PP 2509/2/2004

ISSN 0126-5539

PERSATUAN GEOLOGI MALAYSIA

WARTA GEOLOGI

NEWSLETTER OF THE GEOLOGICAL SOCIETY OF MALAYSIA

Jan – Feb
2003

Jilid 29
No. 1

DIKELUARKAN DWIBULANAN
ISSUED BIMONTHLY

Volume 29
No. 1

PERSATUAN GEOLOGI MALAYSIA
Geological Society of Malaysia

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Published by the Geological Society of Malaysia,
Department of Geology, University of Malaya, 50603 Kuala Lumpur.
Tel: 603-7957 7036 Fax: 603-7956 3900 E-mail: geologi@po.jaring.my

Printed by Art Printing Works Sdn. Bhd., 29 Jalan Riong, 59100 Kuala Lumpur.

CATATAN GEOLOGI
GEOLOGICAL NOTES

The geology and aquifer potential in Peninsular Malaysia

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Abstract: Water management requires the understanding of the sources of this essential resource. Groundwater from geologic strata is an essential source of water. In this article the lithology, to the extent it is specified, is extracted from the geological map to depict the hydrogeological character of the rock types and convey the paucity of explicit lithological characterisation and the need for it.

INTRODUCTION

Water is a resource that is essential for sustaining life. The management of this resource, according to Bennett and Doyle (1997), has three components i.e. resource acquisition, redistribution and water treatment and disposal. Groundwater from the subsurface contained in pore spaces in rock is an essential source of water. This water source is a component in the management of this resource. This article studies this important source of water.

SOURCES OF GROUNDWATER

Geologic strata are saturated at some depth below the land surface. The interface between the saturated and unsaturated section is called the water table. The primary sources of groundwater below the water table are aquifers, which are, saturated permeable geologic strata that yield significant quantities of water under ordinary potential gradients. Other rock units which may serve as sources of groundwater are either aquicludes i.e. saturated geologic strata that are incapable of transmitting significant quantities of water under ordinary potential gradients or aquitards which are saturated geologic strata that is capable of transmitting water under ordinary hydraulic gradients but not in sufficient quantities to allow completion of production wells within them. An aquifer that lies between two aquitards is referred to as a confined aquifer while an aquifer in which the water table forms its upper boundary is called an unconfined aquifer. Perched aquifers may occur above an unconfined aquifer when movement of groundwater downward is impeded by a discontinuous aquiclude or aquitard.

ROCK TYPES AS AQUIFERS

The hydrologic property of a rock type as a source of groundwater supply is important as it determines the hydraulic conductivity. The water bearing strata is mainly of layers of sedimentary rock. An aquiclude is generally formed from materials with very low hydraulic conductivity, such as clay in which surface tension effects hold water. Aquitards can still yield significant groundwater under an abstraction regime designed to stress it slowly. Aquitards contain water in storage for a long time that has reached chemical equilibrium with the matrix. Aquitards, therefore, only release water very slowly. This often means water released from an aquitard is of a lower quality to that from an aquifer.

Other aquifers are unconsolidated sediments. These are deposited material insufficiently compressed for induration into rocks. They are present as a mantle of unconsolidated to semi-consolidated gravel, sand, mud and clay (Stauffer, 1973).

Apart from these the igneous and metamorphic subsurface lithologies are generally impermeable so do not serve as groundwater sources. Price (1996) mentions that these rocks possess little primary porosity down to 1% so hydraulic conductivities are unlikely to exceed 10^{-5} m/day.

ROCK TYPES OF PENINSULAR MALAYSIA

Peninsular Malaysia has a varied geology. Igneous rocks constitute almost half the total surface area in Peninsular Malaysia. These rocks constitute the most common lithology of the mountain ranges of the peninsula forming their topographic highs (GSDM, 1996). Metamorphic rocks of regional and thermal origin are also widespread (GSDM, 1996). The remaining rock type is sedimentary rock. The metamorphic rocks and sedimentary rocks underlie the other half of the surface area.

As mentioned above, aquifers (underground saturated rock capable of transmitting water) are normally found in sedimentary rocks although these rock types may also form aquicludes (rocks with little or no capacity to transmit groundwater) or aquitards (rocks that retard water flow) (Hasan, 1994).

The unconsolidated sediments are Quaternary deposits laid down in an interval of time from the present to about 2.0 million years ago. This short interval of time has not enable the deposited material to be sufficiently compressed for induration into rocks. They are, as mentioned above, present as a mantle of unconsolidated to semi-consolidated gravel, sand, mud and clay. These unconsolidated to semi-consolidated deposits are found along the coast and inland valleys (GSDM, 1996) and overlie the other rock types. They also find localized expression on terraces or as remnants of erosion deposits at higher levels (Stauffer, 1973).

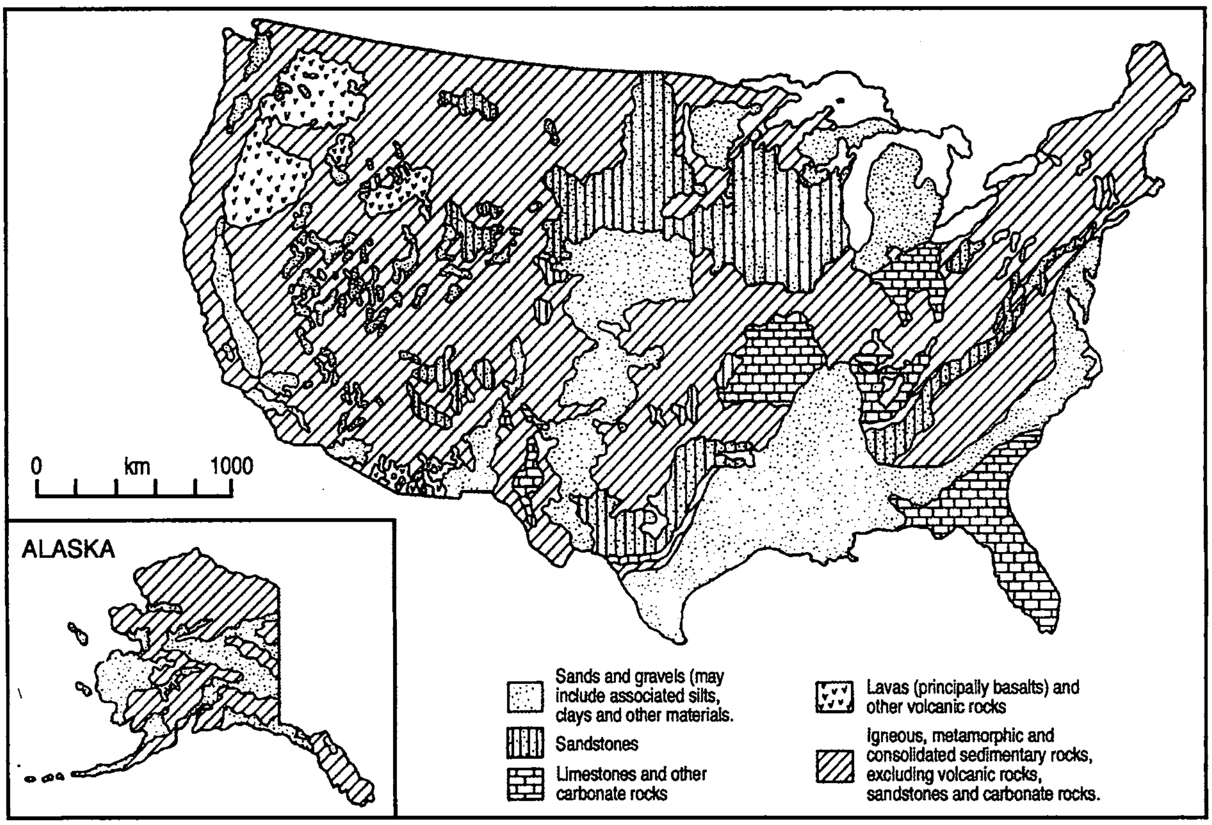

Figure 1. Rock types of continental United States — grouped according to hydrological characteristics (Copyright, R.C. Heath, Journal of Groundwater, All Rights Reserved).

THE GEOLOGIC AQUIFER POTENTIAL

Geological maps usually highlight the stratigraphic i.e. time-rock relationship that focuses on the age, spatial-temporal juxtapositions of rocks and geological events in time. The rocks are grouped together chronologically in geochronological units i.e. the sum total of rocks formed during a specified increment of geological time (Prothero, 1990). The unconsolidated sediments constituting the Quaternary geochrological unit on a geological map denote an interval of time from the present to about 2.0 million years ago (Some maps depict this period as two smaller geochronological units called the Pliestocene and Holocene).

Geological maps, therefore, depict the temporal constitution of an area as well as their spatial distribution. The secondary feature portrayed in geological maps is the rock types but this portrayal is usually partial in nature. The igneous rocks are customarily shown as stand alone units. The depiction of the other two rock types as independent units is variable. These may be shown as independent units or as undifferentiated units.

The geological rock types are the initial indicators of the subsurface aquifer potential as described above. The differentiation of the lithology into the separate rock types is facilitates the evaluation of the potential of the availability of groundwater. This allows for the rock types to be grouped according to their hydrological characteristics. Examples of the United States of America, as illustrated by R.C. Heath, and the United Kingdom by the simplification of geological maps are given in Figures 1 and 2 respectively.

The above two examples were selected as they represented two geological areas of varying aerial extents.

THE GEOLOGIC AQUIFER POTENTIAL IN PENINSULAR MALAYSIA.

Lithological Map

The prerequisite for the identification of groundwater potential requires the differentiation of the geological map into the different rock types. A lithological map shows the distribution of the different types of rocks that enables the potential for the availability to be deduced.

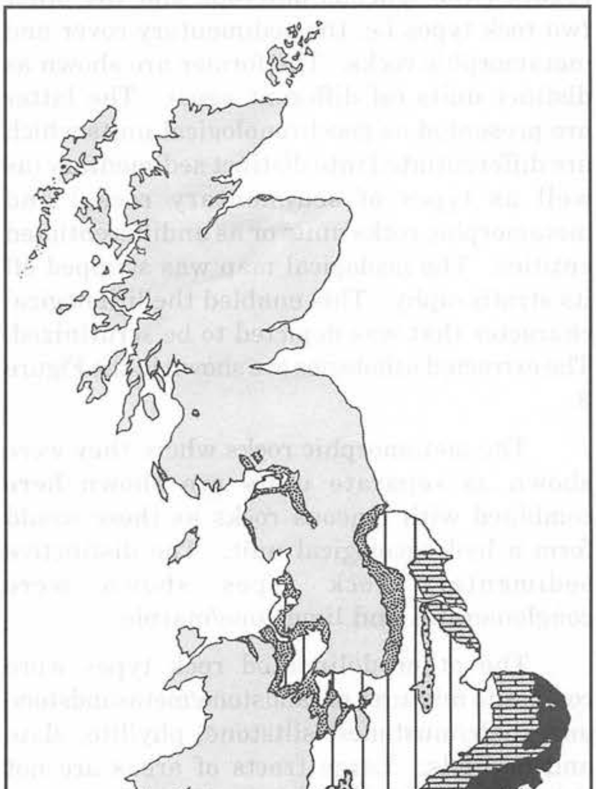

Figure 2. Important rock aquifer groups of the United Kingdom (modified from Price, 1996).

Extraction of a Lithological Map for Peninsular Malaysia

The geological map of Peninsular Malaysia depicts the various stratigraphic units. Lithologically, the major apportionment is between the igneous outcrops and the other two rock types i.e. the sedimentary cover and metamorphic rocks. The former are shown as distinct units (of different ages). The latter are presented as geochronological units which are differentiated into distinct sedimentary (as well as types of sedimentary rocks) and metamorphic rocks units or as undifferentiated entities. The geological map was stripped off its stratigraphy. This enabled the lithological character that was depicted to be scrutinized. The extracted lithologies are shown in the Figure 3.

The metamorphic rocks where they were shown as separate units are shown here combined with igneous rocks as these would form a hydrogeological unit. The distinctive sedimentary rock types shown were conglomerates and limestone/marble.

The other delineated rock types were composite mixtures of sandstone/metasandstone and shale/mustones, siltstone, phyllite, slate and hornfels. Large tracts of areas are not lithologically demarcated. The tracts are undifferentiated but the composite lithology mentioned in the legend to the map lists some lithological units that may have potential importance as aquifers.

Composite Compositions and Undifferentiated Tracts

The lithologies of these need to be further demarcated to exhibit the main lithologies occupying these areas. The minor outcrops may be omitted to obtain a simplified geological map as in Figures 1 and 2. The minor outcrops of aquifer potential may be of local importance.

HYDROGEOLOGICAL UNITS

The various types of hydrological units as a function of their aquifer potential that may be characterized may be the following:

1. Igneous and Metamorphic Unit
2. Sedimentary Units
   (a) Conglomerates
   (b) Limestone/Marble
3. Composite Sedimentary and Metamorphic Units
   (a) Sandstones/Metasandstones
   (b) Shale/Mustone/Siltstone/Phyllite/Slate/Hornfels
4. Quaternary Unit
5. Undifferentiated Unit

The spatial lithological extent and distribution of the different hydrological units show that they are interspersed as well as dispersed (Fig. 3). Vast tracks of consanguineous areas cannot be demarcated as hydrogeological units except for the igneous and metamorphic unit and quaternary unit. It is discernible, however, that most of these units stretched in a north south direction. The surface area occupied by the various hydrological units is given in Table 1 and a comparison is made in Figure 4 of the relative proportions of the surface area occupied by each.

The above analysis shows that proportionally a much smaller surface area is constituted from the lithologies with a clear potential for accommodating groundwater. In addition these potential areas are not spatially large in any one area. It is imperative to determine the predominant nature of the undifferentiated lithology to assess its potentiality as well as the degree of metamorphism present in the sandstone.

CONCLUSION

The portrayal of the lithological disposition of the hydrogeological propensity in the peninsula based on the geological map (GDSM, 1996) has been attempted to the extent that the lithology is shown on the said geological map. This to a certain degree shows the potential and distribution of the different rock types as sources of groundwater. For a more exact appreciation of the groundwater resources of the peninsula the resolution of the composite lithologies and undifferentiated tracts is necessary.

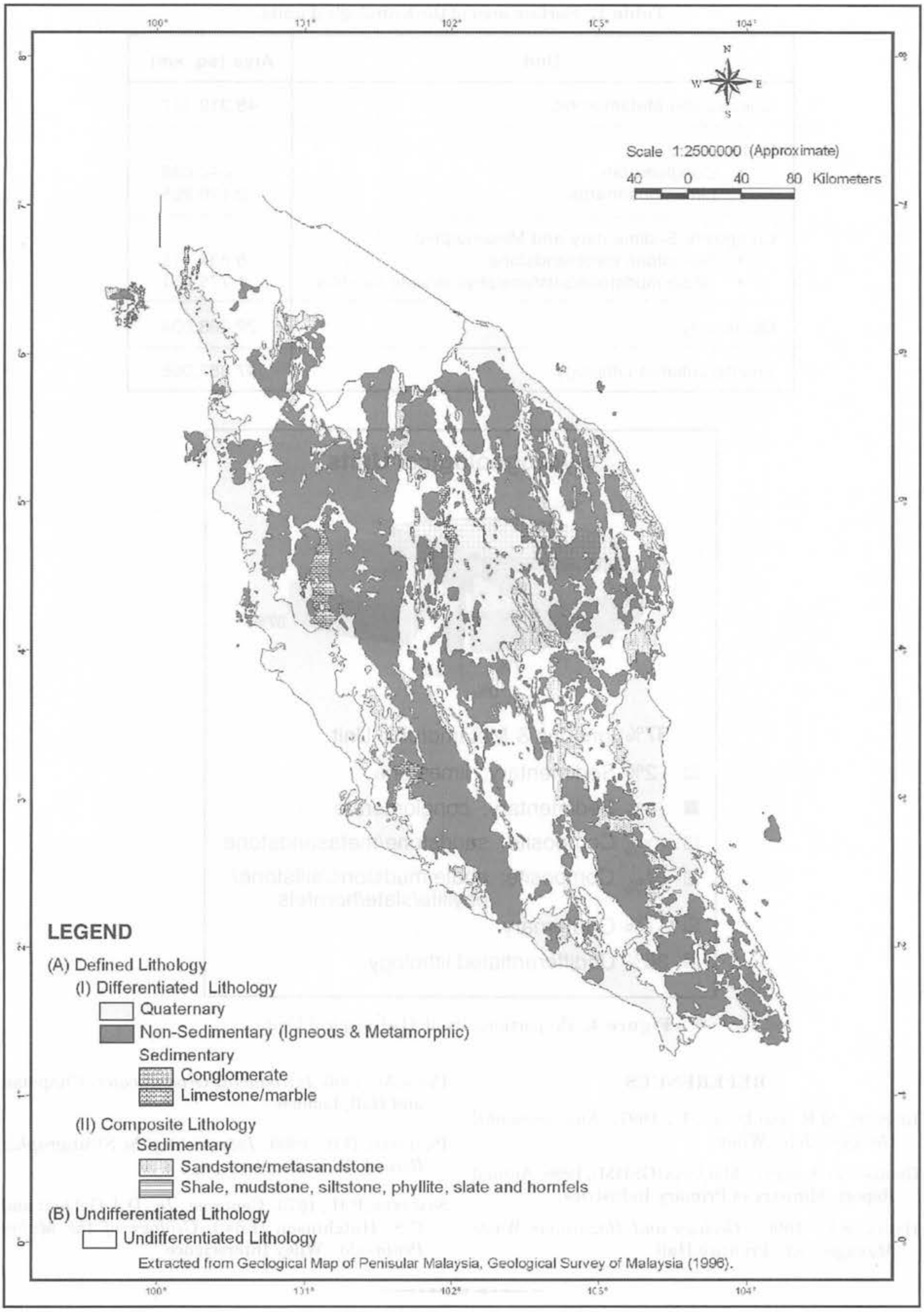

Figure 3. Map of Peninsular Malaysia showing the lithology (from Geological Survey of Malaysia, 1996).

Table 1. Surface area of the hydrological units.

Unit	Area (sq. km)
Igneous and Metamorphic	48,319,327
Sedimentary	
• Conglomerate	640,088
• Limestone/marble	2,126,255
Composite Sedimentary and Metamorphic	
• Sandstone/metasandstone	8,834,115
• Shale/mudstone/siltstone/phyllite/slate/hornfels	1,775,451
Quaternary	22,383,004
Undifferentiated Lithology	47,883,066

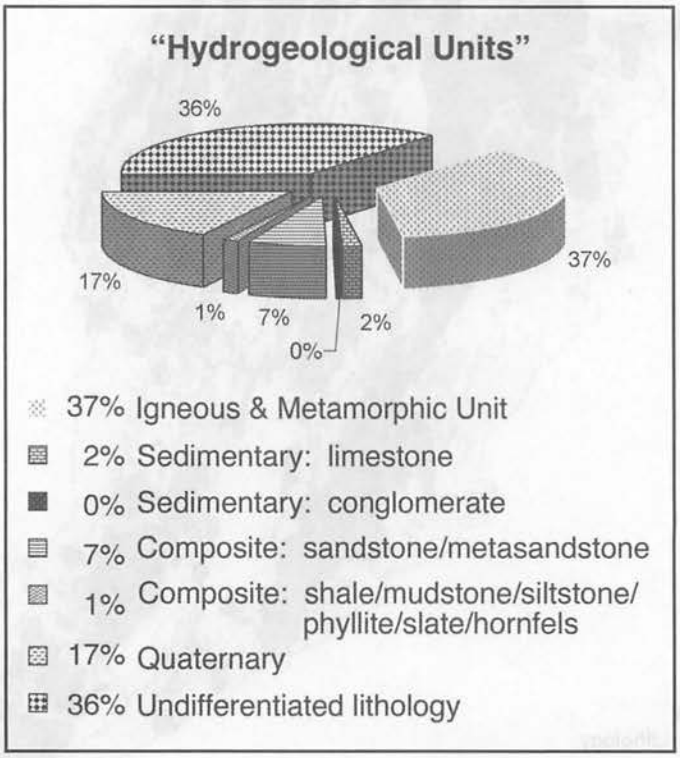

Figure 4. Proportionality of 'Hydrological Units'.

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Manuscript received 10 May 2002

CATATAN GEOLOGI
GEOLOGICAL NOTES

Soils suitability for landfill liner material: a case study from South Wales, United Kingdom

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Abstract: Physical and chemical properties greatly influence the suitability of a soil to be used as engineered clay liner in landfills. The physical properties of a soil affect its capability to be compacted to achieve a minimum requirement of hydraulic conductivity of $1x10^{-9}$ m/sec. Meanwhile, the chemical properties of a soil can influence the natural attenuation of contaminants by the soil via various chemical reactions; i.e. ionic exchange, precipitation, complexation, and adsorption. Soils with high clay contents are capable of being compacted to densities and permeabilities consistent with the function as a liner. Clay content influences plasticity, natural moisture content and permeability of soils. It also affects several chemical parameters of the soils such as the Cation Exchange Capacity (CEC) and Specific Surface Area (SSA). Soils with high pH, high carbonates, organics, amorphous oxides/hydroxides and high CEC/SSA values are capable of functioning as liner materials and possess high natural attenuation capabilities. Finally, the prediction on the suitability of the candidate soils to function as landfill liner material can be successfully made by investigating their physical and chemical properties.

INTRODUCTION

Compacted soils have been utilised as an engineered liner under landfill sites to impede the migration of very polluted leachate into the environment. Natural soils react physically to leachate by retarding flow and chemically by contaminant sorption processes to attenuate the contaminants. The ability of clay soils to function as landfill liner is greatly influenced by their physical and chemical properties. The main objective of this paper is to discuss how physical and chemical parameters affect the suitability of clay soils to function effectively as engineered landfill liner.

Murray (1998) stated that it is usual to specify the use of clay with suitable material characteristics as defined by its plasticity, material variability and clay content. Benson *et al.* (1994) estimated the hydraulic conductivity based on the minimum values of basic soil properties and compaction conditions. They also stated that the soil properties are often correlated and thus, satisfying one criterion may also satisfy the other criteria.

MATERIALS AND METHODS

Twenty-nine soil samples were collected from landfill sites in South Wales, United Kingdom, namely weathered mudrocks (MR1–MR4) and glacial till (GT1–GT5) from Aberdare; glacial till from Swansea (SGT1–SGT5); and estuarine alluvial soils from Neath (NEA1–NEA5), Newport (PEA1–PEA5) and Cardiff (CEA1–CEA5). The samples were subjected to various physical and chemical tests such as particle size distribution, Atterberg limits and permeability test (falling head test). The physical tests were carried out in accordance with the British Standard BS 1377 (1990).

Meanwhile, chemical test procedures that were used in the study were adopted from the Laboratory Manual of the Geotechnical Research Centre of McGill University, Montreal, Canada. Thus for example, Specific Surface Area (SSA) was determined using Ethylene Glycol Monoethyl Ether (EGME) based on the method by Carter *et al.* (1965). Amorphous contents (Si, Al, Fe oxides/hydroxides) were determined using the method reported by Segalen *et al.* (1968), and carbonate contents were determined using the titration method suggested by Hesse (1972).

Cation Exchange Capacity (CEC) was determined using the method from ASTM D4319 (1984) with ammonium acetate at pH 7.0. Species and concentrations of all cations were analysed using Atomic Absorption Spectrometer (AAS). Clay mineralogy was determined from X-Ray Diffraction technique.

RESULTS AND DISCUSSIONS

Physical properties

Physical properties influence the hydraulic conductivity performance of the liner. The soil needs to be compacted to reach minimum requirement of about $1x10^{-9}$ m/sec. The acceptance criteria for the soil material for landfill liner should meet the following (DOE, 1995; CIRIA, 1996; Murray, 1992; NRA, 1992):-

(i) Permeability of $1x10^{-9}$ m/sec
(ii) Minimum clay content of 10%
(iii) Liquid limit not greater than 90%
(iv) Plasticity index not greater than 65%

Permeability

The permeability values for all soils tested are depicted in Table 1. These values complied with the minimum requirement value for compacted clay liner as stated above. The permeability results indicated that estuarine alluvial soils (NEA, PEA and CEA) possess lower values compared to other soils (MR, GT and SGT). This is mainly due to the different percentages of finer materials in both groups of soils; where estuarine alluvial samples have high percentages of clay compared to others. This argument is in accord with Benson *et al.* (1992); where they stated that clay size particles fill the voids between the coarse particles, therefore reducing the size of the pores controlling flow and decreasing the permeability values.

Table 1. The range of permeability values in all soil samples.

Soil samples	Hydraulic conductivity ($x10^{-10}$ m/sec)
MR1–MR4	2.4–7.0
GT1–GT5	2.0–17.3
SGT1–SGT5	2.7–11.6
NEA1–NEA4	1.0–2.5
PEA1–PEA5	0.6–2.6
CEA1–CEA5	1.8–2.2

Particle Size Distribution

In general terms, materials with high clay contents or high silt/clay contents will have a lower permeability. Soils that contain high percentage of gravel should not be used as liner materials. Clay is an important component in candidate soil liner and it is essential that the clay content is sufficient to achieve the required permeability values. Table 2 shows the percentage of gravel, sand, silt and clay in all soil samples. It shows very clearly that estuarine alluvial soils (EA) contain high percentages of silt and clay compared to soils of weathered mudrocks (MR) and glacial till (GT).

According to NRA (1992), a candidate soil for liner must possess at least 10% of clay fractions. From Table 2, one can say that all soil samples are suitable for use in engineered liner; however estuarine alluvial soils are even more suitable due to an absence of coarse particles, i.e. gravel and sand. Soils with high gravel contents would have higher permeability values; and this is in accord with the argument made by Benson *et al.* (1994) where permeability values increase with the increasing contents of gravel and sand.

Figure 1 and 2 show the correlation between the permeability values against clay and sand

Table 2. Particle size distribution of soil samples.

Soil samples	Gravel %	Sand %	Silt %	Clay %
MR1–MR4	43–49	19–22	9–23	15–21
GT1–GT5	19–26	27–41	17–36	11–30
SGT2–SGT5	24–40	31–37	13–25	9–16
NEA1–NEA4	0–1	5–8	42–49	45–50
PEA1–PEA5	0	2–4	37–46	52–61
CEA1–CEA5	0	0–2	41–50	49–59

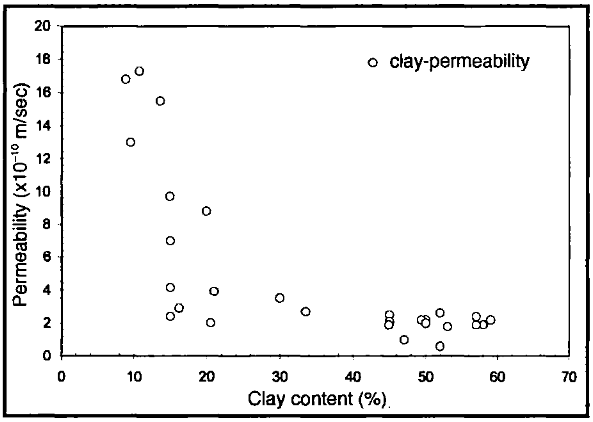

Figure 1. The relationship between the permeability with clay contents for all soil samples used in this study.

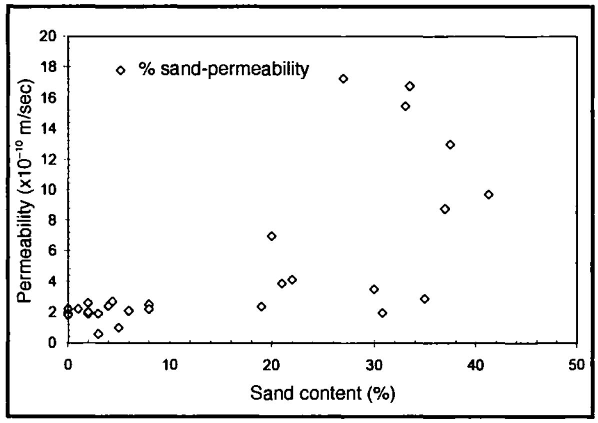

Figure 2. The relationship between the permeability with sand contents for all soils.

contents in all soil samples. Permeability values decreased with clay contents as depicted in Figure 1. Meanwhile in Figure 2, the permeability values increased when the content of sand increased.

Atterberg Limits

The results of Liquid Limit (LL), Plasticity Index (PI), soil classification and clay activity are presented in Table 3. The LL and PI values are best presented using plasticity chart, as depicted in Figure 3. According to Murray *et al.* (1992), materials which are plotted below the A-line are defined as unsuitable; i.e. materials with greater permeability. Soils that plot above the A-line are deemed suitable or marginal. Based on Figure 3, all soil samples are located very close to the A-line.

Sample MR, PEA, and CEA were categorised as suitable while sample SGT and GT were classified as marginal, and NEA was located below the A-line inside the unsuitable area. Due to the fact that all samples were plotted very close to the A-line, these materials were considered acceptable to be used as engineered liner material. Activity is an index of the surface activity of the clay fractions. All estuarine alluvial samples (NEA, PEA, CEA) were classified as inactive clays with an activity of less than 0.75. Other soil samples namely, MR, GT, and SGT were classified as inactive-normal with broad range of activity values from 0.4–1.0. According to Benson *et al.* (1994), a minimum activity of 0.3 is a lower limit to achieve the minimum permeability of less than $1x10^{-9}$ m/sec. Permeability would decrease with the increase in activity. All samples as depicted in Table 3 show an activity larger than 0.3; therefore, capable of achieving the minimum permeability required for the landfill liner material.

Table 3. The classification of soil samples based on Atterberg limit values and the clay activities.

Soil samples	LL (%)	PI (%)	Class	Activity (PI/Clay)
MR1–MR4	31–32	12–13	CL	0.6–0.9
GT1–GT5	27–36	10–14	CI-CL	0.4–1.0
SGT1–SGT5	20–38	7–20	ML-CL	0.6–0.8
NEA1–NEA5	30–70	11–33	ML-MV	0.6–0.7
PEA1–PEA5	51–75	27–38	MV-CH	0.5–0.7
CEA1–CEA5	46–55	23–30	CL	0.4–0.5

Table 4. Average values of the chemical properties of the five types of soils used in this study.

Properties	MR1	GT1	NEA4	PEA3	CEA3
pH (1:10 ratio)	7.4	7.78	7.93	8.72	8.62
Carbonates (%)	1	2.5	3	16.5	18
Amorphous oxides/hydroxides (%)	9.6	10.8	9.9	13.4	8.5
Organic (%)	2.32	2.77	5.11	3.78	3.63
SSA (m^2/g)	46.38	69.87	73.34	74.97	66.62
CEC (meq/100 g)	11.89	23.92	14.84	39.43	38.5
Clay mineralogy*	K > I > C	K > I ~ C	I ~ C > K	I ~ C > K	I ~ C > K

SSA = specific surface area; CEC = cation exchange capacity; K = Kaolinite; I = Illite; C = Chlorite
(*the estimation of mineral abundances is based on CEC and SSA values)

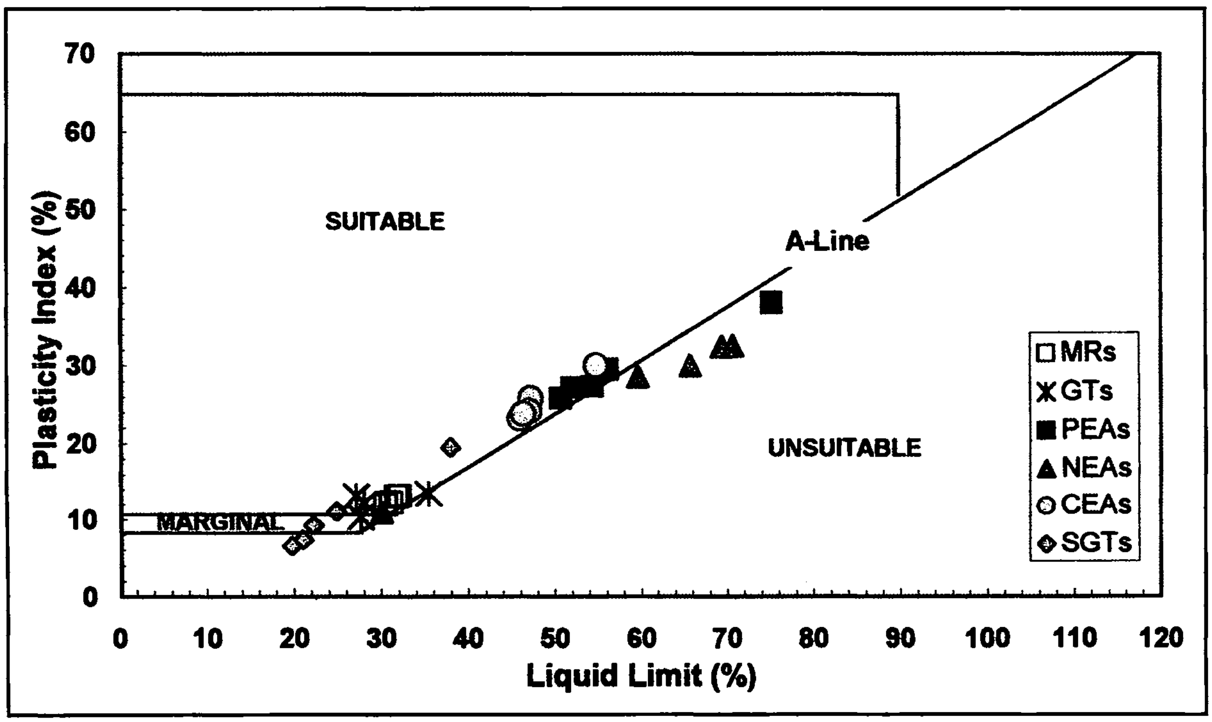

Figure 3. Material suitability illustrated on the plasticity chart for soil samples from South Wales.

Chemical Properties

The chemical properties influence the attenuation capability of the soil to attenuate the movement of the contaminants. Chemical properties such as pH of the soils, cation exchange capacity (CEC), specific surface area (SSA), carbonate contents, organic contents, amorphous oxides hydroxides and clay mineralogy are important factors in the attenuation of the inorganic pollutant in leachate. All of these chemical properties influence the attenuation of pollutants via ionic exchange, adsorption, complexation and precipitation. Thus, high composition of these soil solids may increase the capability for pollutants retention.

Table 4 shows the average values of chemical properties for the five soil types. Note that sample NEA, PEA, and CEA possess high soil pH, high carbonates, high organic contents and high CEC-SSA values compared to sample MR and GT. Samples that contain high values of these chemical properties may influence the capability of the soil to attenuate the pollutants via various retention mechanisms. Therefore, estuarine alluvial soils have better potentials in attenuating the contaminants in leachate compared to the other soils (MR and GT).

This is in accord with a finding by Bright *et al.* (1996) who stated that the maximum attenuation by clay soils could be achieved by high clay content, organic carbon content, and carbonate content. Anderson and Christensen (1988) stated the same whereby clay content, organic matter and hydrous Fe and Mn oxides provide most of the high energy binding sites for metal sorption.

Correlation between physical and chemical properties

There is a close relationship between the physical and chemical properties of the clay soils. Generalised relationship can be expected between

the plasticity, the chemistry of the clay particles and permeability. The more plastic the clay, the greater the CEC and SSA (Fig. 4) and the less the permeability. Clay that contains mainly kaolinite (samples MR and GT in Table 4) is of relatively low plasticity, CEC and SSA, and has a higher permeability than the clay soil comprising illite (main composition in samples NEA, PEA and CEA; Table 4).

Particle size is an important factor that influences the retention of heavy metals (Cope *et al.*, 1983). The effects of clay contents on the retention of heavy metals are: (i) clay has high SSA that provides large particle surfaces for chemical, physical and biological activity and increase the opportunity for pollutant interaction, (ii) greater surface area (SSA) enhances the chemical reactions such as ionic exchange, adsorption and precipitation, (iii) high clay content is associated with low hydraulic conductivity, (iv) permeability is controlled by SSA and clay content, and finally (v) buffering capacity of the soil is favoured by finer clay rather than coarser textured soil.

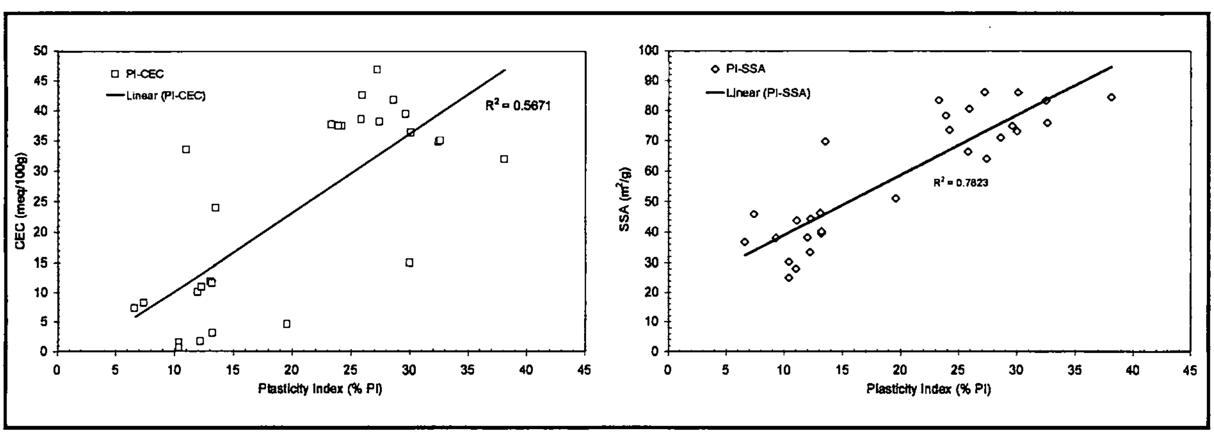

Figure 4. The correlation between the plasticity of the soil samples with the cation exchange capacity (CEC) and specific surface area (SSA).

The soils in the current study show that clay content increases the value of SSA and CEC values (Fig. 5). This is true due to (i) clay particles which are very fine (< 2 mm) have very large specific surface area and (ii) high clay contents can produce higher negatively charged surfaces (i.e. clay particles carry net negative charge primarily caused by isomorphous substitution). The negative charge is balanced by exchangeable cations, which lead to the retention of metal cations (i.e. cation exchange mechanism). There is also a linear relationship between the clay content and the amount of carbonates and organic matter in the soils investigated.

CONCLUSION

From the study, there are four important physical properties that affect the selection of liner material:

(i) Atterberg limits (12% < PI < 65% and 20% < LL < 90%)
(ii) clay contents (%Clay >10%)
(iii) gravel contents (%Gravel <30%)
(iv) hydraulic conductivity (< 1.0×10^{-9} m/s).

All candidate soils must be thoroughly investigated and tested to fully comply with the minimum physical requirements as suggested above. This is important in order to achieve a very competent liner material that will protect the natural environment (e.g. groundwater system) from polluted leachate.

Chemical properties of the clay soils which may affect the natural attenuation capability need to be quantified. The chemical properties that greatly influence the retention capability of the soils are (i) pH of the natural soils, (ii) cation exchange capacity of the soils, (iii) specific surface area, (iv) clay mineralogy of the clay soils, and (v) carbonate, organic matter and amorphous oxides/hydroxides contents. All materials tested display permeability values well below the 1.0×10^{-9} m/sec threshold. However, estuarine alluvial soils (NEA4, PEA3 and CEA3) are preferable to weathered mudrock (MR1) and glacial till (GT1), based on: (i) its capability to be compacted to achieve lower permeability and, (ii) effective attenuation of contaminant leachate as suggested by the chemical properties of the soils.

Estuarine alluvial soils from Cardiff, Neath and Newport are therefore better candidates to function as landfill liner compared to soils from weathered mudrocks and glacial till in the Aberdare area. The weathered mudrock should be eliminated, but glacial till could still be used, though it must be sieved prior to usage to remove all the coarse materials and large pebbles. Estuarine alluvial soils from Neath, Newport and Cardiff are highly recommended for use as landfill liner materials.

ACKNOWLEDGEMENT

We would like to acknowledge Prof. R.N. Yong for his contribution and assistance. The first author conveys special thanks to Dr. Steve Bentley and Dr. Charles Harris for their great supervision and advice and acknowledges

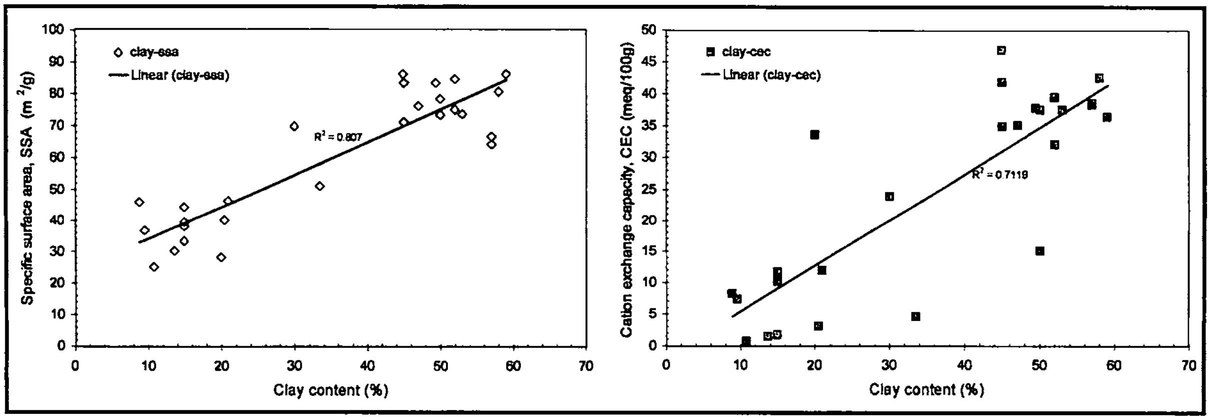

Figure 5. Linear correlation between the clay content with cation exchange capacity (CEC) and specific surface area (SSA).

Universiti Kebangsaan Malaysia for financial support to undertake this research.

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Manuscript received 27 August 2002

PERTEMUAN PERSATUAN
MEETINGS OF THE SOCIETY

Ceramah Teknik (Technical Talk)

Chairman's Lecture III

Saturday, 22nd February 2003
Geology Programme
Universiti Kebangsaan Malaysia

Technique and roles of geophysics in unravelling subsurface structures and information of the earth

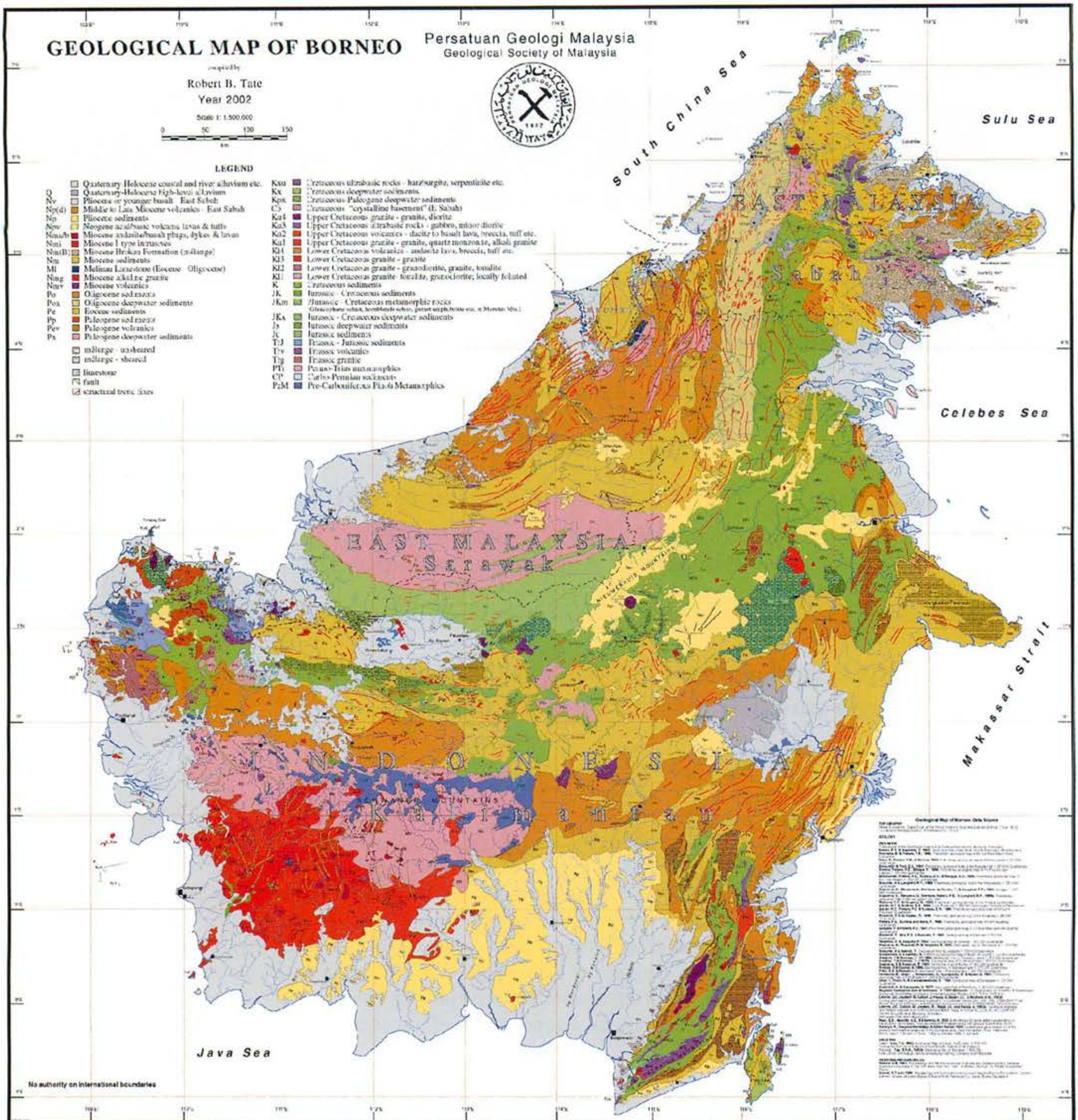
ABDUL RAHIM SAMSUDIN

Laporan (Report)

Prof. Dr. Abdul Rahim Samsudin, Head of Geology Programme, School of Environment & Natural Resource Science, Universiti Kebangsaan Malaysia, Bangi, Selangor, and currently Chairman of GSM Geophysical Working Group, gave the above talk on Saturday 22nd February 2003 at 11.00 am at Geology Programme, Universiti Kebangsaan Malaysia. The talk was organised by the Geophysical Working Group of the Geological Society of Malaysia in collaboration with the Geology Programme of Universiti Kebangsaan Malaysia and was attended by a mixed crowd of Society members and postgraduate and undergraduate students of Universiti Kebangsaan Malaysia (~ 40 participants). There was a good round of questions and lively discussions after the presentation.

Abstrak (Abstract)

Geophysics is a branch of earth science which uses principles of physics to study the interior of the earth. This field of science has developed for several decades and has become an important technological tool to unravel the earth's internal structures in order for geologists to either credit or discredit the global tectonic theory of the earth. By measuring different physical properties of the earth material, geophysicists have successfully mapped subsurface structures deep enough to enable exploitation of hydrocarbon resources which are the lifeline of the modern industrial nations in the world. The rapid development of electronically based geophysical field equipment assisted with microcomputer data processing technology have increased the efficiency and cost effectiveness of the geophysical techniques, especially in exploration of natural resources as well as resolving many geotechnical and geoenvironmental problems. There is great potential for this technology to be used for archaeological investigation.



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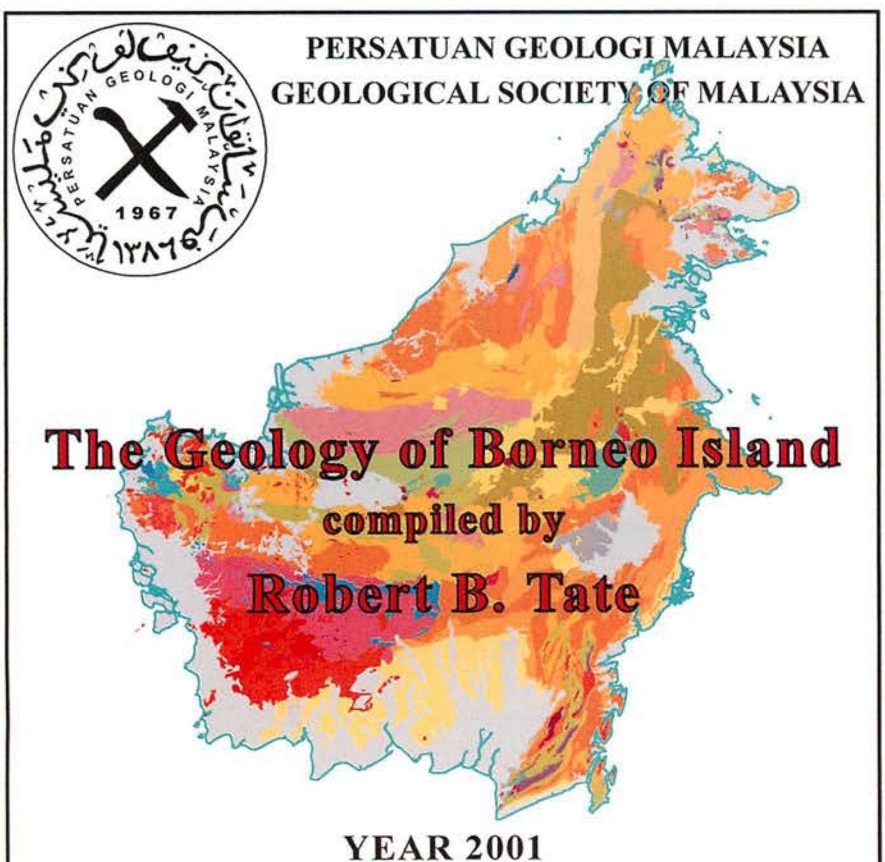

The Geology of Borneo Island

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Robert Tate

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In recent years the application of geophysics for solving geotechnical problems has increased especially in mapping subsurface weak structures and in evaluating problematic zones of development sites. Improved geophysical technology and interpretation procedures have been successfully used in resolving environmental problems especially on the issue of groundwater contamination and assessment of contaminated land of a development area.

The greatest challenge for the geophysicists in the 21st century is the paradigm shift in their research orientation from a strong bias towards the hydrocarbon industry to other important areas of applied sciences such as for geotechnical engineering and environmental applications. The wealth accumulated from the hydrocarbon industry should be invested in such studies as well as venturing in research for other possible sources of environment-friendly energy. In addition, there is an obvious need for both engineering and environmental geophysics to be introduced to all the engineers and environmentalists. In order for such geophysics to become more useful to the geotechnical engineers, better means of communication are necessary between these two groups of scientists. The rapidly expanding discipline of archaeo-geophysics needs to be brought to the attention of all archaeologists so that the geophysical techniques can be used as part of the routine procedure in the archaeological exploration programme.

BERITA-BERITA PERSATUAN
NEWS OF THE SOCIETY

KEAHLIAN (Membership)

The following applications for membership were approved:

Full Members

1. Christi Gell
Landmark Graphics, 11th floor, 207, Jalan Tun Razak, 50400 Kuala Lumpur.
2. Tan Yaw Tzong
18th floor, Faber Tower 1, Faber Tower, Jalan Desa Bahagia, Taman Desa, off Jalan Klang Lama, 58100 Kuala Lumpur.
3. Jonathan Redfern
Oxford Brooked University, Geology (BMS) Gipsylane, Headington, Oxford OX3OXP.
4. Adnan A.M. Aqrawi
Statoil ASA, International E&P, 4035, Stavanger, Norway.
5. Mohd. Rohani bin Elias
Menara Exxon Mobil, Geoscience Dept., KLCC, 50088 Kuala Lumpur.
6. Mohazam bin Mohd Iqbal
No. 64, Jalan Telipok, Taman Sri Mersing, Mersing, Johor.
7. Azli bin Abu Bakar
PCSB, Aras 25, Menara 1, KLCC, 50088 Kuala Lumpur.
8. Padlo Tognini
Suite 9.02 Level 9, Menara Tan & Tan, 207 Jalan Tun Razak, 50400 Kuala Lumpur.
9. Khalid Ameen
No. 2, Kallang Pudding Road, 09-04 Mactech Ind. Building, Singapore 349307.
10. Mohamad Md Tan
Program Geologi, Fakulti Sains & Teknologi, UKM, Bangi.

Student Members

1. Bahaa-Eldin Elwadi Abdel Rahim
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.
2. Yong Cheng Yeu
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.
3. Siti Hasmah Ayub
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.
4. Isney Zaireen Rose Zaini
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.
5. Wan Nurhasbey Wan Yusof
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.
6. Nor Azlida Ismail
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.
7. Noor Nashira Azda Ab. Halim
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.
8. Azlizawati Roslan @ Abd. Aziz
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9. Mohamad Faizal Idris
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

10. Hartini Hashim
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

11. Md. Fairul Adnan
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

12. Haryanty Hashim
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

13. Muhammad Sofi Mohd. Nasir
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

14. Lai Kian Voon
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

15. Noor Farinda Salim
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16. S. Ahmad Yasir S. Ab. Hamid @ S. Said
Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

17. Sabariah Mohd. Said
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Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

24. Suharsono
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

25. Mohd. Khairul Azmi Mohd. Yassin
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

26. Yip Chia Chun
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27. Mohd Shafiq Farhan Mohd Zainudin
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Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

29. Tan Poh Li
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

30. Ng Chee Seng
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

31. Yee Shun Wen
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

32. Tan Boon Hu
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

33. Tham Kam Theng
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

34. Tan Han Kee
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

35. Lee Kok Yeong
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

36. Wong Meng Li
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

37. Chan Eng Hoe
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor.

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Jabatan Geologi, Universiti Malaya, 50603 Kuala Lumpur.

39. Fazlan Fadzin
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

40. Hairel Dean Abd. Samad
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

41. Shahril Jamil
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

42. Iskandar Shah Abd. Rahman
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

43. Hatem S.A. Abieja
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

44. Nurfauziah Hani Ibrahim
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

45. Siti Wahida Omar
School of Physics, Universiti Sains Malaysia, 11800 USM Penang.

PETUKARAN ALAMAT (Change of Address)

The following members have informed the Society of their new addresses:

1. Ian Cross
IHS Energy, 5333 Westheimer Road, Suite 100, Houston, Texas 77056.

2. Tong Pow Mun
Thales GeoSolutions (M) Sdn. Bhd., 11th Floor, Wisma Genting, Jalan Sultan Ismail, 50250 Kuala Lumpur.

3. Aniza Abdul Rahman
SH4, Jalan Mutiara, Taman Bukit Ampang, 68000 Ampang, Selangor

4. Khairun Niza bt. Baharaldin
23 Jalan Tengkolok 10/8, Seksyen 10, 40100 Shah Alam, Selangor

5. Paul Ponar Sinjeng
48, Lane 4, Lintang Park South, 93200 Kuching, Sarawak

6. Leong Lap Sau
No. 17, Lintang Delima 15, Island Glades, 11700 Penang, Malaysia

CURRENT ADDRESSES WANTED

The GSM is seeking the address of the following member. Anyone knowing the new address please inform the Society.

1. David G. Bowen
7 Lyne Terrace, Penincuik, Midlothian EH26 8HF, U.K.

PERTAMBAHAN BAHARU PERPUSTAKAAN
(New Library Additions)

The Society has received the following publications:

1. American Museum Novitates, 2002: nos. 3371, 3372, 3375, 3379, 3381.
2. Bulletin of the American Museum of Natural History, no. 273, 2002.
3. AAPG Explorer, Jan 2003.
4. Episodes, vol. 25, no. 4, 2002.
5. Mineralogia Polonica, vol. 32, nos. 1 & 2, 2001.
6. Quarterly Notes, nos. 112 & 113, 2002.
7. Monthly statistics on mining industry in Malaysia, Sept & Oct 2002.
8. Geoscience Journal, vol. 6, no. 4, 2002.

BERITA-BERITA LAIN
OTHER NEWS

KALENDAR (CALENDAR)

2003

March 27–30
NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION (Annual Meeting), Philadelphia, Pennsylvania, USA. (Contact: NESTA, 2000 Florida Ave., N.W., Washington, D.C. 20009, USA. Tel: +1-202 462 6910; Fax: +1-202 328 0566; E-mail: fireton@kosmos.agu.org)

March 30 - April 2
SALT WATER INTRUSION IN COASTAL AQUIFERS: MONITORING, MODELING AND MANAGEMENT (2nd International Conference), Merida, Yucatan, Mexico. Workshops (27–29 March) preceed the Conference, field trips (3–5 April) follow the conference. (Contact: Prof. Luis E. Marín, Sección de Hidrogeología y Sistemas Hidrotermales, Departamento de Recursos Naturales, Instituto de Geofísica, Universidad Nacional Autónoma de México, Mexico City, Mexico CP 04510. Tel: 52-555622-4212; Fax: 52-555-550-2486; E-mail: lmarin@tonatiuh.igeofcu.unam.mx; Website: www.igeofcu.unam.mx/swica2/)

April 6–11
EUROPEAN GEOPHYSICAL SOCIETY + AMERICAN GEOPHYSICAL UNION + EUROPEAN UNION OF GEOSCIENCES (Joint Assembly), Nice, France. (Contact: EGS office, Max-Planck-Str. 13, 37191 Katlenburg-Lindau, Germany. Tel: +49-5556-1440; Fax: +49-5556-4709; E-mail: egs@copernicus.org; Website: www.copernicus.org/EGS)

April 7–9
BRAIDED RIVERS (International Conference), Birmingham, UK. (Contact: Greg Sambrook Smith, School of Geography & Environmental Sciences, University of Birmingham, Birmingham, B15 2TT U.K. Tel: +44 (O)121 4158023; E-mail: g.smith.4@bham.ac.uk; Website: www.cwr.bham.ac.uk/braid/)

April 14–17
URANIUM GEOCHEMISTRY, Nancy, France. (Contact: Michel Cuney. Tel: 33 3 83 68 47 09; E-mail: mcuney@persmail.uhp-nancy.fr)

April 28–30
SUBMARINE SLOPE SYSTEMS: PROCESSES, PRODUCTS AND PREDICTION (International Conference), University of Liverpool, Liverpool, UK. Sponsored by the Geological Society of London and International Association of Sedimentologists. (Contact: David Hodgson, Dept. of Earth Sciences, University of Liverpool, Liverpool, UK. Tel: +44 151 794 5141; E-mail: hodgson@liv.ac.uk; Website: http://www.slope2003.net/)

April 30 - May 2
WATER RESOURCES MANAGEMENT (2nd International Conference), Las Palmas, Gran Canaria. (Contact: Conference Secretariat, Water Resources03, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK. E-mail: shobbs@wessex.ac.uk; Website: www.wessex.ac.uk/conferences/2003/waterresources03)

May
INTERNATIONAL SYMPOSIUM ON KARST AND HARD ROCK FORMATIONS, Esfahan, Iron. (Contact: Dr. A. Afrasiabian, National Karst Study and Research Center, P.O. Box 15875-3584, Tehran, Iran. Tel: +98 21 7520474; Fax: +98 21 7533186)

May 11–14
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS AND SOCIETY FOR SEDIMENTARY GEOLOGY (SEPM) (Joint Annual Meeting and Exhibition), Salt Lake City, Utah, USA. (Contact: AAPG Conventions

Dept., P.O. Box 979, Tulsa, OK 74119, USA. Tel: +1-918 560 2679; Fax: 1-918 560 2684; E-mail: convene@aapg.org; Website: www.aapg.org)

May 12–16

GEOFLUIDS IV (4th international conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts), Utrecht University, Utrecht, The Netherlands. Sponsored by Netherlands Institute of Applied Geoscience TNO-National Geological Survey. (Contact: Ms. J.M. Verweij, P.O. Box 80015, 3508 TA Utrecht, The Netherlands. Tel: +31-30 256 4600; Fax: +31-30 256 46 05; E-mail: j.verweij@nitg.tno.nl; Website: www.nitg.tno.nl).

May 18–23

COASTAL SEDIMENTS '03 (5th International Symposium on Coastal Engineering and Science of Coastal Sediment Processes), Clearwater Beach, Florida, USA. (Contact: Darlene K. Gregory, Conference Secretariat. Tel: +1-361 939 9004; Fax: +1-361 939 9355; E-mail: dgregory@coastalsediments.net; Website: http://www.coastalsediments.net/)

May 18–24

GEOLOGY OF INDUSTRIAL MINERALS, "BETTING ON INDUSTRIAL MINERALS" (39th Forum), Sparks, Nevada, USA. Sponsored by the Nevada Bureau of Mines and Geology, Nevada Division of Minerals, and Nevada Mining Association. (Contact: Terri Garside, NBMG/MS 178, University of Nevada, Reno, NV 89557-0088; Tel: +1-775 784 6691, ext. 126; Fax: +1-775 784 1709; E-mail: tgarside@unr.edu; Website: www.nbmg.unr.edu/imf2003.htm)

May 19–23

VII INTERNATIONAL SYMPOSIUM 'CULTURAL HERITAGE IN GEOSCIENCES, MINING AND METALLURGY: LIBRARIES-ARCHIVES-MUSEUMS' "Museums and their collections", Leiden, The Netherlands. (Contact: Dr. Cor F. Winkler Prins, Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA LEIDEN, The Netherlands. Tel: +37.71.5687643; Fax: +31.71.5687666; E-mail: winkler@nnm.nl).

June 4–6

FLUID INCLUSIONS (17th Biennial European Current Research Conference), Budapest, Hungary. (Contact: Department of Petrology and Geochemistry, Budapest, Pázmány Péter sétány 1/C, Budapest H-1117, Hungary. Tel: +36-1 209 0555 ext. 8338; Fax: +36-1 381 2108; E-mail: ecrofi17@geology.elte.hu; Website: ecrofi17.geology.elte.hu/)

June 7–12

CLAY MINERALS SOCIETY (CMS) AND MINERALOGICAL SOCIETY OF AMERICA (MSA), "Classic Clay and Minerals" (Joint Meeting), Athens, Georgia, USA. (Contact: Paul A. Schroeder, General Chairman, Department of Geology, University of Georgia, Athens, GA 30602-2501, USA. Tel: +1-706 542-2652; E-mail: schroe@gly.uga.edu; Website: http://www.gly.uga.edu/)

June 8–13

ALLUVIAL FANS (International Conference), Sorbas, Almeria, Spain. (Contact: Martin Stokes, Department of Geology, University of Plymouth, Drake Circus, Devon PL4 8AA, UK. E-mail: alluvialfans@plymouth.ac.uk; Website: alluvialfans.net)

June 9–12

ORIGIN OF PETROLEUM, BIOGENIC AND/OR ABIOGENIC AND ITS SIGNIFICANCE IN HYDROCARBON EXPLORATION AND PRODUCTION (Hedberg Conference sponsored by the American Association of Petroleum Geologists and Institute of Petroleum), London, UK. (Contact: Debbi Boonstra, AAPG Education Dept., P.O. Box 979, Tulsa, OK 74101-0979; Fax: +1-918 560 2678; E-mail: debbi@aapg.org; Website: www.aapg.org/education/hedberg/london/index.html)

June 15–17

7TH ICOBTE — INTERNATIONAL CONFERENCE ON BIOGEOCHEMISTRY OF TRACE ELEMENTS, Uppsala, Sweden. (Contact: George R. Gobran. Fax: 46 (18) 67 34 30; E-mail: George.Gobran@eom.slu.se or ICOBTE7@slu.se; Website: http://www.eom.slu.se)

June 16–18

5TH INTERNATIONAL CONFERENCE ON THE ANALYSIS OF GEOLOGICAL AND ENVIRONMENTAL MATERIALS, Rovaniemi, Finland. (Contact: Website: http://www.gsf.fi/geoanalysis2003)

June 20–25
ROLE OF LIGHT ELEMENTS IN ROCK-FORMING MINERALS (International Symposium), Nové Mestona, Czech Republic. (Contact: Dr. Milan Novák, Chairman, LERM, Masdaryk University, Kotlárská 2, 611 37 Brno, Czech Republic. Fax: +420-5 412112; E-mail: mnovak@sci.muni.cz; Website: sci.muni,cz/~lerm/index.htm).

June 22–27
KIMBERLITE (8th International Conference), Victoria, British Columbia, Canada. (Contact: 8IKC, Conference, Secretariat, c/o Venue West Conference Services Ltd., 645 - The Landing, 375 Water Street, Vancouver, BC, Canada V6B 5C6. Tel: +1-604 681-5226; Fax: +1-604 681-2503; E-mail: 8IKC@venuewest.com; Website: www.venuewest.com/8IKC)

June 30 – July 11
INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS (IUGG) (23rd General Assembly), Sapporo, Japan. (Contact: Dr. Kiyoshi Suyehiro, General Secretary of LOC XXIII General Assembly, Japan Marine Science and Technology Center (JAMSTEC), 2-15 Natsushima-cho, Yokosuka 237-0061, Japan. Fax: +81-468 66 5541; E-mail: IUGG_service@jamstec.go.jp; Website: www.jamstec.go.jp/jamstec-e/iugg/index.html)

July 8–10
CARBONATE SEDIMENTOLOGISTS (12th Bathurst Meeting), Dunham, UK. (Contact: Maurice Tucker or Moyra Wilson, Department of Geological Sciences, University of Durham, Durham DH1 3LE, U.K. Tel: +44-191 374 2524 or 2501; E-mail: M.E.Tucker@durham.ac.uk *or* Moyra.Wilson@durham.ac.uk; Website: www.dur.ac.uk/bathurst.2003/)

July 14–25
IGCP 450 MEETING AND FIELD EXCURSION (Proterozoic Sediment-hosted Base Metal Deposits of Western Gondwana: Intra and Intercontinental Correlation of Geological, Geochemical and Isotopic Characteristics, Southern Atlantic), Lubumbashi, D.R. Congo. (Contact: Dr. Jacques Cailteux, Organiser of the event, Groupe G. FORREST international, E.G.M.F., Lubumbashi, D.R. Congo. Fax: 243-23 42 275; Tel: 243-970 32 625; E-mail: egmf@forrestrdc.com)

July 23–31
INTERNATIONAL ASSOCIATION FOR QUATERNARY RESEARCH (INQUA) (16th Congress) "Shaping the Earth: A Quaternary Perspective", Reno Hilton, Reno, NV, USA. (Contact: Nick Lancaster, Desert Research Institute. Tel: +1-775 673 7304; E-mail: nick@dri.edu; Website: www.dri.edu/DEES/INQUA2003/inqua_home/htm)

July 30–31
GEODYNAMICS & METALLOGENY (International Conference), Ulaan Bataar, Mongolia. Organized by the Mongolian National Group of the International Association on the Genesis of Ore Deposits (IAGOD) and co-sponsored by IAGOD; post-conference expert fieldtrip 1–7 August 2003 to Oyu Tolgoy. (Contact: O. Gerel, E-mail: gerel@mtu.edu.mn)

August 9–21
FIELD CONFERENCE IN URUMQUI, CHINA, IGCP-473 annual field conference in Urumqui with excursion to Chinese Tienshan and Altay (Xinjiang). Sponsored by the International Association on the Genesis of Ore Deposits (IAGOD). (Contact: Prof. Mao Jingwen, CAGS Beijing. E-mail: jingwenmao@263.net; Website: www.nhm.ac.uk/mineralogy/cercams/index.htm)

August 10–13
GeoSciEd IV, Calgary, Canada. (Contact: Website: www.geoscied.org)

August 18–21
9TH INTERNATIONAL SYMPOSIUM ON THE ORDOVICIAN SYSTEM, 7TH INTERNATIONAL GRAPTOLITE, AND FIELD MEETING OF THE SUBCOMMISSION ON SILURIAN STRATIGRAPHY, San Juan City, Argentina. (Contact: ISOS: Guillermo L. Albanesi. E-mail: galbanesi@arnet.com.ar or Matilde S. Beresi. E-mail: mberesi@labocricyt.edu.ar; IGC-SSS field meeting: Gladys Ortega. E-mail: gcortega@arnet.com.ar or Guillermo F. Aceñolaza. E-mail: acecha@unt.edu.ar)

August 26–30
PRESENT STATE AND FUTURE EVOLUTION OF PALEOGENE STRATIGRAPHY, A symposium of the International Subcommission on Paleogene

Stratigraphy, Leuven, BELGIUM. (Contact: Noël Vandenberghe, Dept. Geografie-Geologie, Afd. Historische Geologie, KU Leuven, Redingestraat 16, B-3000 Leuven Belgium. E-mail: noel.vandenberghe@geo.kuleuven.be; Website: www.uni-tuebingen.de/geo/isps/news)

August 29 - September 3
INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM (21st of the Association of Exploration Geochemists), Dublin, Ireland. (Contact: Eibhlin Doyle, Secretary LOC. E-mail: eibhlindoyle@gsi.ie; Website: http://www.aeg.org/)

September 5-6
TERRANE PROCESSES AT THE PACIFIC MARGIN OF GONDWANA (International Conference), Cambridge, England. Sponsored by the British Antarctic Survey and the Geological Society. (Contact: Dr. Alan P.M. Vaughan, British Antarctic Survey, Cambridge CB3 0ET, England. Tel: +44-1223 221419; Fax: +44-1223 221646; E-mail: a.vaughan@bas.ac.uk)

September 7-11
ENVIRONMENTAL GEOCHEMISTRY (6th International Symposium), Edinburgh, Scotland, UK. (Contact: John Farmer, Dept. of Chemistry, The University of Edinburgh, Kings Buildings, West Mains Road, Edinburgh EHP 3JJ Scotland. E-mail: J.G.Farmer@ed.ac.uk; Tel: 0131-650-1000; Fax: 0131-650-4757)

September 8-12
ORGANIC GEOCHEMISTRY (21st International Meeting), Krakow, Poland. Sponsored by the European Association of Organic Geochemists. (Contact: IMOG 2003, Society of Research on Environmental Changes "Geosphere", Al. Mickiewicza 30, 30-059 Kraków, Poland. Fax: +48-12 623 78 28; E-mail: imog@imog.agh.edu.pl; Website: http://www.imog.agh.edu.pl)

September 8-12
INTERNATIONAL CONGRESS ON ROCK MECHANICS "Technology Roadmap for Rock Mechanics" (10th of the International Society for Rock Mechanics), Sandton (Gauteng-Johannesburg), South Africa. (Contact: Mrs. Karen Norman, The Conference Co-Ordinator, Technology Roadmap for Rock Mechanics, P.O. Box 61127, ZA-2107 Marshalltown, South Africa. Tel: +27-11 8341273 or 8341277; Fax: +27-11 833 8156 or 838 5923)

September 15-18
INDUSTRIAL MINERALS AND BUILDING STONES — IMBS 2003, Istanbul, Turkey. (Contact: Erdogan Yüzer, Maden fakültesi, Ayazaga KampÜsÜ, 80626 Maslak/Istanbul, Turkey. Tel/Fax: 90 212 285 61 46; E-mail: yuzer@itu.edu.tr)

September 15-19
GROUNDWATER IN FRACTURED ROCKS (International Conference of IAH), Prague, Czech Republic. (Contact: Jiri Krasny. E-mail: krasny@natur.cuni.cz)

September 17-19
SEDIMENTOLOGY (22nd Annual Meeting of the International Association of Sedimentology), Opatija, Croatia. (Contact: Davor Pavelic, IAS-2003, Institute of Geology, HR-10000 Zagreb, Sachsova 2, Croatia. Fax: +385 1 6144718; E-mail: dpavelic@yahoo.com; Website: www.igi.hr/ias2003)

September 21-24
AAPG INTERNATIONAL CONFERENCE EXHIBITION, "CROSSROADS OF GEOLOGY, ENERGY AND CULTURES", Barcelona, Spain. Sponsored by the American Association of Petroleum Geologists. (Contact: AAPG Convention Department, P.O. Box 979, tulsa, OK, 74101-0979, USA. Fax: +1-918-560-2684; E-mail: convene@aapg.org; Website: www.aapg.org/)

September 22-26
1ST INTERNATIONAL CONFERENCE — GROUNDWATER IN GEOLOGICAL ENGINEERING, Ljubljana, Slovenia. (Contact: Slovene Committee of IAH, Andrej Juren, Kebetova 24, SI-1000 Ljubjana, Slovenia. E-mail: andrej.juren@siol.net or Nadja Zalar, E-mail: nadja.zalar@siol.net; Website: http://www.iah.org)

September 28 - October 3
SOCIETY OF EXPLORATION GEOPHYSICISTS (73rd Annual Meeting and International Exposition), Dallas, Texas, USA. (Contact: SEG Business Office, Tel: +1-918 497 5500; Fax: +1-918 497 5500; Fax: +1-918 497 5557; Website: seg.org/)

October 4–9
AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS (40th Annual Meeting), Glenwood Springs, Colorado, USA. (Contact: Tom Fails, 4101 E. Louisiana #412, Denver, CO 80246. Tel: +1-303 759 9733; Fax: +1-303 759 9731; E-mail: thomgeol@aol.com; Website: www.aipg.org/www.aipg.org/)

October 5–8
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS (International Conference & Exhibition), London, UK. (Contact: AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101-0979, USA. Tel: +1-918 560 2679; E-mail: Website: www.aapg.org)

October 24–27
INTERNATIONAL SYMPOSIUM ON HYDROMETALLURGY — IN HONOR OF IAN RITCHIE, Vancouver, British Colombia, Canada. (Contact: Courtney Young. Fax: 406 496 4133; E-mail: cyoung@mtech.edu; Website: cms.tms.org)

November 2–5
GEOLOGICAL SOCIETY OF AMERICA (Annual Meeting), Seattle, Washington, USA. (Contact: GSA Meetings Dept., P.O. Box 9140, Boulder, CO 80301-9140, USA. Tel: +1 303 447 2020; Fax: +1 303 447 1133; E-mail: meetings@geosociety.org; Website: http://www.geosociety.org/meeting/index.htm)

December 8–12
AMERICAN GEOPHYSICAL UNION (Fall Meeting), San Francisco, California, USA. (Contact: San Francisco, California, USA. (Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1 202 462 6900; Fax: +1 202 328 0566; E-mail: meetinginfo@agu.org; Website: http://www.agu.org/meetings)

2004

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ASIAN MARINE GEOLOGY (5th International Conference), Bangkok, Thailand. (Contact: Thanawat Jarupongsakul, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand. Fax: +(662) 2185464-5; E-mail: thanawat@sc.chula.ac.th)

March 27 - April 4
NATIONAL EARTH SCIENCE TEACHERS ASSOCIATION (Annual Meeting), Atlanta, Georgia, USA. (Contact: NESTA, 2000 Florida Ave., N.W., Washington, D.C. 20009, USA. Tel: +1-202 462 69 10; Fax: +1-202 328 0566; E-mail: fireton@kosmos.agu.org)

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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS AND SOCIETY FOR SEDIMENTARY GEOLOGY (SEPM) (Joint Annual Meeting and Exhibition), Dallas, Texas, USA. (Contact: AAPG Conventions Dept., P.O. Box 979, Tulsa, OK 74119, USA. Tel: +1-918 560 2679; Fax: 1-918 560 2684; E-mail: convene@aapg.org; Website: www.aapg.org)

May 17–21
AMERICAN GEOPHYSICAL UNION AND CANADIAN GEOPHYSICAL UNION (Joint Meeting), Montreal, Canada. (Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1 202 462 6900; Fax: +1 202 328 0566; E-mail: meetinginfo@agu.org; Website: http://www.agu.org/meetings)

June 27 - July 2
WATER-ROCK INTERACTION (11th International Symposium), Saratoga Springs, New York, USA. (Contact: Dr. Susan Brantley, Secretary General, Dept. of Geosciences, The Pennsylvania State University, 239 Deike Building, University Park PA 16802, USA. Tel: +1-814 863 1739; Fax: +1-814 863 8724; Website: www.outreach.psu.edu/C&I/WRI/)

July 4–9
INTERNATIONAL PALYNOLOGICAL CONGRESS (11th), Granada, Spain. (Contact: Technical Secretary. E-mail: eurocongres@eurocongres.es; Website: www.ugr.es/~bioveg/)

August 20–28
INTERNATIONAL GEOLOGICAL CONGRESS (32nd), "The Renaissance of Geology", Florence, Italy. (Contact: Ms. Chiara Manetti, Universitàdegli Studi di Firenze, Dipartimento di Scienze della Terra, Via La Pira, 4, 50121 Firenze, Italy. Tel/Fax: +39-055 238 2146; E-mail: cmanetti@geo.unifi.it; To request the First Circular, send e-mail to: 32igc@32igc.org or visit the Congress Website:

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August 27 – September 4

VLADIVOSTOK-2004 INTERIM IAGOD CONFERENCE (Metallogeny of the Pacific Northwest: Tectonics, Magmatism & Metallogeny of Active Continental Margins), Vladivostok, Khabararovsk, Magadan, Russian Far East, Russia. (Contact: Russian National IAGOD Group, Federal Far East Geological Institute, Far Eastern Branch of Russian Academy of Sciences, 159, Prospekt 100-letiya, Vladivostok, 690022, Russia. Tel: 7(4232)31-87-50; Fax: 7(4232)31-78-47; E-mail: iagodconf@fegi.ru or fegi@online.marine.su; Website: http://www.fegi.ru/IAGOD/index.htm)

September 11–19

TECTONICS, MAGMATISM AND METALLOGENY OF ACTIVE CONTINENTAL MARGINS (Interim International Conference on Metallogeny of the Pacific Northwest), Vladivostok, Russia. Sponsored by the Russian Academy of Sciences and The Society of Economic Geologists. (Contact: Far East Geological Institute, Far Eastern Branch of Russian Academy of Sciences, 159, Prospekt 100-letiya, Vladivostok, 690022 Russia. Tel: +7(4232)31-87-50; Fax: +7(4232)31-78-47; E-mail: iagodconf@fegi.ru or fegi@online.marine.su; Website: http://www.fegi./ru/IAGOD/)

September 15–17

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October 10–15

SOCIETY OF EXPLORATION GEOPHYSICISTS (74th Annual Meeting and International Exposition), Denver, Colorado, USA. (Contact: Debbi Hyer, 8801 S. Yale, Tulsa, OK 74137, USA. Tel: (+1-918) 497 5500; E-mail: dhyer@seg.org; Website: meeting.seg.org)

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December 13–17

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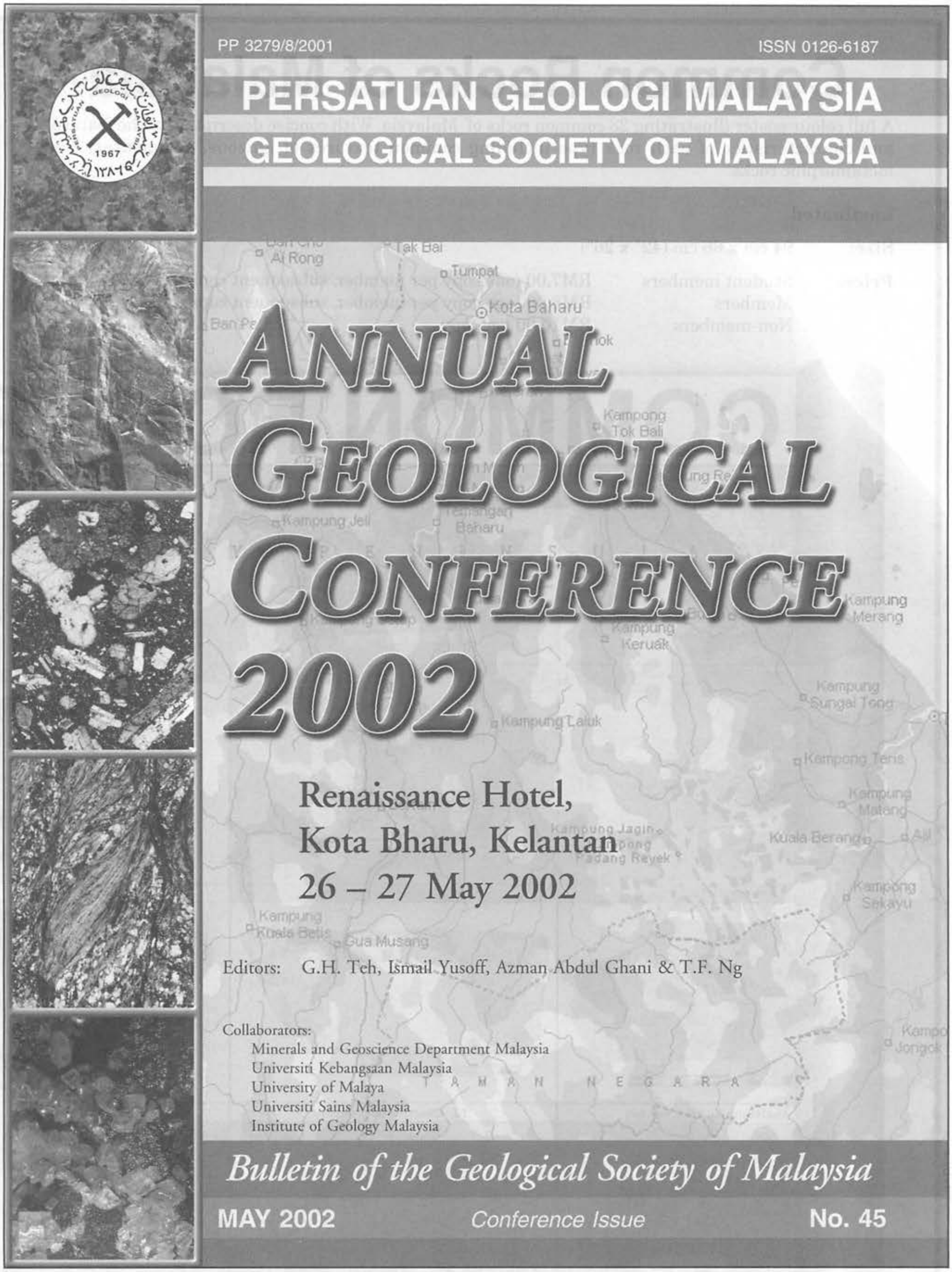

PP 3279/8/2001
ISSN 0126-6187
PERSATUAN GEOLOGI MALAYSIA
GEOLOGICAL SOCIETY OF MALAYSIA
ANNUAL GEOLOGICAL CONFERENCE 2002
Renaissance Hotel,
Kota Bharu, Kelantan
26 – 27 May 2002
Editors: G.H. Teh, Ismail Yusoff, Azman Abdul Ghani & T.F. Ng
Collaborators:
Minerals and Geoscience Department Malaysia
Universiti Kebangsaan Malaysia
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PP 2509/2/2004 ISSN 0126-5539

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Newsletter of the Geological Society of Malaysia

Jilid 29, No. 1 • Volume 29, No. 1 • January–February 2003

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