muscovite granite that has been sheared and strongly fractured as it is located within the Kuala Lumpur Fault Zone. This Fault Zone is about 15 km wide and extends in a general southeast-northwest direction over some 100 km (Ng, 1992). The granite is characterized by mega-crysts of coarse rounded quartz and feldspars set in a groundmass of dark grey, medium to coarse grained, equigranular mosaic of quartz and feldspars and fine biotite and muscovite flakes (Ng *et al.*, 2013). Minor late phase differentiates such as microgranite, aplite and pegmatites are sometimes seen as dykes and small lenticular bodies (Yusari, 1993).

In thin-sections, the granite is holocrystalline with hypidiomorphic to allotriomorphic grains; the primary

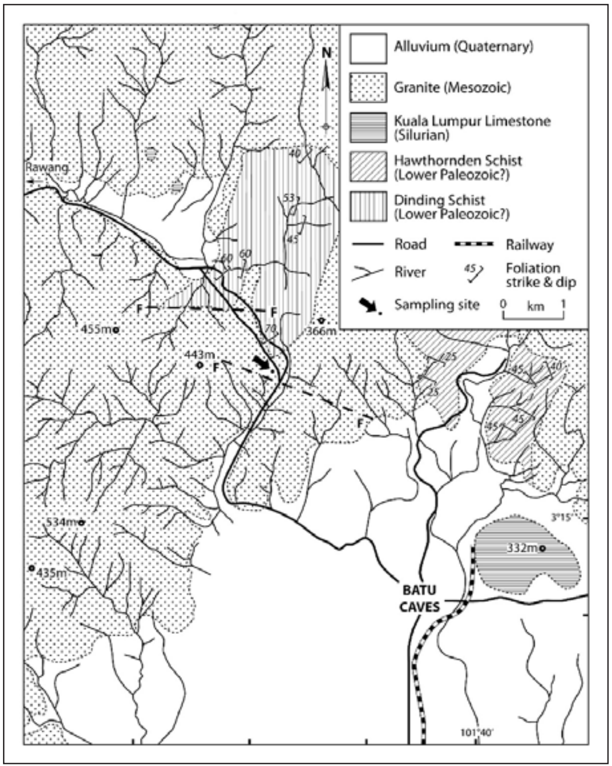

Figure 1: Geological sketch map of the Batu Caves area, Kuala Lumpur (after Gobbett, 1965; Yusari, 1993).

minerals being quartz, alkali feldspar, plagioclase, muscovite and biotite (Yusari, 1993). The accessory minerals include tourmaline, apatite and opaques, whilst chlorite and epidote are seen as secondary minerals. Quartz occurs as anhedral to subhedral crystals, both as phenocrysts and in the groundmass, and often shows a wavy extinction. Inclusions present include zircon, apatite and muscovite. The alkali feldspars include orthoclase and microcline and are found as euhedral to subhedral crystals, both as phenocrysts and in the groundmass. Plagioclase feldspars generally occur as euhedral to subhedral, tabular crystals that exhibit lamellar albite twins. Extensive sericitization has occurred in the plagioclases as well as in some of the alkali feldspars (Yusari, 1993).

Both primary and secondary muscovite is present; the primary variety occurring as individual, anhedral to subhedral grains, or as aggregates, whilst the secondary variety occurs as fine grains in feldspars due to sericitization. Biotite occurs as anhedral to euhedral individual flakes or as aggregates; some of them having been chloritized. Inclusions of zircon occur as euhedral to subhedral grains in the biotite and feldspars, whilst apatite is sometimes seen in quartz, feldspars and biotite (Yusari, 1993).

Seepage was seen at the foot of the slope cut during excavation works and indicated the presence of an unconfined groundwater table at the bottom of the exposed weathering profile.

METHODOLOGY

Tape and compass traverses were first carried out along all berms of the slope cut to describe the exposed earth materials in terms of the Soil Survey Manual for Malayan Conditions (Leamy & Panton, 1966) and the Guidelines for Soil Description of the Food and Agriculture Organization (FAO, 2006). Pedological features that were described included the colour, consistency and soil structure of the earth materials as well as their content of concretions, stains and organic matter. Geological features were also mapped and described, in particular the minerals, textures and structures of the original bedrock material and mass now indistinctly to distinctly preserved (as relict minerals, textures and structures) in the earth materials. Lateral similarity in pedological and geological features was then used to distinguish weathering zones, i.e. zones of earth materials with similar morphological features as color, relict bedrock minerals, textures and structures as well as litho-relicts (core-stones and core-boulders) (Table 1 and Figure 2).

Table 1: Morphological features of weathering sub-zones.

Sub-zone	Vertical depth (m)	Morphological features
IA	0.0-0.7	Yellowish brown, firm, sandy clay. Sub-angular blocky, moist. Friable dry, porous. Some roots & burrows. Boundary irregular, diffuse.
IB	0.7-1.6	Strong brown, gravelly clayey sand. Firm, sub-angular blocky, moist. Friable dry. Some roots. Boundary irregular, diffuse.
IC_1	1.6-6.4	Yellowish red to reddish yellow, stiff, gravelly clayey sand. Sub-angular blocky, moist. Friable dry. Boundary irregular, diffuse.
IC_2	6.4-11.8	Yellowish red with red & yellow mottles. Stiff, gravelly clayey sand. Sub-angular blocky, moist. Distinct relict granite texture. Indistinct relict quartz veins. Boundary irregular, diffuse.
IIA	11.8-17.5	Friable, gravelly silty sands of yellow & red colors with yellow mottles. Sub-angular blocky, moist. Distinct relict bedrock textures & quartz veins. Indistinct relict joint planes. Some thin bands & wedges of yellowish red gravelly clayey sand. Boundary irregular, diffuse.
IIB	17.5-25.9	Friable, gravelly silty sands of mainly white & yellow colours with some red mottles. Distinct relict bedrock textures, quartz veins & joint planes. Indistinct relict fault planes. Some weathered core-stones. Boundary, irregular, diffuse.
IIC	25.9-32.8	Friable, gravelly silty sands of mainly white & yellow colours. Distinct relict bedrock textures, quartz veins, joint & fault planes. Many partly weathered to fresh core-boulders (<30% by area). Boundary irregular, diffuse.
IID	32.8-43.7	Friable, gravelly silty sands of mainly white & yellow colours. Distinct relict bedrock textures, quartz veins, joint & fault planes. Many, partly weathered to fresh core-boulders (>50% by area).

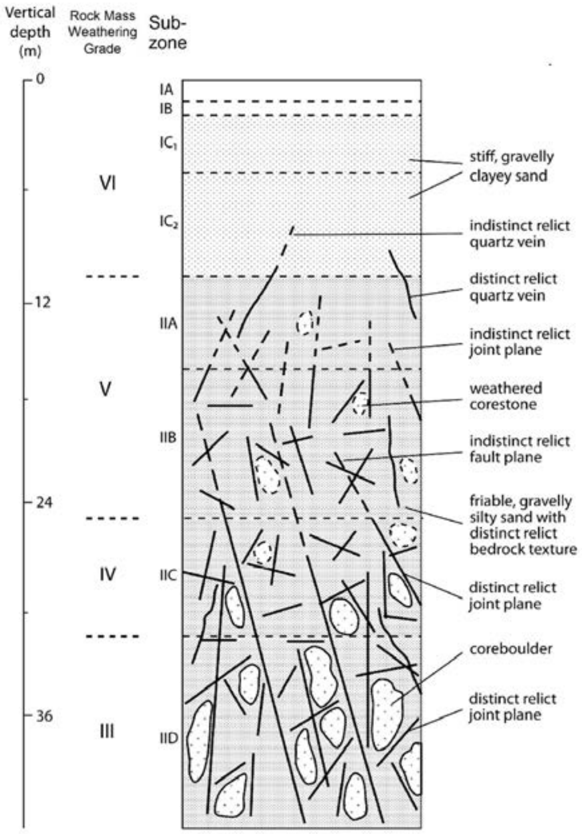

Figure 2: Schematic sketch of morphological features at the weathering profile.

Brass rings of 4 cm length and 7.6 cm internal diameter were then used to collect constant volume samples from *in situ* weathered granite (saprock) at depths of 26.53 m, 31.29 m and 41.93 m (Figure 3). The rings had a constant wall thickness of 0.3 cm except at one end where the lower half tapered to 0.15 cm thick to provide a cutting edge. A brass ring was first driven into the soil by hammering gently on its top until the top was flush with the ground surface. A second brass ring, with its cutting edge facing upwards, was then placed on the top of the first ring which was then driven deeper into the soil by gently hammering on the top of the second ring; a piece of wood placed over the second ring to minimize damage and disturbance of the sample. Both rings were then dug out from the ground by excavating the surrounding and underlying soil. The sample in the upper ring was discarded whilst the sample in the lower ring was trimmed and sealed with rubber discs that were held in place by screwed-on metal plates. Prior to sampling, the rings were externally greased to facilitate entry into the soil, whilst materials on the slope were excavated to a depth of some 0.5 m to minimize surface disturbance. Prior to sampling, the soil was also trimmed into an approximately cylindrical shape, slightly larger than the ring diameter, to reduce

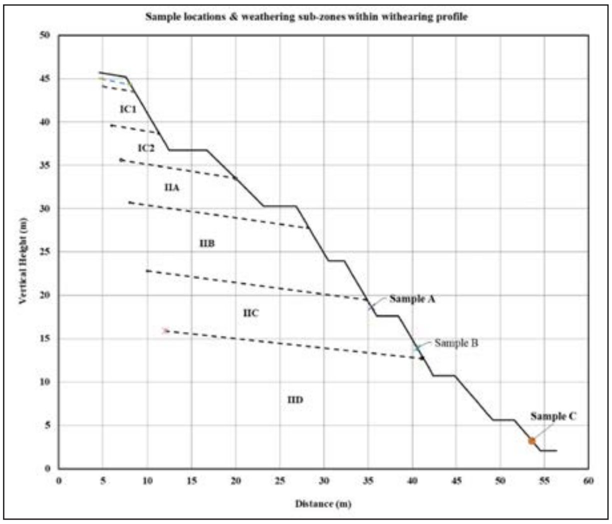

Figure 3: Sample locations and weathering sub-zones.

lateral compaction. Two constant volume samples were collected at each sampling point; one for determination of its physical and soil index properties, and the other for determination of its soil moisture retention characteristics.

The sample rings were transported to the laboratory where the moisture contents, unit weights and densities of one set of samples were determined before the specific gravity of constituent mineral grains was measured using a pycnometer (ASTM, 1970). Porosities, void ratios and degrees of saturation of the samples were then calculated before the plastic limits of the fine fractions (<0.42 mm size) were determined (ASTM, 1970). The particle size distributions of the samples were next determined using the sieving, and sedimentation, methods for the coarse (>0.0625 mm diameter), and fine (<0.0625 mm), grained fractions respectively (ASTM, 1970). The main minerals present in the gravel, sand and silt sized fractions were then identified with the aid of a binocular microscope, whilst X-ray diffractograms of the clay fractions were prepared under normal, glycolated, and 500^{o}C heated, conditions to identify the minerals present (Thorez, 1975; Poppe *et al.*, 2001). It is to be noted, that the size limits for soil particles is based on the Wentworth (1922) Scale where gravel refers to particles with diameters between 2 and 64 mm, sand to particles with diameters between 0.0625 and 2 mm, silt to particles with diameters between 0.0039 and 0.0625 mm, and clay to particles less than 0.0039 mm in diameter.

Samples from the second set of brass rings were extracted in the laboratory and cut into five pieces of about similar volumes which were then saturated by allowing them to stand in water overnight. The moisture content of one of the five saturated samples was determined, whilst the remaining samples were placed on water saturated ceramic porous plates in four separate chambers. The air pressures in the pressure chambers were then adjusted to subject the samples to different pressures; the lower side of the porous plates being exposed to atmospheric pressure. The pressures were kept constant for one week until the overflow of excess water had stopped. After release of the pressures, the samples were removed and their moisture contents determined. The pressure plate tests were carried out at the Soils Laboratory of Universiti Pertanian Malaysia (now Universiti Putra Malaysia) where such tests were being routinely carried out for agricultural soil surveys.

WEATHERING ZONES AND ROCK MASS WEATHERING GRADES

Variations in preservation of the minerals, textures and structures of the original granitic bedrock material and mass allowed differentiation of the pedological soil (zone I), and saprock (zone II), zones of the pedo-weathering profile concept (Tandarich *et al.*, 2002) (Table 1 and Figure 2). The zones are developed approximately parallel to the overlying ground surface and are of maximum thickness below the ridge crest but thin towards the valley sides.

The pedological soil (zone I) is some 11.8 m thick and can be separated into A, B and C soil horizons; the A and B horizons representing the solum, and the C horizon, the saprolite (Table 1). The solum is relatively thin (1.6 m) and consists of brown, friable to firm, gravelly sandy clay, whilst the saprolite is some 10.2 m thick and comprises yellowish red, stiff, gravelly clayey sands with indistinct relict granite textures. The saprolite can be separated into upper (IC_1), and lower (IC_2), sub-zones characterized by the absence, or presence, of indistinct relict quartz veins, respectively (Table 1).

The saprock (zone II) is some 31.9 m thick and consists of silty sandy gravels to gravelly silty sands that indistinctly to distinctly preserve the minerals, textures and structures of the original granite; the degree of preservation increasing with depth. Zone II can be sub-divided into four sub-zones; the upper two sub-zones IIA and IIB consisting of white to yellow and red, friable, gravelly silty sands with distinct relict granite textures and quartz veins, but indistinct to distinct, relict joint and fault planes. The top IIA sub-zone with indistinct relict joint planes is 5.7 m thick and devoid of litho-relicts, whilst the lower IIB sub-zone with distinct relict joint planes, is 8.4 m thick and contains a few weathered core-stones. In the lower sub-zones IIC and IID, small to large core-boulders (litho-relicts) are prominent and separated by thin to broad, bands of white to yellow, friable, gravelly silty sands with distinct relict textures, quartz veins, fracture and fault planes. Core-boulders form less than 30% by area of sub-zone IIC (6.9 m thick), but more than 50% of the lower IID sub-zone (10.9 m thick).

Several schemes have been proposed for assigning rock mass weathering grades to weathering zones; the more widely known ones being those by IAEG (1981), GCO (1988) and GSL (1990). In terms of these published schemes, the pedological soil (zone I) would constitute rock mass weathering grade VI, whilst the bottom sub-zone IID with its' many core-boulders would be classified as grade III. Sub-zone IIC would then constitute rock mass weathering grade IV, and sub-zones IIA and IIB, constitute rock mass weathering grade V (Figure 2).

The earth materials of the weathering profile are classified as residual soils over granite in geotechnical work for their excavation has only involved scraping and ripping or "common excavation" (JKR, 2007). The residual soils would also be considered as being unsaturated soils as they located above the unconfined groundwater table (that is seen at the bottom of the weathering profile).

RESULTS

Descriptions of saprock samples

Binocular microscope examinations show the gravel and sand sized fractions to consist predominantly of vitreous quartz grains with some altered (whitish) and fresh (cloudy) feldspar grains. The silt sized particles, however, are seen to consist almost entirely of sericite flakes with a few, larger muscovite flakes. These sericites originate from not only sericitization of feldspars in the original granite (Yusari, 1993), but also from *in situ* alteration of feldspars within the weathering profile. The *in situ* alteration of feldspars is considered to result from leaching of its cations as there has been downward migration of the unconfined groundwater table at the profile (Raj, 1983). X-ray diffractograms of the clay fractions furthermore, show kaolinite and illite to be the only clay minerals present (Table 2).

Physical properties of saprock samples

As the samples were collected at different depths, there are some variations in physical properties. Samples A and B have closely similar values of dry unit weight of 16.45, and 15.96, kN/m^3, and dry density of 1,677, and 1,626, kg/m^3, whilst sample C has corresponding values of 14.22 kN/m^3, and 1,450 kg/m^3 (Table 3). In view of similar primary and secondary minerals, the specific gravity of soil particles in all samples shows little variation (Table 3).

Porosity is somewhat variable; samples A and B with a similar value of 37%, whilst sample C is more porous with 44% (Table 3). Void ratio is also variable; samples A, B and C having values of 0.58, 0.60 and 0.79, respectively (Table 3).

Soil index properties of saprock samples

Differences in depth of samples give rise to some variation in soil index properties (Table 4). Gravel contents are quite variable; samples A and B with 33%, and 31%, and sample C with 24%. Sand contents, however, are less

Table 2: Descriptions of saprock samples.

Sample	Vertical Depth (m)	Sub-zone	Description
A	26.53	IIC	Yellow to white, friable, silty sandy gravel with distinct relict bedrock texture. Highly weathered granite. Coarse fraction of quartz grains, sericite & muscovite flakes & some (kaolinized) feldspar grains. A few fresh (cloudy) feldspar grains. Clay fraction of kaolinite & illite.
B	31.29	IIC	Yellow to white, friable, silty sandy gravel with distinct relict bedrock texture. Highly weathered granite. Coarse fraction of quartz grains, sericite & muscovite flakes & some (kaolinized) feldspar grains. A few fresh (cloudy) feldspar grains. Clay fraction of kaolinite and illite.
C	41.93	IID	White to yellow, friable, gravelly sandy silt with distinct relict bedrock texture. Moderately weathered granite. Coarse fraction of quartz grains, sericite & muscovite flakes & several fresh (cloudy) feldspar grains. Also some (kaolinized) feldspar grains. Clay fraction of kaolinite & illite.

Table 3: Physical properties of saprock samples.

Sample	Vertical Depth (m)	Dry Unit Weight (kN/m^3)	Dry Density (kg/m^3)	Particle Specific Gravity	Porosity (%)	Void Ratio
A	26.53	16.45	1,677	2.65	37	0.58
B	31.29	15.96	1,626	2.60	37	0.60
C	41.93	14.22	1,450	2.62	44	0.79
Average		15.54	1,584	2.62	39.33	0.66

Table 4: Soil index properties of saprock samples.

Sample	Vertical Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Plastic Limit (%)
A	26.53	33	27	22	18	21.8
B	31.29	31	24	25	20	21.6
C	41.93	24	28	38	10	34.9

variable; samples A, B and C having contents of 27%, 24% and 28%, respectively. Total sand and gravel contents are also variable with samples A, B and C having 60%, 55%, and 52%, respectively (Table 4).

Silt contents are quite variable; samples A and B with 22%, and 25%, and sample C with 38% (Table 4). Clay contents are also variable; samples A and B with 18%, and 22%, and sample C with 10% (Table 4). Differences in the silt and clay contents furthermore, give rise to some variation in plastic limits; samples A and B with closely similar values of 21.8%, and 21.6%, and sample C with a value of 34.9% (Table 4).

Soil moisture retention curves of saprock samples

The pressure plate tests show gravimetric moisture contents of the samples to decrease with increasing suctions (Table 5 and Figure 4). In sample A, the gravimetric moisture contents decrease from 31.9% through 28.6% and 23.3% to 16.9% and 6.8% under increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1,500 kPa. Under similarly increasing suctions, gravimetric moisture contents in sample B decrease from 32.1% through 24.9% and 21.5% to 17.8% and 7.4%, whilst in sample C, they decrease more abruptly from 31.6% through 30.3% and 27.3% to 23.5% and 9.5% (Table 5).

Storage and drainage pores in saprock samples

In agriculture, soil suction or soil moisture tension is considered to be the most important soil moisture characteristic for a growing plant and is usually defined in units of bars (where 1 bar = 100 kPa). A saturated

Table 5: Gravimetric moisture contents retained under different suction pressures.

Sample	Sub-zone	Vertical Depth	Gravimetric moisture content (%)				
			0 kPa	0.98 kPa	9.8 kPa	33 kPa	1,500 kPa
A	IIC	26.53 m	31.9	28.6	23.3	16.9	6.8
B	IIC	31.29 m	32.1	24.9	21.5	17.8	7.4
C	IID	41.93 m	31.6	30.3	27.3	23.5	9.5
Average			31.9	27.9	24.0	19.4	7.9

Table 6: Drainage and storage pores in saprock samples.

Sample	Sub-zone	Vertical depth (m)	Quick drainage pores (%)	Slow drainage pores (%)	Total drainage pores (%)	Storage pores (%)	Total porosity (%)
A	IIC	26.53	8.6	6.4	15.0	10.1	25.1
B	IIC	31.29	10.6	3.8	14.4	10.4	24.8
C	IID	41.93	4.3	3.8	8.1	14.1	22.2
Average			7.8	4.7	12.5	11.5	24.0

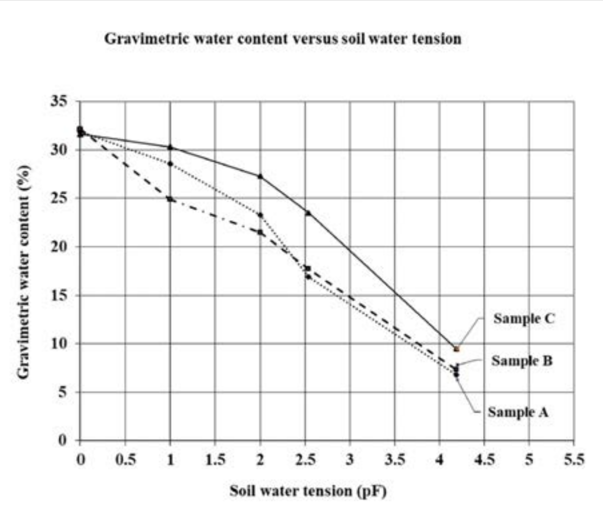

Figure 4: Soil moisture retention curves of saprock samples.

soil has a soil moisture tension of about 0.1 kPa or less, whilst at field capacity, most soils have a soil moisture tension between 5 kPa and 33 kPa; field capacity defined as the level of soil moisture left in the soil after drainage of gravitational water which frequently takes a few days to drain through the soil profile. The wilting point, which is defined as the soil moisture content where most plants cannot exert enough force to remove water from small pores in the soils, is at about 1,500 kPa soil moisture tension for most agronomic crops. Water, held between field capacity and the wilting point is available for plant use, whilst capillary water held in the soil beyond the wilting point can only be removed by evaporation (Scherer *et al.*, 1996). In view of these relationships, results of soil water retention curves are often expressed in terms of 'quick' and 'slow' drainage pores as well as 'storage' pores; these values being determined from the following equations:-

Quick drainage pores (%) = moisture content (0.0 kPa) - moisture content (0.98 kPa)
Slow drainage pores (%) = moisture content (9.8 kPa) - moisture content (33 kPa)
Storage pores (%) = moisture content (33 kPa) - moisture content (1,500 kPa)

Percentages of quick and slow drainage pores in the samples are quite variable, though the total drainage pores of samples A and B are closely similar with 15.0% and 14.4%, whilst sample C has 8.1% (Table 6). Total percentages of storage pores in samples A and B are also closely similar with 10.1% and 10.4%, whilst sample C has 14.1% (Table 6).

DISCUSSION

Comparison with published data

In earlier publications, it has been pointed out that the earth materials in a weathering profile over porphyritic biotite granite varied with depth in not only texture and composition but also in the extent of preservation of the original bedrock minerals, textures and structures (Raj, 1985; 2010). It was thus emphasized that discussions on the physical and soil index properties of earth materials in weathering profiles (and residual soils), as well as their soil moisture retention characteristics, be carried out with reference to the locations of samples. Results of the present study are thus only compared with the results of the study involving saprock samples from the weathering profile over porphyritic biotite granite (Raj, 2010).

Pressure plate tests in the present study show gravimetric moisture contents to decrease on average from 31.9% through 27.9% and 24.0% to 19.4% and 7.9% with increasing suctions from 0 kPa through 0.98 kPa and 9.8 kPa to 33 kPa and 1,500 kPa (Table 5). These decreasing moisture contents are quite similar to those of saprock samples from sub-zone IID of the weathering profile over porphyritic biotite granite where moisture contents decreased on average from 24.3% through 21.2% and 14.7% to 10.6% and 3.3% with similar increasing suctions (Raj, 2010). The decreases in moisture contents, however, are not identical for there are significant textural differences between the samples. The saprock samples of the present study consist on average of 29% gravel, 26% sand, 28% silt and 16% clay, sized particles, whilst the saprock samples of the earlier study consist on average of 10% gravel, 68% sand, 17% silt and 6% clay, sized particles (Raj, 2010).

Quick and slow drainage pores in samples of the present study constitute on average some 7.8%, and 4.7%, respectively, whilst the total drainage porosity is 12.5%, and the total storage porosity some 11.5% (Table 6). In the earlier study involving saprock samples from sub-zone IID (Raj, 2010), the quick and slow drainage pores were found on average to constitute some 9.7%, and 4.1%, whilst the total drainage porosity was 13.8%, and the total storage porosity some 11.0%. The two sets of results are similar but not identical for there are significant textural differences between the samples.

Reasons for retention of soil-moisture under high suction pressures

The pressure plate tests show the soil moisture contents retained under different suction pressures to be variable with particle size distributions (Tables 4 and 5). Gravel contents appear to have little influence for regression analyses of their plots against moisture contents retained at high suctions (33 kPa and 1,500 kPa) yield negative trends with large (and unrealistic) intercept values. Sand contents similarly have little influence with regression analyses of their plots yielding positive trends with very low correlation coefficients (R^2 <0.4000). Clay contents also appear to have little influence with regression analyses of their plots yielding negative trends with large (and unrealistic) intercept values. Total clay and silt contents, however, appear to have some influence with regression analyses of their plots yielding positive trends with moderate correlation coefficients (R^2 <0.7957) but negative (and unrealistic) intercept values.

Regression analyses of silt contents plotted against moisture contents retained at high suctions (33 kPa and 1,500 kPa) furthermore, yield positive trends with large correlation coefficients (R^2 >0.9966) and low (reliable) intercept values (Figure 5). Silt sized particles are therefore, expected to influence the moisture contents

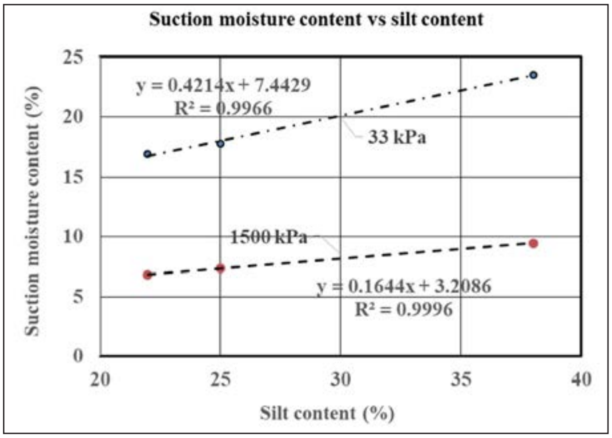

Figure 5: Silt contents plotted against moisture contents retained at high suctions (33 kPa and 1,500 kPa).

retained in the saprock samples at high suctions (33 kPa and 1,500 kPa). Retention of moisture by the silt sized particles results from the adsorption of water onto their surfaces; the silt sized particles having very large specific surface areas. Van der Waal forces furthermore, are considered to be primarily responsible for such particle surface hydration (Lu, 2016).

CONCLUSIONS

The weathering profile can be differentiated into an upper, 11.8 m thick pedological soil (zone I) comprising gravelly clayey sands and a lower, 31.9 m thick saprock (zone II) consisting of silty sandy gravels to gravelly silty sands that indistinctly to distinctly preserve the minerals, textures and structures of the original bedrock material and mass. Regression analyses of gravel, sand, clay, and total clay and silt, contents plotted against moisture contents retained at high suctions (33 kPa and 1,500 kPa) yield variable trends with unreliable intercept values and low to moderate correlation coefficients (R^2 <0.7957). Regression analyses of silt contents plotted against moisture contents retained at high suctions (33 kPa and 1,500 kPa) yield positive trends with large correlation coefficients (R^2 >0.9966) and low intercept values. It is concluded that adsorption of water on the surfaces of silt sized particles (of mainly sericite derived from the weathering of feldspars) that gives rise to the retention of soil moisture in saprock.

ACKNOWLEDGEMENTS

This study was supported by an F-Vote Research Grant from the University of Malaya. Grateful thanks are extended to the two anonymous reviewers for their valuable comments.

CONFLICT OF INTEREST

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

REFERENCES

Agus, S.S., Leong, E.C. & H. Rahardjo, 2001. Soil-water characteristic curves of Singapore residual soils. Geotechnical & Geological Engineering, 19, 285-309.

American Society for Testing Materials (ASTM), 1970. Special Procedures for Testing Soil and Rock for Engineering Purposes. Special Publication 479, American Society for Testing Materials, Philadelphia. 630 p.

Bujang, B.K.H., Faisal Hj. Ali & S. Hashim, 2005a. Modified shear box test apparatus for measuring shear strength of unsaturated residual soil. American Journal of Applied Sciences, 2(9), 1283-1289.

Bujang, B.K.H., Faisal Hj. Ali & Affendi Abdullah, 2005b. Response of suction, moisture and temperature of unsaturated residual soil to rainfall. Electronic Journal of Geotechnical Engineering (EJGE), 10, D, Paper 2005-0545.

Cobbing, E.J., Pitfield, P.E.J., Darbyshire, D.P.F. & D.I.J. Mallick, 1992. The granites of the southeast Asian Tin Belt. British Geological Survey Overseas Memoir 10. 369 p.

Faisal, H.A., Bujang, B.K.H. & T.H. Low, 2005. Infiltration characteristics of granitic residual soil of various weathering grades. American Journal of Environmental Sciences, 1(1), 64-68.

FAO, Food and Agricultural Organization, 2006. Guidelines for Soil Description, 4th edition. Food and Agriculture Organization of the United Nations, Rome. 109 p.

GCO, Geotechnical Control Office, 1988. Guide to Rock and Soil Descriptions. Geoguide 3. Geotechnical Control Office, Hong Kong. 186 p.

GSL, Geological Society of London, 1990. Tropical residual soils. Geological Society Working Group Report, Quarterly Journal of Engineering Geology, 23, 1-102.

Gobbett, D.J., 1965. The Lower Palaeozoic rocks of Kuala Lumpur, Malaysia. Federation Museums Journal, 9, 67-79.

Hamdan, J., Ching, L.B. & B. Ruhana, 2006. Saturated hydraulic conductivity of some saprolites from Peninsular Malaysia. Malaysian Journal of Soil Science, 10, 13-24.

IAEG, International Association Engineering Geology, 1981. Rock and soil description for engineering geological mapping. Bulletin International Association of Engineering Geology, 24, 235-274.

JKR, Public Works Department of Malaysia, 2007. Guidelines for hard material/rock excavation. Technical Note (Roads) 24/05. Road Division, Jabatan Kerja Raya Malaysia, Malaysia. 15 p.

Leamy, M.L. & Panton, W.P., 1966. Soil Survey Manual for Malayan Conditions. Division of Agriculture Malaysia, Malaysia. 22 p.

Lu, N., 2016. Generalized soil water retention equation for adsorption and capillarity. Journal of Geotechnical & Geoenvironmental Engineering, 142(10), 1-15.

Ng, T.F., 1992. Petrography, structure and geotechnical studies of the Kuala Lumpur Granite, eastern part of Kuala Lumpur, Peninsular Malaysia. M.Phil. Thesis, Institute for Advanced Studies, University of Malaya, Kuala Lumpur. 527 p.

Ng, T.F., Raj, J.K. & Azman A. Ghani, 2013. Potential alkali-reactivity of granite aggregates in the Bukit Lagong area, Selangor, Peninsular Malaysia. Sains Malaysiana, 42(6), 773-781.

Poppe, L.J., Paskevich, V.F., Hathaway, J.C. & Blackwood, B.S., 2001. A Laboratory Manual for X-Ray Powder Diffraction. United States Geological Survey Open-File Report 01-041. 88 p.

Raj, J.K., 1985. Characterization of the weathering profile developed over a porphyritic biotite granite bedrock in Peninsular Malaysia. Bulletin International Association of Engineering Geology, 32, 121-128.

Raj, J.K., 2009. Geomorphology. In: Hutchison, C.S. & Tan, D.N.K. (Eds.), Geology of Peninsular Malaysia. University of Malaya and Geological Society of Malaysia, Kuala Lumpur. 479 p.

Raj, J.K., 2010. Soil moisture retention characteristics of earth materials in the weathering profile over a porphyritic biotite granite in Peninsular Malaysia. American Journal of Geosciences, 1(1), 12-20.

Scherer, T.F., B. Seelig & D. Franzen, 1996. Soil, water and plant characteristics important to irrigation. EB-66, www.ag.ndsu.edu/pubs/ageng/ irrigate/eb66w.htm.

Thamer, A.M., Faisal Hj. Ali, S. Hashim & B.K.H. Bujang, 2006. Relationship between shear strength and soil water characteristic curve of an unsaturated granitic residual soil. American Journal of Environmental Sciences, 2(4), 142-145.

Tandarich, J.P., Darmody, R.G., Follmer, L.R. & D.L. Johnson, 2002. Historical development of soil and weathering profile concepts from Europe to the United States of America. Journal of Soil Science Society of America, 66, 335-346.

Thorez, J., 1975. Phyllosilicates and Clay Minerals – A Laboratory Handbook for Their X-Ray Diffraction Analysis. G. Lelotte, Belgium. 582 p.

USBR, United States Bureau of Reclamation, 1974. Earth Manual. United States Government Printing Office, Washington. 810 p.

Vanapalli, S.K., Fredlund, D.G., Pufahi, D.E. & Clifton, A.W., 1996. Model for the prediction of shear strength with respect to soil suction. Canadian Geotechnical Journal, 33, 379-392.

Wentworth, C.K., 1922. A scale for grade and class terms for clastic sediments. Journal of Geology, 30, 377-392.

Yusari, H.B., 1993. Geologi sekitaran empangan Batu - Kanching dengan penekanan kepada geokimia dan petrologi batuan granit. B.Sc. (Hons) Thesis, Department of Geology, University of Malaya, Kuala Lumpur. 142 p.

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CERAMAH TEKNIK TECHNICAL TALK

Geohazard risk assessment on the acid tank and pipeline gas leakage using 2D SSPT geomodelling and partial discharge (PD) testing method

Dr. Abdull Halim Bin Abdul
Date: 11 August 2021
Platform: Facebook Live GSM

Poster prepared by the promotion working group of GSM.

The technical talk moderator, Dr. Nor Shahidah Mohd Nazer from Program Geologi, UKM.

A technical talk with focus on the application of seismic method to determine soil properties was held on 11th August 2021. The topic for this talk is Geohazard Risk Assessment on the Acid Tank and Pipeline Gas Leakage Using 2D SSPT Geomodelling and Partial Discharge (PD) Testing Method, presented by P.Geol. Dr. Abdull Halim Bin Abdul, the CEO of Groundwave SSPT Sdn. Bhd.

The recorded session can be watched at this link: https://fb.watch/7p_bW_tx7c/

Report prepared by:
Mohd Hariri Arifin,
Nor Shahidah Mohd Nazer &
Norazianti Asmari

CERAMAH TEKNIK TECHNICAL TALK

Geohazard evaluation and mitigation for highway rock cut slopes

Dr. Goh Thian Lai
Date: 18 August 2021
Platform: Zoom/GSM Facebook Live

The above talk was delivered by Ir. Dr. Goh Thian Lai (UKM) on 18th August 2021, via Zoom/Facebook Live. Some 70 members participated. An abstract of the talk is provided below.

Abstract: Highways or expressway are the primary backbone network of transportation in Malaysia. The highway operators cut the rock hills into cut slopes during the highways construction. There was a lack of engineering geological inputs during construction especially in the design of mitigation measures. Thus, a systematic engineering geological approach was proposed in this study. This study adopted continuum and discontinuum approaches in the process of assessment of rock slopes stability. The mitigation for the highway rock cut slopes were designed based on the outcome of the slope stability assessments, geophysical survey and rock fall analysis. The recommended rock barriers in the case study ranged from 1500 kJ to 3000 kJ with the height of 3 m – 5 m. Besides, the active nets with the capacity of 200 kN were proposed to be installed at the highly fractured slopes.

We thank Dr. Goh for his support and contribution to the Society's activities.

Prepared by:
Tan Boon Kong
Chairman, Working Group on Engineering Geology

Geothermal energy

Date: 25 August 2021
Platform: Zoom/GSM Facebook Live

A technical talk from the geoenergy talk's series entitled Geothermal Energy was held on 25th August 2021 with 4 speakers. The summary/main topic of their talks are as the following:

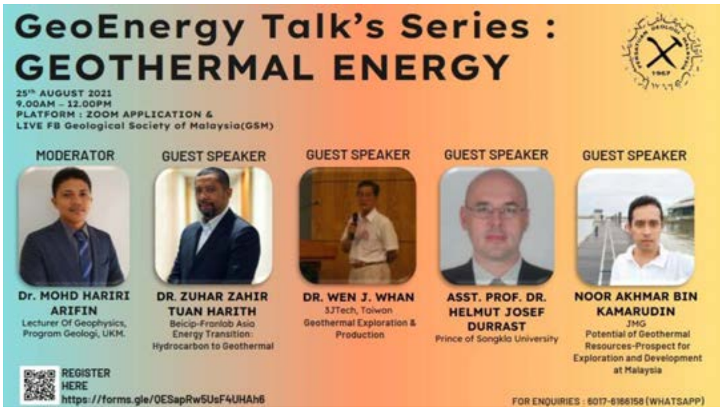
1) Dr. Zuhar Zahir Tuan Harith: The energy transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At its heart is the need to reduce energy-related CO_2 emissions to limit climate change. Geothermal energy is one of the renewable energy sources that have gained widespread acceptance as an alternative to fossil fuels energy. How big is the potential of this geothermal in Malaysia?

2) Dr. Wen J. Whan: Introduction of 3JTech and the Founder; Geothermal Direct Uses & Power Plants; Conventional & Unconventional Geothermal Development; Geothermal Development Program; Financial Assistant from the Government in Taiwan & Japan; A Volcanic & Non-Volcanic Related Geothermal Reservoirs; Why Magnetotelluric (MT) Exploration is Needed in Geothermal Development; Advantage of MT Array; Comparison of MT Array Results with the Drillings in Taiwan; An Extended Linear Ramp Control Source EM Exploration and its Potential Application in Geothermal.

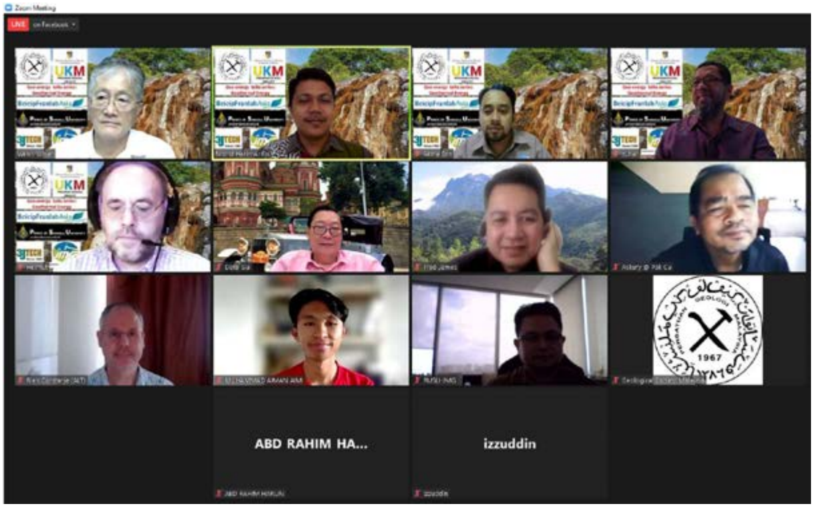
3) Asst. Prof. Dr. Helmut Josef Durrast: Distribution of hot springs at southern part of Thailand with their geophysical propertie. Sharing on Fang Geothermal Power Plant in Thailand.

4) Mr. Noor Akhmar Kamarudin: Sharing on JMG scope of works which include geological exploration, geochemical analysis and geophysical survey in Malaysia; Comparison of geothermal resources for energy, recreation and agriculture & prospect for geothermal development at Malaysia.

The recording of this event can be viewed at https://fb.watch/7BvOdPhsMM/.



Poster for the event managed by the promotion unit of GSM.



Some of the participants of the talk.

Prepared by:
Mohd Hariri Arifin &
Norazianti Asmari

CERAMAH TEKNIK TECHNICAL TALK

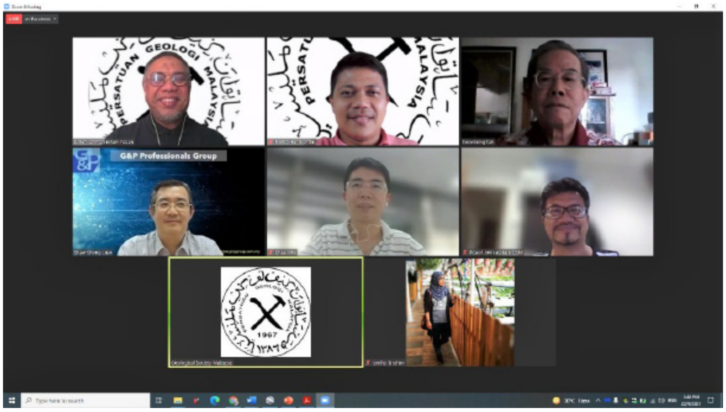
Investigating and mitigating measures for peat fire, sinkholes in limestone formation and boulder fall

Ir. Liew Shaw Shong (G&P)
Date: 22 September 2021
Platform: Zoom/GSM Facebook Live

The above talk was delivered by Ir. Liew Shaw Shong (G&P) on 22nd September 2021, via Zoom/Facebook Live. Some 60 members participated. An abstract of the talk is provided below.

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

Abstract: This lecture aim to present three case studies on peat fire, sinkhole in limestone quarry and diorite boulder fall of a quarry site. The first case involving fire hazard arising from the peat deposits at a palm oil mill estate at Province of Riau in Sumatra, Indonesia and its severe consequences of the suspended particles of PM10 and PM2.5 to health problems. The solution solving the problem associates with the proposed rising groundwater by weir structure at the widely established canal networks with primary objective to increase the oil content yield in the fruits and also to provide sufficient draught depth for water navigation at the region. The second case study consists of the solution to plug the sinkholes at the open limestone quarry site with river at close proximity breaching the infilled solution channel to open channel flow. Use of well graded stones and rock fragments of various sizes from the quarry in repeated filling sequence to create interlocking and arching of the well graded stones dumped into the subvertical sinkhole shaft. Once the dumped materials stabilised at the sub-horizontal solution channels gradually plugging the channel flows, ingression of river water was controlled for subsequent repair of the river concrete linings. Final temporary plugging at the sinkhole was by earth fill levelled to the river invert level. 2D resistivity scanlines with complementary boreholes were used to identify connectivity between the upstream sinkholes and solutioned channel with downstream exit locations. The combined techniques show promising results with proper response matrix in the interpreted resistivity inversion tomograph. The last case study provides good insight of the detachment mechanisms of the core boulders, which started from the cyclic climatic induced shrink-swell behaviours of spheroidal weathered materials around the core boulders creating gaps and voids and permitting material erosion by the runoff flow. When the erosion substantially exposes the boulders until the completely loss of initial area support from the embedment, the point contacts of the upper boulders sitting atop of the underlying boulders cause bearing crushing and further creates a kinematic condition for the loose giant round boulders to roll down the hill. Solutions of injecting the viscous mortar with rock/stone fillers and steel mesh for ductility providing the area support beneath the potentially unstable boulder was adopted to stabilise the giant hanging boulder. Additional reinforced concrete buttress was constructed at the downhill side of the boulder for additional support.



Prepared by:
Tan Boon Kong
Chairman, Working Group on Engineering Geology

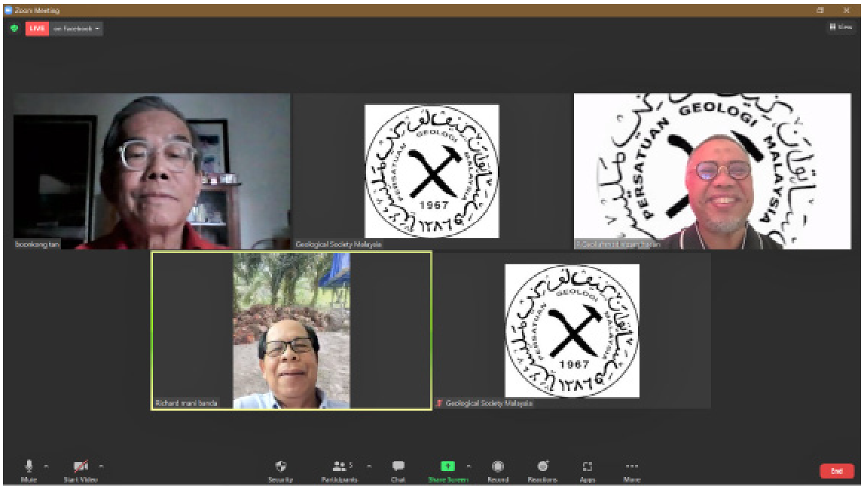
CERAMAH TEKNIK TECHNICAL TALK

Engineering geology of rock slopes – Some case studies

Mr Tan Boon Kong
Date: 13 October 2021
Platform: Zoom/GSM Facebook Live

The above talk was delivered by Mr Tan Boon Kong (Consultant) on 13th October 2021, via Zoom/Facebook Live. Some 60 members participated. An abstract of the talk is provided below.

Abstract: Rock slopes feature in many construction projects, such as highways, housing developments, dams, etc. The investigation of rock slopes is a major activity of the Engineering Geologist. The fundamental properties of the rock slope to be investigated include lithology, structure and grade of weathering. This paper presents some case studies of rock slopes covering various lithologies (granite, sandstone/shale, schist, quartzite/phyllite, and limestone). The construction projects concerned include highways, dam, housing developments, and a water theme park.



Prepared by:
Tan Boon Kong
Chairman, Working Group on Engineering Geology

CERAMAH TEKNIK TECHNICAL TALK

Tarikh : 13 Oktober 2021
Platform: Zoom/GSM Facebook Live

Satu bicara bersama ahli geologi dan geofizik muda telah diadakan pada 13 Oktober 2021 dengan dibarisi oleh 3 orang panel iaitu:

1) Dr. Muhammad Taqiuddin bin Zakaria (Pasca Doktoral Universiti Sains Malaysia): Geophysics and the application for landslide study.

2) En. Mohammad Noor Akmal bin Anuar (Calon PhD, Universiti Kebangsaan Malaysia): The bittersweet of geoscience academic study by research mode.

3) En. Muhamad Afiq bin Saharudin (Applications Engineer, Guideline Geo): The fundamental of geophysical techniques.

Rakaman bicara ini boleh ditonton di pautan berikut: https://fb.watch/8C7llteItr/

Geophysics and the application for landslide study

MUHAMMAD TAQIUDDIN BIN ZAKARIA

Geophysics is a subject of natural science concerned with the physical processes and properties of the Earth and its surrounding space environment and the uses of quantitative and qualitative methods for their analysis. Geophysics refers to the application of earth physics principles to study the Earth, where the Earth is comprised of materials with different physical properties. Geophysical investigation of the Earth's interior involves the measurement at or near the Earth's surface influenced by the internal distribution of physical properties. The analysis of these measurements provides insight into how the physical properties of the Earth's interior vary vertically and laterally. As a field of science, geophysics has played a significant role in increasing our knowledge of the Earth's properties and physical processes. Today geophysical methods are utilised for mapping large geological areas to improve our understanding of the Earth's structure; locating and recovering resources such as hydrocarbons, minerals, and groundwater; mapping the uppermost meters of the Earth's crust for tunnel construction, as well as potential locations for pipelines/cables on the ocean bottom floor; archaeological survey; assessing the risk of geohazards such as earthquakes, tsunamis, and landslides.

In landslides study, geophysical methods contribute a significant role in understanding the behaviours of the slope properties. The destabilisation and mass movement of soil and rock on slopes occurs as a common phenomenon across the globe. It causes loss of life and severe damage to the property and infrastructure in the affected areas (Froude & Petley, 2018; Whiteley *et al*., 2019). Numerous methods have been used to investigate the geometry of landslides and the information on stability conditions. The investigations of subsurface landslide features are indispensable for performing forward modelling and subsequently predicting the potential slope failures, including the run-out distance of the mass movement and the mobilised volume (Malet *et al*., 2005; Rosso *et al*., 2006). Geophysical investigations are principally applied at the ground surface to measure the subsurface physical properties (e.g., resistivity and seismic). The approaches were capable of identifying the spatial variations of physical parameters of the landslide subsurface by physical property contrasts, including the physical extent of the landslide, slip surface, lithological contact, distribution of the movement of moisture throughout the landslide body, evaluation of the emergence and growths of fractures as well as for the understanding of water dynamics and possible reactivation by rainfall (Whitley *et al*., 2019; Pazzi *et al*., 2019). However, the complexity and the variation of the ground condition produce a varying efficiency of the methods. Further research concerning the suitability of these methods is highly required to examine and improve the applications. The methods provide insights into how spatial distributions of geophysical properties are used to minimise the uncertainty in the ground models.

The cross-plot analysis is based on the integration of resistivity and velocity values capable to provides comprehensive subsurface images. This analysis applies different geophysical parameters to represents the two or more attributes relationship. Inazaki (2011) employed the cross-plot analysis to integrate S-wave velocity and resistivity results as a qualitative vulnerability assessment in producing a map of permeability distribution and stiffness of the levee system. Hayashi & Suzuki (2004) and Immamura *et al*. (2007) revealed a similar application of cross-plot analysis, where the degrees of compaction (loose or dense) were divided using correlations between S-velocity values and N-values, and soil types by comparing to borehole data. Cross-plot analysis using electrical resistivity and seismic refraction results is an approach where different soil types and subsurface conditions are classified based on their seismic velocities and resistivity values (Hayashi & Konishi, 2010). Instead of analysing the results from each method separately, four-quadrant criteria based on the ranges of electrical resistivity and seismic velocity were introduced. Solutions of injecting the viscous mortar with rock/stone fillers and steel mesh for ductility providing the area support beneath the potentially unstable boulder was adopted to stabilise the giant hanging boulder. Additional reinforced concrete buttress was constructed at the downhill side of the boulder for additional support.

The bittersweet of geoscience academic study by research mode

Mohammad Noor Akmal bin Anuar

According to the Cambridge dictionary, conventional research is a detailed study of a subject in the systematic investigation using materials and sources, especially to discover (new) information or reach a (new) understanding that later establishes facts and reaches new conclusions. Although this sentence is already accepted within our community, yet the practicality of it is not at its uttermost cognitive phase on human intellectual within the local community, especially when it comes to the research gap. Geosciences communities always look up to the quote "the present is the key to the past", yet it is still incomplete as it is missing the future – and how about it? Research is a combination of two word re – search. Nowadays, students and academicians should focus on researching previous information, factual, reliable, and published articles while making scientific discoveries. Knowledge is being inherent through human beings with symbols and notation from the beginning of civilization. Therefore, to do research, it takes students to read, think, and synthesize that information and relate it with the modern solutions, a novelty or breakthrough into existing problems and the state of the unknown in certain areas. The study's output should be shared with the world ethically via scientific publication within selected journals at international levels or any form of information sharing like colloquium, conferences, and even popular writing such as newspaper. Thesis writing alone is insufficient to permit a student to pass the postgraduate study within research mode. The scientific publication is a form of nurturing future expertise within a specific area and provides writing skills in a comprehensive report for future works. Plagiarism and any form of piracy are ethically wrong, and it is unacceptable within the academic community, even in religion.

The fundamental of geophysical techniques

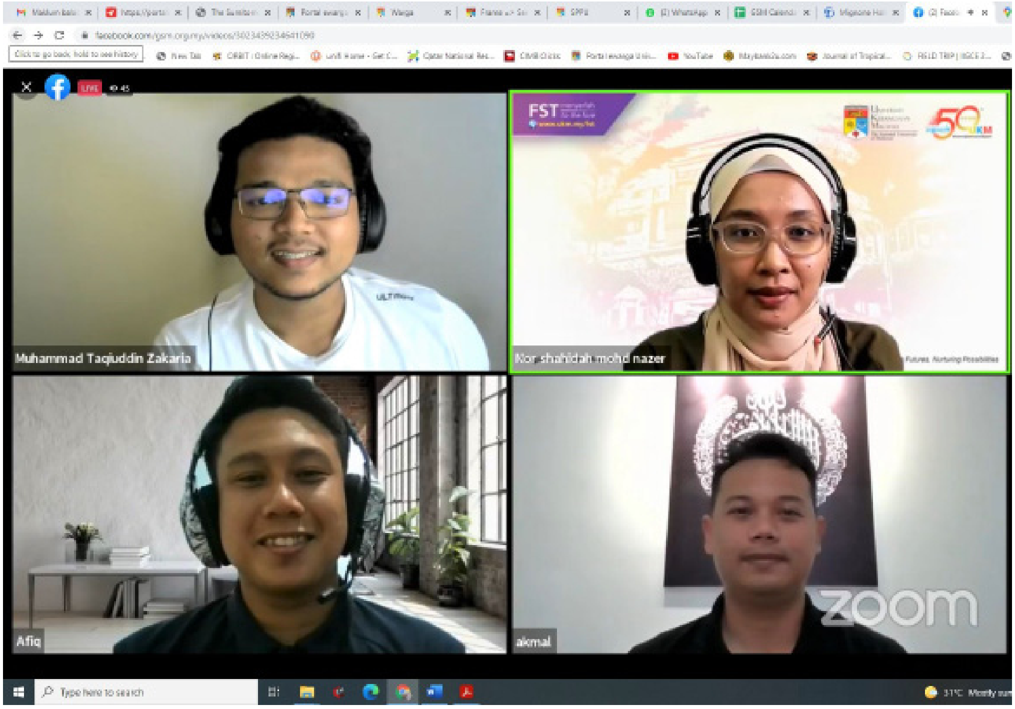
Muhamad Afiq bin Saharudin

Geophysical studies can be used for various applications such as subsurface structures determination, depth of bedrocks, nature of overburden materials and near surface structures detection such as sinkholes, cavities, voids, faults, and boulders. Appropriate geophysical method must be based on objectives and site conditions to produce a good result and could produce an accurate data for future use. Each of geophysical methods has their own limitation. Regarding some of the limitation of each method, it is crucial to not only depend on one method to achieve a good and accurate result.

Resistivity is an active geophysical prospection method which measures the ground's electrical properties. It injects current into the ground and measures the voltage between certain electrodes. Resistivity surveys will show the subsurface distribution of resistivity value. The knowledge about the subsurface and geology of the surveyed area is important during resistivity interpretation. Different rocks may different resistivity value. By calculating the resistivity, a ground model of the subsurface can be generated. Igneous and metamorphic rocks commonly have high resistivity values depending on the degree of fracturing and percentage of the fractures filled with groundwater, but sedimentary rocks tend to have low resistivity due to high porosity and high-water content (Loke, 1999).

Seismic surveys use a physical energy source to transmit elastic waves through the ground. Elastic waves propagate from an energy source through the ground. "Elastic" is a term used in earth mechanics – it means that the ground shifts, contracts or stretches but largely returns to its original state after the wave has passed. The speed and path of the waves is determined by the density and elasticity of the ground. Higher density produces faster speeds. Higher elasticity produces slower speeds. By analysing the speed and nature of the responses, a model of the sub-surface layer velocities can be produced.

The GPR data can be obtained by distributing EM waves from transmitting antenna into the subsurface and later being reflected by features coincide to the changes in the electrical properties of the earth materials. EM waves that were reflected and diffracted toward the surface receive by a receiving antenna. The time travel of the EM waves is measured and converted into depth penetration profile between the targets and the antenna. By analysing some of characteristic properties of the returned EM waves, all the details such as depth about the target can be obtained (Daniels *et al*., 1988; Davis & Annan, 1989).



Tangkap layar pada rakaman penceramah yang hadir. Atas kiri (Dr. Taqiuddin) dan moderator (Dr. Shahidah) manakala bawah kiri (En Afiq) dan kanan (En. Akmal).

Laporan disediakan oleh:
Mohd Hariri Arifin & Norazianti Asmari

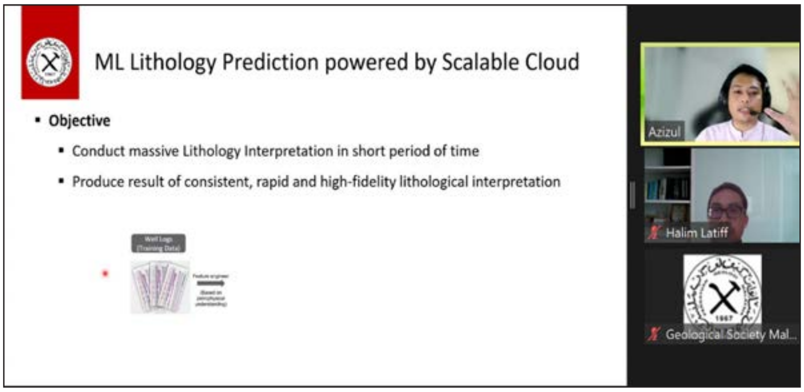
CERAMAH TEKNIK TECHNICAL TALK

Scalable cloud solution for exploration geology and geophysics workflow

Mr Azizul Yahya
Date: 22 October 2021
Platform: Zoom/FB Live GSM

A technical talk by Mr Azizul Yahya from Halliburton was held via Zoom Platform on the 22nd of October 2021. The talk with the title of "Scalable Cloud Solution for Exploration Geology & Geophysics workflow" was broadcast live through FB Live GSM platform and was attended by more than 30 participants. The GSM geophysics working group with Centre for Subsurface Imaging, UTP organised the technical talk related to geophysical exploration and basic understanding of oil and gas exploration.

Summary of talk:
The talk started at 3.00 pm with the welcoming remarks and introduction on the topic by the speaker. Mr Azizul's talk primarily focused on the scalable cloud solution that provides unlimited computation power to handle big data and complex algorithms. This accelerates geophysical workflow of seismic data without the need for data resolution reduction and sub-divide. The talk focused on how scalable cloud solution can help reduce exploration geology and geophysics interpretation workflow turnaround time. Mr Azizul and Halliburton experience and expertise in cloud solution had provide a good insight of the subsurface imaging of the basin, in comparison to conventional geology and geophysics workflow. The talk was concluded at 4.00 pm after a 15 minutes question and answer session between the speaker with the participants.



Prepared by:
Abdul Halim Latiff
GSM Geophysics Group

CERAMAH TEKNIK TECHNICAL TALK

Slope engineering for tropical country

Dr. Low Thian Huat
Date: 17 November 2021
Platform: Zoom/Facebook Live GSM

The above talk was delivered by Ir Dr Low Tian Huat (Mohd Asbi Associates) on 17th November 2021, via Zoom/Facebook Live. Some 45 members participated. An abstract of the talk is provided below.

We thank Dr Low for his support and contribution to the Society's activities.

Abstract: Malaysia, being a tropical country, experiences wet tropical climate with an average annual rainfall exceeding 3500 mm, which explains the majority of landslides, is triggered by prolonged and intense rainfall. Most reported cases of landslides in residual soil/rock are on man-made cuts where the presence of relict discontinuities is often ignored in the design of such slopes. Although the decomposition from weathering is intense, relict discontinuities inherited from parent rock are commonly well preserved. The important information of these relict discontinuities are very difficult to be retrieved from soil investigation and laboratory tests. However, these relict discontinuities which form planes of weakness can easily be seen during slope cutting. Limit equilibrium methods have been widely used for slope design applications or landslide assessment works. Some engineers have been focussing mainly on the combination of soil properties and geometry in their analysis. Some may even dynamically coupled hydrological-slope stability models in their stability analyses. Can such approach warrant high confident level in determining the potential of slope instability? Can such Hydrological-Stability model adequately model the water flux conditions within the slope? A accurate hydrological model on slope not just limiting to intensity and duration but many other factors i.e., catchment, soil type, angle, vegetation covers, geological settings, existing soil moisture, ground water etc.

This presentation will highlight the approaches to deal with slope instability issues in tropical region ie., Malaysia.

Prepared by:
Tan Boon Kong
Chairman, Working Group on Engineering Geology

BICARA TALK

Tarikh: 4 Ogos 2021

Satu ceramah perkongsian daripada ‘orang lama’ telah diadakan pada 4 Ogos 2021 selama dua jam setengah (9.00 – 11.30 pagi) dengan tajuk Otai Masih Berbisa. Ceramah ini dibarisi oleh dua orang lama iaitu Dr. Abdul Ghani Md Rafek iaitu pesara akademik dan Dato Amran Mohamad seorang ahli perniagaan dalam bidang geologi kejuruteraan (Foto 1). Ceramah berlangsung secara maya menggunakan platform Zoom dan disiar secara langsung di Facebook Geological Society of Malaysia.

Rakaman sesi ini boleh dicapai menggunakan media FB Live (Foto 2) pada pautan berikut: https://fb.watch/79-v27z6-U/.

Antara pesanan oleh Dr. Abdul Ghani adalah supaya geologist muda melakukan sesuatu perkara yang kita sendiri minat. Ini membolehkan kita menikmati pekerjaan yang kita lakukan dan memastikan kesihatan fizikal dan mental kita terjaga.

Manakala Dato Amran berpesan supaya peserta aktif dalam berpersatuan, menjaga agama dan solat serta fokus dalam sesuatu bidang paling dikuasai berbanding melakukan pelbagai kerja tanpa fokus. Beliau juga menasihati pendengar agar mengamalkan tiga sikap untuk berjaya iaitu berani, rajin dan cerdik.

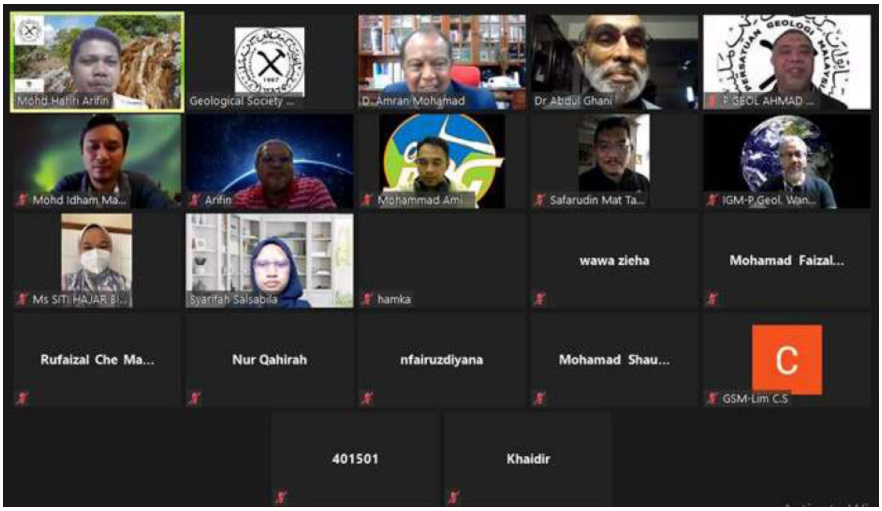


Foto 1: Sesi ceramah Otai Masih Berbisa dikendalikan oleh Dr. Mohd Hariri Arifin dan Cik Norazianti Asmari turut dihadiri seramai 22 orang di dalam talian dan sebahagian besar menonton secara live di Facebook GSM.

Foto 2: Siaran di Facebook GSM juga turut mendapat sambutan dan peserta mengambil peluang untuk bertanya kepada panel yang dijemput.

*Laporan disediakan oleh Norazianti Asmari. Jika anda mempunyai cadangan program Live Facebook, sila emel kepada noraziantiasmari@gmail.com.

BICARA TALK

Tarikh: 15 September 2021

Bicara santai bertemakan Geosaintis dan Kepimpinan di bawakan khas oleh unit promosi GSM dengan membariskan panel-panel yang sedang dan pernah memegang jawatan pentadbiran di universiti. Berikut merupakan maklumat bicara tersebut yang telah diadakan pada 15 September 2021 sekitar jam 9.00 pagi hingga 12.00 tengahari:

1) Profesor Dr. Ismail Yusoff,
Dekan Fakulti Sains, Universiti Malaya.

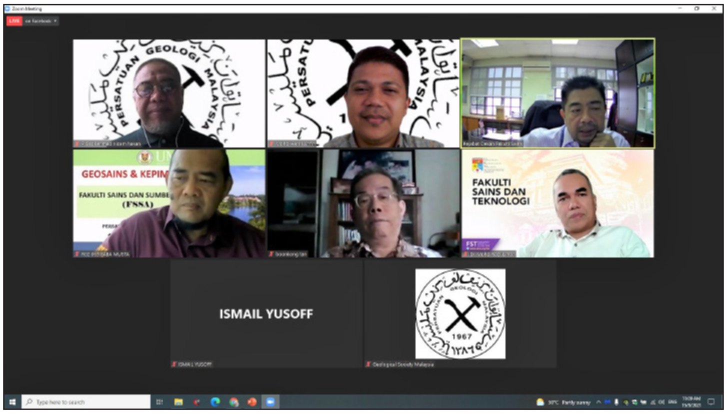
2) Profesor Baba Musta
Mantan Dekan Fakulti Sains & Sumber Alam, Universiti Malaysia Sabah

3) Dr. Mohd Rozi Umor:
Ketua Program Geologi, JSBAS, Universiti Kebangsaan Malaysia

4) Profesor Emeritus Dato' Dr. Ibrahim Komoo
Mantan Naib Canselor Universiti Malaysia Terengganu

Isi buah fikiran yang telah dibincangkan oleh ahli panel boleh ditonton di pautan berikut: https://fb.watch/8Crd_bjLJr/

Prof. Emeritus Dato' Dr. Ibrahim Komoo memulakan bual bicara sebagai pembentang pertama.



Majlis yang turut dihadiri oleh Presiden Persatuan Geologi Malaysia (En. Ahmad Nizam Hasan) dan barisan panel yang dijemput (paling kanan: Prof. Ismail), Prof. Baba (bawah paling kiri), En. Tan Boon Kong (ahli majlis), Dr. Rozi (bawah paling kanan).

Laporan disediakan oleh:
Mohd Hariri Arifin (moderator majlis) & Norazianti Asmari (ketua unit promosi)

LAPORAN REPORT

Pada 13 November 2021, pihak Persatuan Geologi Malaysia telah mengadakan promosi anjuran Kelab Geologi di Program Geologi, Universiti Kebangsaan Malaysia. Majlis dihadiri oleh Presiden (En. Ahmad Nizam Hasan) dan Timbalan Presiden (Dr. Mohd Hariri Arifin) serta 40 orang pelajar.

Berikut merupakan beberapa tangkap layar sepanjang majlis tersebut berlangsung:

Foto 1: Pembentangan disampaikan oleh En. Ahmad Nizam Hasan dengan menekankan peranan Persatuan Geologi Malaysia atau lebih dikenali sebagai Geological Society of Malaysia (GSM).

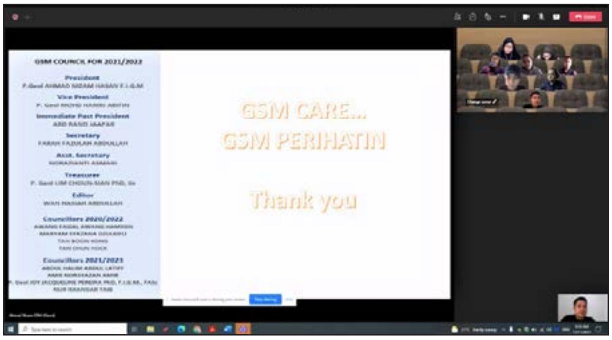


Foto 2: En. Ahmad Nizam juga turut memperkenalkan barisan ahli majlis bagi sesi 2021/2022.

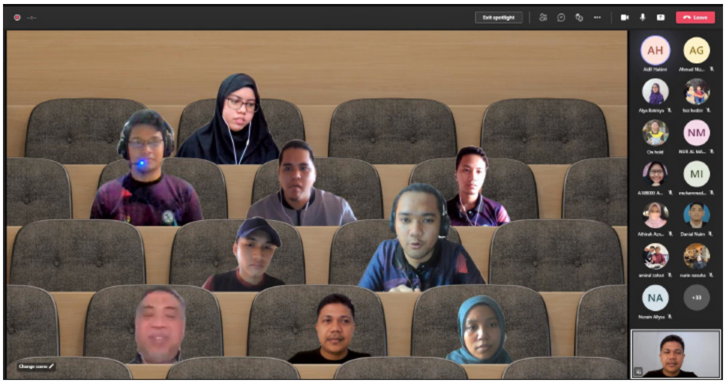


Foto 3: Pelajar tidak melepaskan peluang untuk bertanya soalan secara terus terutama cara untuk menjadi ahli serta jenis-jenis keahlian yang ada dalam GSM.

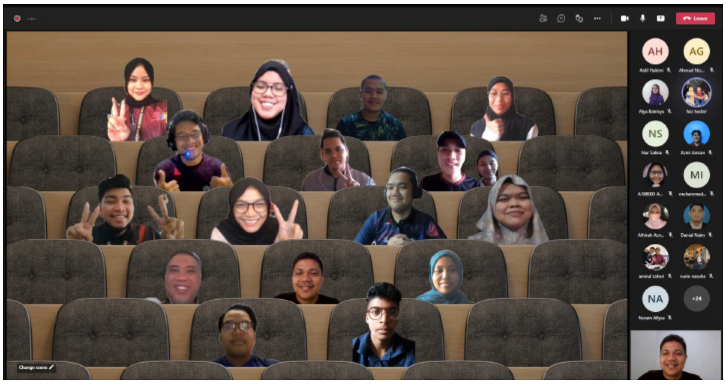


Foto 4: Ahli jawatankuasa mengambil peluang untuk bergambar kenangan bersama walaupun majoriti pelajar baharu tahun 1 masih malu-malu untuk membuka kamera.

GSM COUNCIL MEMBERS

PRESIDENT

P.Geol Ahmad Nizam Bin Hasan F.I.G.M is the founder and Chief Executive Officer of Geo Solution Resources group of companies, a well-known geological, environmental, mining and geotechnical consultancy based in Selangor, Malaysia with various branches in Southeast Asia. He graduated with Honours from the University of Malaya (UM) in 1990. He has more than 28 years of experience and his expertise is in engineering geology and mining geology. Currently, he is the President of the Geological Society of Malaysia (GSM), as well as Treasurer and Fellow of Institute Geology Malaysia. He is also an Industrial Council Member of Action Group of Entrepreneur (AGE) of University Malaysia Kelantan (UMK), a lecturer at IKRAM Skill and Development Center, a Council member of International Association of Engineering Geology (IAEG) and a member of European Geoscientist Union (EGU). His mission in GSM is to strive for sky-high success, sustainability and transforming to everlast and relevance society for geoscience community and beyond.

VICE-PRESIDENT

Dr. Mohd Hariri Arifin is a senior lecturer at Universiti Kebangsaan Malaysia (UKM) with over 10 years of experience in teaching, research and consultation works. He obtained his bachelor's degree in geology from UKM, then proceeded with his master's studies in engineering geology in the same university and completed his PhD in geophysics exploration at Universiti Sains Malaysia in 2017. He is a registered professional geologist with Board of Geologist Malaysia (PG29) since 2016 and a member of Institute of Geology Malaysia. He established Geo Technology Resources in 2011 before handing it over to his partners, a company with a focus on geophysical and geological services. He has conducted numerous researches, mainly in the field of geothermal exploration, groundwater potential, slope stability, settlement problems and tunnel stability. His passion and dedication in research has resulted in him publishing over 33 articles and getting more than 88 citations in the span of 10 years. His target is to ensure the young generation obtain the best geological education and awareness to enable them to connect to the industry world.

SECRETARY

Ms. Farah Fazulah Abdullah is a Geologist in energy industry and is currently based in Australia but still an active member of GSM. She is a member of the Society since 2017 and has served as Assistant Secretary and Secretary to GSM for the past 3 terms. She obtained her BSc degree in Geology in 2005, and MSc degree in Petroleum Engineering in 2016. She is passionate about knowledge sharing, and has represented GSM since 2005 in promoting geology in schools. Apart from that, she was also responsible for initiating the GSM expedition to Sungai Lembing to visit the remnants of the mining industry. Her mission as a GSM member and for the Geology Communities are:

- To continue promoting geology to younger generations
- Bringing fresh ideas of activity to working groups
- Hoping to co-organize more expedition post Covid restrictions.

ASSISTANT SECRETARY

Ms. Norazianti Binti Asmari earned a B. Sc (Hons) in Geology in 2008 from the University of Malaya in Kuala Lumpur. Since 2012, she has served as the Managing Director and founder of Geoxpert (GEX) SDN BHD. She has nearly 13 years of experience in the engineering geology sector, primarily consulting on geological aspects of highland development, such as geological terrain mapping, slope assessment mapping, and site investigation (S.I.). Her vision and mission are to give back to the geological community in any way possible, and she began contributing officially by serving the Society. In fact, she had already started to give back actively even before becoming a GSM member, by sharing her knowledge across a variety of platforms, particularly on social media. Her sharing is not only beneficial to the geological community, but is also beneficial to the general public in terms of disaster risk reduction education.

TREASURER

Dr. Lim Choun Sian, P.Geol, MIGM, Gs, is the Senior Researcher and Head of Geohazards Program in Southeast Asia Disaster Prevention Research Initiative (SEADPRI) from Universiti Kebangsaan Malaysia and Editorial Manager for Bulletin of the Geological Society of Malaysia. Prior to the current post as Treasurer in the GSM Council, he served as the Secretary. He is a professional geologist registered with the Board of Geologists Malaysia. His main fields of expertise are landslide, flood, earthquake and natural/human-induced geohazards. His research is focused on Mountain and Urban Geohazards, Engineering Geology, Geomorphology, Disaster Science; Policy and GIS in Earth Sciences. In Malaysia and Indonesia, he is involved in post-disaster investigation studies, i.e. landslides in Bukit Antarabangsa and Ampang Jaya, tsunami in Malaysia (2004), Padang-Indonesia earthquake (2009), Sabah earthquake (2015); Disaster Risk Reduction DRR education and training i.e. as a trainer to ASEAN Youth Volunteer Program (AYVP); and DRR policy for land use planning. He also served as a member in the Technical Committee for Earthquake to Department of Standards Malaysia in drafting for Malaysia National Annex to MS EN 1998-1: 2015, Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings.

EDITOR

Dr. Wan Hasiah Abdullah, a retired professor since 2020, began her academic career in 1984 upon undertaking a postgraduate programme at the University of Newcastle Upon Tyne, UK. For her Ph.D., she worked on a succession of sedimentary rocks from Spitsbergen, Svalbard. She started teaching in the Department of Geology, University of Malaya in 1990. Her research interest is in assessing oil-generating potential of coals and other organic-rich sediments, as well as determining their depositional environments. Throughout the years she has presented her research work in Europe, the Middle East, Southeast Asia and Australia. She has published about 100 papers in ISI/SCOPUS indexed journals, supervised 20 MSc/Ph.D. students and conducted consulting projects for several major oil companies. Dr. Wan Hasiah served as Head of Geology Department (2004-2007), as coordinator of MSc Petroleum Geology (2005-2015), Deputy Director of the University of Malaya's Consultancy Unit (2013-2020) and member of the Board of Geologists Malaysia (2018-2020). Presently she is a professional geologist registered with Board of Geologists, Malaysia, a fellow of the Institute of Geology, Malaysia and Editor of the Geological Society of Malaysia.

IMMEDIATE PAST-PRESIDENT

Mr. Abd Rasid Jaapar is the Chief Executive Officer of GMT Group, a multidisciplinary geoprofessional firm providing consultancy and services in geoscience, geomechanics, geomatics and geospatial. He is a registered professional geologist with Board of Geologists Malaysia (BOG) and a registered environmental specialist with Department of Environments Malaysia (DOE). He is also a professsional member of the Institution of Geospatial and Remote Sensing Malaysia (IGRSM) and an associate member of the Insititution of Engineers Malaysia (IEM). He has almost 30 years of experience working in construction industry as well as in oil and gas industry. While in the oil and gas industry, he used to manage multimillion ringgit projects covering Malaysia, Southeast Asia, Australia, Papua New Guinea, West Asia, Central Asia and Western Europe. He is the President of the Institute of Geology Malaysia (IGM); Immediate Past President of Geological Society of Malaysia (GSM); Vice President of Society for Engineering Geology and Rock Mechanics, Malaysia (SEGRM) which is affiliated to International Association of Engineering Geology and the Environments (IAEG) and International Society for Rock Mechanics and Rock Engineering (ISRM); and Secretary of Malaysian Geoscience Consultants and Services Association Malaysia (MyGeo). He was the youngest and among the first group of Board Member that served the Board of Geologists Malaysia from 2015 to 2017, and now re-appointed for 2020-2023. He is appointed as Adjunct Professor at the Faculty of Earth Science, University of Malaysia Kelantan (UMK) and Adjunct Lecturer at the Department of Management & Humanities, University of Technology Petronas (UTP) where he teaches Professional Practice and Practical Management for Geoscientists. He is a member of Curriculum Committee, Department of Geology, University of Malaya (UM) and an academic board member of New Academic Programme, Faculty of Science and Natural Resources, University of Malaysia Sabah (UMS). Internationally, he is a member of IAEG Commission 35 on Engineering Geological Model and IAEG Commission 38 on Rock Mass Characterisation with Emphasis on Rock Fall. He obtained his Master degree in Applied Geoscience (Engineering Geology theme) from the University of Hong Kong (HKU) in 2006 where he won Halcrow Prize as a mark of distinction and overall best student and, Bachelor with Honors degree in Geology from the National University of Malaysia (UKM) in 1992. In 2015, he received Tokoh Alumni Swasta Award from the Geological Club of UKM. He is also the President of Sekolah Dato Abdul Razak Alumni (SDARA), one of the public premier boarding schools in Malaysia.

COUNCILLOR

Dr. Abdul Halim Abdul Latiff is currently leading the Centre for Subsurface Imaging (CSI), an oil and gas industry-oriented research centre in Universiti Teknologi PETRONAS (UTP). He obtained his MEng, MSc and Doctorate from Imperial College London, UTP and Universiti Sains Malaysia (USM) respectively with special interest in seismic technology and deep-earth seismology. His main area of expertise is in seismic processing and imaging, both for active and passive seismic (including earthquake seismology). With several years as an industry practitioner with CGG Malaysia as well as researcher and academician with UTP, Halim is on a mission to spread the knowledge in geosciences and nurturing more earth scientist for a sustainable and better future. Halim currently serves GSM as a councillor for 2020-2022.

Ms. Amie Amir graduated with a bachelor's degree in Geology from Universiti Kebangsaan Malaysia, in 2007. She is now working as the upstream asset valuation consultant with IHS Markit based in Kuala Lumpur. A versatile petroleum geologist with 15 years of industry experience, specialising in upstream business portfolio, asset valuation and field development planning. She holds a strong passion in the subject of energy and sustainability. She currently serves as a council member of the Geological Society of Malaysia. Her long-term vision for the earth sciences community in Malaysia is women's empowerment, and to promote environmental awareness in the younger generation through early exposure and education.

Mr. Faizal Hamssin takes care of Vale's communications in Malaysia. Vale is one of the world's largest mining companies. He is a Geology graduate from the University of Melbourne, and has had an experience in exploration geology in the oil and gas sector.

COUNCILLOR

Professor Dr. Joy Jacqueline Pereira is a Principal Research Fellow at Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM) and Fellow of the Academy of Sciences Malaysia.

Professor Pereira is Vice-Chair of the Intergovernmental Panel on Climate Change (IPCC) Working Group 2 on Impacts, Adaptation and Vulnerability. She was Coordinating Lead Author for the Asia Chapter of the IPCC Fifth Assessment Report released in March 2014; Review Editor for the 2012 IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC-SREX); and Lead Author for the IPCC-AR5 Synthesis Report. Prof. Pereira is also a Member of the United Nations Office for Disaster Risk Reduction (UNDRR) Asia Pacific Science, Technology and Academic Group (APSTAAG), which supports governments in science-based decision making to implement the Sendai Framework for Disaster Risk Reduction. She is a Director of the Asian Network on Climate Science and Technology (ANCST), working closely with University of Cambridge.

Professor Pereira chairs the Malaysia Research Network on Climate, Environment and Development (MyCLIMATE) and serves as a Resource Person to the Malaysian Government in negotiating international agreements. She is a professional geologist registered with the Board of Geologists Malaysia, Past President of the Geological Society of Malaysia and Fellow of the Institute of Geology Malaysia. She was active in the Commission on Geoscience for Environmental Management of the International Union of Geological Sciences (IUGS-GEM) for about a decade and retired after serving as Chair from 2004 to 2008.

Professor Pereira obtained a Ph.D. from University of Malaya in 1996, Master of Science from University of Leicester in 1991 and Bachelor of Science with Honours from Universiti Kebangsaan Malaysia in 1989, specialising in the field of geoscience. She has graduated about 40 doctoral and masters candidates through research supervision and published over two hundred peer reviewed articles.

Ms. Maryam Syazan Dzulkefli graduated with a Specialization Degree in Geology from the University of Alberta, Canada. During her degree period, Maryam has developed a keen interest in structural geology, contributed from the many field trips to the Canadian Rockies. She presented a final thesis on fracture patterns observed in the Paleozoic rock succession of Fundy Basin, Nova Scotia, Canada. Before returning to Malaysia, Maryam served a three months internship with Shell Canada Ltd., focusing on Athabasca Oil Sands Development. Maryam started off her career with PETRONAS as an operation geologist, which has exposed her to offshore well-sitting in Malaysia, as well as internationally. Currently, Maryam serves as an Exploration Geologist, focusing on prospect maturation for Peninsular Malaysia exploration. Maryam has keen interest in young student development, hence she is the council's Young Geoscientist WG, as well as Petroleum Geoscience WG.

COUNCILLOR

Dr. Nur Iskandar Taib holds a BSc in Geology, MSc in Geology and PhD in Geology from the Indiana University, Bloomington, in the USA. He was a Senior Lecturer at University of Malaya from 2002 to 2021 and is currently retired as of September 2021. His research interests and expertise are igneous and metamorphic petrology and geochemistry. Currently he is working on the geochemistry of volcanic ash deposits in Perak and Kedah.

Mr. Tan Boon Kong was formerly Associate Professor of Engineering Geology at Universiti Kebangsaan Malaysia (UKM), Bangi, where he had served for 33 years. He retired from the university in October 2006. He obtained B.Sc. Hons in Applied Geology (UM) in 1973, M.S. in Geological Engineering (U. Missouri) in 1975, and M.S. in GeoEngineering (U. Minnesota) in 1977.

While at UKM, in addition to teaching and research, Mr. Tan was also engaged occasionally on an ad-hoc or project basis in consultancy practices in Engineering Geology with the private sectors, mostly with the Geotechnical and Civil Engineering consulting companies or contractors. He then continued his practice as an independent freelance Consultant Engineering Geologist. He has published widely on Engineering Geology and Rock Mechanics in local and international conferences and technical journals.

Mr. Tan has also been actively involved in professional bodies such as the Geological Society of Malaysia (GSM), the Institute of Geology Malaysia (IGM) and the Institution of Engineers Malaysia (IEM) as a member of the Council (GSM, IGM) or Technical Divisions (IEM). He is the Chairman of the Working Group on Engineering Geology, GSM.

Awards include: 25-year service award (UKM), 30-year service award (UKM) and Long Service Award (GSM).

Mr. Tan Chun Hock graduated with a degree in Geology from University Malaysia Sabah in 2002. He obtained his Master of Science in Petroleum Geoscience from Chulalongkorn University in 2010. He is now working as a Senior Geologist in Shell Malaysia. He has almost 19 years of experience in a wide range of subsurface evaluation and specializing in 3D static modeling. He also serves as a volunteer with AAPG, helping out the student divisions during his free time. His vision is focused on helping geoscience students to improve job securing skills and begin new careers in the energy industry.

NEW MEMBERSHIP

Student Membership

1. Ahmad Fahmi Afiq Mohd Ghauth
2. Arav Annamalai
3. Arifah Mohamad Nazor
4. Arnie Nabila Mohd Shasulbahari
5. Darell Dylan Paskol
6. Intan Norsheira Yusoff
7. Ma Hanisa Sapawi
8. Mohammad Aliff Rusdi
9. Nur Ain Hafifah Baharom
10. Nurul Haziqah Hipni

Full Membership

1. Ahmad Zulqurnain Ghazalli
2. Chaw Li Min
3. Hairil Azwan Razak
4. Isa Kamaruddin
5. Mohd Khairudin Muhamed
6. Mohd Suhaimi Mat Rasat
7. Muhamad Syafiq Salim
8. Muhammad Aidil Hakim
9. Muhammad Anasrullah
10. Nadia Shafika Mohd Zuki
11. Navakanesh M Batmanathan
12. Siti Salwa Samigin
13. Stephan Ongetta
14. Valerie Lilian Kevin Janis
15. Yong Wai Yen

Associate

1. Annamalai Muthupalaniyappan
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The evolution and extinction of the Petroleum Geoscience Conference & Exhibition (1977-2013)

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All good things must come to an end. That was what happened to PGCE, short for Petroleum Geoscience Conference & Exhibition, the once long-running flagship conference of the Geological Society of Malaysia (GSM). Like other scientific societies whose main objective is to disseminate knowledge to its members and the public, GSM had with PGCE the most important petroleum geology conference in the Malaysian geoscience calendar. PGCE had even overshadowed its other conference, the Annual Geological Conference, known since 2006 as the National Geoscience Conference (NGC), which was designed specifically for the non-petroleum audience. Perhaps, many do not realise that the first NGC did not take place until 1986, ten years after the first "Petroleum Seminar", the precursor of the PGCE, was held in 1977. Since its inception, the PGCE received the full support of its co-organiser, PETRONAS, along with other oil and gas companies as sponsors.

Unfortunately, the successful 33-year run of PGCE came to an abrupt end after the conference was held for the last time in 2013. Events that had led to the untimely demise of PGCE are described in a report that was read at the GSM 48th Annual General Meeting on 25 April 2014[1]. According to the report entitled "The Future of PGCE, Revisited" the agreement between GSM and PETRONAS as co-organisers of the conference effectively ended with a letter to GSM dated 11 February 2014 from the Vice-President/CEO of PETRONAS Exploration informing the GSM of the decision by the national oil corporation to terminate the relationship.

GSM has since moved on and focused its efforts on strengthening the NGC while continuing with its other core activities, including publishing its two periodicals, *Warta Geologi* and the *Bulletin*. Younger generations may not be aware of the history of what was once the only avenue through which petroleum geoscience knowledge in Malaysia could be disseminated outside of an otherwise exclusive industry. I have decided to write this story, my story, of PGCE based on personal experience and perspective, having been part of its evolution and transformation as well as having witnessed the events that led to its extinction. I am telling this story from a unique perspective by having been both an active GSM member, including as council member for the terms 1991/92, 1998/99, 2009-2021, as well as a PETRONAS employee until 2017. I was also actively involved with the organizing committees during the later years of PGCE, including in a number of subcommittees such as Technical Papers & Programme (2008), Field Trips & Short Courses (2009), Editor and Publication (2011) and Field Trip Leader (2012).

This note is also a brief history of the PGCE which I have summarized based on reports of the conference published in the past issues of *Warta Geologi* and its fore-runner, the *Newsletter of the Geological Society of Malaysia*. All the information is public record and, like the *Bulletin* and *Warta Geologi*, is available freely on GSM website (www.gsm.org.my). Tables 1 and 2 chronicle all the petroleum conferences held from 1977 to 2013, with the changing names, attendance size and number of papers presented. Also listed for each year are the chairman of the organizing committee, the sitting GSM president, as well as the invited Guest-of-Honour (VIP) who officiated the conference. There were four "unconformities" or gap years when the PGCE was not held. On two occasions, PETRONAS and GSM played host to other international and regional petroleum events in Kuala Lumpur, namely the International Symposium on Tectonic Framework and Energy Resources of the Western Margin of the Pacific Basin (1992) and AAPG International Conference and Exhibition (1994). In 2008 GSM hosted the regional ASEAN geoscience conference, GEOSEA IX (2008).

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[1] Report entitled "The Future of PGCE, Revisited", Warta Geologi vol. 40, no. 1-2, 2014, p. 36-37.

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Table 1: The Petroleum Seminars and Conferences from 1977 to 2013.
*actual name "Seminar on Petroleum Geology of the Sunda Shelf". n.a. = information not available.

No	Name	Year	Date	Venue	pax	papers	Organising Chairman	Current President
1	*Petroleum Seminar	1977	16-Dec	Equatorial Hotel	160	9	Mohammad Ayob	BK Tan
2	Petroleum Seminar	1978	11-Dec	Jaya Puri Hotel, Petaling Jaya	175	6	James Lau	BK Tan
3		1979	15-Dec	Merlin Hotel	200	8	Leong Khee Meng	BK Tan
4	Petroleum Geology Seminar	1980	12-13 Dec	Merlin Hotel	180	15	Ahmad Said	Mohammad Ayob
5		1981	7-8 Dec	Merlin Hotel	200	16	Michael Leong	Mohammad Ayob
6		1982	6-7 Dec	Merlin Hotel	140	14	Michael Leong	TT Khoo
7		1983	5-6 Dec	Holiday Inn	n.a.	n.a.	Nordin Ramli	TT Khoo
8		1984	3-4 Dec	Merlin Hotel	170+	14	Nordin Ramli	Leong Khee Meng
9		1985	6-7 Dec	Ming Court Hotel	200+	18	Michael Leong	John Kuna Raj
10		1986	8-9 Dec	Ming Court Hotel	200	16	Ahmad Said	John Kuna Raj
11		1987	7-8 Dec	Ming Court Hotel	234	20	Hila Ludin Abu Hazim	Hamzah Mohamad
12		1988	7-8 Dec	Ming Court Hotel	>240	22	Hila Ludin Abu Hazim	Hamzah Mohamad
13		1989	4-5 Dec	Shangri-La Hotel	400	32	Hila Ludin Abu Hazim	Hamzah Mohamad
14		1990	27-28 Nov	Putra World Trade Centre	400	26	Abu Samad Nordin	Ahmad Said
15		1991	26-27 Nov	Shangri-La Hotel	400	26	Khalid Ngah	Ahmad Said
16		1993	7-8 Dec	Concorde Hotel	336	27	Effendy Cheng	Fateh Chand
17		1995	11-12 Dec	Concorde Hotel	432	31	Hoh Swee Chee	Khalid Ngah
18		1996	9-10 Dec	Rennaissance Hotel	300	29	Ali Mohd Sharif	Khalid Ngah
19		1997	1-2 Dec	Istana Hotel	300	24	Robert Wong	Khalid Ngah
20		1999	23-24 Nov	Shangri-La Hotel	200	28	Barney Mahendran	Ibrahim Komoo
21	Petroleum Geology Conference	2000	22-23 Nov	Shangri-La Hotel	300	39	Yusoff Johari	Abd. Ghani Mohd Rafek
22	Petroleum Geology Conference and Exhibition	2001	19-20 Sep	Mutiara Hotel (formerly Hilton)	300	23	Nordin Ramli	Abd. Ghani Mohd Rafek
23		2002	15-16 Oct	Istana Hotel	450	24	Ali B Mohd Shariff	Abd. Ghani Mohd Rafek
24		2003	17-18 Dec	Shangri-La Hotel	521	59	Jaizan Hardi Mohamed Jais	Abd. Ghani Mohd Rafek
25		2004	15-16 Dec	Istana Hotel	500+	34	Md Yazid Mansor	Lee Chai Peng
26		2005	6-7 Dec	Istana Hotel	n.a.	n.a.	Awalludin Harun	Lee Chai Peng
27		2006	27-28 Dec	KLCC Convention Centre	1200	58	Salahuddin Saleh	Lee Chai Peng
28		2008	14-15 Jan	KLCC Convention Centre	500+	70	Idris Ibrahim	Yunus Abd Razak
29		2009	2-3 Mar	KLCC Convention Centre	1000	70	Jamlus Md Yasin	Yunus Abd Razak
30		2010	29-30 Mar	KLCC Convention Centre	1600	104	Azhar Yusof	Yunus Abd Razak
31		2011	7-8 Mar	KLCC Convention Centre	1300	106	Abdul Manaf Mohammad	Joy Jacqueline Pereira
32	Petroleum Geoscience Conference and Exhibition	2012	23-24 Apr	KLCC Convention Centre	2000	92	Peter Majid	Joy Jacqueline Pereira
33		2013	18-19 Mar	KLCC Convention Centre	2600	114	Redhani Rahman	Joy Jacqueline Pereira

Table 2: Keynote speakers and guests-of-honour at the Petroleum Seminars and Conferences.
Special keynote categories: 1 – Keynote, 2 – Keynote paper or Key paper, 3 – Special Keynote Address on Geologist Act (2008).

No	Name	Year	Date	Keynote speakers	Official Launching by Guest of Honour
1	Petroleum Seminar	1977	16-Dec	no keynote.	BK Tan, President of GSM
2	Petroleum Seminar	1978	11-Dec	no keynote.	BK Tan, President of GSM
3		1979	15-Dec	no keynote.	BK Tan, President of GSM
4	Petroleum Geology Seminar	1980	12-13 Dec	no keynote.	Datuk Dr Nik Hussein, Deputy Minister of Energy
5		1981	7-8 Dec	no keynote.	En. Mohd. Nawawi bin Mahmud, Deputy Secretary General to the Ministry of Energy, Posts and Telecommunications on behalf of Dato' Leo Moggie, the Minister
6		1982	6-7 Dec	no keynote.	Tun Hussein Onn, Adviser to PETRONAS
7		1983	5-6 Dec	no keynote.	Y.B. Datuk Dr James Ongkili, Minister in the Prime Minister's Department
8		1984	3-4 Dec	no keynote.	YM Raja Tan Sri Mohar bin Raja Badiozaman, PETRONAS Chairman
9		1985	6-7 Dec	no keynote.	Y.B. Tan Sri Abdullah Mohd Salleh, PETRONAS President
10		1986	8-9 Dec	no keynote.	Dato' Abdul Ajib bin Ahmad, Minister in the Prime Minister's Department
11		1987	7-8 Dec	no keynote.	Y.B. Datuk Dr Siti Zaharah Sulaiman, Deputy Minister in the Prime Minister's Department
12		1988	7-8 Dec	no keynote.	Dr. Abdul Aziz Hj. Mahmud, Vice-President, Exploration & Production Division, PETRONAS
13		1989	4-5 Dec	no keynote.	Y.B. Datuk Dr. Sulaiman Haji Daud, Minister in the Prime Minister's Department and Minister of Justice
14		1990	27-28 Nov	Douglas Waples Robert Morley	Y.B. Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department
15		1991	26-27 Nov	Brian Anderson (Shell) Karl F Swensen (Esso)	Y.B. Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department
16		1993	7-8 Dec	no keynote.	Tuan Haji Mohamed Zohari Shaharun, Vice-President, Exploration & Production Sector, PETRONAS
17		1995	11-12 Dec	Tan Ek Kia (Sarawak Shell) John Willet (EPRCo)	Dato' Mohamad Idris Mansor, Senior Vice-President, PETRONAS and Managing Director & CEO Petronas Carigali Sdn. Bhd.
18		1996	9-10 Dec	Nick De'Ath (Triton) Chris Wright (Mobil New Ventures)	Dato' Mohamad Idris Mansor, Senior Vice-President, PETRONAS and Managing Director & CEO Petronas Carigali Sdn. Bhd.
19		1997	1-2 Dec	no keynote.	Mr. Yeow Kian Chai, General Manager, Petroleum Management Unit, E&P Business, PETRONAS
20		1999	23-24 Nov	Bill Schaefer, Jr (Santa Fe)	Tuan Haji Akbar Tajudin Abdul Wahab, Senior General Manager, E&P Business, PETRONAS
21	Petroleum Geology Conference	2000	22-23 Nov	Mike Shirley (Murphy Oil)	En. Abu Bakar Mohamed, Senior General Manager, Petroleum Management Unit, E&P Business, PETRONAS

22		2001	19-20 Sep	David Abrahamson (Amerada Hess)	Dato' Lim Haw Kuang, Chairman of Shell Malaysia
23		2002	15-16 Oct	Mohamad lohari Dasri (PCSB)	Tuan Haji Akbar Tajudin Abdul Wahab, Senior General Manager, Petroleum Management Unit, PETKONAS
24		2003	17-18 Dec	Nick Walker (Talisman Malaysia Limited) Sid Williams (Landmark Graphics)	Y.B. Datuk Tan Chai Ho, Deputy Minister of Energy, Communications & Multimedia
25	Petroleum Geology Conference and Exhibi-tion	2004	15-16 Dec	Wouter Hoogeveen (Shell Asia-Pacific) Paul Ebdale (Amerada Hess)	En. Abdullah Karim, Vice-President, E & P Business, PETRONAS
26		2005	6-7 Dec	David Trice (NewField) Effendy Cheng Abdullah (PETRONAS)	En. Abdullah Karim, Vice-President, E & P Business, PETRONAS
27		2006	27-28 Dec	Peter M. Barber (Isis Petroleum Consultants) Stephen Pickering (WesternGeco) Mohammad Yamin Ali (PRSS)	En. Mohd Johari Dasri, MD/CEO Petronas Carigali (on behalf of VP Exploration/Production, PETRONAS, Abdullah Karim)
28		2008	14-15 Jan	Hovey Cox, Sr. (CGGVeritas) Richard Hillis (Uni-versity of Adelaide)	Y.B. Dato' Azmi Khalid, Minister of Natural Resources & Environment
29		2009	2-3 Mar	Kurt Rudolph (ExxonMobil) Lawrence Bernstein (Talisman) William Schneider (Newfield) [3]Seet Chin Peng (Institute of Geology Malaysia)	En. Ramlan Abd Malek, E&P Business, PETRONAS
30		2010	29-30 Mar	[1]Ceri Powell (Shell) [2]Alister C MacDonald (Roxar) [2]Stephen Warner (Schlumberger)	En. Ramlan Abd Malek, E&P Business, PETRONAS
31		2011	7-8 Mar	[1]Suhail Al-Maz-rouei (Mubadala) [2]Jim Handschy (ConocoPhillips)	Tan Sri Datuk Seri Panglima Joseph Kurup, Deputy Minister of Natural Resource and Environment
32	Petroleum Geoscience Conference and Exhibition	2012	23-24 Apr	Craig Beasley (WesternGeco/ Schlumberger)	Dato' Wan Zulkiflee Wan Ariffin, COO and Downstream VP, PETRONAS
33		2013	18-19 Mar	John Harris (Baker Hughes) Dominique Janodet (Total)	Tan Sri Dato' Shamsul Azhar B Abbas, President & CEO of PETRONAS

INCEPTION

It all started on 16 December 1977 with a "Seminar on Petroleum Geology of the Sunda Shelf", held at the Equatorial Hotel in Kuala Lumpur. According to a seminar announcement[2] (Figure 1) the main purpose of the seminar was "to promote a better understanding of petroleum geology and petroleum exploration amongst geologists and other interested individuals including students in this country". The inaugural event was organised by a committee on "Petroleum Geology Seminar" chaired by En. Mohammad bin Ayob who was then a senior manager at the Exploration Department, the fore-runner of the current Malaysia Petroleum Management Unit (MPM) at PETRONAS. It was a successful first event with 160 participants and only 9 papers presented. Financial support was received from PETRONAS and Esso. The follow-up seminar in 1978, simply called "Petroleum Seminar", was attended by 175 people and had only 6 papers presented by oil companies. The programme included an exhibition by PETRONAS and other petroleum companies of specimens of basement rocks and oil-bearing sandstones from offshore wells, as well as some exhibits of offshore petroleum technologies. In 1980 the event name was changed to "Petroleum Geology Seminar". In 1995 the name was changed again to "Petroleum Geology Conference" to reflect the increasing number of people in attendance (Figure 2).

Without a doubt, the petroleum seminars/conferences of GSM would not have been possible without the contribution of papers from oil companies operating in Malaysia and the support of PETRONAS. The latter was critical for ensuring adequate funding of the events through sponsorship by the oil and gas operators, who were production-sharing contractors to PETRONAS, and the service companies. PETRONAS's support was also vital as all papers using Malaysian data to be presented at the conference must be pre-approved by PETRONAS. Interestingly, in an announcement for the 1979 Petroleum Seminar[3], the organizing committee had appealed to "private individuals" to respond to the call for papers, stating that "it is in this sector that [papers] seems to be lacking". It is unclear who those private individuals were, given that oil exploration data are owned by oil companies which are ultimately under the custody of PETRONAS.

For many years, the *Bulletin of the Geological Society of Malaysia* had been the main channel for the publication of papers presented at the petroleum conference, sometimes as special issues (Table 3). Figure 2B indicates that most of the papers presented at the GSM petroleum seminars and conferences have been published in the *Bulletin*. GSM is proud that the *Bulletin* has become an important source of reference for petroleum geoscience information in Malaysia, as many of the classic papers are still being cited by researchers worldwide. The first article on petroleum geology published in the *Bulletin* was the paper on Sarawak Cycles by Ho (1978)[4], which was probably one of the

Seminar on 'The Petroleum Geology of the Sunda Shelf'

As a result of an earlier circular, positive responeses were received from geoscientists in oil companies, petroleum consultant firms, universities and other individuals, indicating their willingness to attend and in some cases to present papers at the Seminar. The venue for the Seminar originally planned to be held in Ipoh immediately following the Annual Senior Officers' Conference of the Geological Survey of Malaysia has been rescheduled to Kuala Lumpur. The reason is because the Geological Survey of Malaysia will not be holding the conference in Ipoh but instead in Penang in late December. As Kuala Lumpur is considered more convenient for members, the Seminar is now planned to be held at Hotel Equatorial in Kuala Lumpur, on 16th December 1977.

The Organizing Committee would like to emphasise that the main purpose of the Seminar is to promote a better understanding of petroleum geology and petroleum exploration amongst geologists and other interested individuals including students in this country. The Seminar is therefore open to everyone.

Papers are still being accepted for the Seminar. If you intend to present a paper, please contact:

Mohammad Ayob
Chairman, Organizing Committee on Petroleum Geology Seminar,
c/o Dept. of Geology
University of Malaya, Kuala Lumpur 22-11.

Figure 1: An announcement of the first Petroleum Seminar in 1977, published in *Warta Geologi*, vol. 3, no. 5 (1977).

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[2] Warta Geologi, vol. 3, no. 5, 1977, p. 116.

[3] Warta Geologi 1979, vol. 5, no 4, July – August.

[4] Bulletin of the GSM 1978, vol. 10, p. 1-13.

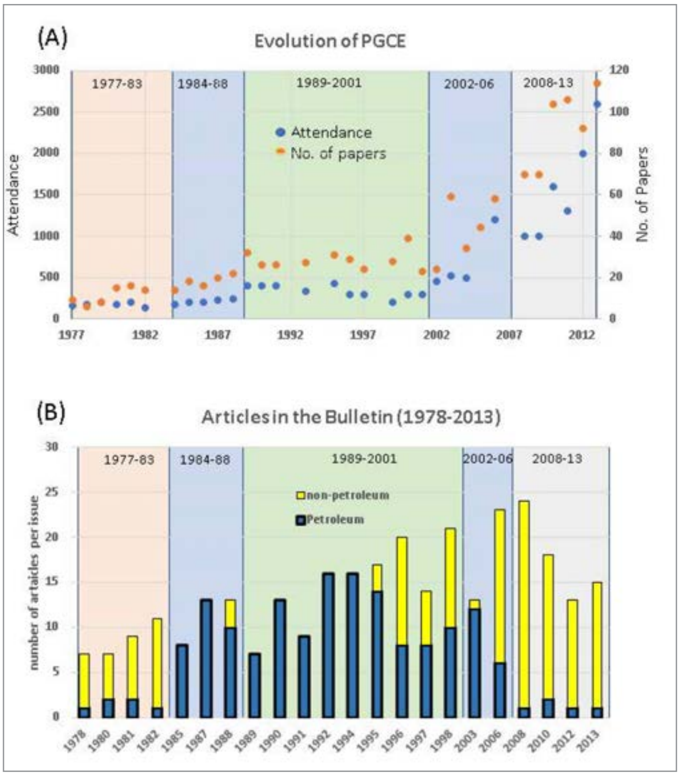

Figure 2: Evolution of PGCE from 1977 to 2013. (A) Attendance at the PGCE (left y-axis) and number of papers (right y-axis). (B) Number of articles from PGCE (petroleum papers, blue bars) versus non-petroleum papers (yellow bars) published in the *Bulletin*.

papers presented at the inaugural seminar in 1977. Some papers that were presented at the 1979 Petroleum Seminar, notably the classic papers by Bol and van Hoorn (1980)[5] on Sabah offshore and Epting (1980)[6] on the Central Luconia carbonates, were published in volume 12 of the *Bulletin* in 1980. For reasons unknown, after 2006, full write-ups of papers presented at the conference came in more sporadically and, as a result, special issues dedicated to petroleum geology no longer became viable. Interestingly, the rapid decline in manuscript submissions to the *Bulletin* seem to coincide with the switch to a bigger conference venue in 2006 (Figure 2B).

Throughout the life of the PGCE from 1997 to 2013, a total of 161 papers presented at the petroleum conferences related to petroleum geology were published in the *Bulletin*. This number constitutes more than half the total number of papers published during that period (Table 3). The big number of papers presented, including ~1200 abstracts from all the petroleum seminars and conferences up to 2013, suggests that PGCE served as an important platform for the sharing of petroleum geoscience knowledge between the oil and gas sector and the local academic community. It could be argued that the wide dissemination of knowledge on petroleum geology of Malaysia would not have achieved its current level, had there not been the PGCE.

EVOLUTION AND TRANSFORMATION

Over the years, as the crowd size at the petroleum conference increased, the event had to be held at increasingly large venues from humble hotel venues (the first was at Equatorial Hotel on Jalan Sultan Ismail) to eventually in 1990 at the Putra World Trade Centre (PWTC), which was the largest conference venue in Kuala Lumpur at the time. By 2005, the Petroleum Seminar had evolved from a small 200+ person conference to a 1000+ attendance; the venue changing from small to medium-sized to 5-star hotels in Kuala Lumpur's Golden Triangle (e.g., Ming Court, Shangri-La, Istana hotels). In 2006 the event was held for the first time at the KLCC Convention Centre as the crowd size grew above 1000 and the number of paper presentations approached 100. The 2006 event at the KLCC Convention Centre heralded a new era of PGCE, with a more elaborate Malaysian-style opening ceremony, complete with a cultural performance as a welcoming treat for the participants from abroad. A larger number of papers accepted at

5 Bulletin of the GSM 1980, vol. 12, p. 1–16.

6 Bulletin of the GSM 1980, vol. 12, p. 17-30.

Table 3: Papers published in the Bulletin from 1978 to 2013 that came directly from the Petroleum Geology Seminars and Conferences.

Bulletin no.	Year	Special issue	Number of papers from petroleum conferences/seminars	Number of other papers
10	1978	no	1	6
12	1980	no	2	5
14	1981	no	2	7
15	1982	no	1	10
18	1985	yes	8	0
21	1987	yes	13	0
22	1988	yes	10	3
25	1989	yes	7	0
27	1990	yes	13	0
28	1991	yes	9	0
32	1992	yes	16	0
36	1994	yes	16	0
38	1995	yes	14	3
39	1996	yes	8	12
41	1997	yes	8	6
42	1998	yes	10	11
47	2003	yes	12	1
49	2006	no	6	17
54	2008	no	1	23
56	2010	no	2	16
58	2012	no	1	12
59	2013	no	1	14
Total			161	146

the conference meant that several technical sessions had to be held simultaneously. Parallel sessions were actually introduced in 2003 and enabled more papers to be included over a two-day programme. Although the rental charges for the venue kept increasing every year, KLCC Convention Centre became the venue of choice for the remaining years of PGCE until 2013.

Guests of Honour were dignitaries (VIP) who were invited to officially launch the conference. During the early years until about 1990, the conference was launched by either a Minister (usually the minister in charge of petroleum) or a top government official, underlining the importance of the event. In the 1980s, there had been events launched by former Prime Minister Tun Hussein Onn in his capacity as PETRONAS Advisor. The chairman and the president of PETRONAS had also officiated the conference in 1984 and 1985, respectively. The 1990 event held at the Putra World Trade Centre (PWTC) was officiated by Y.B. Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department, who did it again the following year at Shangri-La Hotel. Dato' Wong was the only federal government minister who officiated the event for two consecutive years (Table 1). From 1993 onwards the conference was usually officiated by a top executive from PETRONAS, with the occasional Minister appearing on three occasions (2003, 2008, and 2011).

Keynote speakers were invited to present their perspectives at the conference and have included world-renown geoscientists from both industry and academia, as well as top oil company executives (Table 2). Keynote addresses were introduced in the technical programme in 1990, with the initial intention to hear renowned geoscience personalities to speak on a topic of their expertise. The first two keynote speakers ever invited to the PGCE, in 1990, were Douglas Waples on geochemistry and Robert Morley on Tertiary palynology. In subsequent years, most of the keynotes were mainly from the oil/gas operators in Malaysia, as some members in the organizing committee from PETRONAS felt that more opportunities should be given to senior executives from the operators in the local industry to present their views on the business. This was also done in part to acknowledge their important role as the major sponsors of the event.

Thus, at subsequent PGCE events, most of the invited keynote speakers were industry figures either from oil companies or service providers, such as Halliburton and Schlumberger. At the 1991 event the managing directors of Esso and Shell companies in Malaysia were given the two keynote speaking slots. In the subsequent years until 2013, with the exception of several years without keynote speakers, the prestigious speaking slots were given to senior executives from oil companies operating in Malaysia at the time. These included Shell, Esso, Triton, Mobil, Murphy, Santa Fe, Amerada Hess, Talisman, and PETRONAS Carigali. Executives from major service companies, e.g., Schlumberger, Halliburton, CGGVeritas and Roxar, were also given that honour. In 2006 the organizing committee decided to distinguish between "Keynote" and "Technical Keynote", the former refers to "industry review" which was non-technical in nature. That distinction was adopted in subsequent events, although in 2010 "Technical Keynote" was called "Key Paper" instead (Table 2).

In my opinion, over the years the technical content of the paper presentations generally became less geological and more "operational" in nature. In retrospect, this may have been an inevitable consequence of the Malaysian basins becoming more mature and therefore people are less concerned, rightly or wrongly, with the fundamental geological questions compared to the day-to-day technical or operational issues. From a personal perspective, I used to really enjoy attending the petroleum conferences back in the days when there would be interesting discussions on regional geology and tectonic models of SE Asia. I missed the talks given by the likes of the late Professor Charles Hutchison who was a regular speaker even in his later years and never failed to give a presentation on his current views (Figure 3).

PGCE owed much of its success to a once strong relationship between GSM and PETRONAS, which was borne out of the fact that many pioneering senior executives in the oil companies were graduates from the Geology Department of Universiti Malaya, where GSM was founded and has called it home to this day. Since the very beginning, although the event was organized and hosted by GSM, the chairman of the organizing committee for the conference had always been somebody from PETRONAS. This made perfect sense, for without the support of PETRONAS and, by extension, the petroleum industry, there could not have been a petroleum conference. In 2001, after 24 years, GSM and PETRONAS formalized that working relationship with an agreement to be co-organisers of the event. To mark that milestone in the relationship the conference was renamed "Petroleum Geology Conference and Exhibition" (PGCE), as by then the exhibition component of the event had grown large enough to be included in its official name. The PGCE name ran for 10 years until 2011, a decade that could arguably be considered as its "golden years", during which attendance increased from 300+ to more than 500. In 2012, in an apparent attempt at appeasing the geophysicists, the word "Geology" was changed to "Geoscience".

By 2008 the PGCE was practically run by staff of PETRONAS who were assigned to the organizing committee by their superiors. Each year the top geoscience executive of the company (Senior General Manager or Vice President) would hand-pick from among its ranks the chairman of the organising committee, who was usually a somewhat reluctant Senior Manager from either PETRONAS Carigali, PMU (now MPM) or PETRONAS Research

Figure 3: Selected photographs from PGCE events. Left – The late Professor Charles. S. Hutchison was a regular at PGCE, here in 2010. Sadly, he passed away in 2011. Top right – Participants of the Post-conference field trip to Kota Kinabalu with Professor Felix Tongkul, PGCE 2009. Bottom right – The author (right) at his poster greeted by Azhar Yusof, chairman of the organizing committee, PGCE 2010.

Sdn Bhd (PRSB), the three geoscience-dominated PETRONAS units. Much to their credit, the PGCE was always well organized, in part because the task was also their official duties and personal KPI. En. Hila Ludin Abu Hazim holds the record for commendably serving as chairman of the organizing committee for three consecutive years (1987 to 1989). Thereafter, the chairmanship of the organizing committee alternated between PMU and PCSB, and occasionally PRSB. During all those years, GSM usually assumed the two key roles in the organizing committee – registration and publication.

RIFT AND BREAK-UP

During the last two years of its run, PGCE started to show signs of an imminent rift and break-up, due to some disagreements between GSM and PETRONAS. Managers at PETRONAS were purportedly concerned with the rising cost of having too many of its employees involved in organising the PGCE on company time. Finally, it was suggested that a third-party event manager should be hired to organize the conference on behalf of GSM and PETRONAS. In 2012, GSM and PETRONAS agreed to a new cooperative framework for PGCE, whereby the net proceeds from PGCE would be split equally between GSM and PETRONAS. The PETRONAS portion, would be channeled to the Yayasan Universiti Teknologi Petronas (YUTP) for the benefit of geoscience students, and the other portion to GSM. To ensure that the funds from PGCE will be used for the benefit of future geoscientists, GSM council promptly established via a resolution at the 46th AGM[7] in 2012 a special fund called the "PGCE Endowment Fund" which was later renamed the GSM Endowment Fund. GSM administers the Fund as a separate account which is being overseen by a Board of Trustees comprising "at least three independent Full Members in good standing". The aim of the Fund is to ensure that the principal sum is maintained in perpetuity, while the interests earned are used for geoscience "capacity building", which includes a whole range of activities concerning education and training in geoscience[8]. With the new arrangement, GSM and PETRONAS had agreed to appoint EAGE Asia-Pacific Sdn. Bhd. as the event manager for PGCE 2012 and 2013[9].

The penultimate PGCE in 2013 was taglined "Asia's Premier Geoscience Event", signalling a new phase of transformation and expansion of the PGCE brand beyond Malaysia and SE Asia. In retrospect, it was also a sign of its eventual demise, or perhaps metamorphosis into the Asia Petroleum Geoscience Conference & Exhibition (APGCE), a new conference that was to be launched by PETRONAS two years later in 2015. This newly created conference is run by iCEP (International Conference and Exhibition Professionals), a fully-owned subsidiary of PETRONAS, and has no relationship with GSM.

PARTING REMARKS

At the end of its run from 1977 to 2013, a total of 33 petroleum seminars/conferences was held. It was unfortunate for me personally that PGCE ended the way it did in 2013, especially when I had just been elected President of GSM. It was also very unfortunate that due to some misunderstanding and perceptions by some quarters, GSM lost the support of PETRONAS in organizing the PGCE and, along with it, the opportunity to publish the abstracts and manuscripts arising from the conferences. The once successful conference that both organizations had built together from humble beginnings is a legacy of several past leaders in GSM and PETRONAS who played their critical dual roles – as senior managers of PETRONAS as well as active members of GSM. The fact that they were former students of UM's Geology Department where GSM was founded, I believe, also partly explains their strong affinity to GSM.

As mentioned, GSM's primary objective as a geoscientific organization is to disseminate geoscience knowledge among its members and the public freely, by providing free access to all its publications. Alas, with the PGCE now extinct, members of GSM and the public can no longer enjoy free access to the abstracts of papers presented at the biggest petroleum geoscience conference in Malaysia without a subscription to a third-party foreign organization. As a Malaysian geoscientist, I find it sadly ironic and deeply regrettable that Malaysian data are no longer owned by Malaysians!

As we move forward into the energy transition era and beyond, I urge GSM to rebuild the PGCE brand through the NGC by re-establishing good relationships and reconnect with PETRONAS for the benefit of young geoscientists who may aspire to be in the petroleum or energy-related industries. It is my sincere hope that the younger generation of industry leaders will be more receptive to working with GSM for the benefit of the geoscience fraternity in Malaysia.

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[7] Warta Geologi vol. 39, no. 2, 2013, April – June, p. 56.

[8] Warta Geologi vol. 40, no. 1-2, 2014, January – June, p. 35.

[9] Warta Geologi vol. 40, no. 1-2, 2014, January – June, p. 36-37.

Solving the mystery of the Labuan Chimney*

RESEARCHED AND COMPILED BY LYNETTE SILVER

Anyone who has ever visited Labuan knows about the island's most famous and historic landmark – a chimney, constructed in about 1900. The chimney itself is unremarkable as far as chimneys go – just a square-shaped brick tower with two arches at the base, and a decorative frieze at the top. But what it is, and why it was built, has puzzled people for decades.

Theories suggesting it was a ventilation shaft for the nearby coal mines, a beacon, or a shot or bell tower have been examined by experts and dismissed.

However, speculation on The Chimney's origins is not what intrigued me. What I wanted to know was why its origins were such a mystery. It has dominated the landscape for more than a century, yet there is no reference to it, at all, in any archival records or in published accounts of the island.

Map showing location of The Chimney.

The Labuan Chimney.

I had taken only a passing interest in The Chimney on my frequent visits to Labuan until about three years ago, when I drove past one day with my friend and long-time resident Mr Willie Teo. As I glanced up, I again pondered on why its origins were so obscure. Why had no one ever recorded a single word about it?

I then experienced what is described as a light-bulb moment. Could it be that The Chimney was just that – a chimney for some kind of enterprise, an enterprise so commonplace at the time that its very existence had been taken for granted?

I suddenly realised that chimneys similar to the one at Labuan are quite common in Australia. There were two at a brickworks near my childhood home. And there are several others scattered at brickworks around the suburbs of Sydney. Chimneys of similar construction are also found at smelting works all around the country, including one at an iron works established by my great-great great-grandfather and his brother, a metallurgist, who pioneered the iron and steel industry in Australia.

So, was it possible that the Labuan chimney was built as a smoke stack for brickmaking, or for smelting ore?

And, as a chimney is integral and normal to both processes, was this why its very existence had gone unremarked?

The Chimney's story board.

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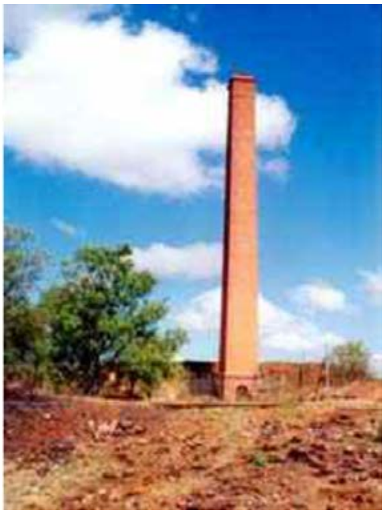
A brickworks chimney.


A smelting chimney.

The investigation begins

I began my investigation by taking Mr David Hosking, an experienced Australian metallurgist, to view The Chimney. He agreed that its construction was entirely consistent with chimneys built for brickmaking and the smelting of metallic ores. Furthermore, an examination of the interior revealed that, above the restored base, the interior was lined with glazed fire-bricks – bricks specifically designed to cope with enormous heat.

The iron bands placed at intervals on the exterior also confirm that the stack was constructed to withstand high temperatures. These bands not only strengthen the brickwork, but also expand and contract when the chimney heats up.


The glazed interior fire--bricks.


Top and iron bands on a brickworks chimney.


Top and iron bands on The Chimney.

Could The Chimney be part of a brickworks?

With published histories and other archival material failing to mention any brickworks on Labuan, it was widely believed that no brickmaking had ever been undertaken on the island. However, this didn't mean that such evidence did not exist, merely that no one had found it. The question was, where might such evidence be? In newspaper files, perhaps?

As I knew from previous historical investigations that the Singapore press reported Labuan news, I began a search of the Singapore Library archives.

I immediately hit pay dirt. Bricks had definitely been made in Labuan, near the coal mine, and for at least 40 years.

Brickmaking in Labuan

In 1870, the press reported that convicts from the Victoria Gaol were making bricks in considerable quantity for use at the coal mine, opened up in 1847 on the northern tip of the island.

Brick making was a common occupation for prisoners in British colonies. In Labuan this work was performed at Coal Point, where there was a large deposit of suitable clay and an almost inexhaustible supply of coal to fuel the kiln. The kiln - almost certainly a small bottle-shaped or beehive kiln with a small inbuilt flue - was situated behind the coal store, not far from the coal company's jetty.

Buildings under construction at Coal Point that required bricks included a small settlement known as Edwardes Town just to the south of the mine; houses for workers and management; stores; offices; sheds; a dispensary; a police station and even a well-stocked library.

Encouraged by these discoveries, I extended my search to other newspapers, in UK, Australia and Sabah. What a bonanza! Reports revealed that, over the next four decades, the mine closed several times, as one company after another ran into financial difficulties. However, after each revival there was a new spate of building activity, all of which required bricks.

A bottle kiln.

A simple beehive kiln.

The development of the mine at Coal Point

Improvements at Coal Point in 1875 included the construction of about a dozen buildings in Edwardes Town, a spacious manager's house on the cliffs above the bay, a blacksmith's forge, engineer's house, two miners' houses, an office, a powder magazine, coolies quarters, a coal store near a new jetty and a huge cattle shed, to house the buffalos hauling wagons of coal along the tramway to the jetty for shipment. The line of a railway, to link Victoria with Coal Point, had also been surveyed.

But it was not to last. Blighted by years of insufficient capital, mismanagement, labour shortages, a disastrous boiler explosion and lack of pumping equipment for a mine that was situated in an area receiving three metres of

A glass negative of the tramway leading to the mine, taken by Gov Edwardes, c 1875.

rain a year, the colliery stood idle, along with the brick kiln, from 1878 until 1889. The beehive brick kiln would have collapsed, as the fire-bricks crumble if allowed to go cold.

By 1881, thousands of pounds worth of machinery was rusting and decaying, with weeds and vegetation rampant. Tens of thousands of pounds of equipment, much of it brand new, was stored in large sheds, along with a new locomotive, proudly gilded with its name – 'Labuan No 1'. The manager's house overlooking the water was in ruins and the fine jetty in a perilous state.

In 1886, when it was made clear to the Labuan government that that the coal syndicate had no intention of re-opening operations at the mine, much of the plant and machinery was put up for sale or auction. However three years later a new owner reopened the works with a start-up capital of 300,000 pounds sterling.

For the next 18 months the mine was under the management of Edmund Lloyd-Owen, a 40-year-old entrepreneurial British mining and civil engineer. The energetic Mr Lloyd-Owen instituted some ambitious expansion projects involving a new wharf and facilities in town, the sinking of a new shaft, the repair of machinery and plant, and the construction of an 11-mile railway line connecting Victoria to the mine. However, while high-grade coal was recovered from the expanded workings, Lloyd-Owen's spending spree, which included the railway line built at an exorbitant cost of 2500 pounds sterling per mile, landed the company in difficulties and in 1894 work once more came to a standstill.

A new company was formed, and the mine reopened. With the kiln out of action, bricks for construction were obtained from the old Victoria Gaol, recently demolished to make way for a new prison. The recycled bricks were loaded onto lighters and transported by sea to Coal Point. However, the supply was finite, and by 1898 bricks were once more being made on site at the coal mine, using the nearby clay deposits.

This period of growth heralded further expansion at the mine, with a 'splendid' new wharf in town and the construction of a large, red-roofed depot that could be seen out to sea for many miles. In 1902 coal production was being carried out by the Labuan Coal Company Limited. Using its substantial capital the aim was to carry out the business of 'coal and general mining, colliery proprietors, oil refiners, smelters, manufacturers of patent fuel, briquettes, gas, tar and other coal products'.

A new coal field was also opened. It had three inclined tunnels, all of which were lined with bricks – thousands of them. Brickmaking was in great demand, with the production line turning out bricks stamped with 'L C C L'.

In 1909 there was a further big upgrade at the mine, involving huge expenditure. The number of bricks required for the many new buildings that were planned, including 250 homes for an increased labour force, was substantial. With the large building program and the lining of the inclines with bricks, the number of bricks required between 1898 and 1909 was huge. Large enough to warrant the construction of a large brick kiln that required a smoke stack.

While small beehive or conical kilns can cope with a moderate number of bricks, the kind of large-scale brick making required for the mine's expansion demands a large kiln and a stack, the siting of which was important.

Chinese coolies discharging coal.

The rail line linking Coal Point with Victoria, c 1910.

The railway line and coaling pier at Victoria.

Circular brick kilns and chimneys.

Rectangular kiln and chimney.

The Chimney was not only adjacent to an unlimited supply of coal and extensive clay deposits, it was also on the island's highest point, where prevailing winds could blow smoke and noxious fumes away from the town. As there are two flue archways in the base of the chimney, there were two kilns.

Tests carried out by the Labuan Museum concluded that there are no soot deposits in The Chimney. However, as David Hosking points out, this does not mean that the chimney was not used for brickmaking. The quality of coal mined at Labuan was claimed to be of a very high quality, burning cleanly and with little sooty residue. Furthermore, in the past century more than 1000 feet of heavy tropical rain has cascaded across the non-porous, shiny surfaces of the interior glazed bricks, flushing away any residual soot.

The construction boom at the turn of the century, with the massive increase in demand for bricks, fits neatly into the time frame that experts say the chimney was built. There is no mention of any chimney in any of the historical accounts of visits to Labuan in the late 1880s, nor does a chimney feature in any of the sketches or historic photos made of Coal Point up until that time, supporting the experts' opinion.

The construction of The Chimney, in a community where the coal mine was constantly in the news, and every trivial event was reported by the local and Singaporean press, excited not the slightest interest. Not a single solitary newspaper report on activities at the mine mentioned that a massive brick chimney was towering over the landscape. No reports or documents related to the Labaun coal mine make any mention of a chimney, either.

There is a very compelling and logical explanation as to why this is so.

Bricks had been made at Coal Point since 1870. It was common knowledge in the early 1900s that bricks were being made there in large quantities, a fact widely reported in the press. So the erection of a chimney stack for the greatly expanded brickworks would have gone completely unremarked, as it is a normal and expected part of the brick-making process.

But, was the chimney ever use to smelt ore?

An existing brickworks can easily be converted to smelt ore and The Chimney is certainly of a high enough standard to be used for this purpose. Furthermore, smelting was certainly on the Labuan Coal Company's agenda.

The first mention of smelting at Coal Point was in 1902, when the L C C L listed ‘smelters’ among its proposed new enterprises. However, smelting ore requires an exhaust stack capable of withstanding high temperatures, the construction of which requires a considerable financial outlay. With a chimney suitable for smelting already built for the expanded brickworks, was it possible that the new owners now looked to the future?

They certainly had plenty of high-grade coal fuel on hand to fire a smelter; ready-built, easily convertible facilities; and a heavy gauge rail line to carry the final product to the port facilities in Victoria.

All they needed was a good supply of ore. Borneo had none, so where would it come from?

Smelters are rarely built at the site of an ore deposit, unless there is also ample fuel at hand to fire the furnaces. In Australia, several early smelting enterprises at the site of the ore body failed, due to lack of adequate fuel and the huge expense of transporting it to the site.

It is far more economic to import ore to the fuel source for smelting, and to then export the refined metal. This is a very efficient system if the same ships can be used - a process known as ‘back-lading’.

As the LCCL obviously realised in 1902, when it added smelters to its list of enterprises, Labuan was the perfect place to establish a smelter. The island boasted a bountiful supply of good coal, an excellent harbour and wharf facilities, a railway line with rolling stock to move ore in and ingots out, and plenty of cheap labour.

So, was there ever a proposal to smelt imported ore in Labuan? I discovered that there was. And it involved Australia.

A dual colonial enterprise:

In 1909, at the same time as the big expansion was taking place in Labuan, a proposal was put forward to construct a railway line from large copper deposits in Cloncurry, Queensland, to Point Parker, on the Gulf of Carpentaria. From there, the ore could be ‘**shipped to Labuan, where it could be cheaply smelted, owing to good coal and labour’.** The profit from this low-priced production would pay for a thriving city to be developed at Cloncurry and a busy port at Point Parker.

The nearest copper smelter to Cloncurry in 1909 was at Wallaroo in South Australia, thousands of miles away, involving haulage of ore from the mines by horse-drawn wagons to the Gulf of Carpentaria, where it began the long voyage to the far south coast of the continent.

The idea to export copper ore to Labuan, which was closer to the Cloncurry mines than Wallaroo, appears to be part of a proposed joint enterprise between the two groups of wealthy British backers who had invested in Australian copper and Labuan coal, with Australian interests supplying the ore and the Labuan Coalfields Company carrying out the smelting.

Interestingly, Mr Lloyd-Owen, the manager responsible for considerable expansion at the Labuan colliery, had taken over the lease of a copper mine in outback Queensland. It is not known if he had any input into the smelting proposal but, given his entrepreneurial streak and his knowledge of Labuan,

it is a possibility to seriously consider. Irrespective of who was responsible for promoting the project, The Chimney, lined with glazed bricks to withstand the high temperatures required, was perfect for this joint smelting enterprise.

However, during the next twelve months, things did not go well at Coal Point. In spite of the great improvements and new shafts being opened, with a resultant upturn in coal production, the Coal Company suffered major setbacks in the latter half of 1910.

Despite the increased output, the mine was simply not prospering, and in August the General Manager sailed for England to confer with the company's directors. In early January 1911 it was announced that the mines would be closed by the end of the month. It was hoped that another company would come forward to restart operations but the prospects of this actually occurring were not promising: the current owners were the seventh to go out of business, since the mine was opened in 1847.

In an attempt to keep some form of production going, pumping continued until the end of February to prevent the works flooding and a small amount of coal was recovered on a daily basis. However, by mid-March the mines had closed down completely, never to re-open.

In December 1913, all brick buildings and workshops were demolished and the hundreds of thousands of bricks removed by train to Victoria, where they were bought by an entrepreneurial local, who had great hopes of making his fortune.

The railway line from Cloncurry to the Gulf of Carpentaria, on which such high hopes were placed, was never constructed. Whether this had any bearing on the closure of the Labuan mine is not known. Neither is it possible to establish if the closure of the coal mine was the reason why the rail project was abandoned.

What is clear is that the expansion of the mines at Coal Point to include ore smelting and the push to construct the railway line were inextricably linked, and that both enterprises failed at the same time.

The Chimney was never used for smelting, not even a test run. With the Museum's permission, I had samples of the interior bricks tested for cobalt, copper, lead, nickel and zinc by a mining laboratory in Australia. Scientific analysis showed that the trace elements present were of a very low concentration, consistent with levels expected to be found in the clay from which the bricks were made.

Willie Teo and Lynette Silver, obtaining samples for analysis.

Museum employee obtaining samples.

More than 100 years later, almost every trace of the settlement at Coal Point has disappeared, along with the brickworks, the memory of which has been lost in the mists of time.

It is ironic that something as throw away as a newspaper held the key to establishing the origins of a landmark that has lasted for more than a century. It is also ironic that The Chimney, so everyday and ordinary at the turn of last century, is not only the sole tangible reminder that such an ambitious enterprise ever existed: it has also survived to become Labuan's most famous, and intriguing, landmark.

Lynette Silver
October 2015

Special acknowledgements to Mr David Hosking for his expert opinion, Bureau Veritas-Kalassay for the mineral analysis, Mrs Claire Jordan of Poppy Research in the UK for supplying detailed maps of Coal Point held in UK Archives, Abednigo Chow for additional research assistance in Sabah newspaper archives, and to Mr Willie Teo of Labuan and The Chimney Museum staff for their support and encouragement.

UPCOMING EVENTS

January 14-15, 2022: International Conference on Data Mining for Petroleum Geology, Bali, Indonesia (Digital conference). Visit https://waset.org/data-mining-for-petroleum-geology-conference-in-january-2022-in-bali to obtain more information about the event.

January 14-16, 2022: International Conference on Applied and Environmental Geoscience, Bangkok, Thailand (Digital conference). Visit https://waset.org/applied-and-environmental-geoscience-conference-in-january-2022-in-bangkok for conference details.

February 21-23, 2022: International Petroleum Technology Conference (IPTC) 2022; Dahran, Saudi Arabia. Event webpage: https://2022.iptcnet.org/.

March 14-16, 2022: MEDiNA Technical Conference and Exhibition (AAPG/EAGE Mediterranean and North African Conference and Exhibition); Tunis, Tunisia. Check out further details at https://medinace.aapg.org/2022/.

March 22-23, 2022: International Mining Geology Conference 2022; Brisbane, Australia and online. More details about the event can be obtained at https://www.ausimm.com/conferences-and-events/mining-geology/.

March 22-25, 2022: OTC (Offshore Technology Conference) Asia 2022; Kuala Lumpur, Malaysia. Event website: https://2022.otcasia.org/.

March 23-24, 2022: Geo Connect Asia Conference; Singapore. To learn more about the event where some of the world's biggest players in geospatial technology and location intelligence solutions will meet, visit the event webpage at https://www.geoconnectasia.com/.

March 28 -31, 2022: SGA (Society for Geology Applied to Mineral Deposit) Biennial Meeting 2022 fully virtual conference. Host: Rotorua, New Zealand. Visit the event website, https://confer.eventsair.com/sga2022/ for more details.

March 29-31, 2022: Carbon, Capture, Utilization, and Storage (CCUS) Conference, Houston, USA. For questions or additional information, please contact: Alicia Collins, Event Coordinator, +1 918 560 2616, or email acollins@aapg.org.

April 19-22, 2022: AAPG's International Conference and Exhibition, ICE 22; Cartagena, Colombia. Please find further details at https://www.aapg.org/events/conferences/ice.

May 19-20, 2022: AAPG/PESGB Energy Transition Forum; London. Details are available at https://energytransition.aapg.org/2022/.

June 20-22, 2022: Unconventional Resources Technology Conference (URTeC); George R. Brown Convention Center in Houston, Texas. Visit event website https://urtec.org/2022/ for more information.

June 20-22, 2022: GeoConvention 2022 Hybrid Event; Calgary, Canada. Find more details at https://geoconvention.com/.

July 6-7, 2022: AAPG Geosciences Technology Workshop (GTW) on Structural Geology and Our Future - The Role of Tectonic Geoscience in Energy Transition, Focusing on the Asia-Pacific Region; In-Person in Sydney, Australia and Online. For further details, please contact Programs Manager, AAPG Asia Pacific Region via the event website.

July 15-17, 2022: 4th International Conference on Performance-based Design in Earthquake Geotechnical Engineerin; Beijing, China. Check event website: http://www.pbd-iv2021.com/ for further details.

August 21-24,2022: 9th International Conference on Geoscience Education (IX GeoSciEd); in Shimane, Japan. Further information about the event can be found at https://www.geoscied9.org/.

September 12-14, 2022: MEDiNA Conference and Exhibition (Mediterranean and North Africa Conference); Tunis, Tunisia. Please visit event organiser's website at https://medinace.aapg.org/2022/ for more details.

September 19-23, 2022: International Conference on Physical Modelling in Geotechnics; KAIST, Daejeon, Korea. Please check https://icpmg2022.org/ to learn more about event.

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