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CATATAN GEOLOGI
GEOLOGICAL NOTES

Characteristics and suitability of Sematan-Lundu and Sungai Suai-Kuala Niah silica sand, Sarawak, for glass-making

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Abstract— Silica sand is an essential constituent in commercial glass-making. A high content of silicon dioxide and a very low iron level is required for the making high-quality glass products. The aim of this research is to determine the characteristics and suitability of silica sand extracted from several parts of Sarawak to be used for glass-making. Much work has been done on the silica sand deposits in Sarawak by Department of Mineral and Geosciences. Hopefully, with this additional study, the silica sand areas could be commercialized, so that it will further promote silica-sand mining and its related industries in Sarawak. Seven representative samples from Sematan-Lundu and Sungai Suai-Kuala Niah areas were collected from various depths. Comprehensive mineralogical, physical and chemical tests were carried out to characterise the quality of these sand deposits in accordance with international standards (BS 2975:2004 and MS 710:1981). The specific parameters that were studied are silica content, alkali content; loss on ignition (LOI), organic matter, nickel and vanadium, aluminium, iron, chromium, copper and cobalt contents, heavy mineral components as well as particle size distribution, shape, refractoriness and sphericity.

The study indicates that the natural silica sand deposits in the Sematan-Sungai Suai area, occurring at a depth between 0.5 m and 1.5 m are F, G and H grades and hence are suitable only for lower-end applications for making window panes, containers, green and amber glass and insulating fibre. The silica sand at Lundu and Kuala Niah (up to 1.2 m thick) are of F and G grades, which are suitable for making green and amber glass and insulating fibre. Sand layers below these depths normally are darker in colour due to presence of organic matter, clay minerals and ferruginous minerals that stained the quartz sand. The silica sand at Lundu may need to be processed further before it can be used as raw material for glass-making. Removal of heavy minerals, by magnetic separation as well as particle size screening and classification are essential. The silica sand at Sematan and Lundu contains a higher percentage (> 35%) of particles with size larger than 106 µm. Further mineral processing (washing, scrubbing and acid leaching at appropriate temperatures) would enhance the silica content and aid in the removal of iron and clay minerals. This is important for high-end applications such as for crystal, optical and borosilicate glasses (A to D grades).

Keywords: Industrial mineral deposit, silica sand and glass ceramic

INTRODUCTION

Sand refers to the naturally occurence of unconsolidated minerals and rocks with particle size ranging from 0.25 mm to 2 mm. Silica sand is made up of quartz, which is a silicon dioxide (SiO_2). Other mineral constituents or impurities that may occur in many silica sand deposits are alumina, titania and iron-bearing minerals and organic matter, which reflect of the depositional environments and provenance.

Silica as quartz is one of the most abundant and common mineral in the earth crust. Silica is a common rock-forming mineral in many sedimentary, metamorphic and igneous rocks. Commercial silica sand is often derived from recent sediment deposits, quartz pipes and veins. Silica sand or industrial sand refers to sand with particularly high content of silica that is used in high-end sectors other than for construction. Silica sand is often found in the form of unconsolidated sand and crushed sandstone. The major high-end applications of industrial sand are in glass, ceramic and fillers (micronised form). Silica sand is the essential feed meal in glass manufacturing. Glass is an amorphous solid made from fusing silica with a basic oxide. There are many types of glass, such as optical glass and window glass. Chemical purity is an important factor which determines the grade of silica sand in the manfacturing of various type of glass. For a particular source of sand (deposit) to be used for glass-making, it must not only contain a very high proportion of silica but the content of impurities must be very low. The presence of unwanted metal oxides, especially iron-bearing minerals, will down grade the quality and suitability of the silica sand. The impurities may contribute to colouring in glass. The finished products would appear green or brown.

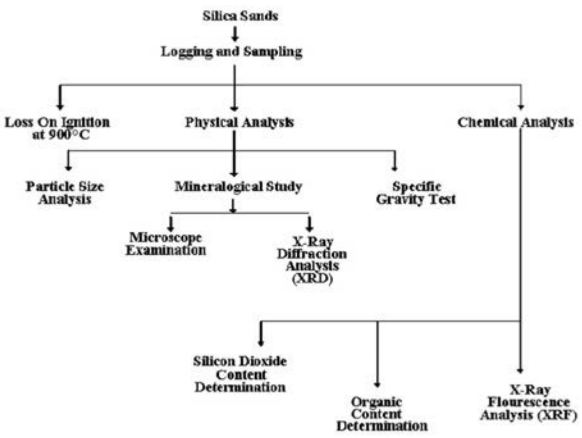

Figure 1: Silica sand characterisation methodology.

Silica sand for glass-making has to meet stringent physical and chemical specifications and the industrial requirements have been specified in international standards such as BS2975:2004 (BSI, 2004) and MS710:1981 (SIRIM, 1981). The category of silica sand is based on the maximum and minimum contents of silica and other metal oxides (impurities). Particle size distribution of the silica sand is also important. Silica sands with particle size ranging from 106 µm to 600 µm are preferable. Table 1 shows the common grade of silica sand for various types of glass-making. Generally, the commercial and industrial graded silica sand for glass manufacturing must comply with the following chemical and physical specification parameters: minimum silica level; maximum levels of aluminium, iron, chromium, copper, cobalt, nickel and vanadium; maximum alkali levels; and maximum losses on heating; and particle size distribution.

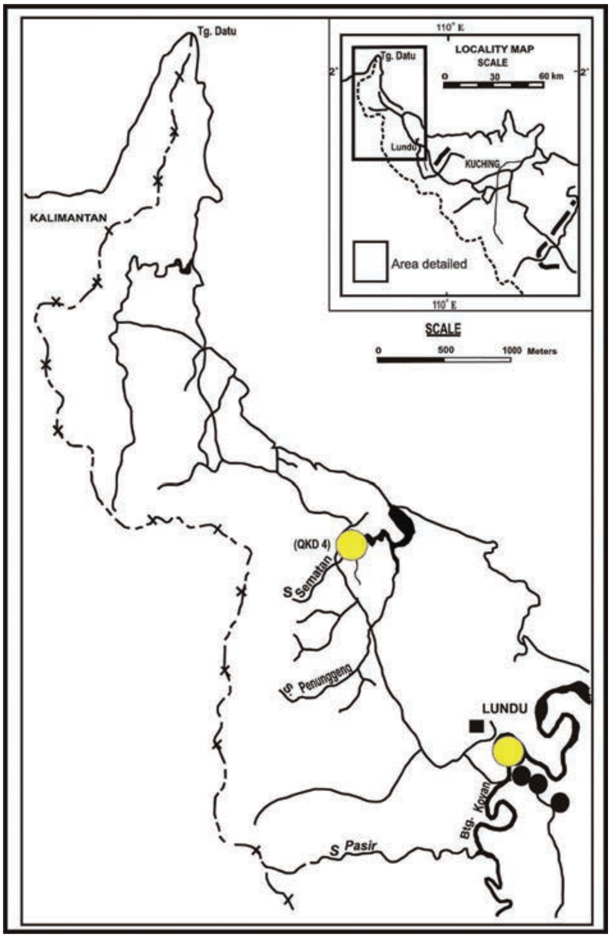

Figure 2: Sematan-Lundu silica sand deposits, Kucing (Studied area - Sematan (01°48'44.6" N, 109°45'07.3" E) and Kampung Belungei, Lundu (01°45'48.9 N, 109°51'02.2" E).

SARAWAK'S SILICA SAND

Sarawak has established itself as being the first state in Malaysia venturing into high-grade silica sand (> 98% SiO_2) mining and is one of the largest producers since the mid 1970's through Glass Sand Company Berhad, the predecessor of Syarikat Sebangun Sdn. Bhd., a Sarawak State and Economic Development Corporation (SEDC) subsidiary company. Sarawak continues to be the leading producer accounting for over 54% of the total Malaysian production. From 1998 to 2004, Sarawak was the largest silica sand producer with a total production of 274,823 metric tonnes (Mineral and Geoscience Department, 2002, 2004). The price of silica sand in Malaysia ranged from RM 20 to RM50 per tonne. Since the rapid development in silica sand mining and high industrial demand, new potential resources for the coming years must be sought. The silica sand is exported to Japan, Philippines, Korea, Middle East countries and other Asean countries.

Generally, the major silica sand deposits in Sarawak are from the coastal areas of Lundu-Sematan, Bintulu and Semilajau-Suai, Roban, Telagus and Sempadi areas (Eki & Menon, 1992; Eki & Ambun, 1996).

OBJECTIVES AND METHODOLOGY

The main objective of this study is to explore and evaluate the potential application of silica sand extracted from Sematan-Lundu and Sungai Suai-Kuala Niah areas, to be used as raw material in glass-making. This study involved various aspects of work, including field work, geological study and laboratory analysis. Representative samples were obtained from various depths of exploratory boreholes, which were logged and described accordingly. This will assist the interpretation of the nature of geological occurrence and depositional environment of these deposits. The laboratory work included physical and chemical characterization of silica sand samples in accordance with MS 701:1981 (SIRIM, 1981) to determine the suitability of these silica sand deposits (Table 1). Figure 1 shows the methodological approach taken for the study.

Seven samples representing four difference locations, obtained from different depths, were examined. They are SE(a) and SE(b) from Semantan, KN(a) and KN(b) from Kuala Niah, S(a) and S(b) from Sungai Suai and one sample from Lundu. Appropriate physical and chemical analyses were performed to characterize and to look

Table 1: Chemical composition of silica sand for glass-making (summarized from MS701:1981 and BS2975:1988).

GRADE OF SAND	SiO_2	Fe_2O_3	Al_2O_3	Cr_2O_3	TiO_2	CaO+MgO	LOI
Grade A: Optical and ophthalmic glass	99.60	0.008	0.05	0.0002	0.03	0.05	0.20
Grade B: Tableware and lead crystal glass (and optical)	99.50	0.015	0.05	0.0002	0.05	0.05	0.20
Grade C: Colourless glass (Borosilicate)	98.50	0.03	0.1	0.0006	0.10	0.10	0.50
Grade D: Flint glass	95.00	0.03	4.00	The limit shall be fixed by agreement between the purchaser and the supplier		0.50	0.80
Grade E: Flat sheet, rolled and polished glass	98.50	0.05	0.5			0.50	0.80
Grade F: Window and container glass	98.00	0.30	0.5			0.50	0.80
Grade G: Green and insulating fibre glass	95.00	0.30	0.5			0.50	0.80
Grade H: Amber glass	98.00	1.00	0.5			0.50	0.80

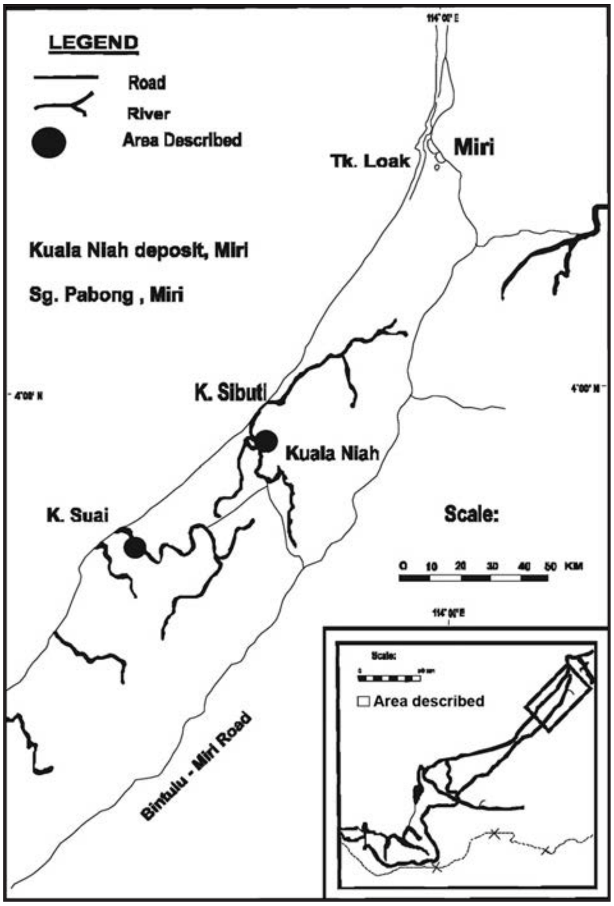

Figure 3: Silica sand deposits from Miri Division, Northern Sarawak. Samples were sought from (Kuala Niah and Kuala Suai, Miri.

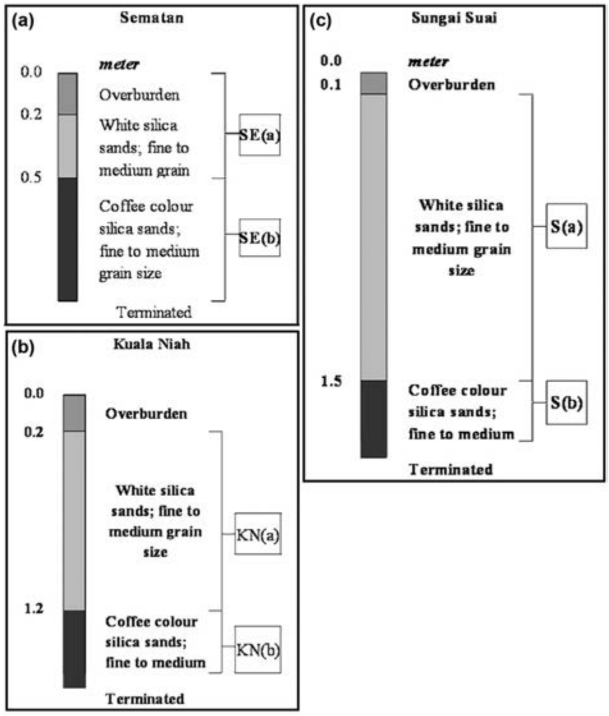

Figure 4: Log description of samples from Sematan (SE), Kuala Niah (KN) and Sungai Suai (S) silica sand beds.

into their industrial potential. The physical analyses include particle size distribution analysis, mineralogical examination (stereo microscope and XRD), and specific gravity test. The chemical analyses were tests for silicon dioxide, organic matter content and loss on ignition (LOI). The total chemical composition of the silica sand was determined using X-ray fluorescence (XRF) analysis.

GENERAL GEOLOGY AND OCCURENCES

There is a long stretch of sandy beach along the Bintulu-Miri and Lundu-Sematan shorelines (Figures 2 and 3). The elevated coastal sand ridges or terraces along the shoreline is usually overlain by Quaternary aluvium of thick sand, clay, silt, and gravel with layer of peat (Eki & Menon, 1992; Eki & Ambun, 1996).

The Sematan-Lundu area is underlain by Kayan sandstone of Late Cretaceous to Miocene age. The Kayan sandstone is made up of thick sandstone beds intercalated with calcareous sandstone, conglomerate lenses, siltstone and varicolored mudstone and rare limestone lenses. This rock unit is locally interbeded with thin shale, lignite and mudstone sequences, characterised by distinct cross-bedding . The Sungai Suai and Kuala Niah areas are overlain by the Tukau, Miri and Sibuti formations, consisting mainly of thick sandstone beds, interbedded with siltstone, shale, clay with some conglomerate and lignite, and is poorly consolidated (Shaw, 1960; Yin, 1992). There are no major igneous rock occurrences in this area.

Table 2: Physical and mineralogical characteristics of selected Bintulu-Miri silica sand in the 600 µm to 106 µm cut-off particle size limits.

Location and Sample	Description	Specific gravity (gm/cm^3)	LOI @ 900°C (%)	Organic matter (%)	SiO_2 content (%)	+106 µm (%)	-600 µm (%)
SE(a)	White silica sands from Sematan	2.69	0.34	-	98.36	39	100
SE(b)	Dark brown color silica sand from Sematan	2.63	1.32	0.49	98.05	28	100
Lundu	White silica sands from Lundu	2.65	0.17	-	99.11	12	98
S(a)	White silica sands from Sungai Suai	2.70	0.2	-	99.47	38	100
S(b)	Dark brown color silica sand from Sungai Suai	2.63	1.44	0.79	97.38	38	100
KN(a)	White silica sands from Kuala Niah	2.68	0.21		99.40	20	100
KN(b)	Dark brown color silica sand from Kuala Niah	2.67	0.6	0.47	98.81	2	100

Table 3: Chemical composition (in %) of Sematan-Lundu and Sungai Suai-Kuala Niah silica sand samples determined using XRF.

Sample	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Cr_2O_3	P_2O_5	ZrO_2	TiO_2	CaO+MgO	LOI	Sand Grade
SE(a)	98.00	0.26	0.42	0.034	0.04	-	0.38	0.82	0.08	0.29	**F,G,H**
SE(b)	96.00	0.19	0.79	0.047	0.03	-	0.22	0.52	0.04	2.50	-
Lundu	99.00	0.20	0.52	0.042	-	-	0.044	0.32	0.04	0.15	**G,H**
S(a)	97.00	0.17	0.46	0.054	0.05	0.025	0.91	0.61	0.05	0.16	**F,G,H**
S(b)	97.00	0.091	1.10	0.15	0.02	-	0.01	0.07	0.07	1.40	-
KN(a)	99.00	0.075	0.56	0.11	-	-	0.052	0.14	0.03	0.28	**G,H**
KN(b)	98.00	0.08	0.84	0.081	-	-	0.01	0.03	0.04	0.51	**G,H**

Note : Y_2O_3 =0.017% in SE(a)

The geology suggests that much of the silica sand within the Lundu-Sematan, Sungai Suai and Sematan areas are originated from the weathering of rock formations rich in sandstones that underlie major parts of Northern Sarawak. As quartz sand (including heavy minerals) transported to the sea they normally accumulate in the river channel or along the coastline. Within the beach intertidal zone, constant wave action leads to the concentration and separation of lighter quartz sand grains and heavier mineral components. Significant silica sand deposits have been discovered at several locations along the low-lying coastal beaches. The sand deposits often form terraces with crest height of almost 8 m above the low lying coastal plain. Much of the silica sand production in Sarawak is exploited from these Quaternary terrace deposits.

RESULTS AND DISCUSSION

A description of the field logs of silica sand deposits is given in Figure 4 and Table 2. A thick bed (150 cm) of white, fine-grained to medium-grained, silica sand occurs in the Sungai Suai area. The silica sand deposits experienced high particle size segregation processes under prolonged hydraulic action experienced during transportation, gravity and wave turbulent mechanisms. A period of trangression and the coastal geomorphological environment has facilitated the formation of this sand ridges. Recent sediments, especially of mud has settled on the deposits to form a thin grey sandy clay overburden.

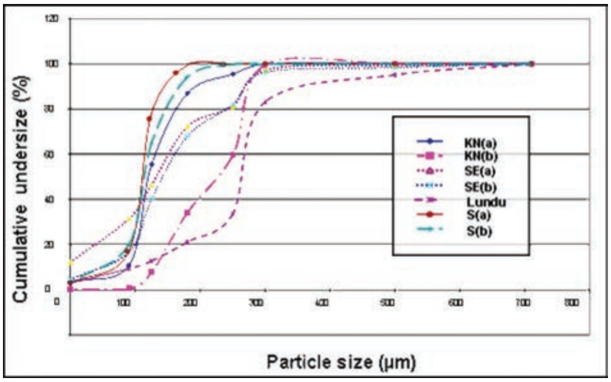

Figure 5: Cumulative particle size distribution of silica sand samples of Sematan-Lundu and Sungai Suai-Kuala Niah, Sarawak.

Physical and Mineralogical characteristics

The particle-size distribution of the samples is shown in Figure 5. The industrial requirement for silica sand particle size distribution should be in the range of +106 µm and –600 µm. Apart from sample KN (b), all samples contain small percentage of –106 µm size fraction, and sample from Lundu has minor sand particles above the top cut-off limit. Deposits with up to 25% of –106 µm fraction can be removed by simple screening.

All samples have greater than 98% of subangular to subrounded, white to clear, quartz fragments (Figure 6). Dark brown colored samples are generally made up of a higher percentage of iron-stained quartz fragments.

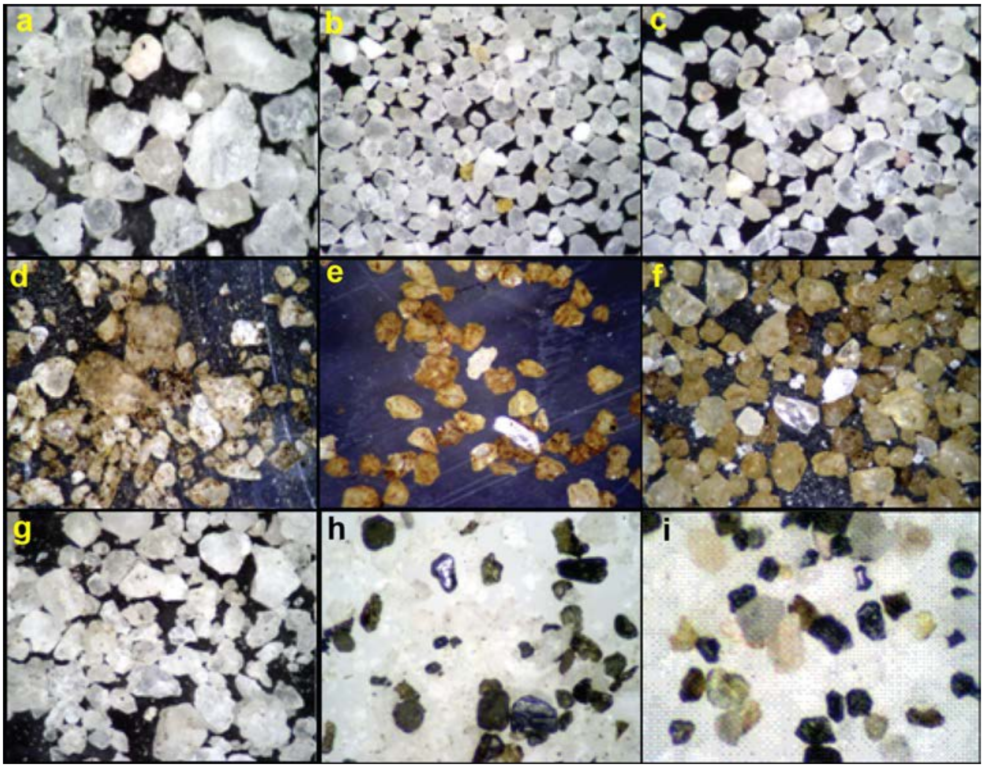

Figure 6: Stereomicroscope photomicrographs of Sematan-Lundu and Sg-Suai-Kuala Niah silica sands.
a: Semantan SE(a)
b: Sg. Suai S(a)
c: Kuala Niah KN(a)
d: Semantan SE(b)
e: Sg. Suai S(b)
f: Kuala Niah KN(b)
g: Lundu
h: Heavy minerals - ilmenite grains
i: S(a) magnetite, ilmenite, zircon, rutile (<0.1%), muscovite and ferrugeneous quartz sand.

Examination of samples pre-concentrated by magnetic seperation indicates that the main heavy mineral constituents are ilmenite, rutile, magnetite and zircon. Ilmenite and magnetite are the most abundant heavy minerals (< 1%). The results are consistent with chemical content test and XRD data (Table 3 and Figure 7). The mineral contents of silica sand samples are shown in Table 4.

Table 4: Estimated results of point counting of relative abudance of minerals in silica sand samples.

Sample	Quartz	Rutile	Ilmenite	Magnetite	Other*
SE(a)	99.0	0.3	0.3	0.2	0.2
SE(b)	99.0	0.3	0.3	0.1	0.3
Lundu	99.0	0.3	0.2	0.2	0.3
S(a)	98.0	0.3	0.5	0.2	1.0
S(b)	98.0	0.1	0.2	0.1	1.6
KN(a)	99.0	0.1	0.3	0.1	0.6
KN(b)	99.0	0.1	0.2	0.3	0.4

Note : * zircon, monazite, mica, tourmaline etc.

Chemical Composition

Silica content by standard wet chemical test has revealed that most of the silica sand deposits have over 98% SiO_2 (Table 2). White silica sand layers from Lundu, Sungai Suai S(a) and Kuala Niah KN(a) are among the purest with SiO_2 exceeding 99%, suggesting that their respective LOI and organic matter contents are low. The dark brown colored sand layers have high proportions of organic matter of about 0.5%. Table 3 shows the chemical composition of the silica sand samples determined using semi-quantitative XRF analysis. The presence of minor iron oxide, zirconia, titania and posphate indicative of the heavy mineral contents, i.e. ilmenite, rutile, zircon and monazite are present in the samples.

CONCLUSION AND RECOMENDATION

The study has indicated that the silica sand deposits along the coastal area in Bintulu–Miri and Sematan–Lundu areas, Sarawak have a good potential because of their high quality and potentially large reserves.

The investigation has shown that good quality silica sand deposits from Sematan and Sungai Suai occur between the depth of 0.5 m and 1.5 m. Such silica sands are graded as F, G and H. The sand is suitable for making containers, window glass, insulating fibre as well as for manufacturing green and amber glass. Silica sand at Lundu and Kuala Niah is graded as G, which is suitable for green, amber glass and fibre glass manufacturing. However, the silica sand at Lundu may require further particle size reduction in order to meet the specifications for glass-making, which may not be economical. The dark coloured silica sands occurring at deeper levels are less suitable for glass-making as their LOI values are above the specification and thus require further treatment.

The silica sand could be upgraded by washing and scrubbing to remove the clay. A combination of gravity separation (using spiral and shaking table), froth floatation and magnetic separation can be used to remove impurities. Chemical treatments involving sulphuric acid as well as hydrofluoric acid at elevated temperatures and thermal shock can be used to remove iron stained-quartz grains but not the inclusion so that it could be upgraded to a higher purity grade (Fe < 0.05%).

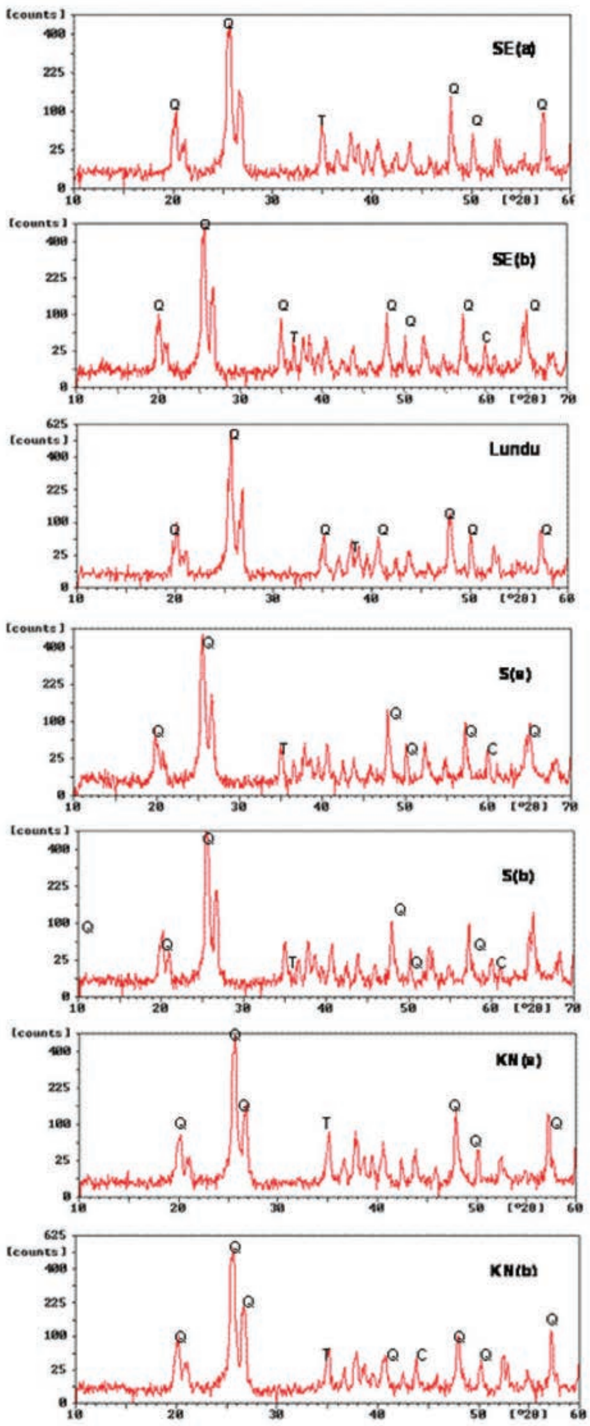

Figure 7: X-ray Diffractogram of Sematan-Lundu [SE(a), SE(b), Lundu] and Sg. Suai-Kuala-Niah [S(a), S(b), KN(a), KN(b)] silica sand samples.

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2-D geoelectrical resistivity survey at a proposed new condominium site of Port Dickson Beach Resort, Negeri Sembilan

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Abstract— 2-D resistivity imaging survey was conducted on a proposed site of a new condominium block at Port Dickson Beach Resort, Negeri Sembilan. The purpose of the survey was to determine the resistivity distribution of the soil underneath the proposed site and to investigate the cause of piling test failures of many driven piles in the site. More than half of the site represents new coastal reclamation land. The resistivity survey has successfully determined the boundary between an original ground surface and the fill material. The undulating surface of the original ground generally shows a gentle slope towards the sea. The original ground material is relatively higher in resistivity value compared with the lateritic filled material of the study area. Data from the bore hole clearly show the distinct boundary of lateritic fill material and the original ground soil underneath the study site. A zone of extremely low resistivity value (<5 Ωm) observed on the western part of the site is believed to be associated with the movement of water below surface which is a contributing factor for the failure of the piling tests.

Abstrak— Survei imej keberintangan 2-D telah dijalankan untuk tapak cadangan blok baru kondominium di Port Dickson Beach Resort, Negeri Sembilan. Survei yang dijalankan ini bertujuan untuk mendapatkan taburan keberintangan tanah di tapak kajian dan untuk menyiasat sebab berlakunya kegagalan dalam ujian pile yang dijalankan ditapak tersebut. Sebahagian kawasan kajian merupakan bahagian tambakan tanah daripada tebusan pantai. Survei keberintangan telah berjaya menentukan sempadan tanah asal dan tanah tambakan. Tanah asal menunjukan permukaan yang beralun dan curam ke arah laut. Tanah asal memberikan nilai keberintangan yang relatif tinggi berbanding tanah tambakan laterit. Data lubang gerudi menunjukkan sempadan yang jelas anatara tanah asal dan tanah tambakan. Zon disebelah barat tapak kajian menunjukkan nilai keberintangan yang amat rendah (<5 Ωm) dan dipercayai disebabkan oleh pergerakan air ke bawah tanah yang merupakan faktor penyebab kegagalan ujian pile di tapak kajian.

INTRODUCTION

Geoelectrical resistivity surveys are commonly used for geotechnical investigations, and environmental surveys (Loke, 1999). Due to its efficiency and effectiveness in producing images of the subsurface, the resistivity-imaging method has now become more popular in electrical exploration (Dahlin & Zhou, 2002). The 2-D geoelectrical resistivity imaging measures the apparent resistivity of the subsurface, which can be inverted to develop a model of the subsurface structure and stratigraphy in terms of its electrical properties (Loke, 2003). The resistivity of the subsurface is affected by porosity, the amount of water in the subsurface, ionic concentration of the pore fluid and the composition of the subsurface materials. The resistivity data can be used to identify fractured zones (Carpenters *et al*. 1991), delineate and map subsurface features such as electrically conductive contamination plumes (Bengtsson, 1994), the vadose zone and electrically conductive lithologic units such as clay (Dawson *et al*, 2002).

In this study the 2-D resistivity survey was used to measure the resistivity of the subsurface soil at a proposed new condominium site of the Port Dickson Beach Resort, Negeri Sembilan. The site represents a new reclamation land which was filled up with lateritic soil (Figure 1). Majority of the driven piles in the construction site has failed the piling tests. The main objective of this survey was to obtain information on the subsurface resistivity and its relation to the cause of the piling test failures at the study area.

MATERIAL AND METHODS

The resistivity of the subsurface materials depends on several factors such as the nature of the solid matrix and its porosity, and the type of fluids (normally water or air) which fill the pores of the rock or soil. In general, rock and dry soil have high resistivities ranging from several hundred to thousand ohm-meter. On the other hand, soil and fractured rock saturated with water have

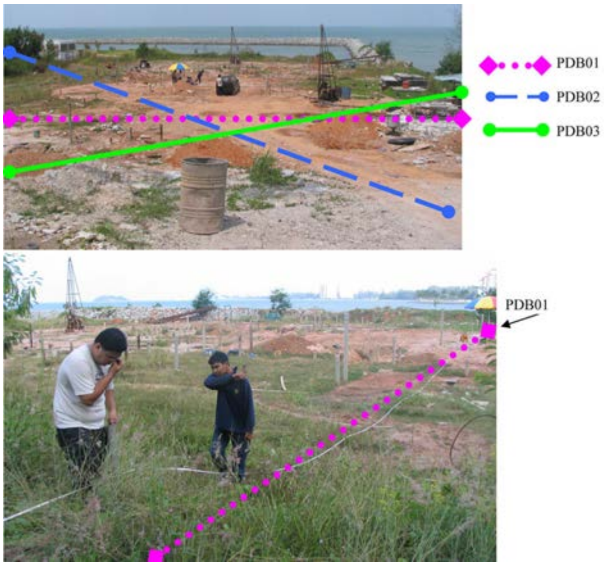

Figure 1: Photographs showing the location of resistivity lines (top) and piles (bottom) on the reclamation area of the study site.

a relatively low resistivity value. The subsurface material resistivity can be measured by injecting a small current into the ground through two electrodes and the resulting voltage on the ground surface is measured at two potential electrodes. By varying the space between the electrodes, as well as the location of the electrodes, a 2-D geoelectrical resistivity image of the subsurface can be obtained.

The 2-D geoelectrical imaging survey in this study was carried out with a SAS1000 resistivity meter and ABEM LUND ES464 electrode selector system. This system is connected to 41 stainless steel electrodes, which were laid out on a straight line with a constant spacing via a multi-core cable. The resistivity meter selects only four active electrodes used for each measurement. The Wenner equal spacing electrode array was used for this survey. For more details about the survey and interpretation method, please refer to the papers by Griffiths and Barker (1993) and Loke and Barker (1996). The measured resistivity data were interpreted using RES2DINV inversion software (Loke & Barker, 1996).

Three resistivity lines (PDB01, PDB02 & PDB03) were established at the problematic area of the site. Map showing site plan and location of the resistivity lines are shown in Figure 2. Line PDB01 was conducted parallel with the coastal line with a resistivity depth section of about 8.9 m. Whereas for PDB02 & PDB03, the surface line coverage were 120 m and 100 m respectively with a maximum depth sections of about 17.2 m and 14.3 m. To validate the results of the survey, all of the three resistivity lines were made to cross each other.

RESULTS AND INTERPRETATION

The results of the interpreted 2-D resistivity sections are shown in Figure 3. The resistivity of the subsurface soil material varies from 1.60 Ωm to a maximum values of more than 400 Ωm. Based on the subsurface soil resistivity, the soil material underneath the site can be divided into two zones i.e. zone of relatively hard material (original ground material) and zone of soft material (soil material). The soft soil material is interpreted to have resistivity of lower than 60 Ωm with its water saturated layer having resistivity less than 5 Ωm. This soft layer zone is most likely associated with the filled material of the study area.

The soil material below surface shows resistivity values ranging from 70 Ωm to more than 400 Ωm (Figure 3). These high resistivity values suggest that the soil layer is relatively hard and most likely represent the original ground surface with undulating topography sloping towards the sea. A bore hole data shows that a hard layer (within the original ground) with N value equal to 50 occurs at depth between 6 m to 10 m below surface (lines PDB02 and PDB03 in Figure 2).

CONCLUSION

The interpreted resistivity sections of profile PDB02 and PDB03 clearly show the boundary of lateritic filled material and the original ground soil underneath the study site. The undulating surface of the original ground generally shows gentle slope towards the sea. Nearly half section of the site is represented by the reclaimed beach land which has relatively low resistivity values. A zone of extremely low resistivity value (<5 Ωm) observed on left side of line PDB01 is believed to be associated with the flow of water below surface. This water appears to have seeped through the filled soil material and reduced the cohesiveness properties of the soil as well as a potential factor that contributing to the failure of many piling tests conducted at the site.

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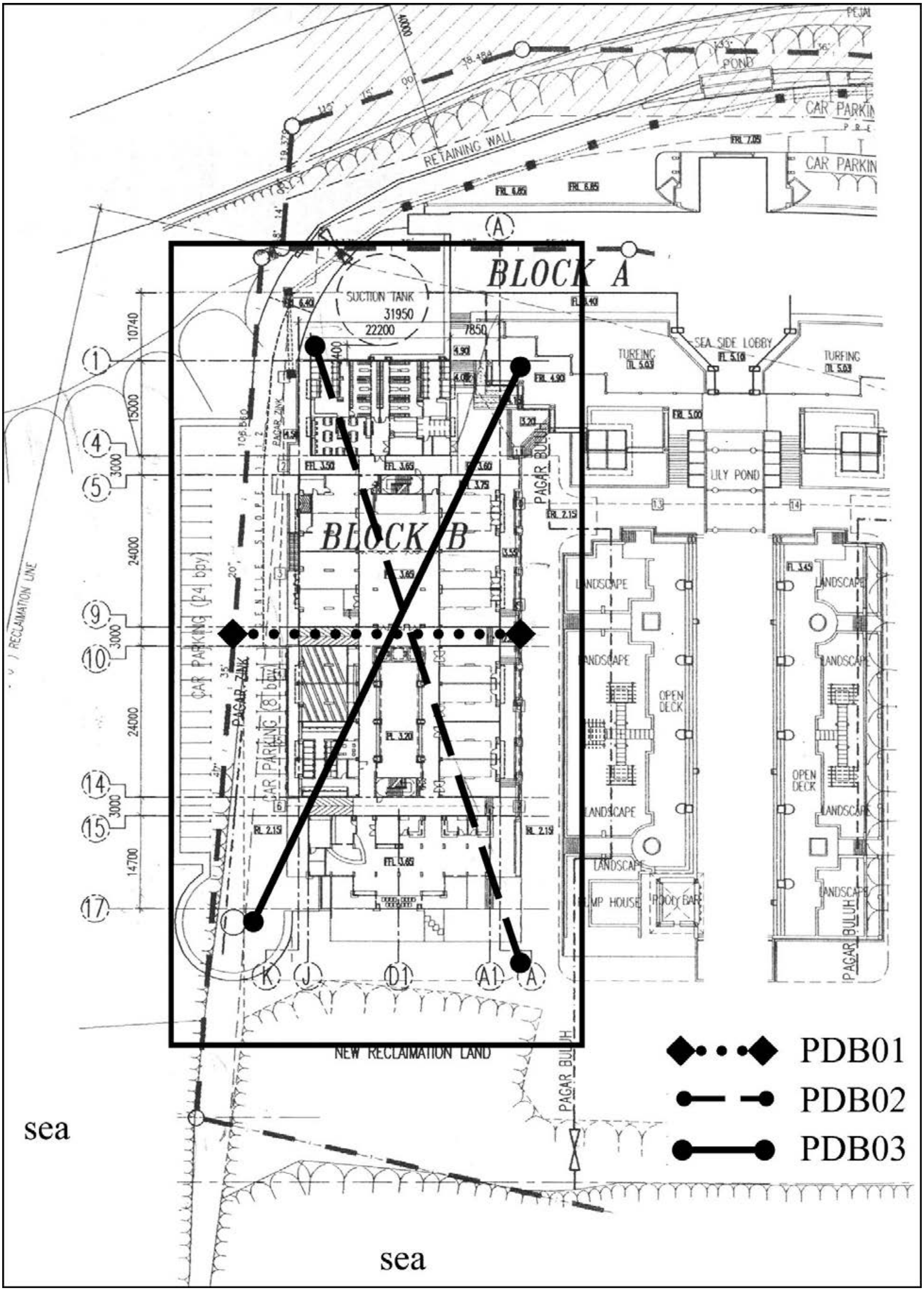

Figure 2: Map showing the site plan and location of resistivity lines.

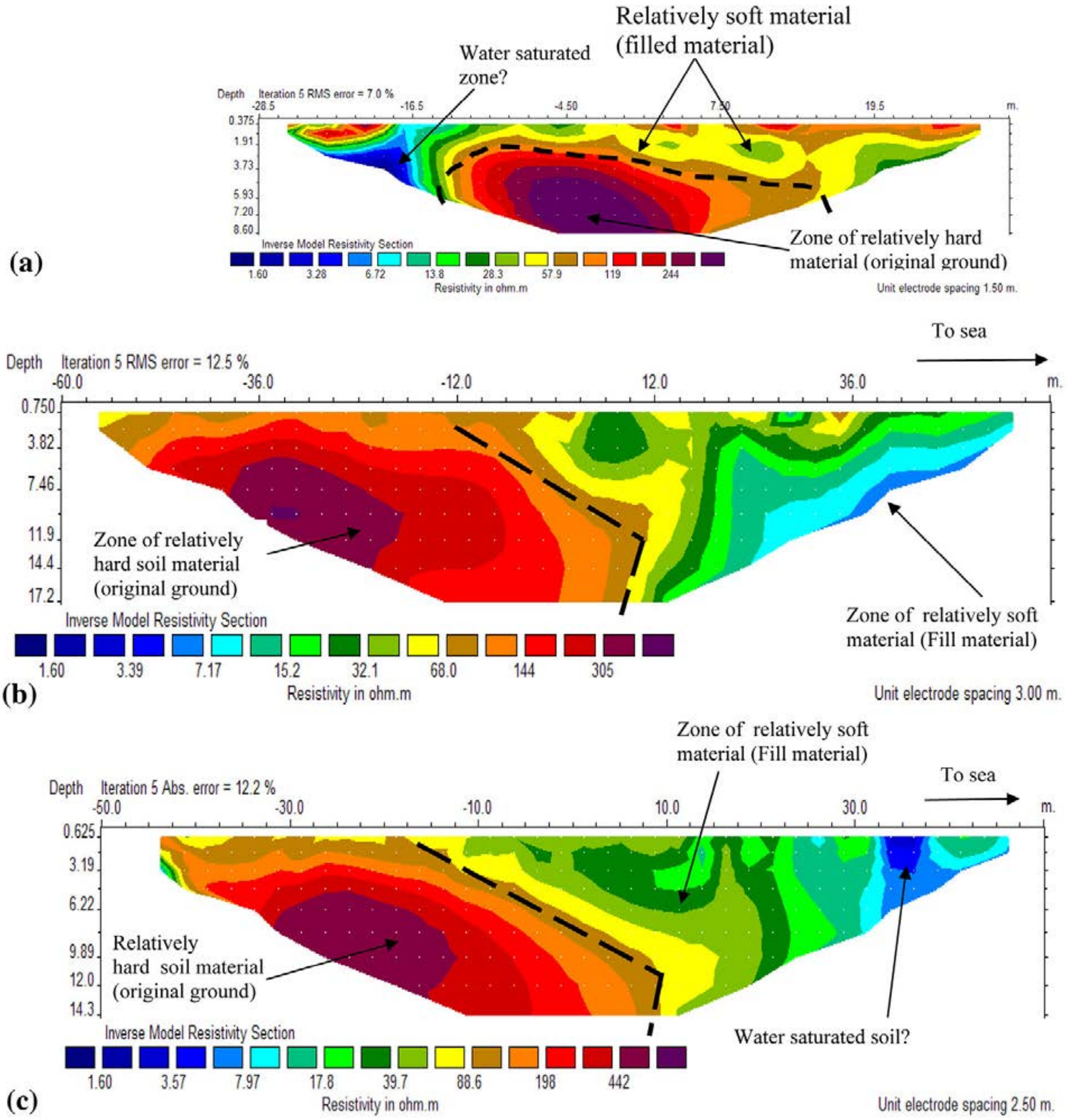

Figure 3: Subsurface resistivity distribution of soil for profiles PDB01(a), PDB02(b) and PDB03(c).

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Seven Major Volcanic Eruptions That Temporarily Cooled World's Climate

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INTRODUCTION

According to the Smithonian Institute, the world counts are some 1500 volcanoes of recent eruption history, and some twenty volcanoes are in activity every moment. Studies suggest that vulcanicity is a rather constant activity, but centered in a number of volcanic belts only. It can be argued, though, that several periods of planets geological history have seen a higher level of activity compared to today.

During all eruptions, volcanoes vent gasses (among these: H_2O, CO_2, H_2S, F) that are either released into the atmosphere, or remain dissolved in the ocean, this being the case of many submarine eruptions.

If we consider volcanic eruptions on land, there are only a handful of known eruptions during the last couple of hundreds of years that temporarily affected world climate. The amount of solid material (ash), and gasses blown into the atmosphere, as well as gas composition are important parameters. Dust blown up in Plinian clouds is dense enough to stall a jet plane's engines in altitudes of 30000 feet and above. Both fine volcanic ash, and sulfur dioxide (SO_2) act as sun-ray absorbers and can cause a cooling of the atmosphere.

But only a few events are powerful enough to cause changes in climate recordable on a global scale. This article summarizes events (sorted in chronological order) related to the eruptions of the volcanoes: Laki (Iceland), Tabora, Krakatau (both Indonesia), Katmai (Alaska), and Mt Pinatubo.

1. LAKI

This volcano in Iceland erupted in 1783 with 130 craters opened with phreatomagmatic explosions because of the groundwater interacting with the rising basalt magma. The eight month emission of sulphuric aerosols resulted in one of the most important climatic and socially repercussive events of the last millennium.

The eruption, also known as the Skaftáreldar ("Skaftá river fires") or Síðueldur, produced an estimated 14 km³ (3.4 cu mi) of basalt lava, and the total volume of tephra emitted was 0.91 km³ (0.2 cu mi). Lava fountains were estimated to have reached heights of 800-1400 m (~2,600-4,600 ft).

In Great Britain, the summer of 1783 was known as the "sand-summer" due to ash fallout. The gases were carried by the convective eruption column to altitudes of about 15 kilometres (10 mi). The aerosols built up caused a cooling effect in the Northern Hemisphere.

The eruption continued until 7 February 1784, but most of the lava was erupted in the first five months. Grímsvötn volcano, from which the Laki fissure extends, was also erupting at the time from 1783 until 1785. The outpouring of gases, including an estimated 8 million tons of fluorine and estimated 120 million tons of sulphur dioxide gave rise to what has since become known as the "Laki haze" across Europe.

Consequences in Iceland

The consequences for Iceland were catastrophic. An estimated 25% of the population died in the famine and fluorine poisoning after the fissure eruptions ceased. Around 80% of sheep, 50% of cattle and 50% of horses died because of dental and skeletal fluorosis from the 8 million tons of fluorine that were released.

Figure 1: The Laki Volcano area. Picture from Wikipedia.

Outside Iceland

Gilbert White recorded his perceptions of the event at Selborne:

"The summer of the year 1783 was an amazing and portentous one, and full of horrible phaenomena; for besides the alarming meteors and tremendous thunder-storms that affrighted and distressed the different counties of this kingdom, the peculiar haze, or smokey fog, that prevailed for many weeks in this island, and in every part of Europe, and even beyond its limits, was a most extraordinary appearance, unlike anything known within the memory of man. By my journal I find that I had noticed this strange occurrence from June 23 to July 20 inclusive, during which period the wind varied to every quarter without making any alteration in the air. The sun, at noon, looked as blank as a clouded moon, and shed a rust- coloured ferruginous light on the ground, and floors of rooms; but was particularly lurid and blood-coloured at rising and setting. All the time the heat was so intense that butchers' meat could hardly be eaten on the day after it was killed; and the flies swarmed so in the lanes and hedges that they rendered the horses half frantic, and riding irksome. The country people began to look with a superstitious awe, at the red, louring aspect of the sun."

Benjamin Franklin recorded his observations in a 1784 lecture:

"During several of the summer months of the year 1783, when the effect of the sun's rays to heat the earth in these northern regions should have been greater, there existed a constant fog over all Europe, and a great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water. They were indeed rendered so faint in passing through it, that when collected in the focus of a burning glass they would scarce kindle brown paper. Of course, their summer effect in heating the Earth was exceedingly diminished. Hence the surface was early frozen. Hence the first snows remained on it unmelted, and received continual additions. Hence the air was more chilled, and the winds more severely cold. Hence perhaps the winter of 1783-4 was more severe than any that had happened for many years."

2. MOUNT TAMBORA (OR TOMBORO)

Mount Tambora is an active stratovolcano, also known as a composite volcano, on Sumbawa island, Indonesia. Sumbawa is flanked both to the north and south by oceanic crust, and Tambora was formed by the active subduction zones beneath it. This raised Mount Tambora as high as 4,300 m (14,000 ft), making it one of the tallest peaks in the Indonesian archipelago, and drained off a large magma chamber inside the mountain. It took centuries to refill the magma chamber, its volcanic activity reaching its peak in April 1815.

Tambora erupted in 1815 with a rating of seven on the Volcanic Explosivity Index, making it the largest eruption since the Lake Taupo eruption in AD 181. The explosion was heard on Sumatra Island (more than 2,000 km or 1,200 mi away). Heavy volcanic ash falls were observed as far away as Borneo, Sulawesi, Java and Maluku islands. The death toll was at least 71,000 people (perhaps the most deadly eruption in history), of who 11,000–12,000 were killed directly by the eruption; the often-cited figure of 92,000 people killed is believed to be an overestimate. The eruption created global climate anomalies; 1816 became known as the Year Without a Summer because of the effect on North American and European weather. Agricultural crops failed and livestock died in much of the Northern Hemisphere, resulting in the worst famine of the 19th century.

During an excavation in 2004, a team of archaeologists discovered cultural remains buried by the 1815 eruption. They were kept intact beneath the 3 m (10 ft) deep pyroclastic deposits. At the site, dubbed the Pompeii of the East, the artifacts were preserved in the positions they had occupied in 1815.

The 1815 eruption released sulfur into the stratosphere, causing a global climate anomaly. Different methods have estimated the ejected sulfur mass during the eruption: the petrological method; an optical depth measurement based on anatomical observations; and the polar ice core sulfate concentration method, using cores from Greenland and Antarctica. The figures vary depending on the method, ranging from 10 Tg S to 120 Tg S.

In the spring and summer of 1816, a persistent dry fog was observed in the northeastern U.S. The fog reddened and dimmed the sunlight, such that sunspots were visible to the naked eye. Neither wind nor rainfall dispersed the "fog". It was identified as a stratospheric sulfate aerosol veil. In summer 1816, countries in the Northern Hemisphere suffered extreme weather conditions, dubbed the Year Without a Summer. Average global temperatures decreased about 0.4–0.7 °C (0.7–1.3 °F), enough to cause significant agricultural problems around the globe. On 4 June 1816, frosts were reported in Connecticut, and by the following day, most of New England was gripped by the cold front. On 6 June 1816, snow fell in Albany, New York, and Dennysville, Maine. Such conditions occurred for at least three months and ruined most agricultural crops in North America. Canada experienced extreme cold during that summer. Snow 30 cm (12 in) deep accumulated near Quebec City from 6 to 10 June 1816.

1816 was the second coldest year in the northern hemisphere since AD 1400, after 1601 following the 1600 Huaynaputina eruption in Peru. The 1810s are the coldest decade on record, a result of Tambora's 1815 eruption and other suspected eruptions somewhere between 1809 and 1810 (see sulfate concentration figure from ice core data). The surface temperature anomalies during the summer of 1816, 1817 and 1818 were −0.51, −0.44 and −0.29 °C, respectively. As well as a cooler summer, parts of Europe experienced a stormier winter.

This pattern of climate anomaly has been blamed for the severity of typhus epidemic in southeast Europe and the eastern Mediterranean between 1816 and 1819. Much livestock died in New England during the winter of 1816–1817. Cool temperatures and heavy rains resulted in failed harvests in the United Kingdom of Great Britain and Ireland. Families in Wales traveled long distances as refugees, begging for food. Famine was prevalent in north and southwest Ireland, following the failure of wheat, oat and potato harvests. The crisis was severe in Germany, where food prices rose sharply. Due to the unknown cause of the problems, demonstrations in front of grain markets and bakeries, followed by riots, arson and looting, took place in many European cities. It was the worst famine of the 19th century.

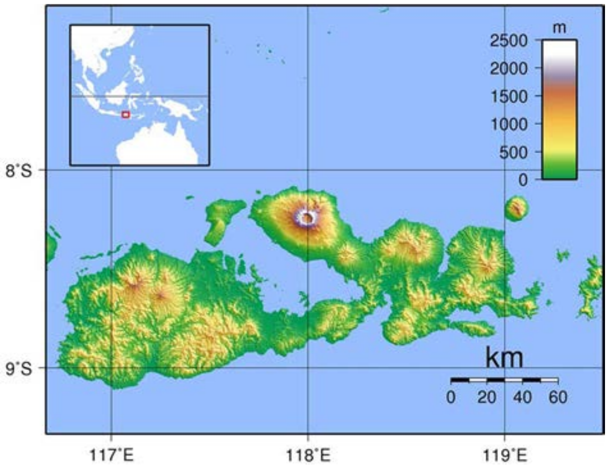

Figure 2: Tambora (north center) on the island of Sumbawa (Indonesia). Map from Wikipedia.

3. KRAKATOA (INDONESIAN: KRAKATAU)

Krakatoa, also spelled Krakatao or Krakatowa, is a volcanic island in the Sunda Strait between Java and Sumatra in Indonesia. The name is used for the island group, the main island (also called Rakata), and the volcano as a whole. It has erupted repeatedly, massively, and with disastrous consequences throughout recorded history. The best known eruption culminated in a series of massive explosions on August 26 - 27, 1883, which was among the most violent volcanic events in modern times. With a Volcanic Explosivity Index of 6, it was equivalent to 200 megatons of TNT — about 13,000 times the yield of the Little Boy bomb (13 to 16 KT) that devastated Hiroshima, Japan.

The 1883 eruption ejected more than 25 cubic kilometres of rock, ash, and pumice, and generated the loudest sound historically reported: the cataclysmic explosion was distinctly heard as far away as Perth in Australia approx. 1,930 miles (3,110 km), and the island of Rodrigues near Mauritius approx. 3,000 miles (5,000 km). Near Krakatoa, according to official records, 165 villages and towns were destroyed and 132 seriously damaged, at least 36,417 (official toll) people died, and many thousands were injured by the eruption, mostly from the tsunamis that followed the explosion.

In the years before the 1883 eruption, seismic activity around the volcano was intense, with some earthquakes felt as far distant as Australia. Beginning 20 May 1883, three months before the final explosion, steam venting began to occur regularly from Perboewatan, the northernmost of the island's three cones. Eruptions of ash reached an altitude of 6 km (20,000 ft) and explosions could be heard in Batavia (Jakarta) 160 km (100 miles) away. Activity died down by the end of May.

The volcano began erupting again around 20 July. The seat of the eruption is believed to have been a new vent or vents which formed between Perboewatan and Danan, more or less where the current volcanic cone of Anak Krakatau is. The violence of the eruption caused tides in the vicinity to be unusually high, and ships at anchor had to be moored with chains as a result. On 11

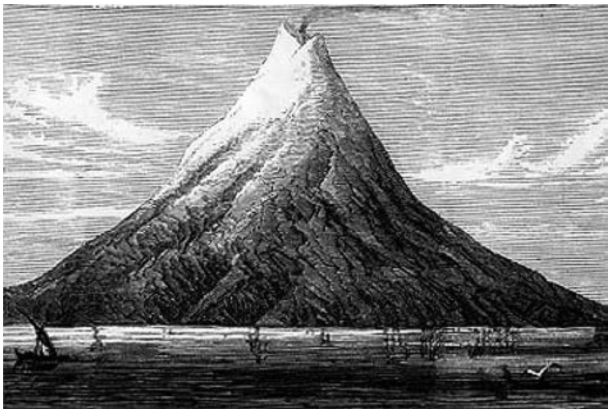

Figure 3: Mt. Karatoa in the years before the explosion. Drawing from Wikipedia.

August larger eruptions began, with ashy plumes being emitted from at least eleven vents. On 24 August, eruptions further intensified. At about 1pm (local time) on 26 August, the volcano went into its paroxysmal phase, and by 2pm observers could see a black cloud of ash 27 km (17 miles) high. At this point, the eruption was virtually continuous and explosions could be heard every ten minutes or so. Ships within 20 km (11 nautical miles) of the volcano reported heavy ash fall, with pieces of hot pumice up to 10 cm in diameter landing on their decks. A small tsunami hit the shores of Java and Sumatra some 40 km (28 miles) away between 6 pm and 7 pm.

Cataclysmic stage

On August 27, the volcano entered the final cataclysmic stage of its eruption. Four enormous explosions took place at 05:30 hrs, 06:42 hrs, 08:20 hrs, and 10:02 hrs, local time. The last explosion was the loudest. Each was accompanied by very large tsunamis, which are believed to have been over 30 meters (100 ft) high in places. A large area of the Sunda Strait and a number of places on the Sumatran coast were affected by pyroclastic flows from the volcano. The explosions were so violent that they were heard 3,500 km away in Perth, Western Australia and the island of Rodrigues near Mauritius, 4,800 km away; the sound of Krakatoa's destruction is the loudest sound in recorded history, reaching levels of 180 dBSPL 100 miles (160 km) away. The pressure wave from the final explosion was recorded on barographs around the world, which continued to register it up to 5 days after the explosion. The recordings show that the shockwave from the final explosion reverberated around the globe 7 times in total. Ash was propelled to a height of 80 km. The eruptions diminished rapidly after that point, and by the morning of August 28 Krakatoa was quiet.

"The Burning Ashes of Ketimbang"

Around noon on August 27, a rain of hot ash fell around Ketimbang in Sumatra. Around a thousand people were killed, the only large number of victims killed by Krakatoa itself, and not the waves or after-effects. Verbeek and later writers believe this unique event was a lateral blast or pyroclastic flow, similar to what happened in 1980 at Mt. St. Helens, which crossed the water. The region of the ashfall ended to the northwest of Ketimbang, where the bulk of Sebesi Island offered protection from any horizontal surges.

The combined effects of pyroclastic flows, volcanic ashes and tsunamis had disastrous results in the region. There were no survivors from 3,000 people located at the island of Sebesi, about 13 km from Krakatoa. Pyroclastic flows killed around 1,000 people at Ketimbang on the coast of Sumatra some 40 km north from Krakatoa. The official death toll recorded by the Dutch authorities was 36,417, although some sources put the estimate at 120,000 or more. Many settlements were destroyed, including Teluk Betung and Ketimbang in Sumatra, and Sirik and Semarang in Java. The areas of Banten on Java and the Lampung on Sumatra were devastated. There are numerous documented reports of groups of human skeletons floating across the Indian Ocean on rafts of volcanic pumice and washing up on the east coast of Africa, up to a year after the eruption. Some land on Java was never repopulated; it reverted to jungle and is now the Ujung Kulon National Park.

Tsunamis and distant effects

Ships as far away as South Africa rocked as tsunamis hit them, and the bodies of victims were found floating in the ocean for weeks after the event. The tsunamis which accompanied the eruption are believed to have been caused by gigantic pyroclastic flows entering the sea; each of the five great explosions was accompanied by a massive pyroclastic flow resulting from the gravitational collapse of the eruption column. This caused several cubic kilometers of material to enter the sea, displacing an equally huge volume of seawater. The town Merak was destroyed by a 46 metre-high tsunami. Some of the pyroclastic flows reached the Sumatran coast as much as 25 miles (40 km) away, having apparently moved across the water on a "cushion" of superheated steam. There are also indications of submarine pyroclastic flows reaching 10 miles (15 km) from the volcano.

Smaller waves were recorded on tidal gauges as far away as the English Channel. These occurred too soon to be remnants of the initial tsunamis, and may have been caused by concussive air waves from the eruption. These air waves circled the globe several times and were still detectable using barographs five days later.

Geographic effects

As a result of the huge amount of material deposited by the volcano, the surrounding ocean floor was drastically altered. It is estimated that as much as 18-21 km³ of ignimbrite was deposited over an area of 1.1 million km², largely filling the 30-40 m deep basin around Krakatoa. The land masses of Verlaten and Lang were increased, and volcanic ash continues to be a significant part of the geological composition of these islands. Poolsche Hoed ("Polish Hat") disappeared. A new rock islet called Bootsmansrots ('Bosun's Rock', a fragment of Danan) was left.

Two nearby sandbanks (called Steers and Calmeyer after the two naval officers who investigated them) were built up into islands by ashfall, but the sea later washed them away. Seawater on hot volcanic deposits on Steers and Calmeyer caused steam which some people mistook for continued eruption.

The fate of Krakatoa itself has been the subject of some dispute among geologists. It was originally proposed that the island had been blown apart by the force of the eruption. However, most of the material deposited by the volcano is clearly magmatic in origin and the caldera formed by the eruption is not extensively filled with deposits from the 1883 eruption. This indicates that the island subsided into an empty magma chamber at the end of the eruption sequence, rather than having been destroyed during the eruptions.

Global climate

In the year following the eruption, average global temperatures fell by as much as 1.2 degrees Celsius. Weather patterns continued to be chaotic for years, and temperatures did not return to normal until 1888. The eruption injected an unusually large amount of sulfur dioxide (SO2) gas high into the stratosphere which was subsequently transported by high-level winds all over the planet. This led to a global increase in sulfurous acid (H2SO3) concentration in high-level cirrus clouds. The resulting increase in cloud reflectivity (or albedo) would reflect more incoming light from the sun than usual, and cool the entire planet until the suspended sulfur fell to the ground as acid precipitation.

Global optical effects

The dramatic skyline in Edvard Munch's The Scream (1893) is thought to be based on the global optical effects caused by the eruption and seen over Oslofjord, Norway. The eruption darkened the sky for days afterwards, and produced spectacular sunsets throughout the world for many months. British artist William Ashcroft made thousands of colour sketches of the red sunsets half-way around the world from Krakatoa in the years after the eruption. In 2004, researchers proposed the idea that the blood-red sky shown in Edvard Munch's famous 1893 painting The Scream is also an accurate depiction of the sky over Norway after the eruption. Munch said: "suddenly the sky turned blood red ... I stood there shaking with fear and felt an endless scream passing through nature." Also, a so called blue moon had been seen for two years as a result of the eruption.

4. MOUNT KATMAI

Mount Katmai is a large stratovolcano (composite volcano) on the Alaska Peninsula in southern Alaska, located within Katmai National Park and Preserve. It is about 6 miles (10 km) in diameter with a central lake-filled caldera about 3 by 2 mi (4.5 by 3 km) in area. The caldera rim reaches a maximum elevation of 6,716 feet (2,047 m). In 1975 the surface of the crater lake was at an elevation of about 4,220 feet (1,286 m), and the estimated elevation of the caldera floor is about 3,400 ft (1,040 m).

On June 6-9, 1912, the most spectacular Alaskan eruption in recorded history and one of the two largest eruptions in the world in the twentieth century (the other being Mt. Pinatubo in 1991) resulted in the formation of a large summit caldera at Katmai volcano. The over 60-hour-long eruption actually took place at a vent about 6 mi (10 km) to the west of Mt. Katmai (now marked by Novarupta dome) from which an estimated 30-35 km^3 of ash flows and tephra were ejected rather than at Mt. Katmai itself. Based on geochemical and structural relationships, it has been suggested that magma drained from beneath Katmai Volcano to Novarupta via the plumbing system beneath Trident Volcano. The withdrawal of magma beneath Katmai resulted in the collapse of the summit area, forming the caldera. Following the subsidence, a small dacitic cinder cone was emplaced on the floor of the caldera; this is the only juvenile material erupted from Katmai caldera during the historical eruption.

Approximately 12-15 km^3 of magma was vented during the 1912 eruption producing about 35 km^3 of tephra. An estimated 11-15 km^3 of ash flow tuff traveled 12 miles (20 km) northwest covering an area of about 120 km^2 in what subsequently came to be known as the Valley of Ten Thousand Smokes. The ash flow tuff produced in the 1912 eruption is made up of a silica-rich volcanic rock called rhyolite. In fact, this is the only major Quaternary eruption of rhyolite to have occurred in Alaska. Maximum thickness of the ashflow is estimated to be about 800 feet (240 m). About 20 km^3 of airfall tephra was carried east and southeast with a minor lobe to the north covering 77,000 km^2 with more than 1 in (2.5 cm) of ash. Light ash fall was reported as far away as the Puget Sound region 1,500 mi (2,400 km) away. Extremely fine ash blown into the stratosphere remained in suspension as aerosols for months and caused spectacular red sunsets in many parts of the world.

Figure 4: Areal picture of Mt. Katmai. Picture from Wikipedia.

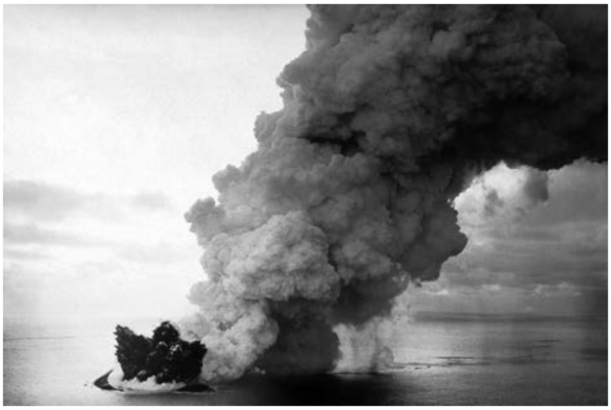

Figure 5: The Surtsey eruption. Photo from Wikipedia.

In 1919, geologists noted a lake covering a large part of the caldera floor, but by 1923 the lake was gone and numerous fumaroles, mud pots, and a large mud geyser had replaced it. The lake has since refilled to a depth of over 800 ft (240 m). Small glaciers have also formed on a bench within the caldera beside the lake.

5. SURTSEY (ICELANDIC: "SURTUR'S ISLAND")

Surtsey is a volcanic island off the southern coast of Iceland. At 63.4° N 20.3° W it is also the southernmost point of Iceland. It was formed in a volcanic eruption which began 130 meters below sea level, and reached the surface on 14 November 1963. The eruption may have started a few days earlier and lasted until 5 June 1967, when the island reached its maximum size of 2.7 km^2. Since then, wind and wave erosion has seen the island steadily diminish in size: As of 2007, its surface area is 1.4 km^2 in size.

The new island was named after the fire god Surtr from Norse mythology, and was intensively studied by volcanologists during its creation and, since the end of the eruption, has been of great interest to botanists and biologists as life has gradually colonised the originally barren island. The undersea vents that produced Surtsey are part of the Vestmannaeyjar (Westmann Isles) submarine volcanic system, part of the fissure of the sea floor called the Mid-Atlantic Ridge. Vestmannaeyjar also produced the famous eruption of Eldfell on the island of Heimaey in 1973. The eruption that created Surtsey also created a few other small islands along this volcanic chain, such as Jólnir and other unnamed peaks. Most of these eroded away fairly quickly.

The explosive phreatomagmatic eruptions caused by the easy access of water to the erupting vents threw rocks up to a kilometre away from the island, and sent ash clouds as high as 10 km up into the atmosphere. The loose pile of unconsolidated tephra would quickly have been washed away had the supply of fresh magma dwindled, and large clouds of dust were often seen blowing away from the island during this stage of the eruption.

By early 1964, though, the continuing eruptions had built the island to such a size that sea water could no longer easily reach the vents, and the volcanic activity became much less explosive. Instead, lava fountains and flows became the main form of activity. These resulted in a hard cap of extremely erosion-resistant rock being laid down on top of much of the loose volcanic pile, which prevented the island being washed away rapidly. Effusive eruptions continued until 1965, by which time the island had a surface area of 2.5 km^2

28 December 1963 saw the onset of submarine activity 2.5 km to the north-east of Surtsey, which formed a ridge 100 m high on the sea floor. This seamount was named Surtla, but never reached sea level. Eruptions at Surtla ended on 6 January 1964, and it has since been eroded from its minimum depth of 23 m to 47 m below sea level.

6. MOUNT ST. HELENS

The 1980 eruption of Mount St. Helens, a volcano located in Washington state, in the United States, was a major volcanic eruption. The eruption was the most significant to occur in the contiguous 48 U.S. states (VEI = 5, 0.3 cu mi, 1.2 km^3 of material erupted), in terms of power and volume of material released, since the 1915 eruption of California's Lassen Peak.

The eruption was preceded by a two-month series of earthquakes and steam-venting episodes, caused by an injection of magma at shallow depth below the mountain that created a huge bulge and a fracture system on Mount St. Helens' north slope.

An earthquake at 8:32 a.m. on May 18, 1980, caused the entire weakened north face to slide away, suddenly exposing the partly molten, gas- and steam-rich rock in the volcano to lower pressure. The rock responded by exploding into a very hot mix of pulverized lava and older rock that sped toward Spirit Lake so fast that it quickly passed the avalanching north face.

The May 18, 1980, event was the most deadly and economically destructive volcanic eruption in the history of the United States. Fifty-seven people were killed and 200 homes, 47 bridges, 15 miles (24 km) of railways and 185 miles (300 km) of highway were destroyed. U.S. President Jimmy Carter surveyed the damage and stated it looked more desolate than a moonscape. A film crew was dropped by helicopter on St. Helens on May 23 to document the destruction. Their compasses, however, span in circles and they quickly became lost. A second eruption occurred the next day (see below), but the crew survived and were rescued two days after that.

In all, St. Helens released an amount of energy equivalent to 27,000 Hiroshima-sized nuclear weapons and ejected more than 1 cubic mile (4 km^3) of material. A quarter of that volume was fresh lava in the form of ash, pumice, and volcanic bombs while the rest was fragmented, older rock. The removal of the north side of the mountain (13% of the cone's volume) reduced St. Helens' height by about 1,313 feet (400 m) and left a crater 1 to 2 miles (2 to 3 km) wide and 2,100 feet (640 m) deep with its north end open in a huge breach.

More than 4 billion board feet (14.6 km^3) of timber was damaged or destroyed, mainly by the lateral blast. At least 25% of the destroyed timber was salvaged after September 1980. Downwind of the volcano, in areas of thick ash accumulation, many agricultural crops, such as wheat, apples, potatoes, and alfalfa, were destroyed. As many as 1,500 elk and 5,000 deer were killed, and an estimated 12 million Chinook and Coho salmon fingerlings died when their hatcheries were destroyed. Another estimated 40,000 young salmon were lost when they swam through turbine blades of hydroelectric generators when reservoir levels were lowered along the Lewis River to accommodate possible mudflows and flood waters.

A volcanic ash column rose high into the atmosphere and deposited ash in 11 U.S. states. At the same time, snow, ice, and several entire glaciers on the mountain melted, forming a series of large lahars (volcanic mudslides) that reached as far as the Columbia River, nearly fifty miles (eighty kilometers) to the south. Less severe outbursts continued into the next day only to be followed by other large but not as destructive eruptions later in 1980.

By the time the ash settled, 57 people (including innkeeper Harry Truman and geologist David A. Johnston; and thousands of animals were dead. Hundreds of square miles were reduced to wasteland, over a billion U.S. dollars in damage had occurred ($2.74 billion in 2007 dollars), and the face of Mount St. Helens was scarred with a huge crater on its north side. At the time of the eruption, the summit of the volcano was owned by the Burlington Northern Railroad, but afterward the land passed to the United States Forest Service. The area was later preserved, as it was, in the Mount St. Helens National Volcanic Monument. As the avalanche and initial pyroclastic flow were still advancing, a huge ash column grew to a height of 12 miles (19 km) above the expanding crater in less than 10 minutes and spewed tephra into the stratosphere for 10 straight hours. Near the volcano, the swirling ash

Figure 6: Erupting Mt. St. Helens. Picture from Wikipedia.

Figure 7: Erupting Mt. Pinatubo. Picture from Wikipedia.

particles in the atmosphere generated lightning, which in turn started many forest fires. During this time, parts of the mushroom-shaped ash-cloud column collapsed, sending additional pyroclastic flows speeding down St. Helens' flanks. Later, slower flows came directly from the new north-facing crater and consisted of glowing pumice bombs and very hot pumiceous ash. Some of these hot flows covered ice or water which flashed to steam, creating craters up to 65 feet (20 m) in diameter and sending ash as much as 6,500 feet (1980 m) into the air.

Strong high-altitude wind carried much of this material east-northeasterly from the volcano at an average speed of about 60 mph (100 km/h). By 9:45 a.m. it had reached Yakima, Washington, 90 miles (145 km) away, and by 11:45 a.m. it was over Spokane, Washington. A total of 4 to 5 inches (100 to 130 mm) of ash fell on Yakima, and areas as far east as Spokane were plunged into darkness by noon where visibility was reduced to 10 feet (3 m) and half an inch (13 mm) of ash fell. Continuing east, St. Helens' ash fell in the western part of Yellowstone National Park by 10:15 p.m. and was seen on the ground in Denver, Colorado, the next day. In time ash fall from this eruption was reported as far away as Minnesota and Oklahoma, and some of the ash drifted around the globe within about 2 weeks.

During the nine hours of vigorous eruptive activity, about 540 million tons of ash fell over an area of more than 22,000 square miles (60,000 km^2). The total volume of the ash before its compaction by rainfall was about 0.3 cubic miles (1.3 km^3). The volume of the uncompacted ash is equivalent to about 0.05 $mile^3$ (208,000,000 m^3) of solid rock, or about 7% of the amount of material that slid off in the debris avalanche. By around 5:30 p.m. on May 18, the vertical ash column declined in stature, but less severe outbursts continued through the night and for several days.

7. MOUNT PINATUBO

Mount Pinatubo is an active stratovolcano located on the island of Luzon in the Philippines, at the intersection of the borders of the provinces of Zambales, Tarlac, and Pampanga. Ancestral Pinatubo was a stratovolcano made of andesite and dacite. Before 1991, the mountain was inconspicuous and heavily eroded. It was covered in dense forest which supported a population of several thousand indigenous people, the Aeta, who had fled to the mountains from the lowlands when the Spanish conquered the Philippines in 1565.

The volcano's eruption in June 1991 produced the second largest terrestrial eruption of the 20th century. The 1991 eruption had a Volcanic Explosivity Index (VEI) of 6, and came some 450-500 years after the volcano's last known eruptive activity (estimated as VEI 5, the level of the 1980 eruption of Mount St. Helens), and some 500-1000 years after previous VEI 6 eruptive activity. Successful predictions of the onset of the climactic eruption led to the evacuation of tens of thousands of people from the surrounding areas, saving many lives, but surrounding areas were severely damaged by pyroclastic flows, ash deposits, and later by lahars caused by rainwater remobilizing earlier volcanic deposits: thousands of houses and other buildings were destroyed.

The effects of the eruption were felt worldwide. It ejected roughly 10 billion metric tons of magma, and 20 million tons of SO2, bringing vast quantities of minerals and metals to the surface environment. It injected large amounts of aerosols into the stratosphere—more than any eruption since that of Krakatoa in 1883. Over the following months, the aerosols formed a global layer of sulfuric acid haze. Global temperatures dropped by about 0.5 °C (0.9 °F), and ozone depletion temporarily increased substantially.

The eruption cloud shortly before the climactic eruption

June 15 saw the onset of the climactic eruption. Large tremors starting at 13:42 saturated all the seismographs at Clark Air Base, and by 14:30 all had been rendered inoperative, mostly by pyroclastic density currents. Intense atmospheric pressure variation was also recorded. On the same day, Typhoon Yunya struck the island, passing about 75 km (50 miles) north of the volcano. The typhoon rains made direct visual observations of the eruption impossible, but measurements showed that ash was ejected to heights of 34 km by the most violent phase of the eruption, which lasted about three hours. Pyroclastic flows poured from the summit, reaching as far as 16 km away from it. Typhoon rains mixed with the ash deposits caused massive lahars.

The ash cloud from the volcano covered an area of some 125,000 km^2 (50,000 mi^2), bringing total darkness to much of central Luzon. Almost all of the island received some ashfall, which formed a heavy, rain-saturated snow-like blanket. Tephra fell over most of the South China Sea and ashfall was recorded as far away as Vietnam, Cambodia and Malaysia.

As the clouds reached Malaysian Borneo, " a haze span over the land, like none had ever witnessed. This haze penetrated every house, every room, and left a millimeter-blanquet of very fine grey ash everywhere (Obong Jau)."

Vast quantities of minerals and metals were brought to the surface. Overall, introduced to the surface environment, was an estimated 800,000 tons of zinc, 600,000 tons of copper, 550,000 tons of chromium, 300,000 tons of nickel, 100,000 tons of lead, 10,000 tons of arsenic, 1000 tons of cadmium, & 800 tons of mercury.

CONCLUSIONS

Estimated duration of cooling		Scale
Laki	2-5 years	global
Tambora	2-5 years	global
Karakatoa	1-3 years	global
Katmai	1-3 years	Northern Hemisphere
Surtsey	1-3 years	Northern Hemisphere
St. Helens	1-3 years	Northern Hemisphere
Pinatubo	2-5 years	global

Dust and gases from major volcanic eruptions can affect world's climate for a number of years, resulting in a temporary cooling, a change of weather patterns that affect harvests in (some) positive and (mostly) negative ways. The toll on human society and nature is frightening. The question, of how many Tambora-style eruption would balance the global warming, remains unanswered. No doubt there will be enormous volcanic eruptions sooner or later on this planet, but it would be unwise to reserve too much hope that such events – catastrophic, random, unpredictable- will solve our man-made problems.

Data source

This article is a selective compilation of data from the following sources:

Smithsonian Institute: http://www.volcano.si.edu

Wikipedia: http://en.wikipedia.org/wiki

Testimony of the Mt. Pinatubo ashfall in Malaysian Borneo

NATIONAL GEOSCIENCE CONFERENCE 2008

1 – 3 June 2008
Impiana Casuarina Hotel
Ipoh, Perak Darul Ridzuan

COLLABORATORS

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Geoconservation
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LAPORAN

PENDAHULUAN

Persidangan Geosains Kebangsaan 2008 telah selamat diadakan pada 2 dan 3 Jun 2008 di Impiana Casuarina Hotel, Ipoh. Tema yang dipilih untuk persidangan kali ini ialah ”Geopemuliharaan, Geopelancongan dan Geobencana” kerana masyarakat kita sekarang ini sangat menitik berat kepada isu-isu yang berkaitan dengan geosains, terutamanya apabila melibatkan pembangunan tenaga, sumber mineral dn pemuliharaan alam sekitar untuk tujuan pelancongan. Ipoh dipilih sebagai tempat persidangan kerana ianya terletak di Lembah Kinta yang sangat terkenal dengan sumber batu kapur untuk pelbagai industri, morfologi karsnya dijaga dan dipromosikan untuk industri pelancongan dan di sini juga banyak bencana yang dikaitkan dengan kewujudan batu kapur. Jadi kawasan Ipoh ini sangat sesuai dengan tema persidangan yang dipilih.

PERASMIAN

Persidangan NGC2008 telah sempurna dirasmikan oleh YAB Ir. Dato’ Haji Mohammad Nizar bin Jamaluddin, Menteri Besar Perak Darul Ridzuan. Selain ucapan perasmian, YAB Menteri Besar juga telah melawat pameran poster yang disediakan oleh peserta NGC2008 dan juga mengadakan sidang akhbar. Majlis Perasmian NGC2008 telah mendapat liputan yang baik daripada pihak media, yang mana beberapa akhbar telah membuat dan menyiarkan laporan dalam pemerbitan mereka. Selain itu, temuramah oleh Y.Bhg Dato Yunus Abdul Razak juga telah disiarkan oleh pihak TV.

KERTASKERJA

Persidangan Geosains Kebangsaan 2008 telah mendapat sambutan yang baik daripada ahli Persatuan Geologi Malaysia. Sebanyak 77 kertaskerja telah diterima dan telah dibahagikan kepada 44 oral presentation dan 33 poster presentaion. Pecahan kertaskerja mengikut bidang-bidang utama geosains adalah seperti berikut:

Bidang Geosains	Oral	Poster	Jumlah
Environmental Geology / Hydrogeology	5	5	10
Engineering Geology / Geohazard	4	4	8
Petrology / Petrography / geochemistry	8	6	14
Sedimentology / Stratigraphy	4	2	6
Tectonics / Structural Geology	4	5	9
Mineral Resources / Economic Geology	7	3	10
Conservation Geology / Geotourism	3	3	6
Geoscience Tools and Techniques	9	5	14
Jumlah	**44**	**33**	**77**

PERBELANJAAN

Terdapat 106 orang peseta yang berbayar. Jumlah perbelanjaan ialah RM21,212.85, manakala jumlah pendapatan ialah RM10,780.00. Ini bermakna lebihan perbelanjaan yang ditanggung oleh Persatuan Geologi Malaysia ialah sebanyak **RM 10,432.85**. Nilai ini hampir menyamai nilai sumbangan yang dipohon daripada Persatuan Geologi Malaysia dalam kertas cadangan menjalankan NGC2008.

SUMBANGAN BUKAN KEWANGAN DARIPADA PIHAK LUAR

Perbelanjaan sebenar menjalankan NGC2008 ini adalah lebih besar daripada belanjawan yang dinyatakan di atas. Selain Petronas yang memberi sumbangan dalam bentuk kewangan, terdapat beberapa pihak telah menyumbang, meminjam atau membayar terus beberapa aktiviti dan barangan untuk persidangan ini. Senarai pihak terlibat dan bentuk sumbangan mereka adalah seperti berikut:

Penyumbang	Jenis Sumbangan
Pejabat Menteri Besar Perak	- Jamuan Makam Malam – 2 Jun 2008
Jabatan Mineral dan Geosains Malaysia	- Jamuan Makam Malam – 1 Jun 2008 - Bas - Kereta 4WD
Pusat Penyelidikan Mineral	- Poster board
Kumpulan Warisan Geologi, Lestari, UKM	- Pen & note pad - Kereta 4WD

LAWATAN

Satu lawatan (Spouses' programme) telah diadakan khusus untuk isteri dan anak-anak peserta NGC2008, iaitu melawat taman tema "The Lost World of Tambun" pada 2 Jun 2008. Seramai 36 orang telah menyertai lawatan ini. Satu lagi lawatan telah dicadangkan pada 1 Jun 2008, tetapi telah dibatalkan disebabkan bilangan peserta yang mendaftar tidak mencukupi. Ini merupakan lawatan ke beberapa tapak geologi menarik di sekitar Lembah Kinta.

PENYATAAN PENUTUP

Jawatankuasa Penganjur NGC2008 mengucapkan berbanyak terima kasih kepada semua pihak yang telah memberi sokongan moral dan segala bantuan kewangan, barangan dan tenaga sehingga Persidangan Geosins Kebangsaan 2008 berjaya diadakan dengan sempurna. Terima kasih khusus ditujukan kepada YAB Ir. Dato' Haji Mohammad Nizar bin Jamaluddin, Menteri Besar Perak Darul Ridzuan kerana sudi merasmikan NGC2008 dan juga atas sumbangan Jamuan Malan Malam di Kediaman Menteri Besar. Terima kasih juga ditujukan kepada pihak Jabatan Mineral dan Geosains Malaysia, Petronas, Pusat Penyelidikan Mineral, Kumpulan Warisan Geologi Malaysia, Lestari UKM, Universiti Teknologi Petronas dan Universiti Malaya atas sumbangan kewangan, material dan tenaga yang telah dicurahkan.

Sekian dilaporkan

Prof. Madya Dr. Kamal Roslan Mohamed
Pengerusi, Persidangan Geosains Kebangsaan 2008

KATA ALUAN DARIPADA MENTERI BESAR PERAK DARUL RIDZUAN

Assalamulalaikum Warahmatullah Hiwabarakatuh dan Salam Sejahtera.

Alhamdulillah, bersyukur kita pada Allah kerana dengan segala limpah kurnianya, kita dapat berkumpul pada majlis perasmian Persidangan Geosains Kebangsaan 2008 ini. Saya mengucapkan terima kasih pada Jawatankuasa Penganjur iaitu Persatuan Geologi Malaysia yang sudi menjemput saya merasmikan persidangan ini.

Kerajaan Negeri amat berbangga atas usaha persatuan untuk berhimpun di Ipoh bagi membincangkan hasil penyelidikan dan masalah berkaitan dengan geosains, bersesuaian dengan latar belakang Perak yang dulunya terkenal sebagai pengeluar bijih timah.

Untuk pengetahuan, Perak juga kaya dengan sumber kekayaan lain seperti lempung kaolin, feldspar, pasir silika dan batu kapur. Kerajaan negeri akan berusaha memastikan sumber semulajadi ini diurus dan dibangunkan secara lestari agar tidak menimbulkan masalah pada alam sekitar.

Perak juga mempunyai lanskap semulajadi yang menarik yang boleh menjadi salah satu daya tarikan pelancongan, seperti lanskap batu kapur di Lembah Kinta yang boleh dipromosikan sepertimana Geopark Langkawi. Ini juga boleh menjadi bahan tarikan pelancongan yang menarik.

Saya juga berharap agar hasil persidangan ini dapat dimanfaatkan sepenuhnya bukan sahaja oleh mereka yang pakar dalam bidang ini tetapi juga masyarakat keseluruhannya. Akhirkata, saya mengucapkan SELAMAT BERSIDANG, semoga membuahkan hasil yang bernas untuk bangsa dan negara.

Sekian, terima kasih.

Y.A.B. DATO' SERI IR. HAJI MOHAMMAD NIZAR JAMALUDDIN
MENTERI BESAR PERAK DARUL RIDZUAN

NGC2008
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KATA ALUAN DARIPADA PRESIDEN PERSATUAN GEOLOGI MALAYSIA

Persidangan Geosains Kebangsaan adalah satu program tahunan Persatuan Geologi Malaysia (GSM). Negeri Perak telah dipilih untuk menjadi tuan rumah bagi 2008 yang merupakan Persidangan kali ke-22. Persidangan telah dan sentiasa berfungsi sebagai forum membolehkan perkongsian ilmu serta maklumat berkaitan geosains di kalangan ahli GSM. Sekalung TAHNIAH dirakamkan kepada Jawatankuasa Penganjur yang diterajui oleh Prof. Madya Dr. Kamal Roslan Mohamed kerana telah berusaha kuat untuk memastikan kejayaan Persidangan.

GSM merasa amat bertuah di atas komitmen YAB Dato' Seri Menteri Besar untuk merasmikan persidangan. Persidangan kali ini adalah istimewa kerana Malaysia dan masyarakat dunia sedang menyambut International Year of Planet Earth 2007-2009 (IYPE). Perishtiharan IYPE oleh Bangsa-Bangsa Bersatu adalah untuk memasti dan menggalakkan penggunaan secara efektif dan meluas maklumat dan pengetahuan berkaitan Sains Bumi ke arah membina masyarakat yang selamat, sihat dan makmur. Sambutan IYPE menekankan kepada penggunaan bahan Bumi secara bijaksana, serta menggalakkan perancangan dan pengurusan yang lebih baik dan mengurangkan risiko kepada penghuninya.

Suatu masa dahulu, bidang geosains di Malaysia cuma dikaitkan dengan aktiviti perlombongan bijih timah. Kemudiannya pengusahahasilan petroleum muncul dan kini fenomena telah berubah apabila pemuliharaan sumber bumi menjadi makin penting. Bilamana geo-pelancungan diperkenal, persepsi masyarakat telah berubah. Banyak tapak-tapak penting geologi telah dikenalpasti, dimajukan dan dibangunkan untuk tujuan pelancongan. Contoh terbaik adalah Geopark Langkawi. Bandaraya Ipoh dan Lembah Kinta juga mempunyai ciri-ciri yang menarik yang mungkin boleh diusahakan untuk dijadikan geopark baru di Malaysia dan GSM akan sentiasa menyokong usaha kearah pengiktirafan sebegini.

GSM ingin merakamkan penghargaan kepada Universiti Kebangsaan Malaysia, Jabatan Mineral dan Geosains Malaysia, Universiti Teknologi Petronas dan Universiti Malaya yang merupakan penganjur bersama Persidangan kali ini. Rakaman yang sama ditujukan kepada semua yang menyumbang kepada kejayaan Persidangan, walau dalam apa bentuk sekalipun.

DATO' YUNUS ABD RAZAK,
PRESIDEN PERSATUAN GEOLOGI MALAYSIA

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KATA ALUAN DARIPADA PENGERUSI JAWATANKUASA PENGANJUR PERSIDANGAN GEOSAINS KEBANGSAAN 2008

Assalamulalaikum dan Salam Sejahtera.

Alhamdulillah, bersyukur kita pada Allah kerana kita dapat berkumpul dalam Majlis Perasmian Persidangan Geosains Kebangsaan 2008 ini. Persidangan kali ini dianjurkan bersama oleh Universiti Kebangsaan Malaysia, Jabatan Mineral dan Geosains Malaysia, Universiti Teknologi Petronas dan Universiti Malaya. Saya ingin merakamkan ucapan terima kasih atas sokongan dan kehadiran semua dalam persidangan kali ini. Setinggi-tinggi penghargaan kepada YAB Menteri Besar Perak kerana sudi merasmikan persidangan ini dan juga kepada Presiden Persatuan Geologi Malaysia selaku Ketua Pengarah Jabatan Mineral Dan Geosains Malaysia atas sokongan penuh yang diberikan. Tahniah juga ditujukan kepada semua ahli Jawatankuasa Penganjur Persidangan dan juga pihak-pihak penaja yang sudi memberi bantuan kewangan yang sangat kami hargai.

Ipoh merupakan sebuah bandaraya yang terletak dan dikelilingi oleh batu kapur yang mempunyai warisan yang sangat tinggi. Gua-gua dan landskap kars telah dijaga dan dipulihara dengan baik dan menjadi tumpuan pelancong. Di sini juga terdapat sumber bumi iaitu batu kapur menjadi satu industri yang penting kepada Perak dan juga Malaysia. Dan Ipoh juga mempunyai masalah semula jadi yang berkait rapat dengan batu kapur. Sesungguhnya pemilihan Ipoh sebagai tempat persidangan kali ini sangat sesuai dengan tema persidangan, iaitu “Geopemuliharaan, Geopelancongan dan Geobencana”.

Jadikanlah persidangan ini sebagai tempat untuk menjalin hubungan baru dan mengukuhkan ikatan sedia ada demi perkembangan ilmu geosains dan keharmonian masyarakat di Malaysia. Harapan saya dan Jawatankuasa Penganjur agar persidangan ini akan berjalan dengan lancar dan kami memohon kemaafan jika ada kekurangan semasa persidangan ini diadakan. Dan akhir sekali, saya ingin mengucapkan selamat bersidang kepada semua.

Sekian, terima kasih.

PROF. MADYA DR KAMAL ROSLAN MOHAMED
PENGERUSI JAWATANKUASA PENGANJUR
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PROGRAMME

Monday, 2 June 2008	
0800 - 0900	Registration
0900 - 1000	**OPENING CEREMONY** Welcoming Address by - Organising Chairman of National Geoscience Conference 2008 - President of Geological Society of Malaysia Officiating Ceremony by - YAB Dato' Seri Ir. Haji Mohammad Nizar bin Jamaluddin, Menteri Besar Perak Darul Ridzuan
1000 – 1100	Poster Session A and Tea Break
1100 - 1130	**Keynote 1:** Prof. Dr Felix Tongkul Sedimentation and accretion of Tertiary sediments in NW Borneo.
Technical Session 1: Sedimentology / Stratigraphy	
1130 - 1150	Some Middle Permian radiolarians from Bukit Yoi, Pokok Sena, Kedah. *- Basir Jasin.*
1150 - 1210	On shallow marine Singa Formation in northwest of Kuah Town, Langkawi, Malaysia. *- Mohd Shafeea Leman & Muhammad Rahmani Hamzah.*
1210 - 1230	Fabric variability within layered Fe-oxide deposits in Mid-Late Miocene sedimentary formations, NW Borneo: Impact on facies architectural interpretations. *- Padmanabhan E. & Franz Kessler.*
1230 - 1400	Lunch / Prayer Break
1400 - 1430	**Keynote 2:** Prof. Dr Azman A. Ghani Geology, geochronology and petrogenesis of the volcanic & plutonic rocks from the islands off southeastern Johor.
Technical Session 2A : Petrology / Petrography / Geochemistry	
1440 - 1500	Geochemical effects of ground basalt application on highly weathered soils in Malaysia. *- Shamshuddin J. & Kapok J. R.*
1500 - 1520	Pengaruh saiz butiran terhadap pengelompokan unsur-unsur major dan surih di dalam sedimen muara Sungai Kelang, Selangor. *- Habibah Hj Jamil & Bonney Basilius.*
1520 - 1540	Kesan proses larut lesap terhadap mikrofabrik tanah volkanik dari Tawau, Sabah. *- Hennie Fitria W., Soehady E. & Baba Musta.*
1540 - 1610	Tea Break
1610 - 1630	Pengelasan batuan siri kalk-alkali Kompleks Benom berdasarkan geokimia: Siri batuan, punca batuan dan sekitaran tektonik. *- Mohd Rozi Umor, Azman Ghani & Hamzah Mohamad.*
1630 – 1650	Occurrence of basaltic dykes from Peninsular Malaysia: Implication to the crustal thickness between Sibumasu and Indochina block of Peninsular Malaysia. *- Azman A. Ghani.*
1650 - 1710	Sifat-sifat fisik dan kimia beberapa jenis tanah terpilih di Selangor. *- Muchlis, Wan Zuhairi WY, Abdul Rahim S, Raihan Taha & Abdul Ghani Rafek.*
1710 - 1730	Sorption experiment and the calculation of retardation factor for soil samples in Kuantan, Pahang Malaysia. *- Fares Yahya Alshaebi, Wan Zuhairi Wan Yaacob & Abdul Rahim Samsudin.*

Technical Session 2B : Mineral Resources / Economic Geology	
1440 - 1500	Mining and the environment: Implications to trade liberalization. *- Azimah Ali.*
1500 - 1520	The undrained behaviour of artificially weakly bonded soils. *- Zulfahmi A.R., Toll, D.G. & Gallipoli, D.*
1520 - 1540	Characterisation and upgrading of granite pegmatite rocks for producing industrial raw materials. *- Osama Twaiq & Kamaruddin Hussin.*
1540 - 1610	Tea Break
1610 - 1630	Uptake of heavy metal by *Melastoma malabathricum* in ultrabasic soil from Kuala Pilah Negeri Sembilan, Malaysia. *- Sahibin Abd.Rahim, Wan Mohd. Razi Idris, Zulfahmi Ali Rahman, Kadderi Md. Desa, Tukimat Lihan & Ng Yet Thing.*
1630 – 1650	EPMA characterisation of the *amang* minerals, monazite and xenotime. *- Teh Guan Hoe, Cheng Kwong Kiong & Jasmi Hafiz.*
1650 - 1710	Sustainability Consumption of Limestone Resource in the State of Perak. *- Selamat Aliman, Ibrahim Komoo & Joy J. Pereira*
1710 - 1730	Mineralogi, variasi kimia dan model perubahan batuan dinding di kawasan Selinsing Gold Mine, Pahang. *- Wan Fuad Wan Hassan, Mohd Basril Iswadi Basori & Ibrahim Abdullah.*
Tuesday, 3 June 2008	
0845 – 0915	**Keynote 3:** Prof. Dr Abdul Ghani Md Rafek Beberapa fikiran tentang penilaian bencana gempa bumi bagi pantai barat Semenanjung Malaysia.
Technical Session 3A : Engineering Geology / Geohazard	
0920 - 0940	Generating mechanism of future tsunami with significant run-ups in the coastal areas of northwest Peninsular Malaysia. *- John Kuna Raj.*
0940 - 1000	Engineering geological study on the slope failure along the Kimanis to Keningau highway, Sabah, Malaysia. *- Rodeano Roslee, Nor Samihah Abdullah Zawawi, Hafvan Eva Mansor & S. Abd Kadir S. Omang.*
1000 - 1020	Penilaian dan pengukuran risiko bencana tanah runtuh untuk rancangan pembangunan di Malaysia. *- Tajul Anuar Jamaluddin.*
1020 - 1100	Poster Session B and Tea Break
Technical Session 3B : Conservation Geology / Geotourism	
0920 - 0940	Geoconservation along the East-West highway, segment W7 Kulim-Baling, Kedah. *- Yuniarti Ulfa, Harith, Z.Z.T.*
0940 - 1000	Geoheritage of the Baliajong River: Potential for geotourism development. *- Joanes Muda & Felix Tongkul.*
1000 - 1020	Sejarah aktiviti pendulangan emas di Semenanjung Malaysia. *- Zakaria Hussain.*
1020 - 1100	Poster Session B and Tea Break
Technical Session 4A : Environmental Geology / Hydrogeology	
1100 - 1120	Kajian kemasinan air bawah tanah di Pulau Tuba, Langkawi. *- Abdul Rahim Samsudin & Khairul Anuar Alang.*
1120 - 1140	Assessment of oil spill vulnerability of southwest Pulau Pinang shoreline. *- Ng T. F., Vijaya V.R., Chow, W.S. & Abdullah Sulaiman.*
1140 - 1200	Short-term sediment yields from small catchment of Sg Anak Bangi, Selangor. *- Mohd Ekhwan Toriman, Mazlin Bin Mokhtar, Othman Karim, Muhammad Barzani Gazim& Raihan Taha.*

1200 - 1220	The high risk of soil erosion in Tasik Chini catchment, Pahang, Malaysia. *- Sujaul Islam Mir, Muhammad Barzani Gasim, Sahibin A Rahim & Mohd Ekhwan Toriman.*
1220 - 1240	The geomorphology and origin of Gua Tempurung. *- Ros Fatihah Muhammad.*
1240 - 1400	Lunch / Prayer Break
Technical Session 4A : Environmental Geology / Hydrogeology	
1100 - 1120	Applications of seismic and resistivity methods on an ex-landfill site for geo-environmental investigations. *- Samsudin Taib & Roslan Hashim.*
1120 - 1140	Simulation of integrated surface-water/groundwater flow for a freshwater wetland in Selangor state, Malaysia. *- Bahaa-Eldin Elwali Abdel-Rahim, Ismail Yusoff, Azmi M. Jafri, Zainuddin Othman & Yagambaram, V.*
1140 - 1200	Use of hydro-geophysical streaming potential (SP) signals in managing the environmental friendly bio-ecological drainage system (BIOECODS™). *- Kamar S. Ariffin, Nik Nur Azza Nik Adik, Mohd Shahrul Saad & Ismail Abustan.*
1200 - 1220	Neutralization of acid mine drainage using calcareous geomaterials : Issues and problems. *- Marcus Jopony, Felix Tongkul & Cyril Jinusie.*
1220 - 1240	Rapid geological mapping system (RGMS) for geological data collection. *- Mohamad Abd Manap, Mustafar Hamzah & Mohammad Firuz, R.*
1240 - 1400	Lunch / Prayer Break
Technical Session 5A : Tectonics / Structural Geology	
1400 - 1420	First look at the Bukit Tinggi earthquakes (November 2007 - February 2008). *- Che Noorliza Lat & Ahmad Tajuddin Ibrahim.*
1420 - 1440	Blasts from the past impacting on peninsular Malaysia. *- Tjia, H.D. & Ros Fathihah Hj Muhammad.*
1440 - 1500	Thrust in the Semanggol Formation, Kuala Ketil, Kedah. *- Zaiton Harun, Basir Jasin, Norshida Mohsin & Azrelawati Azami.*
1500 - 1520	The recent Bukit Tinggi earthquake and its relationship to major structures. *- Mustaffa Kamal Shuib.*
Technical Session 5B : Geoscience Tools and Techniques	
1400 - 1420	Comparative study on inversion of 2D DC resistivity conventional procedures to a newly developed artificial neural network approach. *- Neyamadpour A., Samsudin Taib & Abdullah W.A.T.*
1420 - 1440	Pemetaan potensi tanah runtuh menggunakan faktor penilaian bencana tanah runtuh (LHEF) dengan pendekatan GIS. *- Norbert Simon, Juhari Mat Akhir, Azlikamil Napiah & Tan Han Kee.*
1440 - 1500	Field determination of hydraulic conductivity for a Malaysian residual sedimentary soil. *- Mokhtar Ghani, Ismail Yusoff and Ahmad Farid Abu Bakar*
1500 - 1520	A forgotten shrinkage limit in soil properties: An alternative method. *- Askury Abd Kadir.*
1530 - 1600	CLOSING CEREMONY
1600 - 1700	Tea Break

NGC2008

PERSIDANGAN GEOSAINS KEBANGSAAN 2008
NATIONAL GEOLOGICAL CONFERENCE 2008

1 – 3 June 2008 • Impiana Casuarina Hotel, Ipoh, Perak Darul Ridzuan

NGC2008

PERSIDANGAN GEOSAINS KEBANGSAAN 2008
NATIONAL GEOLOGICAL CONFERENCE 2008

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MALAM ENGINEERING GEOLOGIST MUDA 2008

13 AUGUST 2008, DEPARTMENT OF GEOLOGY, UNIVERSITY OF MALAYA

REPORT

The event "Malam EG Muda 2008" featured 3 speakers, namely Sdr. Ling Nan Lay of JMG, Sdr. Tajul Anuar Jamaludin of UKM, and Sdr. Ng Tham Fatt of UM.

Sdr. Ling presented an interesting case study on the monitoring of slope failure/landslide at G. Pass, one of the largest slope failures, if not the largest, in the country. In addition to site geology, structures, etc., he presented some results of the monitoring of slope movements over the last several years. The question of the nature of the sliding plane appears to be unresolved, and the prediction of the imminent "catastrophic" failure event remains uncertain.

Sdr. Tajul showed numerous examples of debris flow in Malaysia as well as from outside Malaysia. The notable ones in Malaysia are the Genting Highlands debris flow, the Pos Dipang debris flow, and the N-S Highway debris flow near G. Tempurung, all with fatalities.

Admittedly, some of the other examples shown are strictly not debris flow per se, but flow slides/mudslides. Some examples of debris flow mitigation measures to reduce the impacts/damages from debris flows were also presented.

Sdr. Ng discussed the results of a recent research study on the assessment of oil spill vulnerability of coastlines along the SW parts of Penang Island. Various coastline characteristics affect the vulnerability, and they include rock type, soil type, slope, vegetation, etc. Fortunately for Penang Island, there has not been any incident of oil spill in the past.

On behalf of GSM, I thank the speakers for their contributions to the Society's activities.

Tan Boon Kong,
Chairman, W/G on Engineering Geology, Hydrogeology and Environmental Geology

CERAMAH TEKNIK TECHNICAL TALK

DIAMONDS

CALVIN LAU

LAVIN NY, F230, First Floor, 1 Utama Shopping Center

12 August 2008, Department of Geology, University of Malaya

Mr. Calvin Lau is a trained gemologist. He obtained his Graduate Gemologist from the Gemological Institute of America (GIA) at the age of 18, and he subsequently obtained an associate degree in Jewelry Design from the Fashion Institute of Technology (FIT) in New York City.

The talk on diamonds had attracted a large audience of geoscientists and non-geoscientists, and covered by reporters from the English newspaper, The Star. The talk covered topics on the basic 4Cs of diamonds (Carat, Cut, Clarity and Color), on how to read the Rapaport Diamond Report, on the price trend of diamonds and on the investment grade diamonds. After the talk, some samples were shown.

Landfill Site Selection: Principles and Case Study of Qom Province, Iran

Mashalah Khamehchiyan

Associate Professor of Engineering Geology, Tarbiat Modares University, Iran
Head of Iranian Engineering Geology Society (National Group of IAEG)

28 August 2008
Department of Geology, University of Malaya

Abstract : The increasing waste in countries, effects on the environment and ecology. Thus waste management is a major issue through the world. In recent decades the problem of hazardous waste has grown considerably. Hazardous waste is a term used through the world to describe waste which is dangerous or difficult to keep, treat or dispose of, and may contain substances which are corrosive, toxic, reactive, carcinogenic, infectious, irritant or otherwise harmful to human health and also which may toxic to the environment.

Locating a suitable location for a landfill site is becoming a difficult task since elements of the study have to include the environmental impacts of a landfill and also the social, technical, financial and economic factors. Department of Environment of I.R.Iran is responsible to manage construction of landfills for hazardous waste disposal in the country. They requested the Iranian universities to do site selection studies in 30 provinces of Iran. Department of Engineering geology in Tarbiat Modares University has done the job for four provinces.

Proper landfill site selection is fundamental step in waste disposal and the protection of the environment, public health and quality of life. Landfill siting is a difficult and complex process requiring evaluation of many different criteria. This presentation contains a review of criteria for landfill siting and a case study for hazardous waste landfill siting. This work utilized a methodology that comprises two stages: exclusionary analysis and evaluation analysis. First with use of all criteria that are unsuitable for landfill, exclusion area map was prepared and then based on appropriate parameters evaluation map for residual areas was created by using Simple Additive Weight (SAW) method in a GIS environment. This methodology was utilized in the Qom province of Iran, with an area of about 11238km2. Finally 5 areas were proposed in the province for detailed geotechnical and environmental investigations.

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   Tel: 03 89483033 – 1700; Fax: 03 89483044; email: saim@nahrim.gov.my
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7. Wong Chaw Bin, 47, Jalan BU2/1, 47800 Petaling Jaya Selangor
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Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia

Istana Hotel, Kuala Lumpur, Malaysia • 8 – 10 June 2009

GEOSEA 2009

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The Geological Society of Malaysia is organising the Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia (GEOSEA 2009) in Kuala Lumpur on 8 – 10 June 2009 to mark the conclusion of the United Nations International Year of Planet Earth, 2007-2009. The Congress offers an excellent opportunity to exchange scientific and technical information and advancement in geoscience, mineral and energy resources among geoscientists. The GEOSEA Congress is a premier geoscientific event in the region and has been well attended by the geoscientific community world-wide. In addition to countries in Southeast Asia, GEOSEA 2009 is expanded to include participation from East Asia, to establish a new era of regional collaboration among geological institutions.

The technical program of GEOSEA 2009 consists four keynote papers and more than 60 technical papers on geoscience and related aspects of the GEOSEA core region of Southeast Asia as well as East Asia. Other related activities include six side events and a post-congress geological fieldtrip. Please refer to the final circular for details on the programme and list of papers (http://geology.um.edu.my/gsmpublic/geosea/geosea_2009.pdf).

Make a note in your diary and join us in Kuala Lumpur for GEOSEA 2009.

For further information and GEOSEA 2009 circular, please contact:

The Organising Committee, GEOSEA 2009
c/o: Minerals and Geoscience Department Malaysia
20th Floor, Tabung Haji Building, Jalan Tun Razak,
50658 Kuala Lumpur, MALAYSIA
Tel: +603-21611033 Fax: +603-21611036
E-mail: geosea2009@jmg.gov.my

BERITA-BERITA LAIN
OTHER NEWS

OBITUARY

Robert Tate

Was a graduate of Imperial College, University of London. He commenced his career in the Geological Surveys of Nigeria and Ghana, mapping basement rocks and carrying out mineral exploration. He was then appointed State Geologist, Brunei, in 1966 and studied palaeo-environments of the Miocene-Pliocene sequences that are exposed spectacularly along the coast. He also published on Brunei tektites. Subsequently he worked in Afghanistan, Ethiopia, Somalia, Sudan, and China, and was a resident of Hong Kong for several years.

Robert lived two years in Malaysia and in 1996 was awarded an M.Sc. from the University of Malaya for his thesis "The geological evolution of Borneo Island". In 2001, he compiled a CD Rom on the "Geology of Borneo" as well as the first complete regional geological map of Borneo Island.

Between 1991 and 1996 he published papers in the Society Bulletin on the Temburong Formation, cross border correlation with Kalimantan, shear and fault zones and the oldest rocks of Sarawak.

He compiled Bulletin 50 of the Society, which is a Bibliography and Index of Geological Society publications 1994–2004.

He has compiled a 1:1 million geological map of the Malay Peninsula to parallel the Geology of the Malay Peninsula book, to be published in a few months time jointly by the Geological Society of Malaysia and the University of Malaya. Sadly, Robert died in Warrington on the 22nd August 2008 before he could see the map and book published. He had recently reached the age of 70.

Robert lived in Hatton, near Warrington in Cheshire, and made annual visits to Malaysia, Hong Kong and Singapore. He actively participitated in SEAPEX and Geological Society of Malaysia meetings during these visits.

The accompanying photograph was taken by Prof. Lee Chai Peng during a field project in Langkawi, Kedah and Perlis, NW Peninsular Malaysia, held in late October, 2003.

Robert had many friends in the Geology Department and in the Geological Society of Malaysia and his annual visits will be sadly missed.

C.S.Hutchison
15 October, 2008

UPCOMING EVENTS

December 10-12, 2008: Geo-Chiangmai, focusing on new developments in soil & rock engineering, engineering geology & environmental geotechnique, Chiangmai, Thailand. Contact: GT08-Conference Secretariat, CI-PREMIER P/L, 150 Orchard Road #07-14, Orchard Plaza, Singapore 238841. Tel: +65 6733 2922; Fax: +65 6235 3530; email: cipremie@singnet.com.sg)

December 16-17, 2008: Towards Excellence in Science and Technology: 25 Years of Scientific and Technological Progress with COSTAM, Kuala Lumpur Convention Centre, Kuala Lumpur, Malaysia. Contact: COSTAM Secretariat, c/o Pro-Secretariat Management Services S/B, C3A-10, 4th Floor, Lift No. 5, Damansara Intan, No. 1, Jalan SS20/27, 47400 Petaling Jaya, Selangor. Tel: 603 71182062/4; Fax: 603 71182063; email: secretariat@costam.org.my; website: www.costam.org.my

January 5-30, 2009: Computer Assisted Training in Mineral Resources Development. Sponsorship: UNESCO, Division of Ecological & Earth Sciences. Contact: Ecole Nationale Superieure des Mines de Paris, Centre de Geosciences, 35, rue Saint Honore, F 77305 Fontainebleau cedex, France. Tel: 33164694904; Fax: 33164694711; email: claim@geosciences.ensmp.fr

February, 16-21, 2009: International symposium on efficient groundwater – Thailand 2009 (IGS – TH 2009). Contact: Somkid Buapeng, Chairman, International Groundwater Symposium Thailand 2009, 49 Soi 30 Rama VI Road, Phayathai, Bangkok, 10400 Thailand. Tel: +6622993965-6; Fax: + 6622993926; email: igsth2009secretariat@dgr.go.th

February 22-26, 2009: ASEG 09 Brighter Deeper Greener – Geophysics in a Changing Environment, Adelaide, Australia. Contact: email: aeeg09@sapro.com.au; website: www.sapro.com.au/ASEG/home.htm

February 23-26, 2009: International Conference on Implementing Environmental Water Allocations (IEWA), Port Elizabeth, South Africa. Contact: www.wrc.org.za/events_sa.htm#EWA

February 24-27, 2009: 14th Asia Oil Week: Asia Upstream, Orchard Hotel, Singapore. Contact: Global Pacific & Partners, Laan Copes van Cattenburch 60A, 2585 GC, The Hague, The Netherlands. Tel: +31 70 324 6154; Fax: +31 70 324 1741; email: babette@glopac.com or Amanda@glopac.com or gayle@glopac.com

March 2-3, 2009: Petroleum Geology Conference & Exhibition 2009, Kuala Lumpur Convention Centre, Kuala Lumpur, Malaysia. Contact: Organising Chairman, PGCE 2009, Geological Society of Malaysia, c/o Dept. of Geology, University of Malaya, 50603 Kuala Lumpur. Tel: 603 79577016; Fax: 603 79563900; email: geologi@po.jaring.my; website: www.pgcem.com

March 2-6, 2009: Basic Petroleum Geology. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

March 3-4, 2009: 1st Regional Conference on Geo-Disaster Mitigation in ASEAN: Waste Management Regional Conference 2009: Toward Sustainable in GeoEnvironment, GeoHazard and Waste Management, Kuala Lumpur, Malaysia. Contact: The Secretariat, Organising Committee of 1st Regional Conference on Geo-environmental, Geohazard and Waste Management, Engineering and Technology Research Platform, EITD, Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia. Tel: 604 5942148; Fax: 603 5941037; email: hariy@eng.usm.my; wmrc2009@eng.usm.my; kamarshshariffin@gmail.com; website: http://eitd.eng.usm.my/geoenv2009.htm; http://mineral.eng.usm.my/geoenv2009.htm

March 16-20, 2009: Compressional and Transpressional Structural Styles, Houston, USA. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

March 17-20, 2009: Workshop on water recycling via aquifers, Adelaide, Australia. Contact: email: peter.dillon@csiro.au

March 23-27, 2009: AVO, Inversion and Attributes: Principles and Application, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

March 16-20, 2009: Basic Geophysics, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

March 30-April 3, 2009: Basic Drilling Technology, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

April 19-24, 2009: EGU General Assembly 2009, Vienna, Austria. Session NH11.2: Modelling and simulation of dangerous phenomena and innovative techniques for hazard evaluation, mapping, mitigation. Session NH4.14/HS 11.6: Landslide forecasting. Contact: G. Iovine, Tel: +39 0984 835 521; Fax: +39 0984 835 319; email: g.iovine@irpi.cnr.it . Website: www.meetings.copernicus.org/egu2009

May 4-8, 2009: Mapping Subsurface Structures. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

May 5-7, 2009: 33rd IPA Convention and Exhibition, Jakarta Convention Center. Contact: Indonesian Petroleum Association, Indonesia Stock Exchange Building, Tower !!, 20th Floor, Suite 2001, Jl. Jendral Sudirman Kav. 52-53, Jakarta 12190, Indonesia. Tel: +62 (021) 515 5959; Fax: +62 (021) 5140 2545/6; email: tpc@ipa.or.id; website: www.ipa.or.id/33rd-convention/index.asp

May 11-15, 2009: Structural Styles in Petroleum Exploration. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

May 11-15, 2009: Seismic Acquisition Field Techniques – Theory and Practice, London, UK. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

May 13-14, 2009: 3rd International Workshop and Conference on Earth Resources Technology: Stepping towards Sustainable Mining, Metallurgical, and Petroleum Technology Development. Contact: Dr. Tetsuro Yoneda (email: yonet@eng.hokudai.ac.jp) or Dr. Tsutomu Sato (email: tomsato@eng.hokudai.ac.jp); address: Laboratory of Environmental Geology, A6-16, Graduate School of Engineering, Hokkaido University, Kita 13, Nishi 8, Kita-ku, Sapporo 060-8628, Japan. Tel/Fax: (+81) 11 706 6305

June 1-12, 2009: Exploration and Production Process Basics: Understanding the Petroleum Industry Value Cycle. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

June 8-10, 2009: Eleventh Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia, (GEOSEA 2009), Istana Hotel, Kuala Lumpur, Malaysia. Contact: The Organising Committee, GEOSEA 2009, c/o Minerals and Geoscience Department Malaysia, 20th Floor, Tabung Haji Building, Jalan Tun Razak, 50658 Kuala Lumpur. Tel: 603 21611033; 603 21611036; email: geosea2009@jmg.gov.my

June 15-19, 2009: Petroleum Project Management: Principles and Practices. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

June 29-July 3, 2009: Operations Geology, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 13-17, 2009: Development Geology, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 13-17, 2009: 18th IMACS World Congress MODSIM 09, Cairns, Australia: Session
G3: Modelling and Simulation of Dangerous Phenomena, and Innovative Techniques for Hazard Evaluation. Contact: G. Iovine, Tel: +39 0984 835 521; Fax: +39 0984 835 319; email: g.iovine@irpi.cnr.it . Website: www.mssanz.org.au/modsim09/

July 20-24, 2009: Introduction to Seismic Stratigraphy: A Basin Scale Regional Exploration Workshop, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Basic Petroleum Engineering Practices, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Advanced Seismic Stratigraphy: A Sequence-Wavelet Analysis Exploration-Exploitation Workshop, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Basic Reservoir Engineering, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

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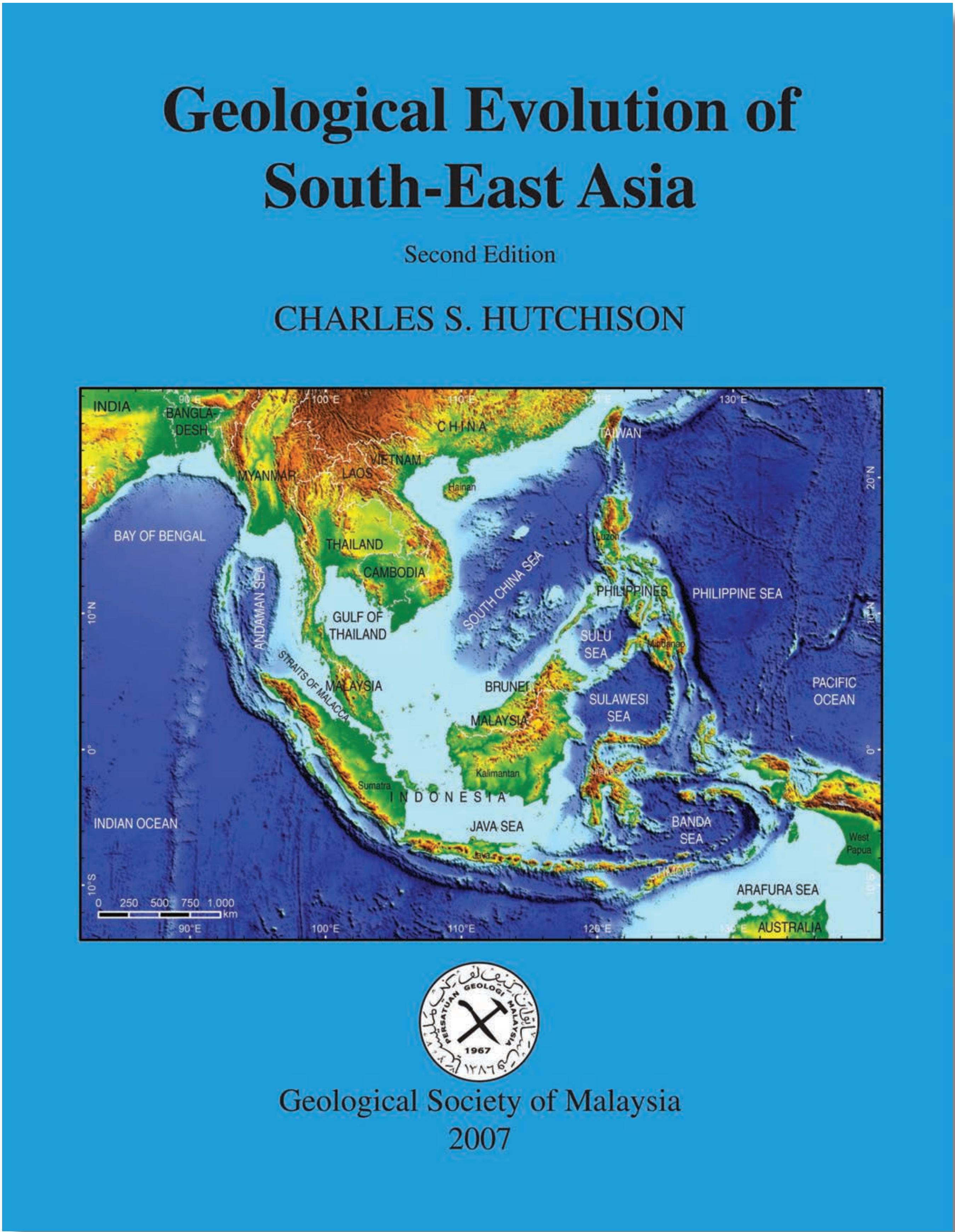
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