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KANDUNGAN (Contents)

CATATAN GEOLOGI (Geological Notes)

PERTEMUAN PERSATUAN (Meetings of the Society)

BERITA-BERITA PERSATUAN (News of the Society)

BERITA-BERITA LAIN (Other News)

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The Society has a membership of about 600 earth scientists interested in Malaysia and other Southeast Asian regions. The membership is worldwide in distribution.

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CATATAN GEOLOGI
Geological Notes

Structural evidence for a probable Paleozoic unconformity at Kg. Kuala Abang, Terengganu

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Abstract: Variably deformed metasedimentary rocks (interbedded metaquartzite, phyllite, slate, etc.) of Paleozoic age exposed at Kg. Kuala Abang, Terengganu, are separable into two units on the basis of discernible differences in structural features. The lower unit exhibits two phases of folding; the earlier southeasterly plunging reclined fold (F1) is refolded by a later southerly plunging upright fold (F2). The divergent axial trends indicate that the two phases of folding are not coaxial. The upper unit appears to have experienced only one phase of folding corresponding to the F2-fold of the lower unit. This is also evidenced by the marked differences in the occurrence of quartz veins in the two units. The lower unit displays two sets of quartz veins corresponding to the axial planes of F1 and F2, whereas quartz veins parallel to the F2 axial plane are only present in the upper unit. The difference in the structural features between the two units suggest that the deposition of the upper unit postdated the F1 folding phase implying the probable existence of an unconformity in the Paleozoic metasedimentary sequence. The age of this probable unconformity remains uncertain and can be resolved only when the ages of the metasediments at Kg. Kuala Abang are known.

INTRODUCTION

Deformed Paleozoic metasedimentary rocks comprising metaquartzite, phyllite, slate, etc. occur extensively from Kelantan to Johor in the eastern belt of Peninsular Malaysia (Tjia, 1974, 1978, 1989; Chand, 1978; Yap and Tan, 1980; Chakraborty and Metcalfe, 1984; Mohd. Pauzi, 1984). The age of these metasediments is poorly constrained with only a few isolated localities yielding fossils, particularly plant fossils, indicating a late Lower Carboniferous age (Asama, 1973; Jennings and Lee, 1985). Extensive tracts of these metasediments, however, remain undated. They are also stratigraphically poorly known as systematic structural and stratigraphic analyses are largely lacking. Consequently, the possibility of having metasediments of different ages with stratigraphic breaks cannot altogether be ignored. In this respect, the coastal exposures of similar metasediments at Kg. Kuala Abang are enlightening. In this paper we briefly discuss some structural features observed at Kg. Kuala Abang that may have important implications for regional structure, stratigraphy and tectonics.

Kg. Kuala Abang is located in the Dungun district of Terengganu, and lies about 6 km northwest of Kuala Dungun and about 2 km northwest of Tg. Jara (Fig. 1). The exposures in Kg. Kuala Abang mainly occur as a small hillock and as a sea stack in the beach (A and B in Fig. 2) and as a large road cut. The structural features observed in the beach exposures are the main concern of this paper. These exposures were also noted by others (Tjia, 1974; Mohd. Pauzi, 1984; Gostelow, 1990). We

have studied the outcrops on several occasions (in 1982 and 1983 by KRC and IM, and in 1989 by KRC). We wish to record our observations and interpretations as they differ from those of other workers in many respects.

STRUCTURAL FEATURES

The beach outcrops at Kg. Kuala Abang comprise an interbedded sequence of metaquartzite and meta-argillite (slate/phyllite, often carbonaceous). The variably deformed metasediments display various types folds, axial planar foliations, and a variety of linear structures including puckers, bedding-cleavage intersection, mullions, quartz rods. The metasediments are also cut by a few faults. There are several structural features, discussed below, that are suggestive of two phases of folding, but what is intriguing is that the whole sequence of the metasediments does not seem to have been affected by these two phases of folding. The evidence of two-phase folding can only be seen in the lower part of the exposed sections, and is apparently lacking in the upper part. A structural disparity thus seems to exist that permits the metasediments in the beach exposures to be divided into two — upper and lower — units (Fig. 2). At the present level of erosion, the upper unit comprises the upper part of the sea stack exposure and perhaps the top portion of the hillock, whereas the lower part of the sea stack and most of the hillock constitute the lower unit. The plane separating the two units is southerly inclined.

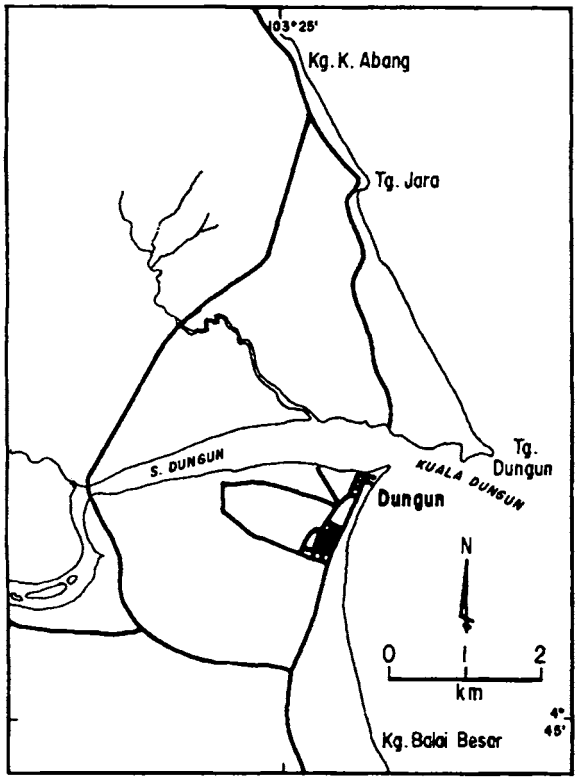

Figure 1. Location map of Kg. Kuala Abang.

In the lower unit, particularly at the base of the small hillock outcrop, a refolded reclined fold can clearly be observed (Figs. 2 and 3). The reclined fold is an earlier F1 structure which has been refolded by an upright F2 fold. The reclined fold axis (F1) plunges 14° towards 148° as shown in the S-pole diagram constructed from the measured attitudes of the bedding planes around the reclined fold (Fig. 4). The F1 axial plane dips southeasterly (055°/25°SE). The upright F2 fold at the lower limb of the reclined fold plunges 16° towards 173°, the attitude of its axial plane being 354°/85°E (Fig. 5). The F1 and F2 folds are evidently non-coaxial as indicated by the divergence of their axial trends.

Within the confine of the outcrops, the F1 reclined fold does not extend upto or involve the beds of the upper unit where only open F2 folds are observed. Also, the S-pole diagram prepared from the upper unit beds clearly defines a single fold axis with a plunge of 8° towards 171° that closely corresponds to the F2 fold of the lower unit (Fig. 5). Evidently, the beds in the upper unit were not affected by two phases of folding. A few lineations that have been measured correspond either to F1 or F2 (Fig. 5).

The structural discordance between the two units is further highlighted by the marked difference in the development of quartz veins in the two units that is particularly noticeable in the sea stack outcrop. The lower unit characteristically displays a set of fine quartz veins which are parallel to the F1 axial plane (Fig. 6). They show small scale folding with axial trends similar to F2. This F1 axial planar quartz veins are cut by a second set of quartz veins (quartz-filled fractures) that are parallel to the F2 axial plane. The lower unit thus contains two sets of axial planar quartz veins

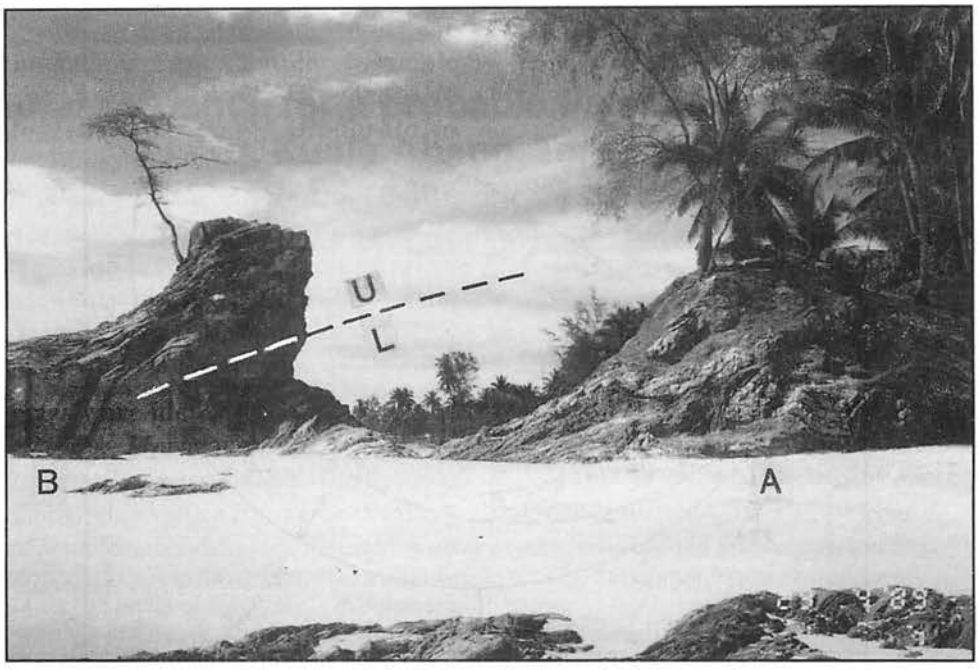

Figure 2. Beach outcrops at Kg. Kuala Abang. On the right is the small hillock (A) and on the left is the sea stack (B). Dashed line marks the boundary between the upper (U) and lower (L) units.

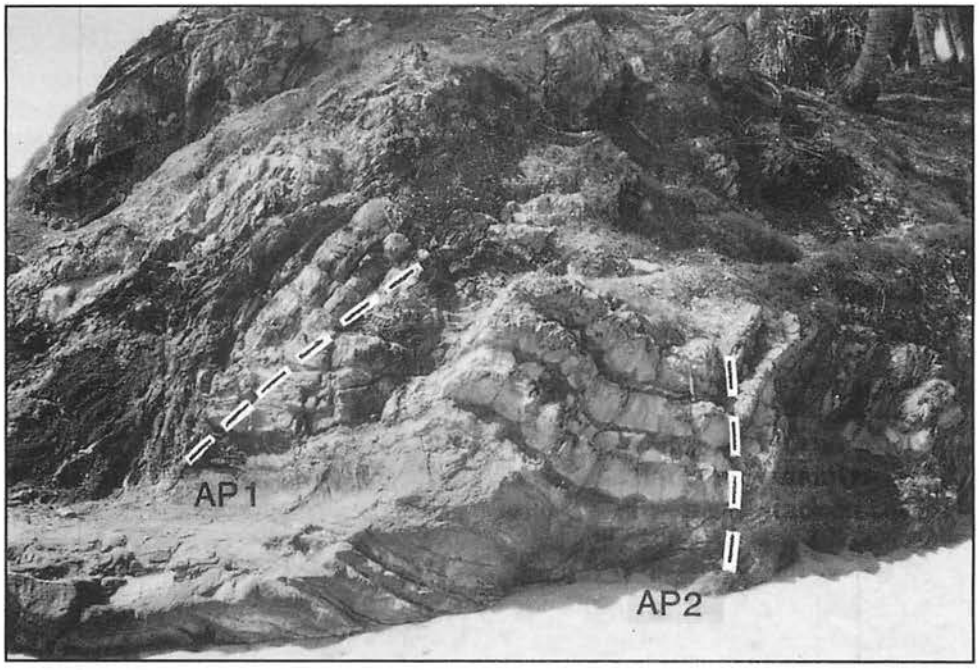

Figure 3. Enlarged view of the small hillock outcrop of Fig. 2. A refolded reclined fold is clearly visible. The lines marked AP1 and AP2 are the traces of the axial planes of the reclined and upright folds respectively.

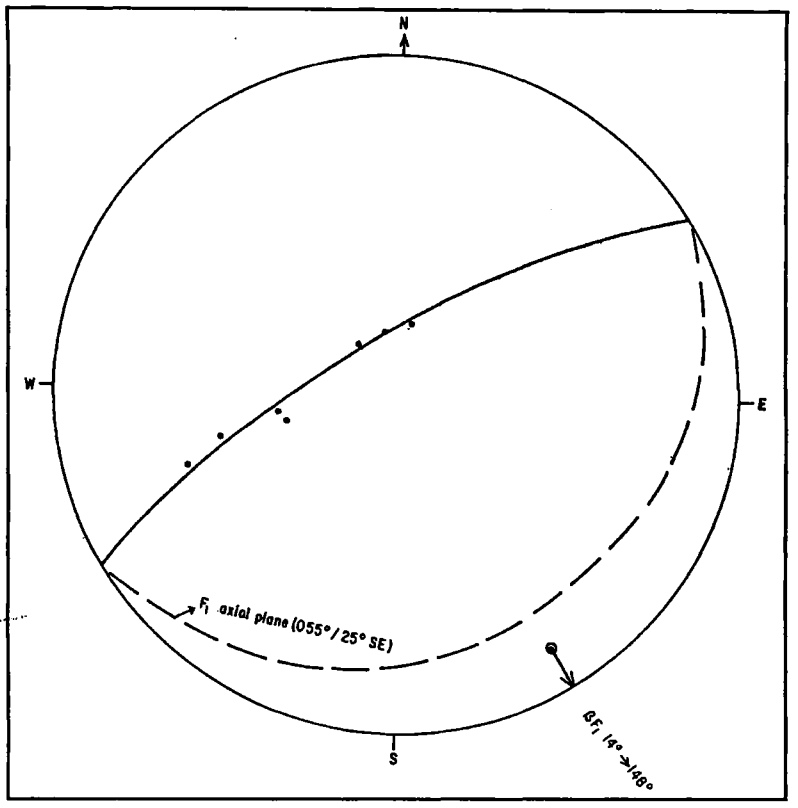

Figure 4. S-pole diagram defining the reclined (F1) fold axis which plunges 14° towards 148°. Bedding measurements were taken around the reclined fold hinge. The attitude of the axial plane measured directly at the reclined fold is 055°/25°SE.

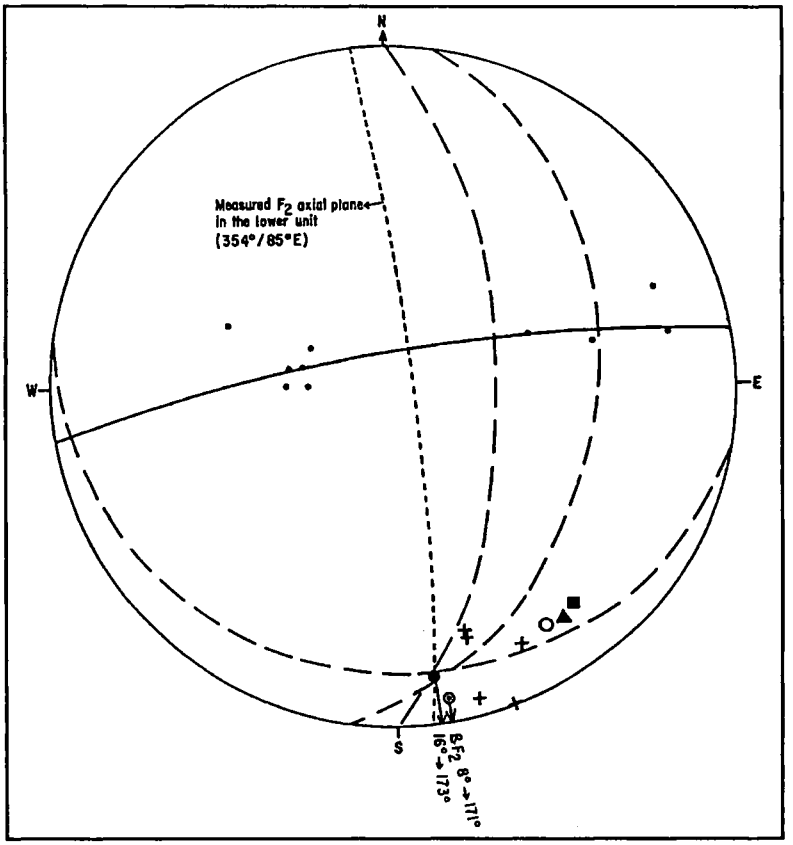

Figure 5. S-pole diagram of bedding planes measured in the upper part of the sea stack outcrop (upper unit) defining the F2 fold axis which plunges 8° towards 171°. The F2 fold at the lower limb of the reclined fold plunges 16° towards 173° as determined by the intersection of the two limbs. A few lineations are also shown: bedding-cleavage intersection (cross), pucker (solid triangle), minor fold axis (open circle), mullion (solid square).

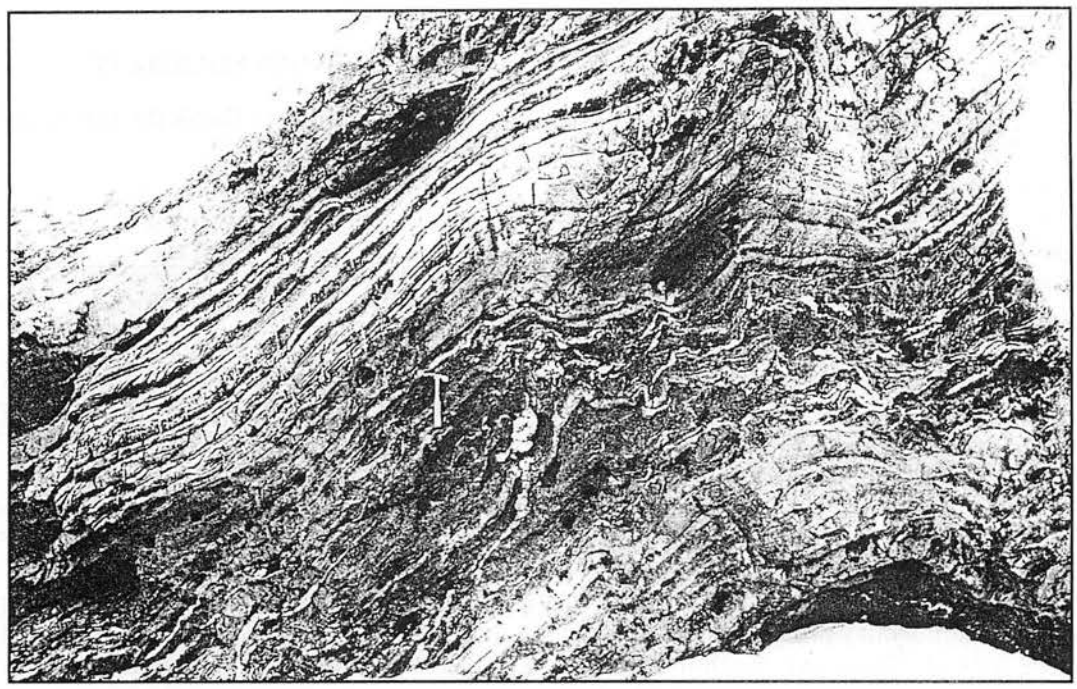

Figure 6. Folded quartz veins, parallel to F1 axial plane, in the lower part of the sea stack outcrop (lower unit). These quartz veins are cut by another subvertical set of quartz veins parallel to F2 axial plane. The hammer is on the lower unit.

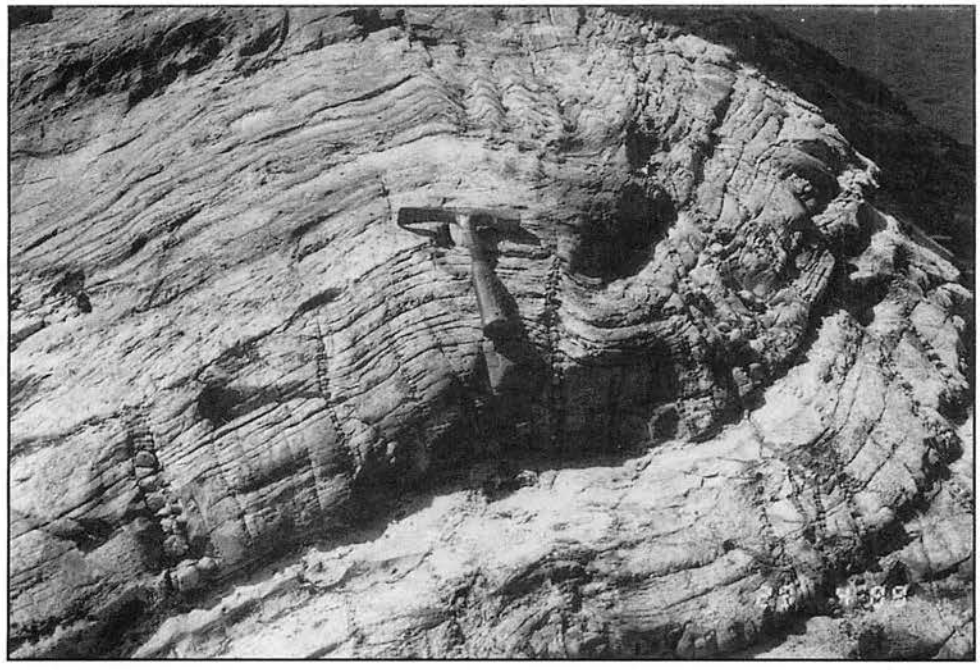

Figure 7. F2 axial planar subvertical quartz veins in the upper unit at the sea stack outcrop. This set of quartz veins are also present in the lower unit.

corresponding to F1 and F2. In the upper unit, on the other hand, only F2 axial planar quartz veins are present; F1 axial planar quartz veins are conspicuous by their absence (Figs. 6 and 7).

INTERPRETATIONS

From the structural features discussed above it is quite apparent that the beds in the upper unit were not subjected to, and hence postdate, the deformational episode that generated the F1 structures in the lower unit. There is also no evidence to suggest that the two units are bounded by a fault contact. The upper unit thus appears to be stratigraphically younger leading to the suggestion that it unconformably overlies the lower unit.

It is possible to put forward other more strenuous interpretations for the observed structural disparities between the two units, but that an unconformity probably exists seems to be more logical. However, further detailed investigation over a larger area is needed before a more definitive conclusion can be made.

CONCLUDING REMARKS

If the interpretation of the observed structural discordance between the two units as an evidence for an unconformity is correct then it has important implications for the stratigraphic, structural and tectonic evolution of the region. At present there is no control on the age of the metasediments at Kg. Abang. If the lower unit below the unconformity corresponds to the dated Lower Carboniferous strata, then the unconformity is likely to be Upper Carboniferous or Permian in age. On the other hand, if the upper unit corresponds to the Lower Carboniferous, then the unconformity has to be pre-Lower Carboniferous leading to the possibility of the existence of hitherto unreported Devonian or older rocks in the eastern belt of Peninsular Malaysia.

ACKNOWLEDGEMENT

Thanks are due to Encik Roshdy Abu Daud for drafting works.

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Some Paleogene planktonic foraminifera from the Lubok Antu Complex, Sarawak

BASIR JASIN AND TAJ MADIRA TAJ AHMAD
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Universiti Kebangsaan Malaysia
Bangi

Abstract: Thirteen species of planktonic foraminifera were retrieved from the mudstone matrix of the Lubok Antu Mélange. Two assemblages were recognised. The oldest assemblage consists of *Subbotina triloculinoides* (Plummer), *Subbotina velascoensis* (Cushman), *Globorotalia quadrilocula* Blow, *Globorotalia pseudobulloides* (Plummer), *Morozovella uncinata* (Bolli), *Morozovella trinidadensis* (Bolli) and *Morozovella praecursoria* (Morozova) indicative of early Middle Paleocene. The other assemblage is characterised by *Morozovella aragonensis* (Nuttall), *Morozovella naussi* (Martin), *Acarinina bulbrooki* (Bolli), *Subbotina linaperta* (Finlay) *Subbotina frontosa boweri* (Bolli) and *Globanomalina indiscriminata* (Mallory). This assemblage represents early Middle Eocene age.

INTRODUCTION

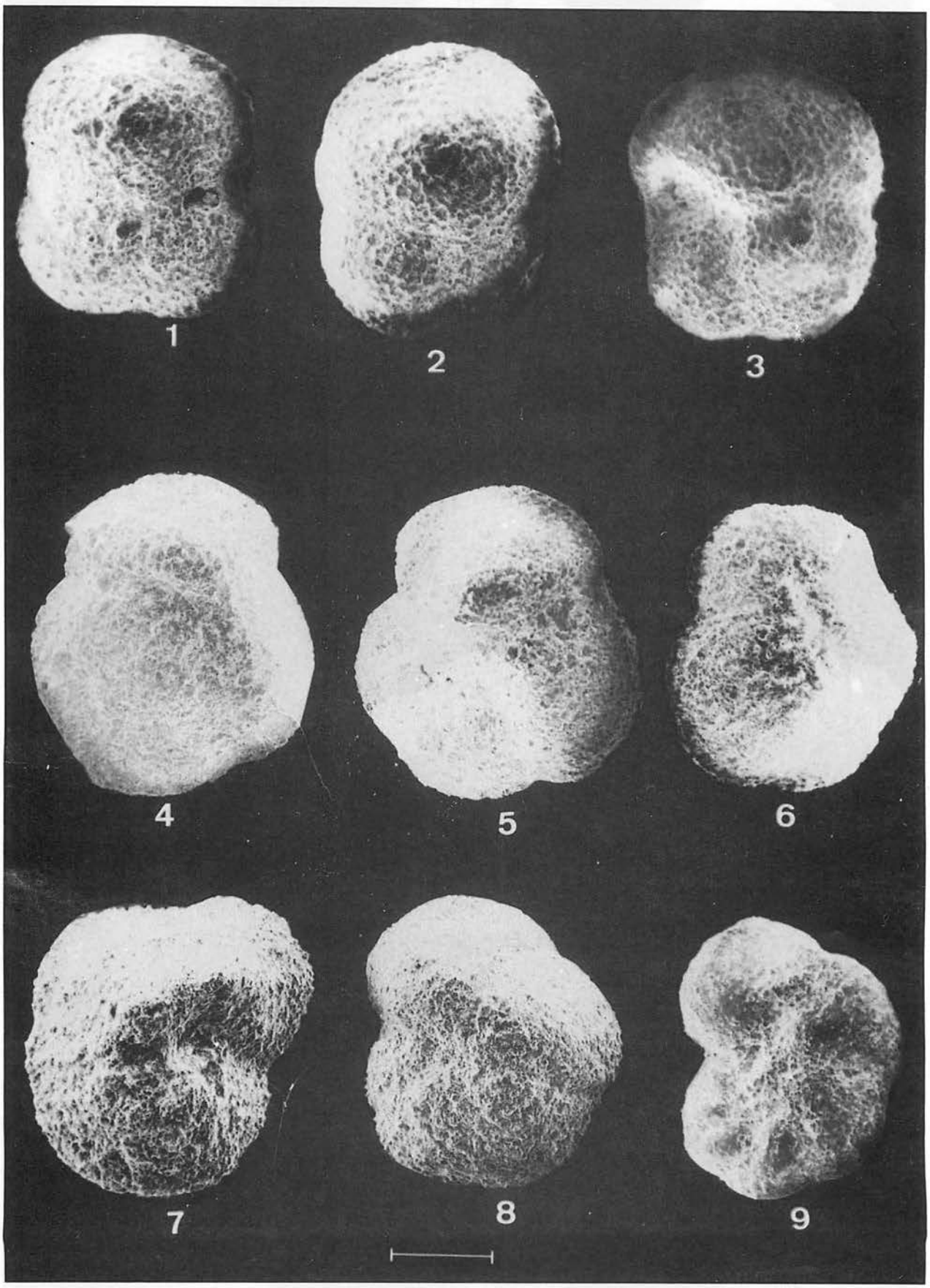
A chaotic assemblage of rocks are exposed in the Lupar Valley, Sarawak. Tan (1979) has proposed the term Lubok Antu Mélange for the rock assemblage. The mélange is composed of various sizes of rock fragments ranging from a few cm to a few km in diameter. The rock fragments consist of chert, sandstone, mudstone, conglomerate, limestone, basalt and gabbro embedded in a sheared matrix of mudstone. The fragments were derived from the older formations. Some fossils were discovered from the chert, limestone and mudstone blocks. Radiolaria from the chert blocks are indicative of Early Cretaceous age. Some Early Tertiary fossils were reported by Tan (1979) from the limestone and chert blocks.

The matrix of the mélange consists of sheared mudstone. The matrix is calcareous and fossiliferous. Several Early Eocene planktonic foraminifera were recovered from the matrix (Tan, 1979). Recently, several samples were collected from the mélange matrix. Samples from outcrops near Bukit Kawi (Locality 1) and near the junction to Engkilili (Locality 2) yielded abundant planktonic foraminifera (Fig. 1).

The term "mélange" is not a formal lithostratigraphic unit. We would like to propose the Lubok Antu Complex to replace the Lubok Antu Mélange as a formal lithostratigraphic unit. The Lubok Antu Complex can be dated by using fossils in the matrix.

GEOLOGICAL SETTING

The Lubok Antu Complex is composed of fragments and blocks of chert, sandstone, mudstone, conglomerate, limestone, basalt, serpentinite and gabbro of variable sizes embedded in a sheared mudstone matrix. Most of the chert and limestone blocks contain Cretaceous fossils. The sandstone, mudstone and conglomerate blocks were derived from the Lupar Formation. A block of a lower part of the Silantek Formation was observed near Engkilili (Taj Madira Taj Ahmad, 1994). This suggests that all the fragments and blocks in the complex were derived from the older rocks. Tan (1979) interpreted that the mélange was a tectonic mélange associated with subduction zone.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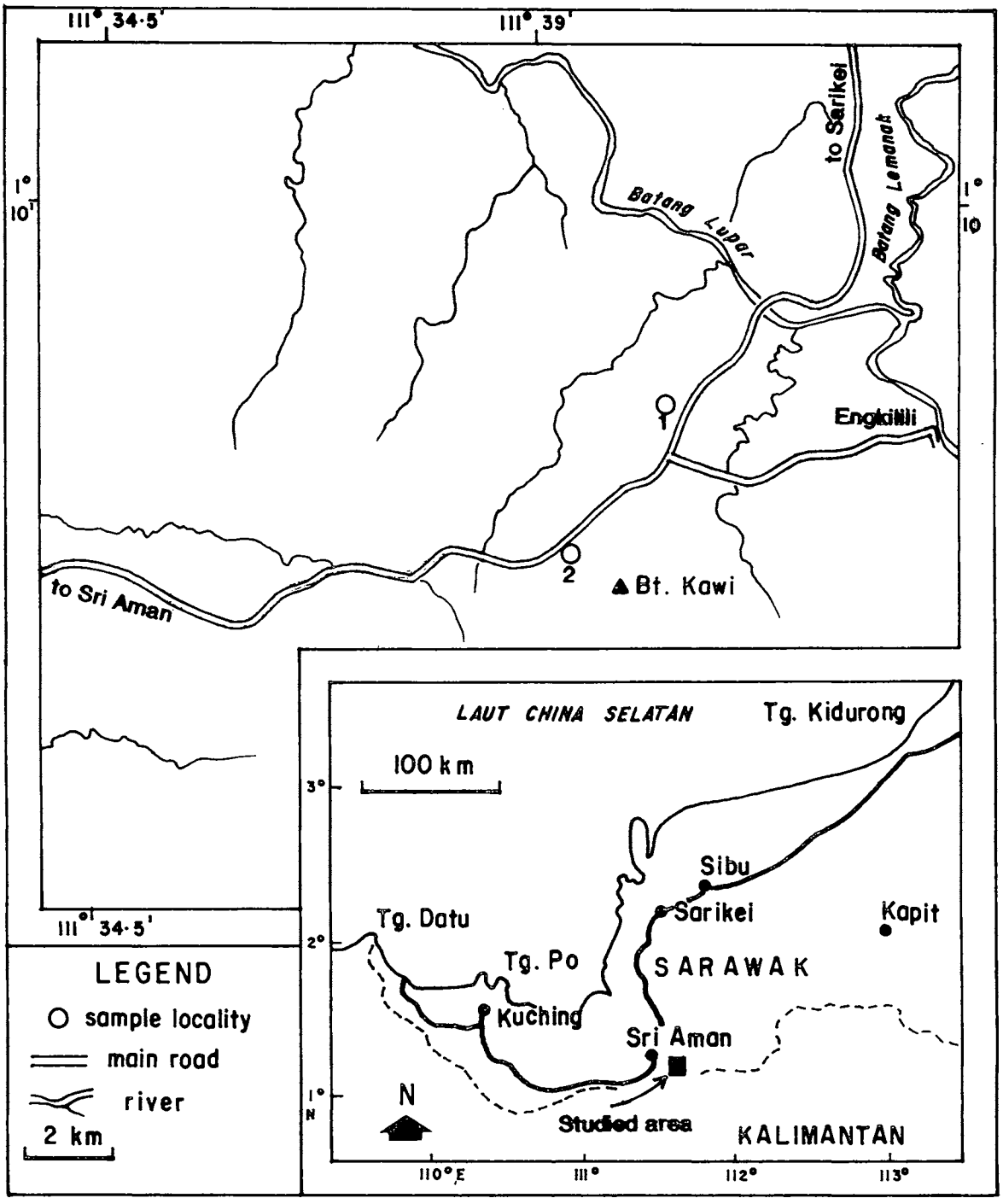
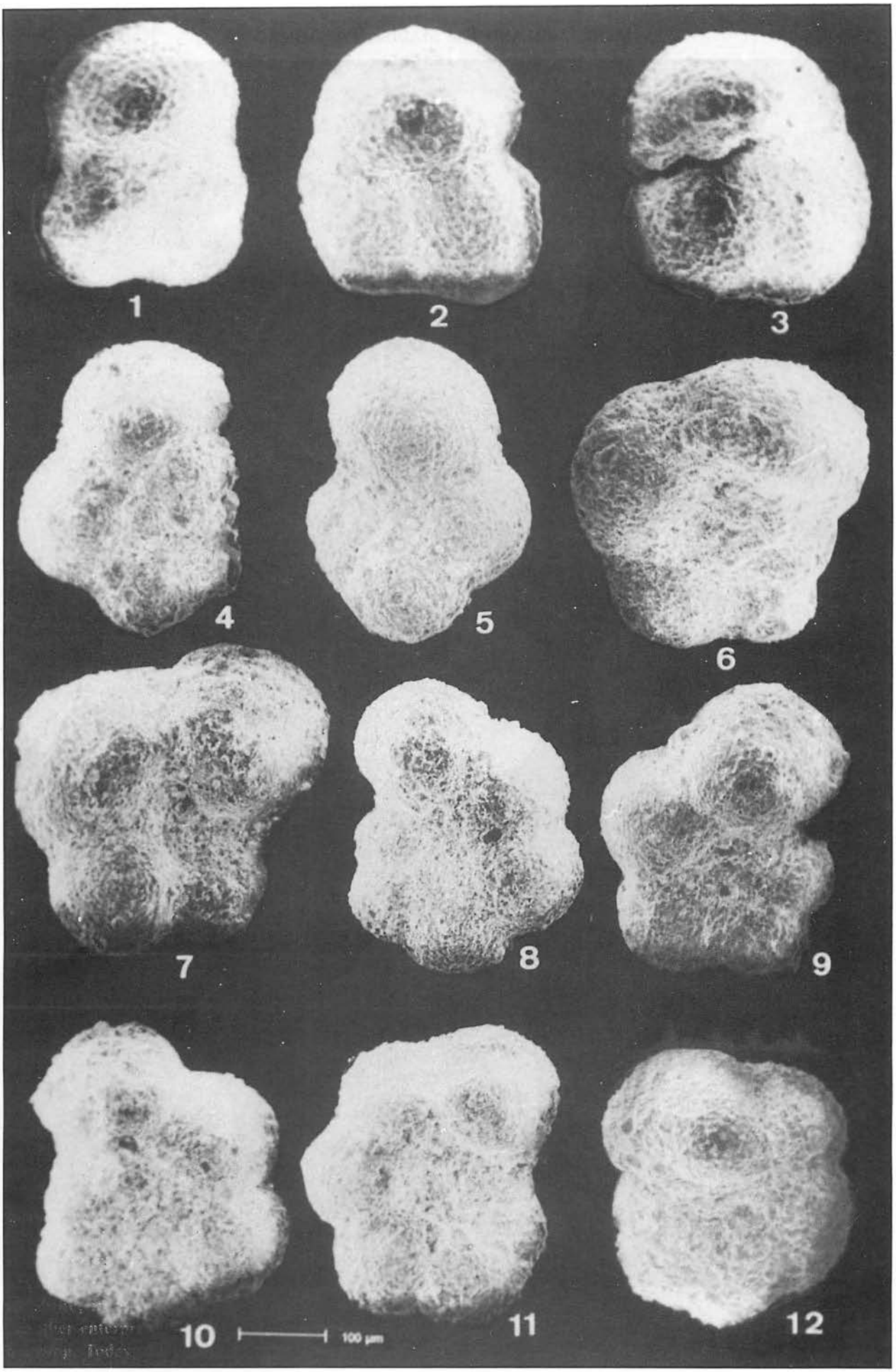


Figure 1. Map showing fossil localities.

Plate 1. (Scale bar = 100 μm)

1, 2. *Subbotina triloculinoides* (Plummer) (1. Spiral view, 2. Umbilical view)
3. *Subbotina velascoensis* (Cushman) (umbilical view)
4, 5. *Globorotalia pseudobulloides* (Plummer) (4. Spiral view, 5. Umbilical view)
6, 7. *Globorotalia quadrilocula* Blow (6. Spiral view, 7. Umbilical view)
8, 9. *Morozovella trinidadensis* (Bolli) (8. Umbilical view, 9. Spiral view)
10, 11. *Morozovella praecursoria* (Morozova) (10. Spiral view, 11. Umbilical view)
12. *Morozovella uncinata* (Bolli) (umbilical view)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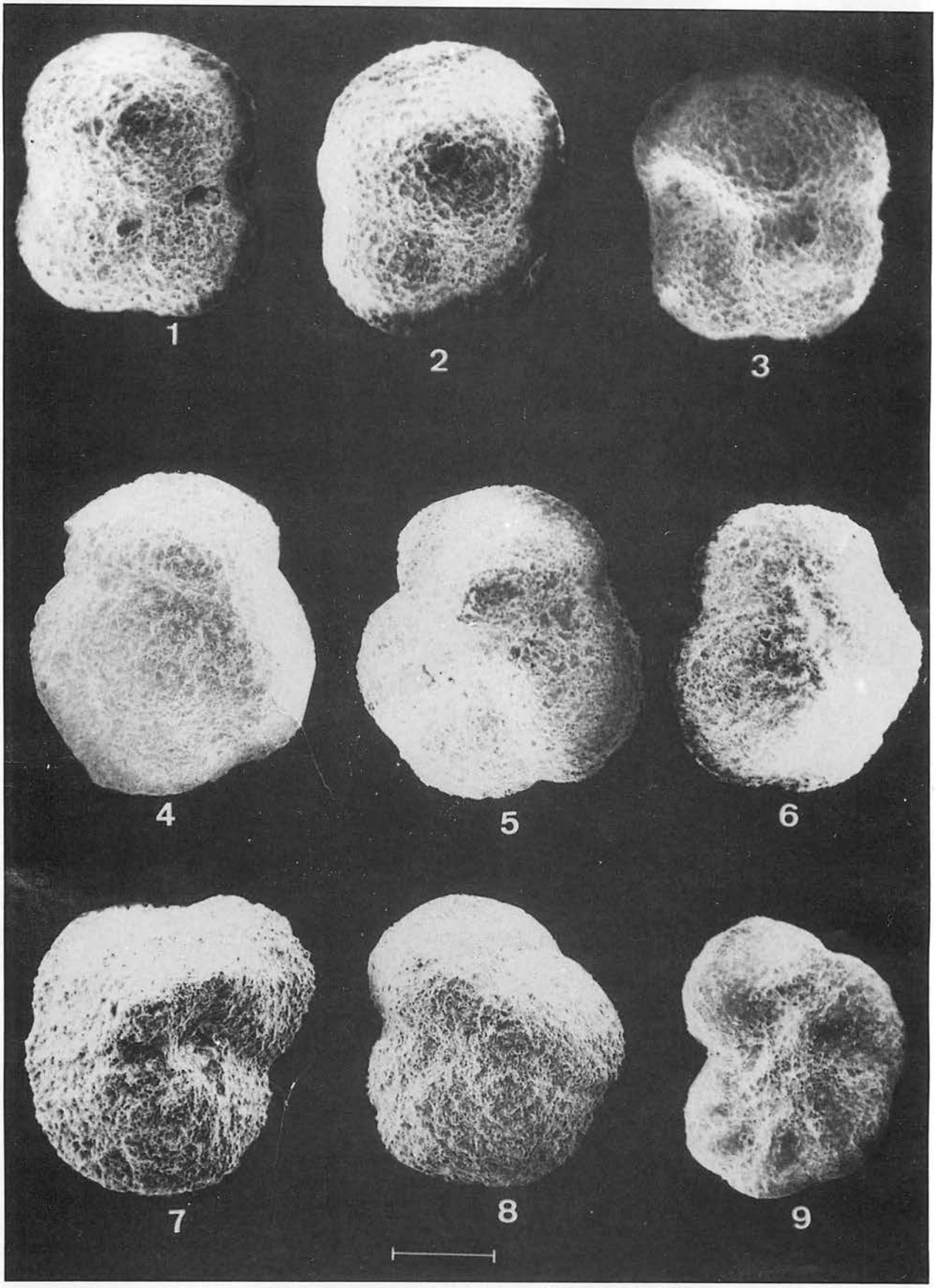
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AGE OF LUBOK ANTU COMPLEX

Two assemblages of planktonic foraminifera were recognised from the mudstone matrix of the Lubok Antu Complex. Sample from locality 1 yielded *Globorotalia pseudobulloides* (Plummer), *Globorotalia quadrilocula* Blow, *Subbotina triloculinoides* (Plummer), *Morozovella uncinata* (Bolli), *Morozovella trinidadensis* (Bolli), *Morozovella praecursoria* (Morozova) and *Subbotina velascoensis* (Cushman) (Plate 1). This assemblage is indicative of *Morozovella uncinata* Zone (P2) early Middle Paleocene.

Six species were identified from a sample at locality 2, i.e. *Morozovella aragonensis* (Nuttall), *Morozovella naussi* (Martin), *Acarinina bullbrooki* (Bolli), *Subbotina linaperta* (Finlay), *Subbotina frontosa boweri* (Bolli) and *Globanomalina indiscriminata* (Mallory). This assemblage represents a wide range of age from late Early Eocene to early Middle Eocene. Based on the occurrence of planktonic foraminifera in the mudstone matrix of the Lubok Antu Complex we conclude that the age of the complex ranges at least from the early Middle Paleocene to early Middle Eocene.

THE ORIGIN OF THE COMPLEX

The occurrence of some planktonic foraminifera in the matrix of the mélange suggests that the mélange was originally sedimentary mélange. The chert blocks and other rock fragments were deposited in the basin by debris flow. The sedimentary mélange has undergone shearing and deformation near the subduction zone then formed tectonic mélange.

CONCLUSION

Two assemblages of planktonic foraminifera were identified. The oldest assemblage is indicative of early Middle Paleocene and the other assemblage represents the early Middle Eocene age. Lubok Antu Complex was deposited during the early Middle Paleocene to early Middle Eocene. This complex was originally sedimentary mélange (Olistostrome) which underwent tectonic deformation near the subduction zone.

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We would like to thank En. Mohd. Yaakob Dato' Ismail , En. Abdul Ghani Idris and En. Ibrahim Mohd. Dom for their assistance in SEM photography, map and plate preparation

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Plate 2. (Scale bar = 100 μm except figures 6 and 7)
1, 2. *Subbotina linaperta* (Finlay) (1. Umbilical view, 2. Spiral view)
3. *Subbotina frontosa boweri* (Bolli) (umbilical view)
4, 5. *Acarinina bullbrooki* (Bolli) (4. Spiral view, 5. Umbilical view)
6, 7. *Morozovella aragonensis* (Nuttall) (scale bar = 160 μm) (6. Spiral view, 7. Umbilical view)
8. *Globanomalina indiscriminata* (Mallory) (spiral view)

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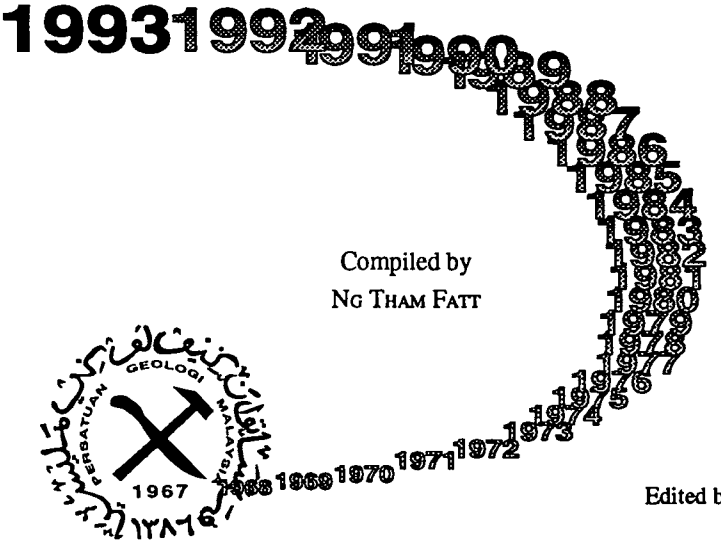

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Geological Notes — Special Communication

Geotechnical engineering investigations of the Highland Tower Condominium collapse, Ulu Kelang, Selangor

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Synopsis: The technical investigation into the collapse of the Block 1 of the Highland Towers Condominium followed the procedure of 'desk study' of available documents, records and drawings, interviews with persons related to the project, site investigation, laboratory testings and data analyses. Many records were incomplete or not available. As such, some information were related by persons affected by the tragedy.

Investigation of the substructure and the surroundings revealed the characteristics of the surface and subsurface condition of the site. From the analysis of data obtained, simulations were made on the possible mode of failure. Excavation of the foundation system of the collapsed Block 1 provided insights into the performance of the foundation during and after the collapse.

Computer simulations of the performance of the superstructure under various combination of loadings that the building might be subjected to were performed. It was determined that the design per se complied with the prevailing code. Tests for the materials sampled from the debris and from the excavation indicated conformance to required quality.

From the findings of the investigation it was concluded that the most probable cause of the failure was due to retrogressive landslides behind the building of Block 1 which consequently induced the instability of the rail pile foundation that was not designed for lateral loading. The inadequate provision of drainage and the lack of maintenance of the drains aggravated the friable nature of the slope materials by increased surface runoff and infiltration that finally triggered the series of landslides.

INTRODUCTION

On 11 December, 1993 at approximately 1.30 pm, Block 1 of the Highland Towers Condominium suddenly toppled over and collapsed. Three victims were rescued alive on the first day; a maid Mrs. Umi Rashidah bt. Khairuman with her 2-year old baby daughter and a 56 years old Japanese lady occupant, Mrs. Shizumi Nakajima. The later succumbed to the injury and died in Kuala Lumpur General Hospital on the same day. After 10 days and nights the concerted rescue efforts failed to find any more victims who are still alive. A more drastic means was then employed to locate and extricate the bodies. In all, 48 bodies were recovered and identified.

Investigation was started immediately after the rescue operation ceased on the 12th day after the collapse. The site investigation works only ended on 5 April 1994. The excavated locations were refilled and levelled with the same materials.

The information and data were obtained and analyzed within the period of 3 months given for the submission of the technical report. The urgency was due to the public anxiety with which the report was awaited.

BACKGROUND

The Highland Towers Condominium project, comprised of 3 blocks of 14 level buildings located in the of Mukim Hulu Klang within the district of Gombak in the state of Selangor, was built during the period from 1974 to 1986 in various stages of completion. The superstructures for the 3 blocks were completed by 1978, whilst the architectural finishes for Block 1 were completed in 1978 and occupied thereafter before similar works on Blocks 3 and 2 commenced later and completed in 1981 and 1986, respectively. Each block consists of two identical towers connected via a common central service cores comprising two staircases and two passenger lifts. Each tower in turn is made up of a lower ground floor car park, a ground floor, 11 floors of apartments and a penthouse on the topmost floor. The building is of reinforced concrete structure consisting of reinforced concrete slabs, beams, staircases, lift shaft and columns. The building was founded on rail piles. A 95 m^3 reinforced concrete ground suction tank was located between the lower ground floor and the ground floor of Block 1. There is a 16 m x 16 m swimming pool located behind Block 2 and was shared by the residents of the three blocks.

It is important to note the location of the Highland Towers Condominium in relation to other recent developments in the vicinity of the adjoining properties. The Highland Towers Condominium is located at the toe level of the high ground that constitutes the backdrop where developments by the Malaysia Borneo Finance (MBF) occupy the higher elevation, some 150 meters above. The mid-level elevation contains bungalow lots development owned by the Arab-Malaysian Finance Berhad (AMFB) The development by MBF started in 1990 and is ongoing whereas that by AMFB was started in 1992 and abandoned shortly thenafter.

From the aerial photographs taken by the Jabatan Ukur dan Pemetaan Malaysia (JUPM) in 1985, much denudation of the hill slope behind the condominium by removal of slope vegetation and trees had occurred. Residents of the Highland Towers claimed that mudflow and siltation onto the Highland Towers Condominium ground occurred during and after the rainfall due to the construction activities of the uphill development. The unsealed access to the slope behind Block 1 embanked by the rubble walls constructed on the hillslope acted as the channel for this precipitated runoff.

SCOPE AND PROCEDURES OF INVESTIGATION

There were limitations of site condition in connection with the investigations. Firstly, this was a case where the whole superstructure of the building had toppled to the ground and the massive dislocations of the adjacent retaining walls, access road and the other temporary structures in the vicinity. What was observed during the rescue operations was that no column or wall was upstanding, except for some column stumps and upper column lengths of the lower floor with protruding twisted steel bars. Secondly, upon the collapse of the building, the foremost consideration was to rescue the persons buried under the debris. Consequently, the debris were removed to several nearby sites to facilitate this operation and not to preserve any members of the structure, such as columns, beams and slabs, for the purpose of the investigation. What remained thereafter at the site were ground beams, foundation, the basement which was uncovered during the excavation, a few column stumps with twisted steel bars, and debris walls. Hence, insofar as the investigation of the material and superstructural members is concerned, their examinations were limited to the remains extracted from the debris at site and from those excavated from the basement and foundation.

The investigation was subdivided into three components to examine the principal roles and contribution from the various stages of the project. The scope of works were as follows:

a. Planning Construction and Supervision Procedures

To establish the construction and supervision procedures relating to the submission, processing and approval of the project by the developer, consultant and various authorities leading to the approval and issuance of the Certificate of Fitness. In this respect, the group was to ascertain compliance with standard procedures, examine all available documents (correspondence, data sheets, calculations, drawings, etc.) relating to the project and to interview the personnel involved in the application, design and construction phases. The findings will establish the degree and level of compliance, and if necessary, make recommendation for reviews of existing Building By-Laws and need for strict compliance with standard procedures and practices.

b. Substructure Analyses and Surroundings

To carry out geotechnical evaluation of the foundation system used, the ground condition of the site and the surrounding areas. As earlier indications had placed landslide as a possible triggering mechanism that toppled the Block 1 building, analyses of the geotechnical contributions must be reconstructed carefully to explain the event. As such, greater emphasis in terms of scope of investigation and specialist inputs were required. In the absence of many records for the foundation works and development of the surrounding areas, the examination will rely on extensive site excavation and measurements. The findings will be extrapolated to address the rectification, or otherwise, of the remaining Blocks 2 and 3, and future requirements to consider the geotechnical aspects in the submission of development plans for similar condition.

c. Superstructure Analysis and Material Investigation

To ascertain the strength and durability of the materials of important structural components and appraising the structural provisions against design inadequacies and defects. In the absence of structural design records, computer simulation of the structural response as a whole, or in components, to accidental loadings was derived from the as-built or tentative drawings, whichever was available. Examinations and tests of materials extracted from the debris and the excavation shall include piles, pilecaps, and other structural components. These would verify their adequacies and durability in the failed structure and the remaining buildings. The adequacy of the materials and structure of the

remaining building is further examined by condition and visual survey of the accessible interiors and exteriors of some apartments in the buildings. Provisions were allowed for core samples of some structural components should the need arise, and to make good the coreholes.

Investigation which had been carried out include the following main tests:

Investigation	Purpose
Soil Classification	Soil grouping
Shear Box	Soil shear strength
Mineralogical analysis	Soil mineral
Petrographic study	Rock type
Surface Infiltration	Permeability
Borehole Permeability	Permeability
Field Density	Soil weight
Compression Tests	Compressive strength of concrete
Tensile Tests	Tensile strength of reinforcement bars and rail piles
Bending Tests	Bending strength of reinforcement bars and rail piles
Impact Tests	Fatigue strength of rail piles
Chemical composition	Carbon content of rail piles
Inclinometer	Lateral movement of soil
Standpipe piezometer	Ground water levels fluctuation
Boreholes	Soil profile
Geological Mapping	Extent of rock type and fractured zones
Seismic refraction	Subsurface lithology

Several unsuccessful attempts were made to extract the embedded lengths of the piles by vibro hammer and pullout by a 45 ton crane. Melting and disengagement of the welded plates to the pile tops occurred on numerous occasions. Stage excavations were employed on only one location to verify the pile lengths.

Reference was made to the Police Department on the possibility of an act of sabotage as the probable cause of collapse. Since there was no discovery or report of any explosive substance at the site the possibility of an explosion and/or act of sabotage was not suggested nor agreed to by all the persons interviewed, an act of sabotage was ruled out as the cause of the collapse.

In order to trace the source of probable contributing factors to the collapse of Block 1, an examination of the adjacent development sites uphill for erosion features and drainage channels was carried out. Isotope survey of the possible flow of surface and subsurface water was carried out.

SUBSTRUCTURE ANALYSES AND SURROUNDINGS

Extent and Sequence of Failure

Observation of the failure site indicated an overall area of the landslide on the hillslope behind Block 1 was about 120 m long and about 90 m wide involving approximately 40,000 cubic metres of debris. Aerial inspection carried out two days after the collapse suggested that there were four successive failure scars. An eyewitness recounted seeing earth movements in the south end corner of the site. The sliding debris moved from the east to the west and then heaped on the car park and the badminton court behind Block 1. The slide lasted for about 3 to 5 minutes, followed by a momentary silence (lull) for about 20 to 30 seconds before the building started to tilt. Parts of the badminton court then cracked up and appeared to slide forward. The terrace ground off the south (front) end of the building apparently gave way. Cars parked on the terrace ground appeared to have sunk. The building then moved forward some 1.5 m to 3.5 m before tilting forward and collapsed.

Design Records

No geotechnical design records were submitted or available on earthworks, slope stability, retaining wall and foundations. It was claimed that some ground investigation was carried out for the purpose of foundation design but no records could be traced as the ownership of the soil investigation company has been changed. Pile driving and pile load test records too cannot be recovered. Many explanations and conclusions on the design aspects were suggested from the information provided by the interviewees, especially from the architect and the structural engineer engaged for the project. Subsequent ground investigation and excavation of the base of the Block 1 have provided useful information in evaluating the triggering mechanism for the soil movement and the possible response of the substructure.

All the three buildings were built on rail pile foundation, driven to set. The piling system consisted of a cluster of three or four rails welded together. Available structural drawing showed single and double cluster per column details. No driving records were available to ascertain the driven lengths of these piles. The structural engineer claimed that two pile load tests had been carried out to twice the working load. However, no records were available to substantiate the pile carrying capacity. The structural engineer claimed that the foundation system was designed by the piling contractor who was also the rail pile supplier.

Maintenance Records

No records of periodic maintenances were available during this investigation. Generally, the maintenance works carried out were to repair functional failure of building services. The scope of work did not extend to inspection of rubble walls, locating surface cracks on road pavement, desilting of drains above and beyond built-up areas. Only on one occasion, when the slope immediately behind the three blocks was cleared, overland flow caused flooding of the basement car park that sandbags were used to stop this flow.

Ground Surface Profile

The ground profile behind the collapsed building was terraced up to several levels and retained by discontinuous lines of rubble walls of varying heights of up to 7 m and thickness from 0.4 m to 1.3 m. Behind Block 1 were two badminton courts and two rows of car shed on one level, at about the same elevation as the 1st floor level (about 4 m above basement) of the said building. Another row of similar car shed was built on the next terrace, approximately 5 m above the first terrace.

The formation level, as deduced from the topography map from the Jabatan Ukur dan Pemetaan Malaysia (JUPM), of the three buildings ranged from R.L. 65 m to R.L. 76 m. Blocks 1 and 2 are located on part cut and part filled ground, whereas Block 3 is totally on cut ground. Rising immediately behind the buildings are steep slopes starting from R.L. 70 m to R.L. 200 m. The slopes in the immediate vicinity of the apartment blocks are terraced and lined with intermittent gravity rubble walls. It was noticed that the rubble walls located on the lower terraces of the slope behind Block 1 had collapsed completely. However, the rubble walls that translated down from the upper terraces were found with some damage. There was also a significant slope failure in the vicinity as noticed in the aerial photograph taken in 1985.

A detailed land survey was commissioned to capture the present state of the ground surface. The upper most failure scar is located at the ninth terrace on the hillslope. The south end of the toppled Block 1 is almost at the centre of the failure zone. Plan view of the shape of the failure shows that landslides occurred in the east-west direction. Five cross-sectional surveys were taken of the site inclusive of one through the centre of the failed area. Generally the gradients of the unfailed hillslope ranged from 20° to 30° which are normal.

Rainfall records

The maximum rainfall intensities for 15-minute, 30-minute, 1-hour and 24-hour durations of the area for the year up to December 1993, measured at TAR College were 36.3 mm, 48.9 mm, 72.2 mm and 90.2 mm, respectively. The daily rainfall measured from 1 December to 10 December 1993 recorded at JPS Ampang were 8.5 mm, 16.0 mm, 59.5 mm, 0.5 mm, 6.0 mm, 0.0 mm, 11.0 mm, 45.0 mm, 3.0 mm and 28.00 mm, giving a total of 177.5 mm, compared to that recorded at TAR College (192.5 mm), Klang Gate Darn (148.1 mm) and Ulu Langat Dam (190.5 mm). This indicates that the total rainfall of the area is not exceptional since the cumulative rainfall for 1st to 10th December 1985 was 236.5 mm at the JPS Ampang Station.

Wind

There is no station measuring wind velocity over the area of study. Nevertheless, the wind data of two stations in Subang and Petaling Jaya showed that the highest gust recorded on the day of 11 December 1993 was 27 km/hour and 21 km/hour, respectively. Assuming a higher value of 27 km/hour wind were to occur at the Highland Towers site, it was insignificant to cause any structural damage.

Aerial Photographs

A series of aerial photographs were obtained from the JUPM. These photographs were taken in 1966, 1974, 1975, 1985, 1992 and 21st December 1993. Interpretation of these photographs took into account the surface features within the Highland Towers Condominium development and the adjacent developments, especially the uphill projects.

The examination of the above photographs showed that the catchment area contributing to main drainage path did not increase in size. However, drainage patterns on the hillslope behind the Highland Towers Condominium changed due to the extensive earthworks that were carried out. Erosion occurring to the south of the buildings was observed in 1966, then progressed into a gully by 1985 and was seen to be overgrown with vegetation by 1992.

The aftermath of the collapse of Block 1 Highland Towers Condominium was observed from the aerial photographs taken 11 days after the tragedy. The building laid skewed, in a north-west direction. Rescue works were still going-on. The drainage pattern and locations of new and old landslide and erosion areas were traced out.

Geology and Geomorphology

The Geological Survey Department provided records and interpretation of the geological data. The eastern part of the Ampang-Hulu Klang area is underlain by steep granite hills. Their gradients range from 28° to 38°. The foot of these hills are

more gentle, with gradient of about 3° to 8° some times after.

Highland Towers Condominium is sited at the foot of a steep granite hillslope which has been terraced with a total of 13 rubble walls along the hillslope. The hillslope behind Blocks 2 and 3 is of residual granitic soil which is mostly silty sand to clayey sand. Except for a large subvertical granite outcrop measuring about 10 m in length and 10 m in height, no other outcrops were observed. There are two major and two minor sets of fracture recorded in this outcrop.

Petrographic studies carried out by the Geological Department of the University of Malaya revealed that the rock types found in and around the site of the collapsed Block 1 of the Highland Towers consist of sheared and fractured muscovite adamellite, banded greisenized fractured adamellite and sericitized fractured pegmatite. They can be classified under the Granite Group in accordance with BS. 812 Part 1. This group of rock is regarded as strong and they generally show excellent engineering properties.

Other textural, physical, and mechanical properties of the 'granitic' rocks are not abnormal for such types of rock except for the shear fracturing and alteration observed in the thin sections. The Block 1 site was close to or within the peripheral zone of a fault. This part of Peninsular Malaysia is tectonically stable and no active fault movements have been recorded.

A large earlier landslide scar can be observed to the south of the landslide which occurred on 11 December 1993. Water seepages were observed at two locations within the landslide scar. Tension cracks were observed just above the crown of the landslide.

As-built Drainage Facilities

The approved drainage system was such that the surface runoff from the hillslopes behind the Condominium blocks would be intercepted, collected and discharged towards Taman Sri Ukay. There were no as-built plans available to show the actual drainage systems of the Condominium and the neighbouring properly. What was observed from the ground after the collapse was that not all the drains us per approved plans were constructed. Field observations showed only some of the roadside drains along the access road to the bungalow lots behind Highland Towers were constructed.

One complaint of flooding was made in 1979 when earthwork was still going on behind the Condominium. No records could be traced as to any remedial works undertaken to improve the situation. Subsequently, a storm in 1992 again caused the surface runoff to flood the compound and basement car park of Highland Towers Condominium. The incident which was videotaped by a resident also showed that the occurrence happened just after clearing of trees on the hillslope behind the Condominium blocks. The flooding could be caused by any combinations of either inadequate drainage provisions for the area, improper earthwork practices or lack of drain maintenance.

After the collapse of the Block 1, field inspection showed that the concrete drains along the access road leading to the bungalow lots behind the Condominium had collapsed. Along stretches where the drains were intact, sediment and vegetation had blocked the smooth flow of surface runoff. An interceptor trench was excavated along the hillslopes to divert surface runoff from the upper catchment area away from the collapse site.

The sizing of the drains and drainage structures was designed in accordance with DID Planning and Design Procedure No. 1: Urban Drainage Design Standards and Procedures for Peninsular Malaysia but was not constructed accordingly.

Subsurface Investigation

Seismic refraction survey conducted on the site identified four (4) seismic layers i.e. top loose soil, unconsolidated fill materials, completely decomposed rocks and weathered to fresh bedrock. Block 1, in particular, is sited near an inferred fault or fracture zone.

Eleven boreholes were drilled along the axis of the recent landslide. Another eleven boreholes were drilled in the north of the recent landslide and also on the hillslope behind Blocks 2 and 3. At South of the landslide zone, two boreholes were drilled. Results showed that almost all the boreholes, except one were sited over fill ground. The fill material generally varied from 4 m to about 14 m thick. Consistency of the fill material ranged from very loose to loose. The fill material was classified as silty sand with gravel. Beneath the fill material was medium dense to dense residual granitic soil which varied from 1.5 m to 5 m thick. In ten of the boreholes, the fill material overlay the completely- to highly- weathered granite. The zone of completely-weathered granite to highly-weathered granite varied from 3 m to 6 m thick. Beneath this, was fresh- to slightly-weathered granite bedrock. Borehole BH7(S), which was located about 5 m to the west of a large outcrop of granite, had a 1.5 m thick cover of residual soil before encountering fresh- to slightly-weathered bedrock.

JKR probes (a light dynamic cone penetrometer

similar to Mackintosh probe) were conducted along the axis of the recent landslide. The probes were conducted in three lines. Four slip surfaces were interpreted from each probe line. Depths of these slip surfaces ranged from 3 m to 5 m below the existing ground level.

Three surface infiltration tests were carried out on the hillslope behind the Condominium blocks. Values of surface permeability were in the order of 10^{-2} cm/sec.

Constant head permeability tests were conducted in two boreholes to ascertain coefficient of permeability values of the subsurface materials. Tests in both boreholes showed that the permeability was in the order of 10^{-4} to 10^{-3} cm/sec, which is termed as a highly permeable subsurface.

Field density measurements were conducted in three trial pit locations to measure the total unit weight of the soil. These measurements averaged out to be 19 kN/m^3 for the fill material.

Excavation to inspect the condition of the pilecaps and top of the piles was made. Deepest excavation level encountered was at the front southwest corner of the toppled building. At this location the pilecap had sunk to about 4 m relative to front northwest corner. All the piles that were inspected were broken at a depth of about 1.5 m to 3 m below the pilecap level. The pilecap at the front southwest corner had also translated horizontally to a maximum distance of 5.5 m. The ground beams and the position of the pilecaps were dipping to the direction of toppling. Ground beams in the back quadrant 3 deformed in a rhombohedron shape. This orientation suggests that the resultant force from the landslides acted at this location, as the position of the southern end of the building was at the centre of the failure scar.

Ground Movement Monitoring

Ground movement monitoring facility was installed within Block 3. Inclinometer tubes were installed at two locations on top of the rubble wall behind Block 3. Their purpose was to monitor any lateral movement induced behind this building. In the period of observation until end of April 1994 approximately 2.5 mm to 3 mm of movement has been registered at the ground surface.

Several standpipe piezometers were also installed along cross-section of Block 3. Monitoring of these piezometric levels was done regularly on alternate days during the investigation. This was to determine any increase or decrease in ground water pressure within the vicinity. No drastic increase or decrease in water pressure was registered.

Soil Properties

Soil classification tests were done on the samples obtained from the site. Tests were conducted in accordance with BS 1377 (1990). The soil above the highly weathered granite zone is generally classified as silty sand of medium to dense, overlain by silty sand of very loose to loose consistency.

Total mineralogical analysis of the soil from the site was carried out to find the differences of the mineral contents especially the clay of the various types of soil and to relate them to the landslide which caused the collapse of Block 1. The most abundant mineral in the soil was quartz which was, however, found almost entirely in the coarse fractions. This was not the "active" component of the soil.

The clay minerals which were the "active" components of the soil, were found in amounts ranging from 15.3% to 37.4% only. The clay mineral contents of the fill material in the landslide mass were about 37% whereas those in the soil of the slopes were between 15.3% to 25.2%. Of all the clay minerals found, kaolinite with contents from 10.5% to 21.1% constituted the most abundant, with the amorphous material which was lumped as amorphous clay or allophane as the next dominant. The amorphous content of the soil samples ranged from 6.0% to 9.3%. The activity of the amorphous clay is very close to that of montmorillonite or smectite. Though the total component of the clay minerals in soil and fill material was relatively low, the presence of significant amounts of amorphous material or allophane in them had contributed to the activity of the soil. It probably can help to explain the very soft and fluid condition of the landslide mass.

The +100 μm fractions of the soil ranged from 61.7% to 80.5%, indicating a quite permeable texture. The fill materials were found to be mixed with some 5% to 20% of weathered and broken rock fragments that could have originated from an abandoned small quarrying operation found two-thirds the distance up the slope of the hill (though no documented proof was available at this time).

Several series of shear box test were conducted on 100 millimetres samples obtained from trial pit locations and from excavation made for foundation inspection. The trial pits were dug 1.0 m to 1.5 m below the ground surface on the unfailed section. The range of undrained shear strengths, c' = 4.0 to 6.0 kPa and undrained friction angles, Ø'= 33° to 41°.

Analysis of Results

Slip circle analysis was performed using Simplified Bishop's Method. The original surface

profile of the failed section was deduced from topography map of the JUPM and the cross-sectional profile by the appointed licensed surveyor. Shear strength parameters were taken from shear box test results. These results were interpreted by assuming lower and upper bound limits. From the classification test results, it was appropriate to adopt these values at this stage to model the mode and sequence of landslides for materials derived from weathered granite. The analysis was run using predetermined slip planes deduced from the JKR probe results with varying ground water profile, beginning with piezometer water levels measured on site.

The lowest factor of safety of 0.96 was obtained if a slip was to occur through the first level car park and originated from two terraces above the second level car park. The water level had to rise up to the toe of the rabble wall retaining the second level car park. This slip surface corresponded with the first failure surface predicted from JKR probe results. Subsequent landslides then followed without any rise in ground water level but occurred due to loss of toe weight from the previous slide. The simulation predicted four slides to occur. The end of the last slide was on the ninth terrace.

A simulation was also carried out to estimate the increase in active earth pressure due to heap of landslide mass on the terrace behind Block 1. The factor of safety obtained was 0.8 (unsafe). This means that the slided mass on top of the terrace behind Block 1 caused a base failure underneath the building. Analysis carried out with the original ground profile prior lo the landslide showed that the factor of safety against base failure was 1.7, meaning that the building was safe prior to the landslide.

An estimate was also made to determine the required pore pressure ratio, r_u to induced failure. This failure mode is quite common in residual soil lying over inclined and shallow bedrock. Pore pressure ratio, r_u of 0.5 with phreatic surface at ground level and 0.7 if phreatic surface is at its present level.

Findings

Retrogressive landslides had occurred behind Block 1. The debris heaped on the car park and badminton court and imposed surcharge loading on the terrace behind Block 1. A slip plane propagated around the pile foundation and mobilised further active force on the front retaining wall. A line crack appeared along the front of the building before collapse indicating the earth and wall mass departed from the edge of the building. As a likely result, there was loss of lateral support for front row piles. The piles broke under active state causing the building to rock, thus developing further structural failures. The foundation could then no longer provide adequate support for the building to be stable.

The failed mass was found to be soft and wet This observation indicated that the failure was positive pore pressure induced or due to rise in ground water level. The rise in ground water level was attributed to several factors. It is difficult to single out and quantify which factor contributed the most. There were no specific ground water monitoring records before the collapse.

Overall, the 'granitic' rocks and the minor amounts of quartz veins which underlay the Block 1 could not have played any significant role in causing its collapse. Mineralogically, the 'granitic' rocks found in and around the collapsed Block 1 did not contain any primary or secondary highly soluble minerals which could result in the formation of solution cavities and caverns which could adversely affect the stability of the foundation of Block 1. No deleterious minerals were detected in the rocks which could cause accelerated deterioration of the physical properties and strengths of the rock beyond that which can be expected in a local weathering process.

Drainage patterns in the surroundings of Highland Tower Condominium have progressively changed over time due to implementation of development projects. Examination of the 1992 aerial photograph also showed that the area in the upper catchment was cleared for development. Investigation made after the incident showed that surface water was flowing on the hillslope which originated from the main drainage path. The clearing would result in greater surface runoff from the upper catchment due to the absence of retention medium which accelerated overland flow and reduced the time of concentration. This led to higher infiltration and percolation of rainfall for the same catchment size. Therefore, hillslope behind Block 1 was easily charged by surface water spilled over by the drainage path from upper catchment beyond the ridge of the hillslope and contributed to the rise the ground water level.

The surface and subsurface material was categorically characterised as porous. Its permeability was in the order of 10^{-2} cm/sec at the surface and 10^{-4} to 10^{-3} cm/sec within the subsurface. Clearing of trees on hillslope in the year 1992 led to greater surface infiltration from rainfall and caused the ground water level to rise.

The surface drainage system constructed at the back of the Condominium was also ineffective. Firstly the drains were not constructed as per approved plans. Secondly, the existing drains were

failure (soil movement) underneath the foundation of Block 1.

The foundation system consisting of rail piles could not have been designed to cater for lateral loads that was introduced by the instability of the underlaying soil.

The rubble wall in front of Block 1 collapsed resulting in the loss of lateral support for the front row piles. This caused instability of the building and its subsequent collapse.

Probable Mode Of Collapse

It was evident that the collapse of Block 1 was triggered off by the landslide. The probable mechanism that caused the collapse of Block 1 was failure of the rail piles foundation in quadrant 2 of the front Block. This came about due to the lateral movement of the 7 m high rubble wall in front of this quadrant. Movement of this wall caused the lost of lateral restraint offered by the surrounding ground to the rail foundations. This reduced the buckling capacity of these rails causing them to sway and eventually sheared off.

Failure of the foundation then caused the centre of gravity of the whole foundation to shift away from the centre of gravity of the superstructure, thereby inducing moment eccentricity that caused instability to the building. The abrupt failure caused the foundation in quadrant 2 to collapse and pulled the other quadrant in a diagonal direction with respect to the original orientation of the building. However, this pulling effect was counteracted by the other quadrants; thus causing the whole building to jerk in the diagonal direction.

A stage was reached where subsequent jerks coupled with the lateral movement of the soil underneath the foundation, had resulted in the induced imbalance moment, that could no longer be resisted. Eventually the whole building was dragged down and toppled in the direction having the weakest stiffness i.e. about its minor-axis.

ACKNOWLEDGEMENT

This paper is but a summary of the 4-month long efforts of the whole investigation team of engineers, architects, geologists, scientists, technicians and field workers, etc., who have contributed their time and energy in reporting the findings to explain the contributory factors to the collapse of the Highland Towers Condominium. The technical report that ensued is a testimonial of their unbiased conclusions from the available evidences.

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Manuscript received 17 May 1995

profile of the failed section was deduced from topography map of the JUPM and the cross-sectional profile by the appointed licensed surveyor. Shear strength parameters were taken from shear box test results. These results were interpreted by assuming lower and upper bound limits. From the classification test results, it was appropriate to adopt these values at this stage to model the mode and sequence of landslides for materials derived from weathered granite. The analysis was run using predetermined slip planes deduced from the JKR probe results with varying ground water profile, beginning with piezometer water levels measured on site.

The lowest factor of safety of 0.96 was obtained if a slip was to occur through the first level car park and originated from two terraces above the second level car park. The water level had to rise up to the toe of the rabble wall retaining the second level car park. This slip surface corresponded with the first failure surface predicted from JKR probe results. Subsequent landslides then followed without any rise in ground water level but occurred due to loss of toe weight from the previous slide. The simulation predicted four slides to occur. The end of the last slide was on the ninth terrace.

A simulation was also carried out to estimate the increase in active earth pressure due to heap of landslide mass on the terrace behind Block 1. The factor of safety obtained was 0.8 (unsafe). This means that the slided mass on top of the terrace behind Block 1 caused a base failure underneath the building. Analysis carried out with the original ground profile prior lo the landslide showed that the factor of safety against base failure was 1.7, meaning that the building was safe prior to the landslide.

An estimate was also made to determine the required pore pressure ratio, r_u to induced failure. This failure mode is quite common in residual soil lying over inclined and shallow bedrock. Pore pressure ratio, r_u of 0.5 with phreatic surface at ground level and 0.7 if phreatic surface is at its present level.

Findings

Retrogressive landslides had occurred behind Block 1. The debris heaped on the car park and badminton court and imposed surcharge loading on the terrace behind Block 1. A slip plane propagated around the pile foundation and mobilised further active force on the front retaining wall. A line crack appeared along the front of the building before collapse indicating the earth and wall mass departed from the edge of the building. As a likely result, there was loss of lateral support for front row piles. The piles broke under active state causing the building to rock, thus developing further structural failures. The foundation could then no longer provide adequate support for the building to be stable.

The failed mass was found to be soft and wet This observation indicated that the failure was positive pore pressure induced or due to rise in ground water level. The rise in ground water level was attributed to several factors. It is difficult to single out and quantify which factor contributed the most. There were no specific ground water monitoring records before the collapse.

Overall, the 'granitic' rocks and the minor amounts of quartz veins which underlay the Block 1 could not have played any significant role in causing its collapse. Mineralogically, the 'granitic' rocks found in and around the collapsed Block 1 did not contain any primary or secondary highly soluble minerals which could result in the formation of solution cavities and caverns which could adversely affect the stability of the foundation of Block 1. No deleterious minerals were detected in the rocks which could cause accelerated deterioration of the physical properties and strengths of the rock beyond that which can be expected in a local weathering process.

Drainage patterns in the surroundings of Highland Tower Condominium have progressively changed over time due to implementation of development projects. Examination of the 1992 aerial photograph also showed that the area in the upper catchment was cleared for development. Investigation made after the incident showed that surface water was flowing on the hillslope which originated from the main drainage path. The clearing would result in greater surface runoff from the upper catchment due to the absence of retention medium which accelerated overland flow and reduced the time of concentration. This led to higher infiltration and percolation of rainfall for the same catchment size. Therefore, hillslope behind Block 1 was easily charged by surface water spilled over by the drainage path from upper catchment beyond the ridge of the hillslope and contributed to the rise the ground water level.

The surface and subsurface material was categorically characterised as porous. Its permeability was in the order of 10^{-2} cm/sec at the surface and 10^{-4} to 10^{-3} cm/sec within the subsurface. Clearing of trees on hillslope in the year 1992 led to greater surface infiltration from rainfall and caused the ground water level to rise.

The surface drainage system constructed at the back of the Condominium was also ineffective. Firstly the drains were not constructed as per approved plans. Secondly, the existing drains were

choked with sediment and undergrowth due to lack of maintenance. Surface runoff overtopped the drains and flowed unchecked along the hill slopes behind Block 1. This had also subjected the ground to surface erosion, resulting in the loss of confinement around the drains thus allowing infiltration of surface runoff through the breaching gaps. Based on the DID Planning and Design Procedure No. 1: Urban Drainage Design Standards and Procedures for Peninsular Malaysia, the surface runoff quantity could double if the vegetative cover of the catchment was removed and the ground surface left bare.

Existing tension cracks above the old landslide scars on the south of the present failure scar could also act as collection area for rainfall as well as surface water lo saturate the subsurface thus giving rise to the ground water level.

The rainfall intensity recorded in the year 1993 is considered not exceptional. However, due to combination of all the mentioned factors above, the landslide occurred on the afternoon of 11 December 1993. Though the rainfall intensity in 1985 was the highest, landslide did not occurred primarily due to absence of the above mentioned contributory factors.

SUPERSTRUCTURE ANALYSIS AND MATERIEL INVESTIGATION

Condition of Block 1 After Collapse

Block 1 consisting of two identical towers toppled forward about its minor axis and laid on its front with only the back tower visible above ground. Floors 3 to 8 of the front tower were completely crushed whilst floors 9 to 12 were scattered. The front tower also had translated approximately 4 floors relative to the back tower. The lower ground floor to the third floor of the front tower had collapsed one on top of the other and was found embedded into the ground. The ground and the lower ground floors of the back tower were not visible as they were buried by the landslide.

Structural Design

No design calculations were available for checking. None of the structural drawings were endorsed by any authorities and no name of the designer appeared.

Structural System

The superstructure of Block 1 consisted of two identical towers of average dimensions 37.2 m long x 8.8 m wide, linked by the access way to the lifts and staircases. Each tower had eleven floors of apartments, a penthouse on the twelfth floor, a ground and lower ground floors. Only at the ground floor were the two towers linked by a complete slab. The building was generally infilled with brickwall partitions except at the lower ground floor where it was used as a car park.

The two towers consisted of reinforced concrete (R.C.) structural frames with slabs and secondary beams nominally connected by a central R.C lift core and staircases. In addition, there was also a reinforced concrete curved wall located at the external central facade of each tower extending from the lower ground floor right up to the 12th floor. A reinforced concrete ground suction tank was located between the lower ground and ground floor of Block 1.

The orientation of the columns was arranged in such a way that the major axis was distributed in both directions. The concrete specified in the drawings was 1:2:4 prescribed mix (Grade 20), with mild steel reinforcement used for slabs and high yield reinforcement for columns, beams and walls.

Foundation

Each column and R.C walls of Block 1 were supported on rail piles. Drawings available, showed only typical details for the single and double pilecaps for the columns, and a six pilecap system for the lift shaft walls. Each pile consisted of a cluster of 3 or 4 individual rails welded to a mild steel plate at the pile head. The piles, consisting of 36 kg/m and 27 kg/m rails, were said to he welded along the length at 770 mm interval with 150 mm long continuous fillet weld. However, upon excavating after the collapse, it was discovered that this was not done for some of the piles. For these piles only spot weldings or lacing welds were done at various spacing along the length of the pile. Most of the extracted piles showed that although the fillet welds at the joints were satisfactory, the connecting plates had dropped off due to poor welding. It was also discovered that the piles had sheared off somewhere between 2.0 m to 3.0 m beneath the pilecap. In addition, it was noticed that some of the jointed piles were of dissimilar section. This practice is considered very unusual .

The column loads ranged between 900 to 2,500 kN for the individual columns and 6,500 kN for the lift shaft. On excavating the foundations of Block 1, it was confirmed that two different types of pilecaps were used. Although the consultant engineer had admitted that he did not design the foundation but he had indicated in the structural drawings that rail piles were to be used and thereafter had left it entirely to the piling contractor to choose the pile configuration and the type of rail to be used for the columns, walls and lift shaft.

Structural Evaluation

A three dimensional frame analysis was carried out on one quadrant of the tower. The original structural design was based on CP114, the prevailing code at that time. The appraisal of all the structural elements for Block 1 was based on the more stringent code of BS 8110 1985.

The loads acting on the superstructure were determined in accordance with BS 6399: Part 1: 1984 for Dead And Imposed Load, and Chap V: Part 2:1972 for Wind Loads computed based on a wind velocity of 30 m/sec. To simulate earth loading acting on the superstructure due to the landslide, lateral earth pressure for a height of three floors above the ground level was computed and was formed to be safe.

The structural analysis and design appraisal for five various load cases were carried out. The findings from these checkings showed that the .stability of the superstructure was adequate against toppling and no uplift of any of the foundations was observed. Generally, most of the elements were structurally adequate. However, some of the beams had insufficient anchorages into the columns and marginally insufficient support reinforcements. Both these deficiencies were insufficient to initiate any failures since most of the span reinforcements had been over provided and the analysis also did not take into account the stiffening effect of the brickwall infill.

Material Investigation

Several concrete cores, reinforcement bars and rail pile samples were taken from the collapsed debris of Block 1. Utmost care was taken to ensure that these samples were in good condition so as to ensure that results obtained would be representative of the quality of material and workmanship for Block 1 before failure.

Tensile tests on flat samples obtained from the webs and flanges of the rails showed that the rails had an average yield strength of 375.38 N/mm^2 (with minimum value of 326.63 N/mm^2) and an average tensile strength of 751.81 N/mm^2 (with minimum value of 732.22 N/mm^2).

Results on test carried out on the concrete core samples reaffirmed that the concrete strength was 20 N/mm^2 and in accordance with the specified concrete strength for prescribed mix concrete 1:2:4. As for the high yield reinforcement bars, test results also showed that the yield strength was 410 N/mm^2 and in conformance with the design strength adopted.

Findings

The superstructure when considered as a whole, was adequate and would not collapse under normal loading condition on the assumption that the buildings were constructed in full compliance with the structural drawings as received. From the material investigation and visual inspection it can be inferred that the quality of materials and workmanship of the superstructure were of acceptable standards.

There were however, doubts on the adequacy of the foundation system. The pile system was proposed by the piling contractor and was not verified by the consultant engineer. No proof of load tests was available to confirm the design. The quality control of the weldings was suspected since it was discovered that some of the weldings done were not in accordance with the requirements of the specialist contractor's normal practice for welding of rail piles. The use of old rails as pile foundation lends itself to criticism. This is because old rails arc of unknown strength characteristics. The rails may have suffered fatigue cracking without being noticed. The low ductility property of the pile section is also well known. Investigation has shown some of the piles has sheared off beneath the pile caps. Its use in a situation where the foundation is subjected to bending and shear in addition to the axial load, is not desirable.

CONCLUSIONS

Superstructure Analysis and Material Investigations

The superstructure was adequately designed in accordance with prevailing code CP114. Structural design checks showed that it did not fully comply with the more stringent BS8110 design code. However, the superstructure would not have collapsed under normal loading conditions.

The materials used in the construction of the superstructure were of acceptable standards.

Substructure Analysis and Surroundings

The surface runoff from the hilltop development aggravated the situation due to the inadequate provision of drains in full compliance with the approved drainage plan. The drainage system on the adjoining property was not constructed according to the approved plans and was not maintained by the developer/owner.

The increase in the infiltration rate from the hilltop development caused a rise in ground water on the slope at the back of the Condominium, thus causing the instability of the rubble walls on the third level terrace above the badminton court.

The collapsed materials from the upper terraces on top of the badminton court level caused a base

failure (soil movement) underneath the foundation of Block 1.

The foundation system consisting of rail piles could not have been designed to cater for lateral loads that was introduced by the instability of the underlaying soil.

The rubble wall in front of Block 1 collapsed resulting in the loss of lateral support for the front row piles. This caused instability of the building and its subsequent collapse.

Probable Mode Of Collapse

It was evident that the collapse of Block 1 was triggered off by the landslide. The probable mechanism that caused the collapse of Block 1 was failure of the rail piles foundation in quadrant 2 of the front Block. This came about due to the lateral movement of the 7 m high rubble wall in front of this quadrant. Movement of this wall caused the lost of lateral restraint offered by the surrounding ground to the rail foundations. This reduced the buckling capacity of these rails causing them to sway and eventually sheared off.

Failure of the foundation then caused the centre of gravity of the whole foundation to shift away from the centre of gravity of the superstructure, thereby inducing moment eccentricity that caused instability to the building. The abrupt failure caused the foundation in quadrant 2 to collapse and pulled the other quadrant in a diagonal direction with respect to the original orientation of the building. However, this pulling effect was counteracted by the other quadrants; thus causing the whole building to jerk in the diagonal direction.

A stage was reached where subsequent jerks coupled with the lateral movement of the soil underneath the foundation, had resulted in the induced imbalance moment, that could no longer be resisted. Eventually the whole building was dragged down and toppled in the direction having the weakest stiffness i.e. about its minor-axis.

ACKNOWLEDGEMENT

This paper is but a summary of the 4-month long efforts of the whole investigation team of engineers, architects, geologists, scientists, technicians and field workers, etc., who have contributed their time and energy in reporting the findings to explain the contributory factors to the collapse of the Highland Towers Condominium. The technical report that ensued is a testimonial of their unbiased conclusions from the available evidences.

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PERTEMUAN PERSATUAN
Meetings of the Society

Ceramah Teknik (Technical Talk)

Geochemical Exploration for Gold Mineralisation in Malaysia

A.G. GUNN

Laporan (Report)

Mr. Gunn's talk held at the Geological Survey Department, Kuala Lumpur on 6 May 1995 attracted about 30 members of the GSM and staff of the GSD. The speaker was in Malaysia briefly to deliver his talk in Kuala Lumpur and at the Geological Survey Department in Ipoh before proceeding to Townsville, Queensland to attend a major geochemical conference there. His talk in Kuala Lumpur was jointly sponsored by the Society and the GSD.

Summary

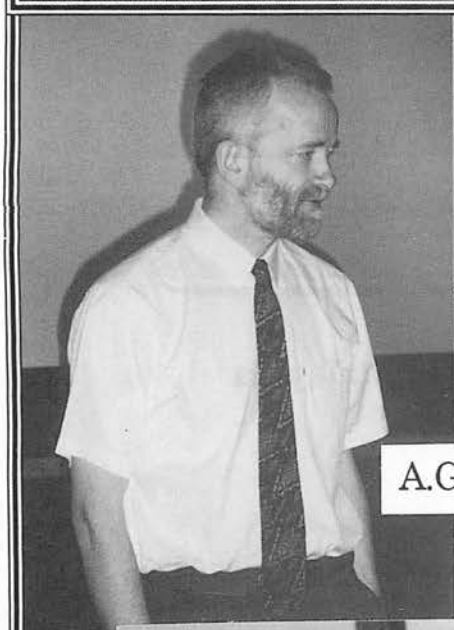
The talk of the primary gold output from Malaysia is derived from the by-product of the Mamut porphyry copper mine in Sabah. Significant production is also derived from epithermal siliceous replacement deposits in the Bau district of Sarawak. In Peninsular Malaysia, current gold production comes from small alluvial workings. However, primary mesothermal lode gold deposits are being worked in Kelantan and Pahang. Raub, Kuala Lipis and the Selangor-Negeri Sembilan border areas have also been mined. Mineralisation has also recently been discovered at Lubuk Mandi and Mersing.

Mesothermal lode-style gold mineralisation were studied in the GSD-BGS programme to determine the optimum exploration methodology. Favoured sites of mineralisation are areas of high strain within fault- and shear-zones subsidiary to major regional strike-slip faults oriented north or north-northwest. At Raub, the north-south oriented ore zone has been mined over a strike length of 6 km to a maximum depth of 335 m. Discontinuous high grade ore shoots occur sporadically in zones of repeated late brittle deformation where multiple episodes of veining and recrystallisation have taken place. Low grade disseminated ore may form a near continuous envelope around the rich ore shoots. At Lubuk Mandi, gold was introduced into the vein system contemporaneously with galena and sphalerite. In contrast, at Penjom a complex ore mineral paragenesis has been established with gold associated or intergrown with galena, molybdenite, chalcopyrite and a range of Bi, Pb, Ag and Au telluride minerals. Hydrothermal alteration around the gold-bearing veins is generally of low intensity and of limited areal extent.

The exploration methodology of the GSD-BGS programme is discussed which includes panning of heavy mineral concentrates, stream sediment, soil sampling and shallow pitting. Geochemical methods can be utilised effectively to detect potentially mineralised regional structures and to pinpoint targets for detailed sub-surface investigation. As and Pb are potentially useful pathfinder elements. Catchment geology should be taken into account during data evaluation due to varying background concentrations of these elements in different lithologies. The dispersion mechanisms of these elements in the secondary environment will generally differ from that of gold. The study highlighted the severity of the nugget effect associated with lode gold mineralisation and the difficulty of obtaining a reliable estimate of the gold contents of geochemical samples. Considerable potential exists for the discovery of mesothermal lode gold deposits in Peninsular Malaysia.

Jimmy Khoo

Technical Talks



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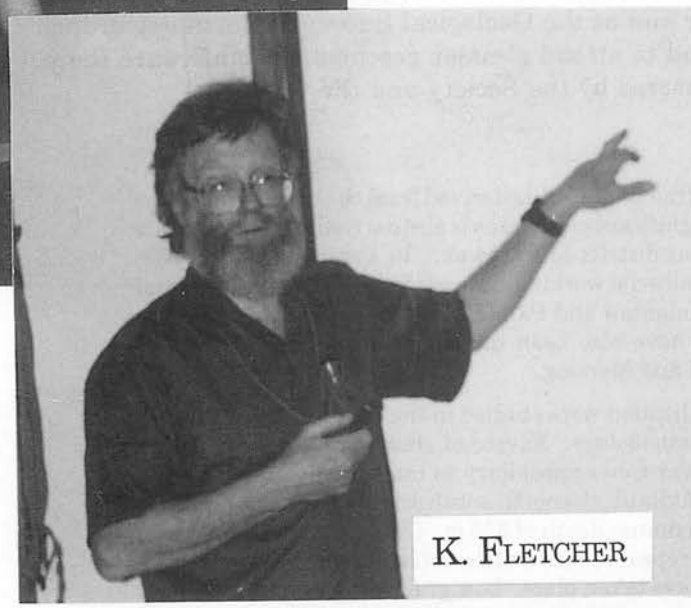
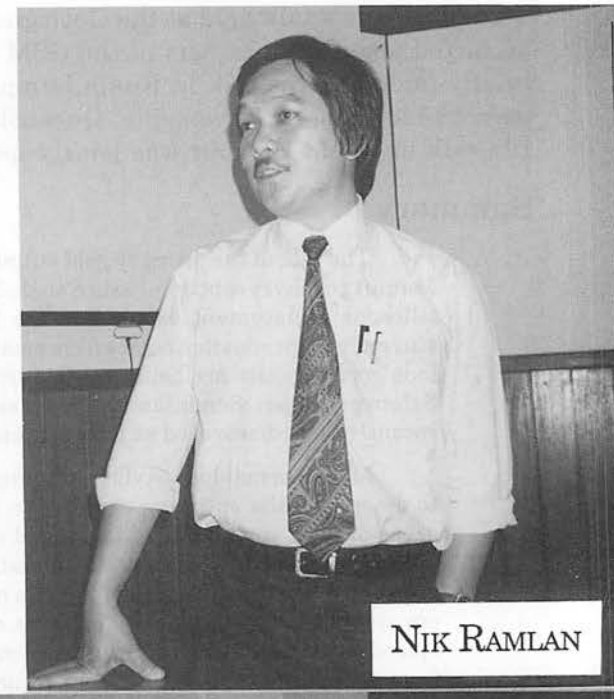
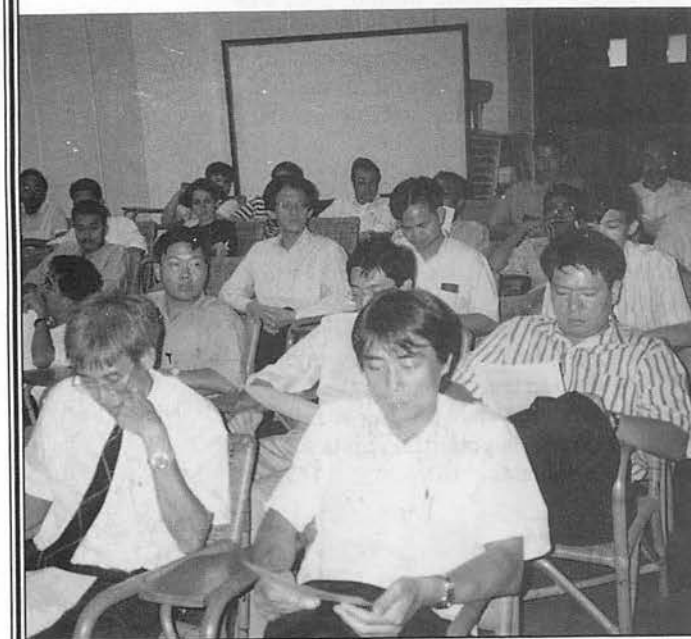
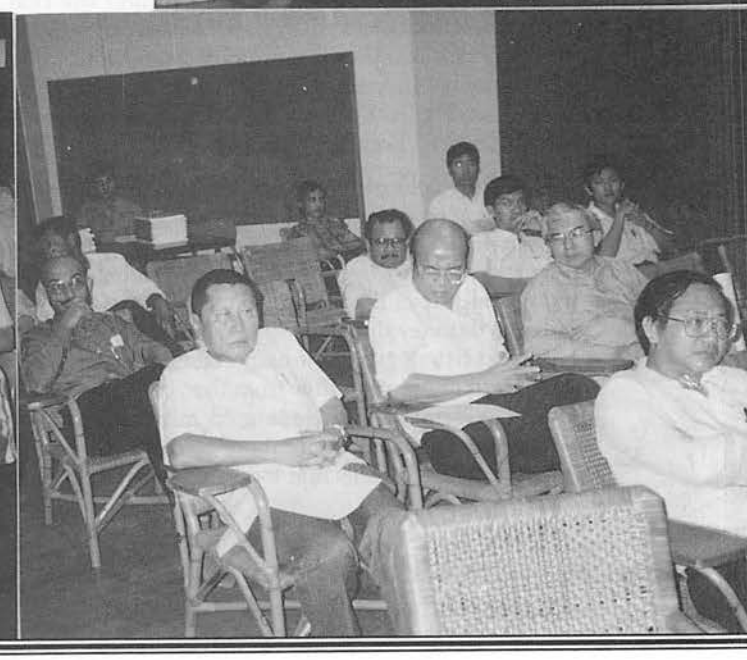


K. FLETCHER



NIK RAMLAN





Exploration geochemistry in SE Asia: soils, sediments and potential for anthropogenic effects

K. FLETCHER

Laporan (Report)

Professor W.K. Fletcher from the Department of Geological Sciences, University of British Columbia, Canada presented the above talk on the 11th of May 1995 at the Geology Department, University of Malaya. This interesting and informative talk attracted an audience of more than 50.

The audience were given an overview of various aspects related to geochemical exploration for gold and base metals in Southeast Asia. Professor Fletcher began his talk by emphasising that inasmuch as the climatic condition of tropical regions are similar, the Southeast Asian region however has relatively higher suspended sediment yields compared to the tropical regions in Africa and South America. Coupled with anthropogenic effects, this has given rise to several features unique to stream sediments and soils in Southeast Asia which have important implications for the design and interpretation of geochemical surveys. Professor Fletcher also highlighted the difficulties associated with conventional stream sediment sampling to reliably detect gold anomalies due to anthropogenic inputs from deforestation and agricultural activities. This was illustrated in the study of stream sediments from Malaysia, Thailand and Indonesia.

F.T. Ng

Geotechnical engineering investigations of the Highland Tower Condominium collapse, Ulu Kelang, Kuala Lumpur

NIK RAMLAN NIK HASSAN

Laporan (Report)

The talk was presented by Dr. Nik Ramlan Nik Hassan, Head, Geotechnical Division, Institut Kerja Raya Malaysia (IKRAM), on the 17th May, 1995, at the Department of Geology, University of Malaya. Dr. Nik was the principal investigator leading the technical committee for the investigations of the collapse.

The speaker deliberated on the causes and mechanisms of the failure, including the series of retrogressive landslips, failures of the rubble walls, and pile foundations. Investigations include geological, geotechnical, seepage/drainage and structural studies, incorporating the use of topographical and geological maps, aerial photographs, boreholes, laboratory testings, and various analyses and simulation studies. The presentation was accompanied by numerous colour slides and transparencies. Many questions and comments followed the presentation, and participants were given yet another further insight into the technical matters related to this collapse.

With kind permission from the speaker/author, the paper containing more details and background of the collapse is reproduced here in this Newsletter for the benefit of the members (see **Special Communication**, p. 153-164).

Tan Boon Kong

Footnote: The Society is happy to announce that it has recently purchased a copy (6 volumes) of the *'Highland Tower'* Report. Members who are interested can read the Report at the klompe reading room.

When is a bivalve not a bivalve?: Tube linings and accessory plates in boring lineages

SIÂN EVANS

Laporan (Report)

Ms. Siân Evans from the Department of Geology, Royal School of Mines, Imperial College, and Department of Palaeontology, Natural History Museum, presented the above talk at 5.30 pm on the 22nd May 1995 at the Geology Department, University of Malaya.

Abstract

The Class Bivalvia show adaptations to a huge range of environments and ecological niches. The plasticity of the shell secretion method allows extremes of morphology to be developed. In some bivalve families, however, additional calcareous structures have developed, such as the boring linings in the Teredinidae and Lithophagainae, and accessory plates in the Pholadacea. How are these structures produced, and how do they fit in with accepted models of bivalve shell secretions?

It is generally assumed that the only calcareous parts of a bivalve are the two shells, hence the name, bivalve. But even this basic assumption is not always correct. Certainly groups of bivalves, those that bore, secrete a range of other calcareous structures, including a lining to the boring. They effectively have more than 2 shells. It is these structures that are the subject of the talk.

The ability to secrete a boring lining seems to have evolved independently in a number of unrelated bivalve clades. In each group the lining is complex in structure and may even be useful in the taxonomy, particularly of fossil specimens.

The Pholadacea are an excellent example of the complexity and diversity of boring lining methods. Before considering the secretion of the boring lining it is necessary to think about the process of shell formation.

The Class Bivalvia exploit a huge range of ecological niches and display extremely diverse morphologies. This is largely a result of the plasticity of the shell, which in turn is related to methods of its secretion. Differences in relative growth rates at the margin edges produce a huge range of shell shape.

The evolutionary plasticity of the method of shell secretion means that groups occupying similar ecological niches show strong convergence in the overall morphology of the shell, even though they are derived from very different ancestors.

In the boring bivalves this convergence is not just confined to the shell shape, but is also seen in additional calcareous structures produced within the boring.

Selsey *Petricola pholadiformis* is a common boring bivalve around the coast of Britain, and *Martesia striata* from Malaysia is a wood borer. These boring bivalves are permanently encased within the substrate. They produce the boring either mechanically using the valves, or by dissolving calcareous substrates using chemical secretions.

The boring habit has evolved independently in a number of different clades within 3 of the bivalve subclasses.

5 of the main groups are Gastrochaenids, Lithophagids, Petricola, Clavagella and the Pholadacea. Emphasis is on the Pholadacea. Boring bivalves have apparently evolved from two different ecological guilds — shallow burrowers and bysally attached nestlers.

What advantages can be gained from the boring mode of life? The obvious advantage is protection from predators. It seems possible that the radiation in the Late Triassic/Jurassic occurred in response to the Mesozoic Marine Revolution, a hypothesised increase in predation pressure, originally proposed by Vermeij.

Despite the differences in their ancestry we see strong similarities in form of the shell and soft parts of different boring groups. Permanent siphonal and pedal gapes, as the shell's primary function of protection is replaced by the substrate — may also be due to wear on the leading edge of the valves. Strong suctorial foot, particularly important in the mechanically boring lineages — allows the bivalve to attach firmly to the substrate whilst the valves are moved into position to allow rasping. Long siphons are common to produce a boring lining.

In addition to these similarities, the ability to secrete a lining is seen in 4 of the 5 clades introduced. In each clade it seems that the primitive condition is to secrete the lining around the siphons, and with increased specialisation, the lining may extend around the outside of the shells and this will only occur during a period when the bivalve is not actively boring.

Why do boring bivalves secrete a lining? These are clear advantages. For containment of the siphons (if the primary reason for is protection from predators then need to make sure that they are tightly encased and if the valves are wider than the siphons then this leaves a lot of slack); attachment site for pallet retractor muscles (Teredinindae allows the closure of the siphonal aperture); smoothing the internal surface of the boring; protection from decay/breakage of the substrate (if this occurs and no lining is developed then bivalve is open to predation); and allows to keep up growth with a dynamic substrate (for example coral borers).

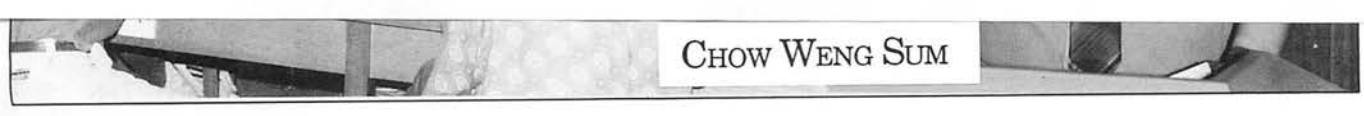
Is the secretion of a lining just another example of convergence, the ability evolving independently, or could it be a capacity of all bivalves to secrete a tube, as they have the capacity to secrete shells in other words could the tube linings be considered homologous characters?

One way to address the issue of homology is to study the fine scale structure of the lining. Whilst shell structure has been examined extensively in the Bivalvia the mineralogy and structure of the tube lining has usually been ignored. The Gastrochaenids and the Lithophagainids appear to secret an aragonitic lining, whilst in some Pholadacea it is calcite. In all cases however it is clear that the structure of the lining is complex, being made up of a number of layers. Brian Morton recognised up to 4 distinct layers in Gastrochaena and suggested that each layer might have been secreted by a different gland in the mantle around the siphons. Also see in all the groups there is an ability to redissolve and repair the siphonal lining throughout life. The lining is clearly carefully mediated, and cannot be considered just as a dump for excess carbonate removed from the substrate by boring. Differences in the mineralogy suggests however that the secretion methods could be different in the different groups, making the homology hypothesis unlikely.

The Pholadacea are an excellent example of the complexity of the tube structure and its importance in exploiting a substrate. They are a group of mechanical borers in which the shells are used as rasps. They are made up of two main groups the Pholadidae (which exploit a huge range of different substrates from rock through to PVC cables) and the Teredinidae (obligate wood borers).

The particularly striking feature of the Pholadidae is the development of additional aragonitic "valves" known as accessory plates — this is an excellent example of a bivalve not being bivalved! It seems that the primary function of the accessory plates to protect the soft parts within the boring. The effect is a series of accessory plates, additional valves, performing a similar role to the tube lining.

Only one genus within the Pholadidae secretes a tube, the Teredina. Rather than secreting the tube around the valves, they are fused into the tube, producing a single structure. The tube



Warta Geologi, Vol. 21, No. 3, May–Jun 1995

168

consists of distinct layers. Teredinas have clear alternation of aragonite and calcite layers. Even within the Pholadidae, two different ways of protecting the bivalve within the boring have evolved. a siphonal tube fused to the valves and accessory plates.

170

Total score = Instability score + Consequence score

To calculate the instability and consequence score, weightages are given to the type of features or structures. For example, a soilslope with an angle of about 90° is given 25 points; for 70°, 20 points; for 45°, 10 points, and for soil slopes less than 5°, 0 point.

Other features of interest include angle of slope above, associated walls, slope condition, condition of walls, geology and water seepages on the slopes.

For the consequence score the proximity of buildings above and below a slope, and the type of property at risk (e.g. a hospital, factory or private road, etc.) are considered.

(ii) Landslip preventive measures programme

Details investigations are carried out on slopes and retaining structures to identify the need for preventive works. The programe is divided into two stages. Stage 1 calls for an initial study to ascertain the need for detailed investigations. In this respect, the height of the slope, the type of structure at the top and bottom of the slope and their distances from the slope are studied.

Should there be a need for further action, Stage II is carried out where detailed investigation involves drilling, Standard Penetration Tests, laboratory testing for the geotechnical properties of the soil and modelling to determine the factor of safety of the slope.

Should the results classify the slope as dangerous, remedial measures will be taken to strengthen the slope.

(iii) Systematic identification of the features in the territory

GEO is presently conducting an exercise to reidentify all the slopes in Hong Kong. In this project, aerial photographs are used. GEO has since 1972, taken aerial photographs of Hong Kong annually.

(iv) Terrain Mapping

Work has been carried out to map the terrain of Hong Kong based on the gradient of the slope, the type of slope (that is whether it is a concave side slope, or crest, or foot slope, etc.) and the intensity and type of erosion on the slope.

From the Terrain Map, other derivative maps are produced. They include Landform Map, Erosion Map, Physical Constraints Map, Engineering Geology Map, Geotechnical Landuse Map, Engineering Appraisal Map and Physical Constraints Map.

As an early warning system, the GEO has installed 48 automatic rain gauges which are connected by a telephone line to the GEO Headquarters.

(v) Other projects

One interesting practice in Hong Kong is that soil nails are popularly used and slopes are now sprayed with concrete instead of being sealed with chunam.

GEO is also aware of the danger of rock slides from loose rock blocks near Victoria Peak and efforts have been undertaken to stabilise these rock blocks. Preventive measures include grouting of joints, construction of buttresses and installation of anchors. Other than these, a primary and a secondary steel-wire fence had been installed in the Mid-Reaches of Hong Kong to trap any falling bounders.

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G.H. Teh

What advantages can be gained from the boring mode of life? The obvious advantage is protection from predators. It seems possible that the radiation in the Late Triassic/Jurassic occurred in response to the Mesozoic Marine Revolution, a hypothesised increase in predation pressure, originally proposed by Vermeij.

Despite the differences in their ancestry we see strong similarities in form of the shell and soft parts of different boring groups. Permanent siphonal and pedal gapes, as the shell's primary function of protection is replaced by the substrate — may also be due to wear on the leading edge of the valves. Strong suctorial foot, particularly important in the mechanically boring lineages — allows the bivalve to attach firmly to the substrate whilst the valves are moved into position to allow rasping. Long siphons are common to produce a boring lining.

In addition to these similarities, the ability to secrete a lining is seen in 4 of the 5 clades introduced. In each clade it seems that the primitive condition is to secrete the lining around the siphons, and with increased specialisation, the lining may extend around the outside of the shells and this will only occur during a period when the bivalve is not actively boring.

Why do boring bivalves secrete a lining? These are clear advantages. For containment of the siphons (if the primary reason for is protection from predators then need to make sure that they are tightly encased and if the valves are wider than the siphons then this leaves a lot of slack); attachment site for pallet retractor muscles (Teredinindae allows the closure of the siphonal aperture); smoothing the internal surface of the boring; protection from decay/breakage of the substrate (if this occurs and no lining is developed then bivalve is open to predation); and allows to keep up growth with a dynamic substrate (for example coral borers).

Is the secretion of a lining just another example of convergence, the ability evolving independently, or could it be a capacity of all bivalves to secrete a tube, as they have the capacity to secrete shells in other words could the tube linings be considered homologous characters?

One way to address the issue of homology is to study the fine scale structure of the lining. Whilst shell structure has been examined extensively in the Bivalvia the mineralogy and structure of the tube lining has usually been ignored. The Gastrochaenids and the Lithophagainids appear to secret an aragonitic lining, whilst in some Pholadacea it is calcite. In all cases however it is clear that the structure of the lining is complex, being made up of a number of layers. Brian Morton recognised up to 4 distinct layers in Gastrochaena and suggested that each layer might have been secreted by a different gland in the mantle around the siphons. Also see in all the groups there is an ability to redissolve and repair the siphonal lining throughout life. The lining is clearly carefully mediated, and cannot be considered just as a dump for excess carbonate removed from the substrate by boring. Differences in the mineralogy suggests however that the secretion methods could be different in the different groups, making the homology hypothesis unlikely.

The Pholadacea are an excellent example of the complexity of the tube structure and its importance in exploiting a substrate. They are a group of mechanical borers in which the shells are used as rasps. They are made up of two main groups the Pholadidae (which exploit a huge range of different substrates from rock through to PVC cables) and the Teredinidae (obligate wood borers).

The particularly striking feature of the Pholadidae is the development of additional aragonitic "valves" known as accessory plates — this is an excellent example of a bivalve not being bivalved! It seems that the primary function of the accessory plates to protect the soft parts within the boring. The effect is a series of accessory plates, additional valves, performing a similar role to the tube lining.

Only one genus within the Pholadidae secretes a tube, the Teredina. Rather than secreting the tube around the valves, they are fused into the tube, producing a single structure. The tube

consists of distinct layers. Teredinas have clear alternation of aragonite and calcite layers. Even within the Pholadidae, two different ways of protecting the bivalve within the boring have evolved, a siphonal tube fused to the valves and accessory plates.

The Teredinidae are a group of obligate wood borers and show extreme specialisation to this niche. The overall shape is remarkable. The aragonite valve are extremely reduced, the body is long and wormlike. The boring is lined with a layered calcite tube. The siphonal end of the tube is secreted very early on in the ontogeny. The tube is only completed after maturity.

At the end of the mantle are a pair of secondary calcite shells, the pallets. They show a very complex, variable morphology and are the basis of species level taxonomy within the group. Their complex morphology indicates carefully mediated biomineralisation. The pallets are forced against the lining around the siphons producing a water and air tight seal. Functionally the pallets and the lining are intimately linked and this is reflected in their structures. Different structures of tube lining are associated with the different pallet morphologies of different genera.

It has previously been considered that the morphology of the boring lining is of no use in recognising taxa, and it has been left out from the trace fossil nomenclature for Teredolites. This is reasonable since the lining is variably developed depending on the age of the individual and the nature of the substrate. However the apertural end is secreted even in young specimens, and as it is closely linked functionally to the pallets it may be of use in at least genus level identification allowing distinction of fossil material where the pallets themselves are not preserved.

If we can understand more about the methods of secretion of the lining and the pallets then we may be able to get more information about the phylogeny of the Teredinidae. Is it valid to consider production of a solid plug from individual layers as an evolutionary trend? It is hoped that this can be achieved by using both modern and fossil material to examine the ultrastructure of the tube

In conclusion we can say that the ability to secrete a lining to the boring has evolved independently in different clades. The structure of the lining is complex and does not fit in with models of bivalve shell secretion. The structure of the tube lining can be particularly useful especially for the Teredinidae.

G.H. Teh

SIÂN EVANS

On-the-job training at the Geotechnical Engineering Office, Hong Kong

CHOW WENG SUM

Laporan (Report)

Chow Weng Sum, of the Geological Survey Department, gave the above talk on the 16 June, 1995 at the Geology Department, University of Malaya.

Mr. Chow punctuated his informative talk with slides of the many geotechnical engineering problems encountered during his stay in Hong Kong.

We are thankful to Mr. Chow for sharing his experiences with us and we should be aware of remedial and early warning systems in our country in the light of heavy rainfall and frequent landslides.

Abstrak (Abstract)

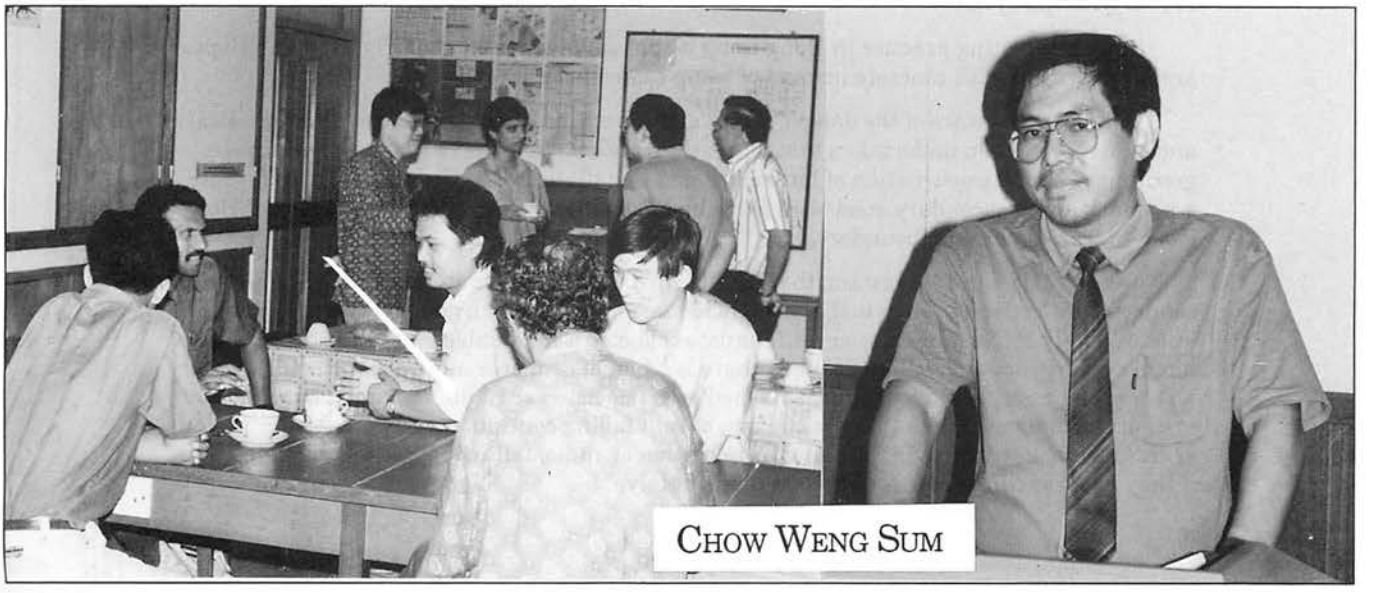
In the summer of 1972, after a period of heavy rain, a road embankment at Sau Mau Ping failed, and the resulting mud avalanche killed 71 people. Four years later, another slope in the same area failed in heavy rain and the mud avalanche killed 18 people. Following these two disasters, the Geotechnical Engineering Office (initially known as the Geotechnical Control Office) was established in July 1977. The Office was created with the main objective of preventing landslide disasters, but it is now also responsible for a wide range of geotechnical activities related to the slope and economic utilisation and development of land in Hong Kong.

The Geotechnical Engineering Office (GEO) has a professional staff of 143 and is divided into three branches, viz, the Island Branch, Mainland Branch and Development Branch. Each branch has nine operational units called Divisions. Each Division has typically, four sections.

Some of the projects implemented which are of interest are as follows:-

(i) Ranking of cut/fill slopes

GEO had conducted an exercise to rank the cut/fill slopes in the whole of Hong Kong. The ranking is based on the total score, where the higher it is, the more urgent it will be to carry out a detailed check of the slope.



Total score = Instability score + Consequence score

To calculate the instability and consequence score, weightages are given to the type of features or structures. For example, a soilslope with an angle of about 90° is given 25 points; for 70°, 20 points; for 45°, 10 points, and for soil slopes less than 5°, 0 point.

Other features of interest include angle of slope above, associated walls, slope condition, condition of walls, geology and water seepages on the slopes.

For the consequence score the proximity of buildings above and below a slope, and the type of property at risk (e.g. a hospital, factory or private road, etc.) are considered.

(ii) Landslip preventive measures programme

Details investigations are carried out on slopes and retaining structures to identify the need for preventive works. The programe is divided into two stages. Stage 1 calls for an initial study to ascertain the need for detailed investigations. In this respect, the height of the slope, the type of structure at the top and bottom of the slope and their distances from the slope are studied.

Should there be a need for further action, Stage II is carried out where detailed investigation involves drilling, Standard Penetration Tests, laboratory testing for the geotechnical properties of the soil and modelling to determine the factor of safety of the slope.

Should the results classify the slope as dangerous, remedial measures will be taken to strengthen the slope.

(iii) Systematic identification of the features in the territory

GEO is presently conducting an exercise to reidentify all the slopes in Hong Kong. In this project, aerial photographs are used. GEO has since 1972, taken aerial photographs of Hong Kong annually.

(iv) Terrain Mapping

Work has been carried out to map the terrain of Hong Kong based on the gradient of the slope, the type of slope (that is whether it is a concave side slope, or crest, or foot slope, etc.) and the intensity and type of erosion on the slope.

From the Terrain Map, other derivative maps are produced. They include Landform Map, Erosion Map, Physical Constraints Map, Engineering Geology Map, Geotechnical Landuse Map, Engineering Appraisal Map and Physical Constraints Map.

As an early warning system, the GEO has installed 48 automatic rain gauges which are connected by a telephone line to the GEO Headquarters.

(v) Other projects

One interesting practice in Hong Kong is that soil nails are popularly used and slopes are now sprayed with concrete instead of being sealed with chunam.

GEO is also aware of the danger of rock slides from loose rock blocks near Victoria Peak and efforts have been undertaken to stabilise these rock blocks. Preventive measures include grouting of joints, construction of buttresses and installation of anchors. Other than these, a primary and a secondary steel-wire fence had been installed in the Mid-Reaches of Hong Kong to trap any falling bounders.

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G.H. Teh

Annual Geological Conference 1995 — Report

The 1995 Annual Geological Conference was held on the 27th and 28th May 1995 at the Malacca Village Paradise Resort, Ayer Keroh, Melaka.

The Conference this year attracted 164 participants. A total of 24 oral presentations, 4 keynote papers and 14 posters were fitted into the 2-day programme.

The Conference was officially opened by YAB Dato' Mohd. Zin Hj. Abdul Ghani, Chief Minister of Melaka. The Society is indeed grateful to the Mentri Besar for gracing the Opening Ceremony despite his tight schedule and for sponsoring the Ice-Breaker Barbecue on Friday 26th May 1995. The Malaysia Mining Corporation Berhad, again sponsored the Conference Dinner on Saturday 27th May 1995.

For the first time the oral and poster presentations were selected under four main themes, namely, 1) Industries Earth Material and Economic Minerals 2) Environmental and Engineering Geoscience 3) Sedimentology and Paleontology and 4) Structure, Tectonics and Magmatism. Each theme was preceded by a keynote paper.

For the first time too, judging was carried out to select the best oral and poster presentations for this year's Annual Conference. Generally, there was an improvement in the quality of oral and poster presentations this year.

Two Pre-Conference fieldtrips were held. The one on Sedimentology and Stratigraphy on the 25th May, led by Dr. Kamal Roslan and Dr. Shafeea Leman, visited the Jurassic/ Cretaceous Paloh Formation at Mambai, Ma'Okil Formation and Lop Formation at Chaah and Semantan/Gemas Formation at Yong Peng and Air Hitam, while the other on Igneous Rocks and Economic Geology was held on 26th May, led by Dr. Yeap Ee Beng, Dr. Teh Guan Hoe and Dr. Ahmad Tajuddin, visited the Compdrill Granite Dimension Stone Quarry at Tampin, the Pottery Stone Quarry at Air Kuning and gold mineralization at Kadanak-Asahan area. There was keen interest and useful discussions between participants at both fieldtrips.

Last but not least, the spouses and children were not forgotten. On the 27th May there was a Historical Tour of Melaka while on the 28th May there was the Recreational Tour.

The Annual Conference 1995, once again proved very successful as indicated by the good turnout, the large number of oral and poster presentations and most of all the fruitful interaction between members of the different universities, the private sector, the Geological Survey Department, Petronas Research & Scientific Services (PRSS) and foreign universities.

Prof. Ibrahim Komoo, the Organising Chairman and his Organising Committee should be congratulated on a job well done.

G.H. Teh

Welcoming Speech by Dr. Khalid Ngah, President Geological Society of Malaysia, at the Annual Geological Conference 1995

Yang amat berhormat Datuk Mohd Zin Abdul Ghani
Ketua Menteri Melaka,

Yang berusaha Dr. Ibrahim Komoo
Pengerusi Jawatankuasa Penganjur,

Invited guests, Ladies and Gentlemen,

Assalamualaikum and Good Morning.

I am very pleased to be here, to be a part of this Conference ....., and to be a part of this growing and active Society. I am pleased because this Society has a wonderful mission, a wonderful commitment to the society as a whole, which is to promote and enhance geological knowledge for the benefit and growth of the country. I am also very pleased because this Society is now truly an international society, with 40% of its members from outside Malaysia.

For those who were not present at the Annual General Meeting held recently, let me repeat in my own simple words, what has been said by Mr. Fateh Chand, the Past President, of the successes and achievements of the Society. The Society has successfully hosted two major international activities: the CPCEMR/GSM in Nov/Dec 1992 and the AAPG/GSM Conference in August 1994, both were well attended, the later by more than 1,100 participants. It has also organised workshops and seminars which have benefited and enhanced professionalism of its members. These successes and achievements have thus placed this Society in an essentially new dimension — a dimension of importance in geological sciences, in today's development.

I would like to take this opportunity to acknowledge the good voluntary work that has been rendered to the Society by Mr. Fateh Chand and his able Council Members, and on behalf of all members and everybody here, I wish them a very warm thank you.

Exactly about this time last year, the Society conducted a similar Conference in Kuala Terengganu, and the response had been equally good. The meeting covered a wide spectrum of geo-science topics, and had attracted professionals, learned geoscientists and teachers.

This year is no different from last year, and in fact I have been told just now that there are 150 registered participants, with some 100 pre-registered a week ago. Sybas, Mr. Organising Chairman.

The Society is grateful to Kota Melaka, and the State of Melaka for providing this excellent facility for the meeting, and with the meeting programme that has been established, I am sure this event will even be more successful.

This Conference in this historic state represents one of two major activities of the Society for this financial year 1995/96; the other being the Petroleum Geology Conference

which will be held in Kuala Lumpur on December 11-12, 1995. As always, a good turn-out is expected. And as always also, an equally good support from the oil industry is expected.

On a much different perspective, I wish to share with you a few minor observations that I have made, in particular on the development of geo-science disciplines in the country. These, however, may appear insignificant, but it is worth pondering.

I see that:

1. There has been a "slowing down" in interest of the younger population to take up science and engineering courses, and finally to turn and make these into careers. I observe that this trend is particularly true in geological sciences where the number of students has shrunk significantly — this is the sad side of the story.
2. The good part of my observation is that there has been an increase in awareness and need for consultation by the construction industry for geologists to provide input on E.I.A., in the development of infra-structures, big and small. I believe that this increase has resulted from a few tragedies in the country involving stability of earth surfaces, the famous one being the Highland Tower collapse in Ulu Kelang, Selangor in 1993.
3. There is a significant increase in activity in the non-metallic industry as a consequence of development. Already we have a shortage of cement in the country, an essential component for building materials. I see both the Geological Survey Department Malaysia, as well as private companies and individuals are now active in evaluating deposits such as limestones, granites, clays and beach sands.

What I can deduce from these observations is that there is future after all, for all geologists, and the geological profession in general. I now see that young geology graduates do not need to look for jobs outside their field of specialisation.

I recall the material I read which appeared in on the front page of the "New Straits Times" dated May 17, 1995, and wish to share with you what YAB Datuk Seri Anwar Ibrahim said to teachers on "Teacher's Day".

I quote what he said: *"The profession (teacher's profession) must change in focus to meet the high expectations and objectives of Vision 2020"*. This may be a repeat of his previous message, but it is certainly worth repeating it here for us all to think.

You may ask *"So, what has it got to do with our profession?"* Let me take you one step back ..... examine our "mission" which is to promote and enhance geo-sciences, and look at the scenarios right now: poor student in-take, yet good job opportunities ahead.

This Society has done a marvellous job to members and society in general. And this momentum must be maintained. But the Society cannot be contented with this achievement. It must do more.

If teachers must change their perception, so must we. This Society must change and move in tandem with the change.

And what comes to mind immediately is that the Society must examine its current activities, and must subsequently develop new ones that are more in focus, focusing not only on the needs of the industry, but also striking a balance on the needs of the academic world.

This year 1995/96 will witness the Society organising activities on a more structured manner. And I wish to take this opportunity to express the possible scopes of emphasis for the year.

1. Intensifying promotion of knowledge and awareness among young minds, especially at schools on the importance of geological sciences in our daily lives; that there is money and good rewards.
2. Establish more focus on technical programmes in Engineering Geology, Hydrogeology and Environmental Geology, and in non metallic minerals.

I deliberately left out programmes in Petroleum Geology, and I believe these are already well established. This field has been and will remain a focal point of activity of the Society.

All these require participation from all members, especially the Council Members who are and will be entrusted to develop these programmes. Already, one sign of such dedication is your participation is this Conference.

Lastly, I wish this 2-day Conference every success.

Thank you.

Annual Geological Conference '95
Captions to Photos

1-3. The ice-breaker barbeque at Poolside.
4-7. At the Opening Ceremony
8. Organising Chairman, Ibrahim Komoo with his Welcoming Address.
9. GSM President, Khalid Ngah with his Address.
10. YAB Menteri Besar Melaka with the Opening Address.
11-13. Discussion, discussion and discussions at tea break.
14-16. Enthusiastic, keen interest at the poster displays.
17-18. The ever popular Conference Dinner.
19. The President thanking MMC representative, Albert Loh.
20. L.H. Teoh with his Keynote Paper.
21. E.B. Yeap receiving momento from Session Chairman, Hamzah Mohamad.
22. Wan Fuad on wall rock alteration.
23. T.H. Tan on barite mineralization.
24. K.K. Liaw on the Nyalau Formation.
25. Tan Boon Kong with his presentation.
26. L.S. Leong replying to a question.
27. Abdul Rahim Samsudin with a paper on geophysics.
28. Clive Foss on magmatic mapping.
29. Abd. Ghani Rafek receiving momento from Session Chairman, Ahmad Tajuddin.
30. Ibrahim Komoo presenting a momento to C.Y. Lee for his poster.
31. S. Mogana receiving momento for his poster.
32. T.F. Ng accepting momento for his poster.
33. J.J. Pereira being presented momento for her poster.
34. Kadderi Md. Desa on weathering path diagram.
35. Khalid Ngah with his Keynote Paper.
36. Ahmad Jantan receiving momento from Session Chairman, C.P. Lee.
37. Mohd. Shafeea Leman happy with his presentation.
38. Basir Jasin on radiolaria.
39. Sivaji presenting GIS technology.
40. Session Chairman C.H. Yeap presenting Uyob Said with a momento.
41. H.D. Tjia ready for his Keynote Paper.
42. Askury Abdul Kadir receiving his momento from Session Chairman, Ibrahim Abdullah.
43. Syed Sheikh Almashoor on brittle fault zone.
44. K.R. Chakraborty posing a question.
45. Liew Kit Kong with his paper.
46. Shariff A.K. Omang on the Tungku area, Sabah.
47. Abdullah Hasan with his presentation.
48. G.H. Teh presenting momento to Che Aziz Ali for his poster.
49. Qalam Azad Rosle receiving momento for his poster.

Annual Geological Conference 1995


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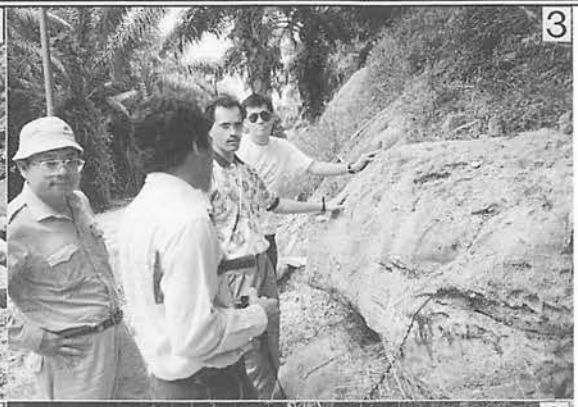
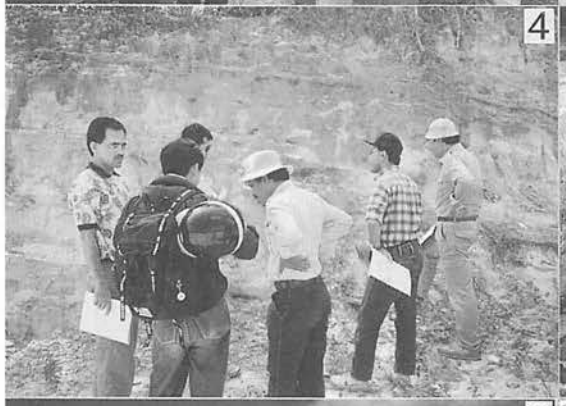
Annual Geological Conference 1995

Annual Geological Conference 1995 — Fieldtrips





Captions to photos

Pre-Conference Sedimentology-Stratigraphy Fieldtrip

1. Kamal Roslan briefing the participants at Mambai.
2. Discussing the stratigraphy at Bkt. Lop, Chaah.
3. A closer look at conglomerates at Chaah.
4. Studying the Semantan/Gemas Formation at Yong Peng.
5. A careful look for fossils at Air Hitam.

Pre-Conference Economic Geology-Igneous Rocks Fieldtrip

6. Observing boulder splitting at Compdrill.
7. On the hill of felsite at Air Kuning.
8. *"The gold vein strikes this way"* at Kadanak-Asahan.
9. *"Here's the gold we were looking for!"*

Ucapan Pembukaan Rasmi Persidangan Tahunan Geologi 1995 oleh YAB Ketua Menteri Melaka Dato' Mohd Zin Hj. Abdul Ghani

Dr. Khalid Ngah
Presiden, Persatuan Geologi Malaysia,
Prof. Ibrahim Komoo
Pengerusi, Jawatankuasa Penganjur Persidangan Tahunan Geologi 1995,
Tetamu-Tetamu Kehormat,
Para Peserta Persidangan.

(Alu-aluan oleh Kerajaan Negeri Melaka)

Saya difahamkan, Persatuan Geologi Malaysia pada tahun ini meneruskan tradisinya membawa Persidangan Tahunannya ke negeri-negeri seluruh Malaysia. Negeri Melaka merasa bertuah kerana telah terpilih sebagai tuan rumah Persidangan 1995. Tradisi ini amat bermakna, kerana ia memberi peluang kerajaan-kerajaan negeri mengenali dengan lebih rapat kegiatan-kegiatan ahli geologi dan sumbangannya kepada negara.

Saya perhatikan persidangan tuan-tuan kali ini mempunyai tema-tema tertentu. Di antara tema yang dibincang ialah aspek mineral Industri dan Geologi Sekitaran. Saya mendapati pendekatan begini sangat bererti kerana hasil perbincangan tentunay mempunyai hubungan terus dan relevan dengan pembangunan negara.

Ekonomi Negeri Melaka tidak bergantung kepada sumber bumi. Ini disebabkan, bukan sahaja Melaka sebuah negeri yang kecil, malahan tidak memiliki longgokan mineral ekonomi yang boleh diterokai secara komersial. Walau bagaimanapun, kami mempunyai sebuah industri hiliran yang berasaskan sumber bumi: Petronas Penapisan (Melaka) yang memproseskan minyak mentah setiap hari. Saya percaya, minyak mentah yang ditapis di Melaka merupakan hasil penerokaan tuan-tuan yang berada di dewan ini.

Saya difahamkan, ahli-ahli geologi profesional tempatan telah mencadangkan kepada Kerajaan Persekutuan untuk mengwujudkan 'Akta Ahli Geologi'. Akta ini sedang diteliti oleh Kementerian Perusahaan Utama sebelum dimajukan untuk kelulusan kerajaan. Saya berharap usaha ahli geologi ini akan memperolehi kejayaan. Dengan adanya akta ahli geologi ini kelak, saya yakin akan wujud peraturan-peraturan yang membolehkan kerja-kerja penerokaan sumber bumi dan pembangunan infrastruktur negara dikendalikan dengan taraf keprofesionalan yang tertinggi. Ini tentunya dapat memberikan keyakinan kepada masyarakat, terutamanya mengenai kesesuaian dan keselamatan pembinaan infrastruktur awam. Sekaligus, akta ini dapat memberikan pengiktirafan kepada profesion geologi.

Tuan-tuan dan puan-puan, Negara kita telah berkembang dengan begitu pesat sejak satu dekad terakhir ini. Asalnya ekonomi negara bergantung kepada sumber bumi iaitu bijih timah, dan hasil pengeluaran pertanian. Kini, kita di kenali sebagai pengeluar utama barangan industri. Banyak sektor ekonomi baru muncul dan menjadi penyumbang berkesan kepada pendapatan Negara Kasar. Industri Pelancongan umpamanya, telah menjadi penyumbang ke-3 terbesar; dan industri ini terus berkembang maju. Jelasnya, negara sedang pesat menuju ke arah Negara Perindustrian. Fenomena ini akan menunjukkan satu 'anjakan' yang berterusan

daripada kebergantungan negara pada 'sektor Huluan' ke 'sektor Hiliran'.

Tuan-tuan, sebagai pengerak utama sektor huluan tentunay merasa, sedikit sebanyak, skop dan tanggungjawab tuan, menjadi semakin kecil, semakin terbatas, dan menjadi kurang penting.

Saya berpendapatan, keadaan ini tidak semestinya benar. Malahan, lebih besar sektor hiliran, maka akan menjadi lebih penting lagi sektor huluan. Sektor perindustrian, memerlukan lebih banyak dan lebih pelbagai bahan-bahan mentah sebagai input industri. Bahan-bahan mentah ini perlu diterokai oleh pakar-pakar geologi seperti tuan-tuan.

Memang benar, keperluan bijih-bijih tradisional, seperti bijih timah, menjadi berkurangan. Ini merupakan hasil kemajuan dan pembangunan teknologi. Bagaimanapun, pelbagai bahan-bahan mineral 'bukan-tradisi' menjadi semakin penting. Negara telah mengimpot beribu juta ringgit setahun bahan-bahan ini untuk mendokong industri pembuatan negara.

Oleh itu, ahli geologi perlu lebih sensetif kepada keperluan 'bahan-bami baru'. Tenaga tuan-tuan perlu disalurkan pula kepada penorakaan sumber mineral bukan-tradisi ini. Usaha-usaha begini, bukan sahaja, dapat membantu negara dengan mengurangkan kos impot bahan mentah, tetapi tuan-tuan telah berjaya mempelbagaikan kebolehan, dan memperbanyakkan lagi, skop sumbangan kepada kemajuan negara.

Tuan-tuan dan puan-puan, negara terus berkembang maju. Banyak pembangunan perlu dilakukan untuk keselesaan rakyat. Pembinaan lebuh raya, pembinaan empangan janakuasa elektrik, dan pembinaan pelbagai infrastruktur berat yang lain. Walaupun pembangunan begini diperlukan dan memberikan sumbangan yang besar kepada negara, tetapi ia ada meninggalkan beberapa 'impak negatif'. Di antaranya ialah aspek 'kemerosotan kualiti alam sekitar' dan meningkatnya fenomena 'bencana cetusan-manusia' (man-induced hazard). Kedua-dua kesan negatif ini, mempunyai banyak kaitan dengan sekitaran fizikal, khususnya, proses-proses alam yang tertindak di muka bumi.

Saya yakin, banyak sumbangan yang dapat dijalankan oleh pakar-pakar geologi untuk membantu negara meminimumkan impak negatif ini, supaya pembangunan dan kemajuan negara dapat diteruskan dengan sempurna. Tuan-tuan sebagai pakar tentang proses-proses bumi, tentunya bersedia menasihati kerajaan dan pihak swasta, cara-cara yang paling sesuai membangun negara, tanpa menjejas kualiti alam sekitar.

Walaupun tuan-tuan perlu menyumbang dalam aspek geologi gunaan untuk memastikan sokongan yang berterusan kepada aktiviti industri, kita masih perlu meneroka ilmu pengetahuan baru menerusi penyelidikan dan pembangunan. Aktiviti R&D asas ini, membolehkan kita menjadi lebih inovatif dan mempu membina teknologi baru.

Tuan-tuan dan puan-puan sekelian, walaupun pada masa ini, sumbangan ahli geologi kepada pembangunan negara, masih belum begitu dikenali oleh mesyarakat umum, tetapi melihat senario global, di mana, sumber-sumber baru menjadi semakin terbatas, dan kesedaran tentang alam sekitar dan penggunaan sumber yang optimum. Saya yakin, peranan tuan-tuan akan menjadi lebih penting di masa-masa yang akan datang.

Sekali lagi, saya ingin mengucapkan terima kasih di atas jemputan dan penghormatan yang diberikan kepada saya, untuk bersama-sama tuan-tuan pada pagi ini.

Saya dengan ini, mengistyharkan Persidangan Tahuna Geologi 1995, dibuka dengan rasminya.

Terima kasih.

ANNUAL GEOLOGICAL CONFERENCE '95

27th & 28th May 1995

Malacca Village, Paradise Resort, Melaka

Programme

THURSDAY 25TH MAY 1995

08.00 : **Pre-Conference Field Trip 1** — Sedimentology and S tigraphy

FRIDAY 26TH MAY 1995

08.00 : **Pre-Conference Field Trip 2** — Igneous Rocks and Econo Geology

20.00 : **Ice-breaker barbecue. Host: Kerajaan Negeri Melaka**

SATURDAY 27TH MAY 1995

08.00 : Late Registration

Opening Ceremony

09.00 : Welcoming address by Prof. Ibrahim Komoo, Organising Chairman of GSM Annual Geological Conference '95

09:10 : Address by Dr. Khalid Ngah, President, Geological Society of Malaysia

09.20 : Opening Ceremony by YAB Dato' Mohd. Zin Hj. Abdul Ghani, Chief Minister of Melaka

09:40 : **Tea Break**

Technical Session I — Industrial Earth Material and Economic Minerals

● **KEYNOTE PAPER 1**

10.00 : *Teoh Lay Hock, Fateh Chand, Seet Chin Peng & Kamal Daril*
Minerals in the national economy of Malaysia: Non-metallics the emerging sector

● **TECHNICAL PAPERS**

10.30 : *Yeap, E.B., Mohd. Tarmizi, M.Z. & John, J.*
Petrographic characteristics and aggregate properties of the dacite porphyry intrusives of Kuching area, Sarawak

10.50 : *Ng, T.F. & Yeap, E.B.*
Production of crushed rock aggregate: Some environmental considerations

11.10 : *Teh Guan Hoe*
Electronprobe microanalysis of SnO_2-CuFeSnZn sulphide ore

11.30 : *Wan Fuad Hassan, Tan Teong Hing, Hamzah Mohamad, Shed Sheikh Almashoor, Suhaimi Hamzah & Khalik Hj Wood*
Perubahan batuan dinding berkaitan dengan pemineralan emas di Bukit Koman, Raub

11.50 : *Tan Teong Hing*
Geochemistry parameters for barite mineralization in central Pahang

12.10 : *Liaw Kim Kiat*
Stratigraphy and coal seam correlation of the Nyalau Formation, Merit-Pila Coalfield, Sarawak

12.30 : **Lunch**

Technical Session II — Environmental and Engineering Geoscience

● **KEYNOTE PAPER 2**

14.00 : *Ibrahim Komoo*
EIA: The necessary and significant role geologists can play

● **TECHNICAL PAPERS**

14.30: *Leong, L.S., Chew, K.W., Ng, B.S. & Tan, T.S.*
Monitoring strong earthquake shaking at the Penang Air Itam Dam, Malaysia

14.50: *Abdul Rahim Samsudin, Abd. Ghani Rafek & Umar Hamzah*
Geophysical investigation for groundwater exploration at UKM's Kuala Pilah Matriculation Centre, Negeri Sembilan

15.10: *Khairul Anuar M. Nayan, Abd. Ghani Rafek, Amiruddin Ismail & Mohd. Masri Mohd. Shiyuti*
The application of seismic P- and S-wave measurements in granitic residual soil

15.30: *Tan Boon Kong*
Engineering geology of the Ipoh-Gopeng segment of the North-South Highway

15.50: *Foss, C.*
Magnetic mapping in Southeast Asia — Dealing with a low inclination field

16.10: *Kadderi Md. Desa*
Weathering path diagram (WPD)

16.30: **Tea Break**

● **TECHNICAL POSTERS**

16.30: *Ng, T.F., Pereira, J.J., Yeap, E.B. & Yap, S.Y.*
Mineralogy and granulometry of airborne dust from a cast iron foundry in Kuala Lumpur: A preliminary study

Yeap, E.B., Pereira, J.J. & Rushdi, M.Y.
Geology, mineralization and mining of the Selinsing gold deposit, West Pahang

Tuan Besar Tuan Sarif & Mior Termizi Mohd Yusof
Kajian penganggaran rizab bijih emas lanar di Jeli, Kelantan

Abd. Ghani Rafek & Tosri Amin
Beberapa sifat geologi kejuruteraan batuan porfir kuarza, kawasan Genting Sempah, Selangor-Pahang

Kamal Roslan Mohamed & Che Aziz Ali
Delta Kelantan: Perubahan geomorfologi berasaskan tafsiran imej LANDSAT TM

Mogana, S. & Ibrahim Komoo
Pengaruh geologi ke atas prestasi mesin gerekan terowong batuan keras

Haryono, Abd. Rahim Samsudin Abdul Ghani Rafek & Nasiman Sapari
Pengunaan kaedah-kaedah hidrogeokimia dan kerintangan geoelektrik untuk mengesan kemasinan air tanah pada akuifer di pantai utara Kelantan

C.Y. Lee, K.Y. Tan & Faridah Abdul Hamid
Magnetic modelling of a subsurface intrusion in the Yan area, Kedah

17.30: **Closing of Technical Session**

20.00: **Conference Dinner. Host: Malaysia Mining Corp. Bhd.**

SUNDAY 28TH MAY 1995

Technical Session III — Sedimentology and Paleontology

● **KEYNOTE PAPER 3**

09.00: *Khalid Ngah*
Sedimentology: Application of concepts in exploration for petroleum, coal and uranium

● **TECHNICAL PAPERS**

09.30: *Che Aziz Ali, Ahmad Jantan & Farshori, M.Z.*
The Holocene monsoonal storm Pahang River Delta Complex, Malay Peninsula: Behaviour in space and in time

09.50: *Mohd Shafeea Leman*
Permian brachiopods from Maran area, Pahang

10.10: *Basir Jasin & Mahadir Ramli*
Radiolaria from the Lubok Antu Complex, Sarawak

10.30 : **Tea Break**

11.00 : *Uyop Said & Nor Asmah Abdul Aziz*
The occurrence of spore and pollen at km 136 Kuching-Sri Aman Road, Sarawak

11.20 : *Ahmad Jantan, Mohamad Md Tan & Uyop Said*
The nature of Permian-Triassic junction in the rock sequence in Central Pahang: Suggestion from geochemical studies

11.40 : *Abdullah Hasan & Juhari Mat Akhir*
Penemuan fosil bivalvia (*Posidonia kedahensis* dan *Posidonia japonica*) di kawasan Sungai Petani dan tafsirannya

● **TECHNICAL POSTERS**

12.00 : *Juhari Mat Akhir & Abdullah Hasan*
Pemprosesan dan pengelasan data LANDSAT 'Thematic Mapper' untuk kegunaan geologi: Satu kajian kes di Sungai Petani, Kedah Darul Aman

Che Aziz Ali
The Subis Limestone: Cement type and paradiagenesis

Uyop Said, Mohamad Asri Omar, Che Aziz Ali & Basir Jasin
A spore and pollen assemblage in Pueh area, Sarawak

Yusri Zakaria & Mohd Shafeea Leman
Hematite mineralization at Bukit Lop, Chaah, Johor

Shariff A.K. Omang
Petrology and geochemistry of the volcanic rocks associated with the Darvel Bay Ophiolite, Lahat Datu, Eastern Sabah, Malaysia

Qalam Azad Rosle & Teh, G.H.
Stratigraphy, sedimentology and structural geology of the Betong–Lepang Nenering border area, Pengkalan Hulu (Keroh), Hulu Perak

12.50 : **Lunch**

Technical Session IV — Structure, Tectonics and Magmatism

● **KEYNOTE PAPER 4**

14.00 : *Tjia, H.D.*
Quaternary tectonics of Southeast Asia

● **TECHNICAL PAPERS**

14.30 : *Askury Abdul Kadir*
Hubungan genetik syis, gneis, migmatit serta granit ditinjau dari aspek petrografi dan petrokimia

14.50 : *Syed Sheikh Almashoor & Zaiton Harun*
Brittle fault zone in granite, Pulau Pangkor

15.10 : *Liew Kit Kong*
Structural history of Hinge fault zone of the Malay Basin

15.30 : **Tea Break**

16.00 : *Shariff A.K. Omang*
Sub-ophiolite metamorphic rocks in the Tungku area, Lahad Datu, Eastern Sabah: Origin and tectonic significance

16.20 : *Chakraborty, K.R.*
Genting Sempah Volcanic Complex: Genetic implications for the Main Range Granite

16.40 : *Sivaji, S.*
Evaluating some applications of GIS technology in geological data management and processing methods: A case study from part of Northwest Borneo Basin, Sabah

17.00 : **Closing Address**

ANNUAL GEOLOGICAL CONFERENCE '95
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Abstracts of Papers

Keynote Paper 1

Minerals in the national economy of Malaysia: Non-metallics the emerging sector

TEOH LAY HOCK, FATEH CHAND, SEET CHIN PENG & KAMAL DARIL
Geological Survey Department

Much has been said about the poor health of the Malaysian minerals industry, the fall in mineral production both in terms of tonnage and value, decrease in mineral exports, decline in mineral sector employment and, above all, the drastic drop in the non-fuel mineral sector contribution to the GDP. However, a closer look at available mineral statistics show that much of the perception has been based on a misconception of what the minerals industry is. Malaysian economists commonly evaluate the non-fuel minerals industry's performance mainly on metallic mineral production without giving much consideration for the non-metallics and the contributions from mineral-based downstream value-added activities. The non-metallic mineral sector has, in recent years, expanded significantly and if its contribution, both in terms of raw material production and output of value added products, was to be taken into consideration, the scenario and prospect of the minerals industry, or more specifically the non-metallic sector, look quite promising.

Statistics compiled by the Geological Survey Department (GSD) show that the total value of mineral production has actually been increasing, from RM1,550 million in 1991 to RM1,649 million in 1993. Although metallic mineral production decreased from RM654 million in 1991 to RM452 million in 1993, this was adequately compensated by a corresponding increase in non-metallic mineral production from RM890 million in 1991 to RM1,171 million in 1993.

Most of the non-metallic minerals produced are consumed locally and therefore their contributions are not reflected in the export performance. Minerals constitute a significant proportion of the raw materials required for value-added manufacturing such as in the ceramic, glass and cement industries. The export of Non-Metallic Mineral Products (NMMP) has been experiencing positive growth annually, from RM369 million in 1988 to RM847 million in 1993. Preliminary statistics indicate that the 1994 export will further increase to RM960 million. Likewise, the intangible contribution of rock materials towards the construction of buildings and infrastructure has not been given appropriate recognition, particularly towards GDP compilation. Many of these inputs are not considered by economists as contributions from the minerals industry. The misleading perception about the poor health of the Malaysian minerals industry, therefore, arises as a result of the lack of understanding of what the minerals industry encompasses, and consequently incomplete data capture, rather than as a result of the actual performance of the industry itself.

The emergence of the non-metallic industrial mineral sector can, to a large extent, be attributed to the implementation of the Industrial Master Plan and also GSD's mineral diversification programme which gives high priority to the search for minerals other than tin, particularly non-metallic industrial minerals. The results of GDS's exploration programme show that the country is well endowed with ball clay, kaolin, silica sand, limestone, sand and gravel, and rocks suitable for the production of aggregate and dimension stone.

The rapid infrastructural and building development and the expansion of the manufacturing sector have created the demand for rock and mineral raw materials for construction and value-added manufacturing such as in the ceramic, glass and cement industries. With this known availability of abundant resource and optimistic projected demand, the non-metallic industrial mineral sector looks set to be the prime mover for the Malaysian minerals industry in the future.

Keynote Paper 2
EIA: The necessary and significant role geologists can play

IBRAHIM KOMOO
Jabatan Geologi, Universiti Kebangsaan Malaysia

Rapid and obvious deterioration of the environment caused by uncontrolled development has compelled the Government to make EIA an integral part of project planning, as important as technical and financial planning. Although the Government has given clear indication about its concern through legislation and awareness campaigns, this concern is sometimes not shared by developers and the significance of the EIA is not fully appreciated by consultants. This situation arises because the developer sees the EIA as one more bureaucratic and financial hurdle. The consultant, on the other hand, usually lacks the integrated knowledge necessary to enable him to see linkages between environmental systems. It is unfortunate that from observation the geological aspect is usually the weakest link in making an EIA effective.

An EIA is a multi-disciplinary and forward-looking predictive process. It starts with a description of the project and the existing environment and ends with providing impact statements, mitigating measures and cost-benefit analysis. Up to now the geologists have played an excellent role in providing information on the existing physical environment. However, it is apparent that the geologist feels that this is his most important role and that is where his contribution ends. What is not realised is that the second and most important part of the EIA is not the purview of any one expert group and the geologists, indeed, have a necessary and significant role to play.

A brief review on the input from geologists in EIA reports in Malaysia reveal the following weaknesses:

- the information given is too academic in nature;
- geological dynamic processes, e.g. mass movement and sedimentation, are not adequately dealt with;
- the full spectrum of geological subfields is not fairly covered, with the report being biased towards one geological expertise;
- the 'standard' reporting format informally adopted by geologists allow non-geologists to provide similar information through a desk-top study;
- there is little committed effort made to link the geological information obtained with the requirements of the EIA.

To overcome these weaknesses the required inputs and outputs should be planned diligently. To accomplish this the geologist has to step out of the traditional geologists' thinking mode. Only then the geologists can play the necessary and significant role that they should.

Keynote Paper 3
Sedimentology: Application of concepts in exploration for petroleum, coal and uranium

KHALID NGAH
PETRONAS Research and Scientific Services

Petroleum, coal and uranium are three very important mineral energy resources; and together, they provide 75% of the total world energy output. Except for uranium which is also found in hydrothermal veins and pegmatites associated with igneous bodies, coals and petroleum are sedimentary in origin. Coal is a sedimentary deposit found *in-situ*, with re-worked coal deposits rarely reported. Petroleum, on the other hand, is a by-product of organic matters, (for example kerogen in shales and sandstones) which is trapped either *in-situ* as in the case of coalbed-methane, or expelled from the source environment and migrated through a porous medium into reservoirs (usually sandstones and carbonates, and less commonly fractured granites and sills).

Uranium deposits in conglomerates, sandstones, shales, or even limestones, have been reported to occur as diagenetic minerals formed or precipitated from uranium-rich solution in generally reducing environments. The uranium deposits have been found in sandstones of intermontane basins where the carbonaceous

materials are present in abundance; in arkosic sandstones and mudstones of continental origin, close to sediment (and uranium) sources, where slight change in the Eh and pH of uranium-bearing solution will trigger the precipitation of uranium; and in shales, lignites and phosphorite where uranium is enriched through sorption or other chemical processes. Uranium deposits in lignites are usually associated with permeable sandstones below a regional unconformity.

Coals in commercial quantity can only be found deposited in coastal/swampy/deltaic environments, where the depositional environments are usually reducing and carbonaceous and/or organic matters are better preserved. Coal deposits are likely to be found in the upper half of the deltas where the environment is favourable for the development of swamp. The extent of coal deposits is a function of size of the prevailing deltas and rate of delta aggradation.

Petroleum is found in a basin where four factors/features must be present: source rocks (coal and coaly materials are good examples), appropriate temperature sufficient to "cook" the source rocks to generate petroleum, reservoir rocks (for the generated petroleum to be stored) and traps (structural, stratigraphic or diagenetic features which impede the migration of petroleum from migrating further). In a sedimentologic complex, it is essential that the depositional environments of sedimentary sequences be determined, as both the source and reservoir rocks, and frequently the stratigraphic and diagenetic traps, are confined to specific sedimentologic settings. In modern day exploration, recognition of the sedimentary sequences is vital, as this will determine the success of an exploration venture. This sequence recognition concept is being applied successfully in the exploration for coal deposits.

Petroleum, coal and uranium deposits play a very significant role in our lives, which provide catalysts for economic growth and development; there is therefore little wonder that mankind fights in wars just to maintain the sovereign right over them. To know their occurrences, it is vital to understand their habitats through application of sedimentologic concepts.

Keynote Paper 4
Quaternary tectonics of Southeast Asia

H.D. TJIA

PETRONAS Research & Scientific Services Sdn. Bhd.

On three sides, west, south and east, the Southeast Asian region experiences the effects of convergence by subducting plates. Since middle Eocene, elongated crustal slabs of Indosinia have been extruded differentially southeast-ward along major NW-trending transcurrent faults (Red River, Mae Ping and Three Pagodas wrench faults). Since Neogene time, the character of convergence and differential slab extrusion has essentially remained the same. Active transcurrent slip-motions along faults within the region are consistent with the orientation of the faults relative to the current direction of plate convergence. WNW-directed convergence of the Pacific Plate extends its influence at least as far west as the longitude of Hainan island. The NNE-directed convergence of the Indian Ocean-Australia Plate influences stress fields in the subregion to the west of that longitude. The opening of the Andaman Basin since 10.8 Ma has been responsible for dextral slip along the Sagaing (in Myanmar) and the Sumatra transform faults. SE-ward extrusion of Indosinia is still active along the Mae Ping wrench fault. The Banda basin area in the southeast corner of the region is also being extruded eastward, probably along E-W faults, of which one is the Irian fault zone. A model predicts that active subduction in a double island arc setting develops six parallel zones where crustal movement alternates between uplift and subsidence. Tendency for subsidence characterizes a zone comprising the trench and part of the accretionary prism nearest the trench, the forearc basin, and the backarc basin. Uplift tends to dominate a zone oceanward from the trench, that part of the accretionary prism bordering the forearc basin, and the magmatic arc. Reversals in sense of vertical crustal movement are to be expected when the rate of subduction decreases or the process ceases to operate. The rate of vertical crustal movement depends on the presence of buoyant material and the rate of lateral displacement this material is being subjected to by the subduction process.

Petrographic characteristics and aggregate properties of the dacite porphyry intrusives of the Kuching area, Sarawak

YEAP, E.B., MOHD. TARMIZI, M.Z. & JOHN, J.
Department of Geology, University of Malaya

The rock types exposed around Kuching and areas stretching southwards until Bau include the following: 1. Sheared and brecciated volcanics (Serian Volcanics); 2. Sandstone and conglomerate (Kedadom Formation); 3. Limestone and marble (Bau Limestone); 4. Sandstone and shale (Pedawan Formation); 5. Meta-argillites and chert (Tuang Formation); and 6. Dacite Porphyry (Mid. Miocene Hypabyssal Intrusives). The chief source of aggregates which supply the urban centre of Kuching and areas south of it are derived from quarries operating on several dacite porphyry intrusives. Field mapping and petrogenetic evidence indicate that in the Kuching area, the older Late Triassic to Late Cretaceous sedimentary rocks and volcanics were intruded by dacite porphyry which took the form of small stocks, dikes and sills. Petrographically, the dacite porphyry contains phenocrysts of plagioclase, hornblende and quartz set in an aphanitic groundmass of quartz and feldspars. Locally, glassy groundmass has been observed and zeolites have been identified.

The intrusives are observed to be affected by late phase magmatic/hydrothermal activities which had caused alterations to the dacite porphyry which can be visually observed on the quarry faces. The alterations identified, often occurring in different degrees of intensities at specific parts of the quarry faces include: 1. Chloritization, 2. Pyritization, 3. Calcitization, 4. Hematization and 5. Kaolinization. Based on the present petrographic study, identification and recognition of various types of alterations in the field are possible.

Fresh dacitic porphyry rocks and their altered phases in all the quarries around Kuching were sampled from the quarry faces and tested for their physical and aggregate properties in the Geological Survey of Malaysia Laboratories in Ipoh. Physical and aggregate properties determined include S.G., Water Absorption, Aggregate Crushing Value, Aggregate Impact Value, 10% Fine (all according to BS 812) and Los Angeles Abrasion Value (ASTM 131).

Fresh dacite porphyry rocks show excellent physical and aggregate properties. On the other hand, altered phases invariably show poorer physical and aggregate properties with some dipping below the requirements or specifications of aggregate properties set by the Jabatan Kerja Raya, Malaysia, for various construction purposes. In the day-to-day operation of the quarries usually, the unaltered dacite porphyries are mixed with the altered phases, thus the properties for the commercially available aggregates are somewhere between the two values.

Petrographic evidence indicates the presence of micro-crystalline and crypto-crystalline quartz (which are potentially alkali-silica reactive) in all the thin sections of the dacite porphyries. Zeolites and glassy matrix are present locally. It is recommended that if the dacite porphyry aggregates are to be used in concrete in which the alkali content in the cement portion is high (<0.6 % NaOH equiv.) the mortar bar tests (ASTM 227) be carried out to assess the alkali-silica and alkali-zeolite reactivities.

Production of crushed rock aggregate: Some environmental considerations

T.F. NG[1] & E.B. YEAP[2]
[1]Institute of Advanced Studies, University of Malaya
[2]Department of Geology, University of Malaya

Introduction — Rock aggregate is important to national development and deserve serious consideration. Rock aggregate and related construction materials are essential in the construction industry and public works. Adequate supply of these materials is necessary to sustain the growth of a nation, the nation's prosperity and quality of life.

In response to rapid development and urbanisation of our country, the aggregate industry represents one of the large scale extractive industry. The establishment of large quarrying operations attract controversy as they pose negative impacts to the environment. Quarrying is often resented by nearby residents as it may cause direct and indirect impact, nuisance and hazards to their well being, as well as damages to the environment, property, crops and livestock.

The most common environmental objections to quarries are related to visual impact, air and water

pollution, noise, ground vibration, air blast and flyrock occurrences. Most of these temporary environmental impacts should be assessed, quantified and reduced to acceptable levels by careful location, design and operation of the quarries, as well as early mitigation measures. Quarrying also causes permanent scarring of the landscape.

Visual intrusion — In developed countries where there is a greater awareness of environmental issues, widespread adverse reaction to the appearance of quarries and mines are noted. However, in Malaysia complaints about the visual impact of quarries and mines are generally unheard of. There is no legislation pertaining to visual impact of quarries and other development projects, although landscaping is advocated as part of quarry restoration upon closure of the quarries.

The most notable visual impact of quarry and its associated facilities are bare steep rock faces or pits which are highly visible due to its visual contrast with the surrounding vegetated areas and skyline. Quarry facilities such as crushing, conveying and screening equipment, machinery sheds and stockpiles are also visually unattractive. Pollutants such as airborne particles may be seen far away.

Air pollution — Air pollution in the form of airborne particulates or dust is one of the main environmental problem in many quarries. Emission of other air pollutants such as carbon monoxide, hydrocarbons, sulphur and nitrogen oxides are often relatively low. Dust problems are particularly severe in dry and windy conditions. The Department of Environment records shows that 3 to 7 percent of all air pollution complaints made by the public are directed at rock quarries. In the year 1992 and 1993 respectively, only 75.8 and 84.5 percent of the quarries in Malaysia complied with the Environmental Quality (Clean Air) Regulation 1978.

Airborne particulates can be categorised into 2 groups: those less than 10 microns in diameter (PM_{10}) which is often considered to be respirable; and those coarser which is non-respirable. Respirable particle hazardous to health and the non-respirable dust is considered a nuisance. These particles can also damage crops and other vegetation. Airborne dust in granite, quartzite and other quartz-bearing rock quarries contain high levels of silica, hence quarry worker and residents living close to the quarries are at risk of developing pneumoconiosis. Studies on workers of government granite quarries in seven Malaysian states in 1978 show that 25 percent of the quarry workers had silicosis and 8 percent had suspected silicosis. To control dust exposures, the Factory and Machinery (Mineral Dust) Regulation 1989 came into force.

The principal sources of dust in the quarry are related to comminution processes (crusher, drilling, blasting), screening, traffic movements, conveying and dumping of aggregate into the hopper and stockpiles. Wind erosion of non-vegetated areas also produce dust.

Water pollution — Siltation can be a serious problem in quarries if appropriate mitigation measures are not taken, particularly during land clearing, site preparation and the early stage of quarry operation. The silt-laden rain water run-off discharged into nearby streams will cause an increase in the suspended solids concentration and turbidity of the stream water. The main effect of siltation is the deterioration of water quality, making the water unfit or less suitable for consumption or industrial use. Siltation also causes ecological damages by reducing the biodiversity of aquatic life.

In the production aggregate, hazardous chemical compounds are rarely use, and thus there will be no introduction of significant concentrations of substances that cause physical and/or chemical changes to the groundwater and surface water. However, water can be polluted by accidental spillage, leakage or discharge of liquid fuel and oil from machinery.

Noise — Noise is often considered a nuisance to the public, and may cause permanent or temporary hearing impairment to quarry workers. The main sources of noise in the quarries are from traffic movements, processing equipment (crusher, screens, conveyor, etc.), drilling and blasting. Presently, there is no enforced regulation on the level of noise generated in quarries that affect the public, although the level of noise the quarry workers are exposed to is governed by the Factories and Machinery (Noise Exposure) Regulation, 1989.

Blasting — Complaints of damage and nuisance due to blasting are common whenever a quarry is located close to residential, commercial and industrial areas. The main problems related to blasting are ground vibration, air blast and the occurrence of flyrocks. All three have damaging effects on buildings, however the effects of ground vibration is more severe over a larger area. Ground vibration also causes physical discomfort to surrounding residents, and flyrocks pose a safety hazard to quarry workers.

Transport — Like all other industry, the aggregate industry requires two-way flow of materials, personnel and products with the external communities. In Malaysia, a great majority of the aggregate is delivered by trucks (road transport), though railroad and water transport also exist. The vehicular traffic, particularly trucks used to distribute rock aggregate has become a source of nuisance and a safety hazard. The main impacts of vehicular traffic are public safety, noise and vibration, air pollution and interference of these traffic with private traffic.

Biological impact — Quarry operations will inevitably cause negative impacts to flora and fauna. The extent of impacts is influenced by the natural condition of the site prior to development (such as topography, abundance and number of species, habitat type, ecology, conservation status), and scale and mode of quarry operation. Development of quarries may cause loss (partial or total) of forested areas and plant/wildlife habitats, loss of flora and fauna (especially rare or endangered species) and reduction in biodiversity.

Reclamation — Quarrying is only a temporary use of land, and the quarry operators are obliged to reclaim the working sites upon exhaustion of the rock materials to a condition suitable for some use. Abandoned quarries can be reclaimed into residential, commercial and industrial site, recreation areas, agriculture land, landfills, and others, dependent on the configuration, topography and hydrogeology of the abandoned site. To reduce the cost and problems related to reclamation, rock extraction and disposal of quarry waste should be made with the final landscape in mind, and reclamation works should be made parallel with rock extraction.

Electronprobe microanalysis of SnO_2-CuFeSnZn sulphide ore

TEH GUAN HOE

Department of Geology, University of Malaya

The electronprobe microanalyzer (EPMA) has become the state-of-the-art tool in earth science for the accurate analysis of not only the major but also minor and trace element compositions of minerals and ores.

Besides the conventional wavelength dispersive spectrometers (WDS) for very accurate composition determinations, EPMAs nowadays have a fully integrated energy dispersive spectrometer (EDS) which will provide for fast full spectrum scan of elemental composition. The EDS results, especially for the heavier elements, are quite close to that of the WDS.

A SnO_2-CuFeSnZn sulphide ore was the subject of compositional analysis by three different makes of EPMAs. The CuFeSnZn sulphide minerals include:

stannite	$Cu_2(Fe, Zn)SnS_4$
kesterite	$Cu_2(Zn, Fe)SnS_4$
stannoidite	$Cu_8(Fe, Zn)_3Sn_2S_{12}$

Besides obtaining accurate quantitative analyses of the various CuFeZnSn sulphide species present, line analyses can be performed as well as X-ray BSE maps which show the concentration of each element versus a colour scale and the area fraction of each concentration segment.

There is also the option of making an overlay of 3 or more different X-ray maps where each element is assigned a certain colour. These maps provide easier differentiation of the various phases present.

The accurate identification of mineral phases by the EPMA together with powerful image processing software and image analysis packages, paragenesis of an ore is greatly enhanced and the resulting maps of mineral distribution will ultimately simplify extraction procedures.

The attachment of an energy dispersive spectrometer to the scanning electron microscope (SEM) has also become standard for the geologist. The analytical data from such setups have also proved to be good and reliable with powerful new image processing and analysis software that are specially designed for SEMs.

Perubahan batu dinding berkaitan dengan permineralan emas di Bukit Koman, Raub

(Wall-rock alteration related to the gold mineralization at Bukit Koman, Raub)

WAN FUAD HASSAN[1], TAN TEONG HING[1], HAMZAH MOHAMAD[1], SYED SHEIKH ALMASHOOR[1], SUHAIMI HAMZAH[2] & KHALIK HJ WOOD[2]

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Lombong emas di Bukit Koman, Raub, yang pernah dikenali sebagai Raub Australian Gold Mine, dan baru-baru ini sebagai Kim Chuan Gold Mine, ialah sebuah lombong emas penting di Jalur Emas Semenanjung

Malaysia. Suatu traves timur-barat pada sebahagian jasad bijih di situ telah dilakukan untuk melihat perlakuan geokimia batuan pada jasad bijih. Batuan telah dianalisis secara sinar-X untuk unsur-unsur major dan dengan NAA untuk emas. Didapati beberapa unsur major menunjukkan korelasi yang baik dengan silika. Analisis yang sama dilakukan terhadap beberapa batuan sedimen di tempat-tempat lain tetapi kali ini korelasinya buruk. Kesimpulan daripada kerja ini menunjukkan bahawa batuan sedimen di Bukit Koman telah diresapi larutan permineralan dengan skala agak meluas dan menyebabkan perubahan batuan dinding yang tidak dilihat dengan mata kasar.

Geochemical parameters for barite mineralization in central Pahang

TAN TEONG HING

Jabatan Geologi, Universiti Kebangsaan Malaysia

Barite mineralization in central Pahang is related to some of the volcanic activities which occurred during the Permian-Triassic sedimentation. The suitable host rocks for barite mineralization are volcanic rocks with intermediate compositions having SiO_2 content varying from about 53 to 54 weight percent viz. andesite and dacite. These host rocks contain relatively high Ba content with values exceeding 5,800 ppm. Felsic and mafic volcanic rocks generally have low Ba content with values not exceeding 530 ppm. In addition, barite mineralization apparently occurred only in peraluminous host rocks containing about 1.05 mole percent of Al_2O_3/Na_2O+K_2O+CaO.

The geochemical characteristics for barite mineralization in intermediate peraluminous volcanic rocks are relatively high with LOI, Al_2O_3, TiO_2, P_2O_5, Sr, Zr, and Nb values exceeding 4.55%, 18.09%, 2.65%, 1.26%, 221 ppm, 561 ppm and 58 ppm respectively. The Rb content in the host rocks is relatively low with values less than 37 ppm, whilst the Ca content is of intermediate values of about 2.45%. The relationship between these geochemical parameters will be shown.

The chemical analyses for major and minor elements present in various volcanic rocks, including those as host rocks for barite mineralization will be shown.

Stratigraphy and coal seam correlation of the Nyalau Formation, Merit-Pila Coalfield, Sarawak

LIAW KIM KIAT

Geological Survey Department

The Tertiary coal-bearing Nyalau Formation in the Merit-Pila Coalfield can be subdivided into 5 main litho-stratigraphic units. These are, the "lower sandstone", the "lower coal zone", the "middle sandstone-shale", the "upper coal zone", and the "upper sandstone" units (Liaw *et al.*, 1987).

The lower units are laterally more continuous whereas the upper units are laterally less continuous. The former have generally sharp contacts whereas the later have more gradational contacts.

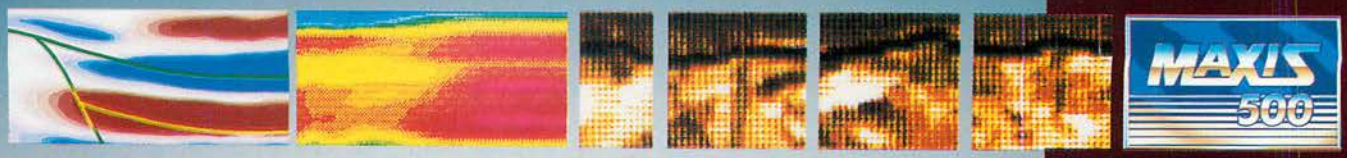
At least 35 coal seams have so far been identified within the 700 m of cored stratigraphic succession. Detailed lateral seam correlation between surface exposures as well as drill-hole intersections have been established within the 50 km^2 of this study.

Monitoring strong earthquake shaking at the Penang Air Itam Dam, Malaysia

LEONG, L.S., CHEW, K.W., NG, B.S., NG, S.J. & TAN, T.S.

Geophysics Program, School of Physics, Universiti Sains Malaysia

The Penang Water Authority, in collaboration with the Universiti Sains Malaysia, recently installed on 8th September, 1994, a free standing solid state accelerograph at the Penang Air Itam Dam. Located on the south-eastern embankment, next to the outlet house, the instrument pier lies on in situ weathered granitic soil derived from coarse-grained megacrystic biotite-granite of the Bunga type in the Northern Penang pluton.



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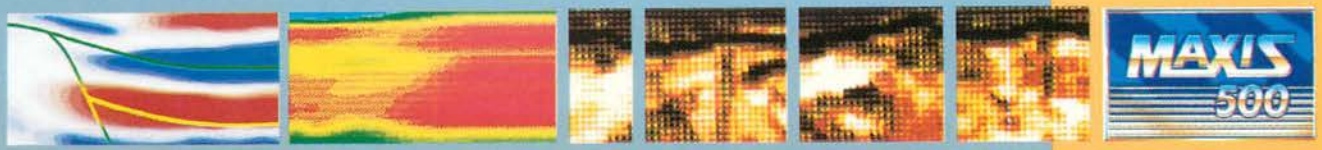

The Schlumberger Ultrasonic Borehole Imager Detects Openhole Problems and Fractures, Even in Oil-Base Muds.

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No other borehole measurement gives you the thin-bed resolution you get with the UBI tool. The images, cross-section plots and pseudo-3D "spiral" plots generated from UBI measurements also reveal keyseats, breakouts, shear sliding and shale alteration to help you avoid the added drilling costs that result from stuck pipe and lost time or equipment. In addition, you get horizontal stress information for mechanical properties evaluations to predict breakouts and perforation stability in unconsolidated sands.

Talk to your Schlumberger representative about detecting openhole problems and fractures acoustically, even in oil-base muds. What UBI images show you could save you time, expense or possibly your well.

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The purpose of this joint research study is to determine quantitatively the level of vibratory ground motion experienced at the Penang Air Itam Dam from earthquake tremors originating from Sumatra in Indonesia. This study attempts to ascertain (a) the peak acceleration, velocity and displacement values, (b) the duration, and (c) the spectral content and predominant period of earthquake shaking felt at the instrument station.

Whereas mechanical-optical type strong motion accelerograph units recording on photographic film has been installed in this country, their performance have not been satisfactory. The digital accelerograph (a KINEMETRICS SSA-16) installed at Air Itam has instead a 16-bit recording resolution and a frequency response bandwidth from 0 to 50 Hertz. Fully micro-processor controlled, the solid state instrument allows a user selected trigger sensitivity from as small as 2.0×10^{-3} g to 0.2 g. This is the first 16-bit solid state accelerograph to be installed in Malaysia with a SONR of more than 96 dB.

We describe next in brief some practical aspects of data acquisition and reduction. Communication with the accelerograph is by factory released software included in the purchase of the instrument package. A flowchart for data retrieval, down-loading, utility housekeeping and waveform display for a quick review of recorded events will be shown. We simplified keyboard usage by installing the factory supplied communications program on to a Direct Access menu. This over-rides the need for DOS commands which we find efficient in the field. In-house data processing uses proprietary Kinemetric's Seismic Workstation Software to (a) correct the accelerogram record for instrument characteristics and integrate this accelerogram to obtain the velocity and displacement records, and, (b) compute the response spectrum to specified dumping values. An example of this data integration and subsequent Fourier spectrum on a tripartite plot from an artificially created spike impulse will be shown. Calibration constants, determined in the factory prior to shipment, for each accelerometer channel can be checked and updated, if necessary, using a recorded accelerograph functional test. A recently conducted test to determine the natural frequency and damping for one particular channel will be shown.

In conclusion, our study suggests that this installation of the first digital accelerograph in Malaysia at the Penang Air Itam Dam is at best a useful academic exercise. We believe it is a fallacy to base a structural design on the basis of one solitary strong motion station located in a specially constrained environment. A more systematic approach is to assemble a collection of strong motion data in selected high rise buildings, elevated interchanges, hydroelectric dams, long span bridges, and under different soil or geological conditions using appropriate instrumental configurations. This data bank, together with other geological/seismological inputs is envisaged to provide a basis for formulating an earthquake building code peculiar to Malaysia and allows improved and more creative engineering designs than presently practised.

Geophysical investigation for groundwater exploration at UKM's Kuala Pilah Matriculation Centre, Negeri Sembilan

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A geophysical investigation was conducted at the UKM's matriculation centre at Kuala Pilah, Negeri Sembilan by the department of geology, Universiti Kebangsaan Malaysia. The study was initiated as a result of water shortage in the area. The normal supply of water by JKR is either insufficient or totally cut off for several days especially during dry season. The aim of the study was to look for the possible source of back up water supply for the centre. Geoelectrical sounding and seismic methods were adopted for assessment of the subsurface condition of the area and nature of the bedrock. A total of eleven sounding stations and eight seismic profiles were established. A layer of low resistivity (<100 ohm-m) was detected at six sounding localities within the study area. The low resistivity layer could be associated with near surface water saturated zone of aquifer. However based on seismic data and by taking velocity of 1,600 to 1,700 m/s as water saturated zone, only one location at SP3 or S4 was found to be favourable. The layer has resistivity value and seismic velocity of about 80 ohm-m and 1,690 m/s respectively. Both geoelectrical and seismic results show good agreement in term of depth below surface (~2 metres) and layer thickness (~30 metres). These results need to be confirmed by drilling.

The application of seismic P- and S-wave measurements in granitic residual soil

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Introduction

Residual soil of granitic origin forms about a third of the soil formation in Peninsular Malaysia. The present methods employed in geotechnical site investigation of residual soil have been that of either wash drilling or foam drilling with standard penetration or the pressure-meter test conducted from the borehole. There remains a need to provide additional information economically to assess conditions for foundations, preferably using a non-destructive method which can be carried out with minimal disturbance to the soil from the boreholes that have been drilled.

Priority is also given to the investigations of the seismic shear wave velocity because of its direct relationship with the dynamic shear modulus and its significance in defining the properties of the soil structure. The corresponding dynamic characteristics obtained were then highlighted for their significance in geotechnical context by comparing with geotechnical data from the in situ tests. In this manner attempts were made to produce empirical relationships which could be used to substantiate the role of the Vertical Seismic Shear-wave Profiling (VSSP) technique in foundation investigations and design.

Objective and Methodology

This research is focused on the use of a geophysical technique commonly known as the seismic downhole or Vertical Seismic Shear-wave Profiling VSSP to investigate the watertable, lithology, weathering grades and to establish emphirical strength and stiffness relationship with the standard penetration and pressure-meter test on granitic residual soil.

The tests that were carried out include:

1. Preliminary seismic refraction survey using the General Reciprocal Method of interpretation.
2. Standpipe piezometers to monitor the water table.
3. Wash drilling with disturbed sampling and standard penetration test.
4. Foam drilling with Mazier sampling for geological logging to IAEG (Matula 1981).
5. Strain controlled pressure-meter tests in foam drilled boreholes.
6. Laboratory classification and index test to BS 1377:1990 on the Mazier samples.
7. Vertical Seismic Shear-wave Profiling (VSSP) from selected boreholes.

Results

1. The colluvium-residual soil interface has not been able to be detected by the shallow seismic refraction method using the General Reciprocal Method (Redpath, 1973) because at this interface the P-wave velocity of the material is lower than the one above it.
2. From the VSSP results of all the boreholes tested, the level at which P- and S-wave velocity were found to be the lowest corresponds to the results from the geological logs, standard penetration tests, hand penetrometer and the pressure-meter tests.
3. The level at which the P-wave velocity reaches the velocity of water corresponds well with the water level measured for all the boreholes.
4. The characterisation of residual soil below the water table using P-wave velocity alone is not possible and thus the use of S-wave velocity (V_s) and the corresponding dynamic shear modulus (G_{seis}) is hereby recommended.
5. The plot of dynamic Young modulus (E_{seis}) versus dynamic shear (G_{seis}) can also be used to classify the weathering grades of granitic residual soil to IAEG (Matula 1981).
6. Emphirical relationships has been obtained from the shear wave velocity V_s and the dynamic shear modulus G_{seis} on the standard penetration test (N) with the following results:
   i. $V_s = 2.89\ N + 167.84$
   with $r^2 = 0.88$
   where,

V_s = shear wave (m/s^2)
N = Standard penetration blow counts for 30 cm penetration

ii. G_{seis} = 4.71 N – 9.98
with r^2 = 0.92
where,
G_{seis} = dynamic shear modulus (MN/m^2)

7. Finally an emphirical linear relationship between the dynamic shear modulus (G_{seis}) and the unload-reload static shear modulus (G_{ur}) was obtained with the equation

G_{seis} = 2.39 G_{ur} + 36.03
with, r^2 = 0.94
where,
G_{ur} = unload-reload static shear modulus (MN/m^2)

Engineering geology of the Ipoh-Gopeng segment of the North-South Highway

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The Ipoh-Gopeng segment of the North-South Highway traverses terrain representing Kinta Geology, i.e. with rock formations comprising limestone, schists, quartzite and granite. Superficial deposits include various residual soils, alluvium, colluvium, mine tailings and slimes.

The construction of the highway in the Ipoh-Gopeng area is very much dictated by the type and nature of the deposits (soils and rocks) traversed by the highway. This paper presents examples of engineering geological works along the highway illustrating the influence of geology on engineering works.

For example, initial mapping of certain section of the highway alignment revealed the extensive occurrence of colluvial deposits, which are rather weak materials. As such, the elevation of the highway alignment was shifted to a higher level to avoid as much as possible these colluviul deposits.

The soft slimes and mine tailings left over from previous tin mining activities were removed or transferred to other ponds away from the alignment wherever possible. Those not removed or transferred elsewhere were subject to soil stabilisation measures such as preloading with pre-fabricated vertical drains to accelerate consolidation of the soft soils.

Cut slopes in residual soils of granite and schists do not present much problems, except that at the base of some of the slopes which were designed and constructed to be at steeper angles, some soil stabilisation works were required such as guniting, soil nailings, soil anchors, etc. An unexpected occurrence of weathered pegmatitic dykes and veins at the base of one of the schist cut slopes did caused some problems to the guniting works carried out at one location.

Cut slopes in granite at the southernmost section of this part of the highway did cause some major concerns and problems during the construction stage. By virtue of the ubiquitous occurrence of several joint sets in the granite and half a dozen or more faults dissecting the granite mass, a number of rock slope failures occurred during the construction stage. Numerous stabilisation measures were adopted, such as installing rock dowels and removal of a major section of the rock slope.

A major overhang at the limestone cliff at Simpang Pulai which was located very close to the highway alignment was similarly "stabilised" by major blasting and removal to yield a benched rock slope. The blasting of steep or overhanging limestone cliffs, however, is not without its associated hazards such as the triggering of rockfalls. The resulting benched slopes, however, are more acceptable since they pose less risk to the highway.

In conclusion, this case study clearly demonstrates the influence of geology (soils & rocks) on construction works.

Magnetic mapping in Southeast Asia — Dealing with a low inclination field

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The low inclination of the geomagnetic field in Southeast Asia poses some challenges in the interpretation of magnetic and aeromagnetic surveys conducted in the region. Foremost among these is that the almost horizontal total-field vector gives rise to a directional sensitivity with more prominent magnetic expression of east-west trending body edges relative to those of a north-south trend. Furthermore, some of the enhancement transforms and automated edge-detection and depth-estimation techniques applied in magnetic interpretation need to be modified for their optimal use at low latitudes. Successful interpretation of magnetic and aeromagnetic surveys within this region, therefore, requires familiarity with the characteristics of anomalies induced in such a low inclination field, and some preparation of the transforms and algorithms to be used in their analysis.

Some of these aspects of anomalies in a low inclination geomagnetic field are illustrated by an example from Malaysia. A magnetic anomaly has been delineated using both total field and vertical component measurements over a small area near Senaling in Negeri Sembilan. The anomaly is closely adjacent to a serpentinite body. It does not appear to be within the serpentinite as mapped by soil colour, but probably represents a magnetite rich pod derived from the serpentinite and intruded into the surrounding schists by igneous, metasomatic or tectonic activity. The total field and vertical component anomalies have peak to trough ranges of 1,900 and 2,500 nT respectively and are essentially independent because their vectors are almost orthogonal. The total field anomaly has been modelled using Encom Technology's Modelvision package. Using this software the total field anomaly is presented as it would have been measured for the same body at different latitudes. Some of the transforms available such as reduction-to-the-pole and analytic signal are presented both of the measured data and of the modelled fields for different geomagnetic inclinations. The study illustrates the capabilities and limitations of applying these transforms at such low latitudes.

The source body for the magnetic anomaly near Senaling is almost equidimensional. The anomaly over an elongate mineralisation-related dike-like body from a nearby area in Indonesia is presented and also interpreted using Modelvision. The modelled source body is rotated horizontally and the new magnetic responses are computed to show the directional sensitivity of the magnetic field at these low latitudes to the trend of the source body. The north-south trending elongate body does not have a single magnetic anomaly, but has discrete polarisation anomalies at its extremities with a very weak magnetic expression across the centre of the body, which is quite different to the magnetic expression of the identical body of east-west trend.

Weathering path diagram (WPD)

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Various methods of quantifying weathering have been proposed. Many based on the compositions of weathered materials (Maynard, 1992; Chittleborough, 1990; Harnois, 1988; Nesbitt and Young, 1984; Roaldset, 1972; Parker, 1970; Ruxton, 1968 and Rieche, 1943). These methods are similar in approach but differ in the value of the calculated indices. Furthermore, the calculated indices do not provide information about the state of weathering profiles, particularly profiles that have been subjected to and overprinted by later processes for example diagenesis and hydrothermal alteration. Nesbitt and Young (1989) state that the compositional trends of many igneous rocks during weathering are similar and that the trend can be calculated. Furthermore these trends can be used as a template against which the chemical history of weathering profiles can be compared, particularly ancient and buried profiles. A weathering path diagram is proposed as a weathering template where the state of weathering profiles can be evaluated. The WPD diagram is constructed based on log K_2O vs $SiO_2/(Al_2O_3+Fe_2O_3)$. The weathering path diagram has the property that all weathering paths converge to a narrow range of $SiO_2/(Al_2O_3+Fe_2O_3)$ ratios between 0.6 and 1.0. It also discriminates between two dominant weathering systems; acid and basic igneous rocks. The plot of log K_2O vs $SiO_2/(Al_2O_3+Fe_2O_3)$ is sensitive to alkali enrichment by diagenetic and hydrothermal processes or alkali leaching during the early stage of weathering; therefore the WPD is a useful tool for characterizing weathering profiles and paleosols.

The $SiO_2/(Al_2O_3+Fe_2O_3)$ ratio is generally known as the Shellmann quotient (after Schellmann, 1982). The quotient reflects slow leaching of silicate and passive enrichment of oxides and hydroxides of aluminium and

iron. It also has the effect of balancing selective removal of aluminium (lateritic environments) or iron (bauxitic environments). Silica should provide a good indicator of weathering since in tropical conditions silica loss correlates significantly with total element loss (Ruxton, 1968), and also a recent experimental work indicates that silica surfaces control the dissolution rate of silicate minerals (Brady and Walther, 1989). The choice of Fe_2O_3 (excluding FeO) is to reflect oxidising conditions associated with weathering (Price, 1992; Curtis, 1976) i.e. it is critical for profiles developed in temperate and cold climatic regions or profiles that show an early or intermediate stage of weathering. For profiles in tropical regions which are dominated mainly by gibbsite-goethite-kaolinite the use of Fe_2O_3 total values has litte effect on the Shellmann quotient because in such environments almost all Fe^{2+} will be oxidised to Fe^{+3}.

The choice of K_2O as one of the axis is made because;

1. It reflects rapid alkali leaching through cation exchange at the beginning of weathering, but the rate of potassium leaching is slow when compared to other alkalis (Na, Li, Rb, Sc) (Hamzah *et al.*, 1990).
2. It suggests diagenetic influences through reverse incorporation of K into clays such illite (Harnois, 1988), vermiculite and mica or irreversible glauconization (Courbe *et al.*, 1972).
3. It indicates hydrothermal alteration by alkali rich fluids or sign of K-alteration and K-metasomatism (e.g. Nesbitt and Young, 1989; Alderton *et al.*, 1980); and
4. It is not influenced by zeolitization process, a common alteration phenomena in basalts, because potassium is a rare constituent of zeolites (Gottardi and Galli, 1985).

Mineralogy and granulometry of airborne dust from a cast iron foundry in Kuala Lumpur — A preliminary study

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Airborne particulate matter was collected near a cast iron foundry in the outskirts of Kuala Lumpur for mineralogical and granulometry characterization. This small-scale foundry melts grey iron out of scrap materials using a Cupola furnace. The Cupola furnace has a total stack height of 8 m. The fumes (gases and particulates) generated during melting goes up the stack and is released directly into the atmosphere. Dust is also generated in other foundry processes such as moulding and core making, shakeout and cleaning which are done manually, as well as handling and transportation of raw materials and finished products.

The type of dust emitted from the foundry is related to the materials used. In the moulding process, washed mining sand is used as the principal moulding material, clay (a clayey silt residual soil) and molasses (a sugar refining by-product) are used as binding material and coal dust as reducing agent. The main materials used in melting are scrap grey iron, coke and limestone chips as flux.

Two dust deposit gauges were placed about 50 m NE of the foundry to monitor the dustfall. The gauges are essentially cylindrical containers about 160 mm in diameter and 320 mm high, placed in a stand with the top of the container at 2 m above ground level. A wind shield is attached to the stand around the container to improve the aerodynamic characteristics of the gauge. The gauges were fabricated using local materials based on ASTM D 1739:89 with some modifications. Modification includes channeling of dust particles settled in the container together with rain water to a 25 litre jerry can, placed on the ground through a plastic hose. Every month, the container, hose and jerry can of the dust gauges are brought back to the laboratory and replaced with clean ones. In the laboratory, the dust and rain water are washed out. The insoluble particles (dust) are separated from the rain water by vacuum filtering using cellulose nitrate membrane filter. The dust is weighed and the rate of dustfall is obtained. The dust is then extracted from the membrane filter and made into slides and grain mounts for X-ray diffraction and microscopic studies, respectively.

Dustfall range from 0.09 (October 1994) to 0.12 $gm^{-2}d^{-1}$ (September 1994) and the average value is 0.11 $gm^{-2}d^{-1}$. Though fugitive dust from the foundry is a major contributor of airborne particles, some of the dust collected are from nearby industrial, residential and other sources. Ash is the principal constituent of dust, comprising spongy particles, glass particles and carbonaceous materials. Spongy particles are often dominant, followed by glass particles. Spongy particles are finely vesicular glass with abundant very fine opaque particles and partially fused minerals. Glass particles are either slag fragments or solidified molten slag globules. The

coarser glass particles have strong colour, usually green or brown. Carbonaceous materials are coal and coky matter that escaped combustion.

The most common mineral is quartz. Minor amounts of tridymite also occurs, transformed from quartz as a result of heating in the Cupola furnace. Other mineral present are alkali feldspar, plagioclase, calcite, mica and haematite. Clay minerals are represented by kaolinite and illite. Extraneous materials include fibres, pollens and other vegetative fragments, and minute insects.

The carbonaceous materials and spongy particles are irregular in shape, the former is often subangular. The shape of glass particles are rather variable and can be categorised into two types. The first is angular particles with shard-like, acicular, lath-like and irregular shapes. The other is near spherical, and is also known as cenosphere. Quartz particles are mainly subangular to angular. The coarser quartz grains often have clay and iron oxide coatings. Feldspar and tridymite grains are angular.

The majority of the dust particles have diameters between 5 and 50 micron, and the coarsest particles approaches 500 micron. The coarsest particles are the carbonaceous matter, ranging from 30 to 500 micron across with the majority between 50 and 150 micron. Sizes of the spongy particles range from 5 to 250 micron (mainly 20 to 50 micron). Angular glass particles have diameters ranging from less than 2 micron to 250 micron, and are mainly 5 to 20 micron; while the spherical particles are usually 30 to 100 micron in diameter. Quartz grains range from less than 2 micron to 150 microns in diameter, with a majority between 20 and 50 micron. The size of tridymite and feldspar particles are 2 to 20 micron and 15 to 50 micron respectively.

Geology, mineralization and mining of the Selinsing gold deposit, West Pahang

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Bukit Selinsing is an elongated hillock trending 350° (measures 800 m by 400 m and is +152 m (+500 ft) high) and is composed of metamorphosed and partially sheared argillites with subordinate tuffaceous arenites, grit and conglomerate which strike between 340° to 350°. Bands of marble have been reported to occur at Bukit Selinsing and chlorite schists have been observed in waste rocks taken out of the old shaft (Mill's Shaft).

The epigenetic hydrothermal gold mineralization of Bukit Selinsing is located within a 50 m to 150 m wide 340° to 350° striking ductile-brittle shear zone which occupies the eastern half of the elongated hillock. The total mapped length of this mineralized zone is in excess of 500 m and continuations of this mineralized zone towards the north (which is known to stretch into the Buffalo Reef area, about 5 km northwards) and south of Bukit Selinsing outside the Selinsing mining lease have been observed.

The rocks in the shear zone is mainly composed of mylonites and a large proportion of it shows distinct s-c fabric. The foliations in these rocks dip mainly from 30° to 85° towards the east though some westward dipping foliations have been mapped. Mapping and petrographic evidence indicates that this shear zone was developed through progressive deformation. The initial deformation was ductile in nature and this caused mylonization of the phyllites, chlorite schists and meta-sediment. Later movements appear to be of brittle nature.

Several phases of silica and gold mineralization were interposed between the various deformation. Some of the quartz veins form porphyroclasts in the mylonite. Field evidence and petrographic studies of oriented sample collected from the field indicate that the shearing movements occur along the strike and along the dip direction. Sinistral movement is detected by one of us (RMY) while essentially normal movement with a minor strike-slip component was detected by another (PJJ).

The gold mineralization takes the form of auriferous quartz filling of fractures parallel, oblique and transverse to the strike of the shear direction of 340° to 350°. Thin mineralized quartz veins which have been deformed were observed to be incorporated into the sheared argillites, tuffaceous host rocks and conglomerates. Deformed quartz lodes are common and they are found as lenses (of up to 5 m thick) occurring obliquely to the strike direction of the shear zone. Small areas with thinner 'stockwork-like' mineralized quartz veins are found within the shear lenses of the more strongly dynamically deformed rocks. Simple planar veins parallel or sub-parallel or oblique/transverse to the strike direction of the shearing are also observed. These veins appear to be one of the latest in the quartz-gold mineralization process. It is noted that not all the vein quartz phases carry

Au-values even if they are found within the shear zone.

Gold is also found as dissemination in the silicified, pyritized and sericitized mylonites. Auriferous quartz may carry values from 5 g to 25 g/tonne of ore but the disseminated ores generally contain values from 1 g to 3 g/tonne. Mineralogically, the ores are composed overwhelmingly of fine to coarse-grained milky to light grayish quartz with minor pyrites, chalcopyrites, galena and tetrahedrite. The very fine gold particles in the ores (from <1 micron to a few mm) constitutes the main problem for the recovery of the gold from the weathered primary ores mined presently. It is estimated that the recovery using the present mill setup which is more suitable for alluvial-eluvial ores is no more then 60%.

The wall rock alteration accompanying the gold mineralization includes silicification, sericitization and pyritization. Silicification most often accompanied the earlier phase/s of mineralization where much quartz veining and deposition had occurred followed by deformation. Sericitization is pervasive and affected nearly all the rocks within the shear zone. Pyritization is a later phenomenon and may have accompanied one of the later phases of gold-sulphide-silica mineralization.

The Bukit Selinsing gold deposit had been intermittently mined since 1880 to 1939. On record, >31,000 troy ounces of Au had were recovered between 1887 and 1931. Mining resumed in the late 1980's and was targeted on the unworked alluvial ores, old mine tailings and the highly disturbed eluvial ores. With the exhaustion of these ores, the present mining operation is concentrating on the lower grade primary ores which were left behind from the previous mining operations. Ores of >2 g/tonne were selected based on easily observable field criteria such as quartz veining, silicification, pyritization (becomes intensely red when weathered) and sericitization or by field panning of crushed weathered rock sampled ahead of the mining face.

The ores together with the weathered rocks within the shear zone are dug up by hydraulic excavators and transported to the processing plant by trucks and dumped at the head of a hopper. Hard large lump pieces of ores (mainly auriferous quartz) are manually broken to below 15 cm. The ore mixtures are fed with the help of strong jets of water and a tractor-pusher which feed the ores into hopper-feeder of large tube/ball mills (1.5 m by 3 m) which disintegrate the softer materials and grind down the harder ores. The 12 mm under-size product of the mill is then distributed and fed into a 4-lane gold palong.

Cleaning of the palong is done daily or once in 2 or 3 days. The palong concentrates are washed down the trap doors located at the tail part of the palong and pumped up to be distributed onto shaking tables in the processing plant. The table concentrate are manually panned or concentrated by passing through the table a second time. The final concentrate of the gold is then dissolved using aqua regia and then the gold is precipitated using $NaHSO_3$. The filtered gold precipitates are torched with oxy-acetylene flame using borax and $NaHCO_3$ as flux and the gold melt is poured as mini gold bars of about 99.7 to 99.9% purity.

Much of the gold particles in the primary ores is very fine (from <1 micron to a few mm) and this constitutes the main problem for the recovery of the gold from the weathered primary ores mined presently. It is estimated that recovery using the present mill setup which is more suitable for alluvial-eluvial ores is less then 60%. The sandy tailings which were sampled and analysed gave gold content ranging from 1 g to 2 g/tonne. The gold in the tailings is present as very fine liberated particles as well as locked-gold in the generally coarser and difficult to grind vein quartz fraction of the tailings.

The Selinsing Gold Mine shows potential for development into a reasonable large open-pit, low-grade and medium-tonnage mine with proper evaluation and metallurgical studies. Evaluation can be carried out using reverse circulation (RC) drilling with some coring. The samples recovered during the coring and RC drilling can be analyzed for evaluating the ore body, then used for petrological study, followed by metallurgical and gold recovery studies. A cyanidization plant (for example CIP) may be required for effective recovery of the fine fraction of the gold particles and this probably would constitute the most difficult problem as approval for using cyanide in the recovery process from the Mines Department requires stringent environmental mitigation measures.

Kajian penganggaran rizab bijih emas lanar di Jeli, Kelantan

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Penganggaran rizab bijih penting bukan sahaja kepada penentuan kandungan bijih berharga yang terkandung di dalam satu-satu jasad bijih, tetapi juga penting kerana ia dapat menentukan untung rugi yang

bakal diraih oleh para pelombong hasil daripada pelaburan yang dibuat dan merupakan asas kepada pengiraan aliran wang tunai.

Di dalam usaha mencari kaedah pengiraan yang paling sesuai yang dapat digunakan kepada kerja-kerja penganggaran rizab bijih emas yang berlaku di Malaysia, satu kajian penganggaran rizab bijih emas lanar telah dibuat ke atas satu kawasan di jajahan Jeli dalam negeri Kelantan.

Kawasan kajian tersebut sudah dicarigali oleh sebuah syarikat perlombongan kecil pada pertengahan tahun 1988. Kawasan ini dicarigali dengan cara mengorek lubang (pitting) dengan jengkaut. Susunan lubang carigali adalah menurut sistem grid segi empat sama. Dalam kajian ini empat kaedah utama penganggaran rizab bijih telah digunakan: 1. kaedah purata pemberat, 2. kaedah taburan normal, 3. kaedah taburan log-normal dan 4. geostatistik.

Kaedah purata pemberat adalah satu kaedah yang lazim digunakan dikalangan pelombong-pelombong kecil. Kaedah purata pemberat menggunakan ketebalan kaksa sebagai faktor pemberat yang akan mempengaruhi pengiraan gred emas purata dan seterusnya rizab bijih emas.

Kaedah taburan normal menggunakan andaian bahawa data carigali menepati taburan normal dan seterusnya rizab bijih diperolehi pada sela keyakinan 90%.

Kaedah log-normal diperolehi dengan menukarkan nilai emas lanar ke nilai log. Dari sini barulah ditentukan parameter yang sesuai untuk digunakan di dalam penilaian rizab bijih.

Geostatistik pula adalah satu kaedah yang baru kepada industri perlombongan emas di Kelantan. Kaedah geostatistik mengambil kira kedudukan sampel-sampel di dalam mendapan bijih. Dalam kaedah geostatistik, perisian komputer diperlukan untuk membantu memperolehi model semi-variogram dan seterusnya penganggaran nilai dan varians kriging (cara kriging digunakan) diperolehi. Nilai varians ini digunakan untuk mendapatkan rizab bijih bagi tiap-tiap blok pada sela keyakinan 90% yang seterusnya memberi jumlah rizab bijih emas bagi kawasan yang dikaji.

Dalam kajian ini didapati sebanyak 75 lubang yang bernilai emas untuk kawasan seluas 300 hektar dengan jarak asas dari satu sampel ke satu sampel sejauh 160 meter.

Perbandingan antara keputusan yang diperolehi daripada kaedah-kaedah purata pemberat, taburan normal, taburan log-noral, dan geostatistik dibuat. Daripada kajian ini ternyata kaedah taburan log-normal dan geostatistik boleh digunakan.

Beberapa sifat geologi kejuruteraan batuan porfir kuarza, kawasan Genting Sempah, Selangor-Pahang

(Some engineering geological properties of quartz porphyry, Genting Sempah area, Selangor-Pahang)

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Pengenalan

Di kawasan Genting Sempah di sempadan negeri Selangor dan Pahang tersingkap suatu sisa bumbung di atas banjaran Titiwangsa berlebar 1-2 km dan mengunjur utara-barat laut. Jujukan batuan tersebut mengandungi batuan sediment, metasediment dan igneus. Batuan porfir kuarza atau porfir riolit berupa sebahagian sisa bumbung tersebut (Haile *et al.*, 1977). Pembangunan dan pembinaan infrastruktur di kawasan Genting Sempah dan Genting Highland mendorong minta untuk mengkaji sifat-sifat geologi kejuruteraan batuan porfir kuarza tersebut kerana data sedemikian untuk batuan ini masih kurang dilaporkan. Sampel batuan untuk kajian ini diperolehi daripada kuari berdekatan dengan simpang jalan Genting Highlands-Batang Kali dan daripada lubang gerudi di Utara portal barat terowong Genting Sempah. Kaedah kajian yang digunakan adalah seperti yang disyorkan oleh International Society of Rock Mechanics (Brown, 1981)

Penjelasan bahan batuan

Batuan porfir kuarza atau porfir riolit mempunyai pelbagai warna dan dicirikan oleh tekstur porfir. Warna utama ialah kelabu dengan kelabu kehijauan. Sampel-sampel berwarna kemerahan juga ditemui. Tekstur porfir jelas kelihatan dengan fenokris bersaiz butiran sederhana (2 mm-5 mm) terbenam dalam matriks halus. Kuarza merupakan mineral utama yang membentuk fenokris berbutir euhedron hingga subhedron dan merupakan mineral yang paling melimpah. Felspar juga wujud sebagai fenokris. Matriks adalah bersaiz halus dan

kandungannya sukar dikenalpasti walaupun dengan bantuan mikroskop. Di antara butiran yang dapat ditentukan ialah kuarza, feldspar, biotit dan klorit.

Beberapa variasi batuan ini ditemui. Selain perubahan warna, terdapat juga batuan yang tericih dan teretak disebabkan oleh cangga tektonik. Kalsit wujud sebahagi pengisian retakan dan menyebabkan batuan berjalur-jalur halus berwarna putih. Jalur-jalur halus berwarna merah jambu dipercayai disebabkan oleh dolomit. Pirit juga wujud sebagai pengisian retakan dan dalam poket terpencil. Hablur kuarza yang halus dan jernih diperhatikan dalam geod yang bersaiz beberapa mm.

Hasil ujian mekanik batuan

Hasil ujian untuk mengkaji sifat fizis dan mekanik batuan bahan batuan porfir kuarza dipersembahkan dalam Jadual 1. Untuk setiap parameter yang diuji nilai purata serta julat nilai beberapa ujian dilaporkan.

Ketumpatan kering porfir kuarza adalah nilai lazim untuk batuan igneus iaitu sekitaran nilai 2.6 g/cm^3. Nilai keliangan yang rendah juga berupa nilai tipikal untuk batuan igneus.

Untuk penafsiran yang lebih bermakna, nilai-nilai kekuatan dibahagikan berdasarkan bentuk kegagalan, iaitu sama ada bahan batuan gagal ataupun kegagalan berlaku sepanjang satah-satah ketakselanjaran. Ini menghasilkan tiga kelompok nilai untuk ujian kekuatan mampatan sepaksi dan dua kelompok untuk ujian beban titik dan ujian kekuatan regangan (ujian Brazil).

Nilai kekuatan mampatan sepaksi batuan porfir kuarza untuk kes di mana kegagalan bahan batuan berlaku adalah sangat tinggi dengan nilai purata 222 MPa. Nilai ini membolehkan batuan tersebut dikelaskan sebagai sangat kuat. Nilai ujian beban titik dan kekuatan regangan yang berkaitan, iaitu untuk kes kegagalan bahan menghasilkan gambaran yang serupa, iaitu batuan ini mempunyai kekuatan yang sangat tinggi.

Kehadiran satah ketakselanjaran menyebabkan nilai kekuatan bahan batuan menyusut. Ujian kekuatan mampatan sepaksi menghasilkan dua kelompok nilai rendah yang jelas berbeza, iaitu 136 MPa dan 66 MPa, iaitu lebih kurang 2/3 dan 1/3 nilai untuk kes kegagalan bahan. Untuk ujian beban titik dan kekuatan regangan juga nilai kekuatan adalah sekitaran 35% hingga 40% sahaja untuk kegagalan satah berbanding dengan kegagalan bahan.

Delta Kelantan: Perubahan geomorfologi berasaskan tafsiran imej LANDSAT TM

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Delta Kelantan terletak di pantai timur Semenanjung Malaysia, dan terdedah kepada tindakan ombak yang kuat, terutamanya semasa musim tengkujuh (November hingga Febuari). Walaupun Laut China Selatan mempunyai pengaruh ombak yang kuat, tetapi bentuk Delta Kelantan ini tidak mencirikan delta kuasaan ombak. Delta Kelantan sekarang mempunyai muara berlumpur yang ditumbuhi oleh pokok bakau, dengan banyak alur pengedar kecil. Morfologi delta sekarang menunjukkan pengaruh sungai lebih penting daripada pengaruh ombak.

Kajian ini dilakukan berdasarkan imej LANDSAT TM (TM 1989), dan dibantu oleh peta topografi serta juga gambar udara. Imej LANDSAT TM jelas menunjukkan delta yang ada sekarang ini merupakan kompleks delta terbaru, sementara binaan delta yang sebelum ini terletak lebih ke selatan. Beberapa peringkat pembentukan dan perkembangan Delta Kelantan ditafsirkan daripada bentuk dan kedudukan alur-alur dan permatang pantai kuno. Delta lebih tua berbentuk juring ("*cuspate*") dan terdapat beting-beting pasir di bahagian selatannya yang menandakan arah garis pantai terdahulu. Delta yang lebih tua ini lebih bercirikan delta kuasaan ombak, berbeza dengan delta yang sedang terbentuk sekarang. Perubahan daripada delta kuasaan ombak kepada delta kuasaan sungai terjadi akibat perubahan-perubahan di bahagian daratan dan pesisir pantai. Di bahagian daratan, imej LANDSAT TM menunjukkan Sungai Kelantan telah menukar arah aliran beberapa kali dan ini mengakibatkan perubahan kedudukan muara. Imej yang diperolehi juga menunjukkan terdapat banyak alur-alur sungai tua yang luas tetapi mempunyai aliran yang kecil, ataupun alur-alur yang kering. Selain itu terdapat juga beberapa tasik memanjang dan tasik ladam, hasil tinggalan sungai lampau. Daripada bentuk dan kedudukan alur-alur sungai tua ini, dapat ditafsirkan sungai utama telah berubah bentuk dari berliku menjadi lurus beberapa kali. Di bahagian pantai pula telah dikesan garis pantai telah berkembang secara progressif ke arah laut (progradasi). Perkembangan garis pantai ditandai oleh permatang pantai yang berkedudukan hampir selari dengan garis pantai sekarang. Permatang pasir ini boleh dikesan hingga 10km

daripada garis pantai sekarang. Pada peringkat awal pembentukan Delta Kelantan, bukit Gunung Panchor (pekan Gunung) dan Bukit Marak merupakan sebuah pulau atau bukit di pesisir pantai dan kedudukan bandar Kota Bharu masih terletak di laut.

Pada masa yang sama muara sungai berhijrah secara berperingkat-peringkat ke arah baratlaut. Muara terawal yang dapat dikesan merupakan muara Sungai Kemasin dan kemudian menghijrah ke Muara Pengkalan Datu. Sebelum berubah kepada kedudukan sekarang, muara Sungai Kelantan telah berhijrah daripada Pengkalan Datu ke Kuala Pak Amat. Perubahan kedudukan muara menyebabkan tindakan proses fizikal (rambatan ombak, angin dan arus pantai) berbeza daripada sebelumnya. Pada masa ini sebahagian besar daripada bahagian luar kompleks delta dipengaruhi oleh aliran pesisir pantai yang menghasilkan pembentukan anak tanjung pasir ("*sandspit*") di bahagian pinggir delta. Kehadiran anak tanjung secara langsung melindung kompleks delta daripada tindakan ombak dan menyebabkan pengaruh luahan sungai dan pasang-surut lebih dominan di bahagian dalam kompleks. Rajah yang disediakan menunjukkan kemungkinan beberapa peringkat perkembangan kompleks Delta Kelantan dari peringkat awal.

Dengan menggunakan kaedah pengkelasan "cluster" (perisian ERDAS75), bahagian laut cetek dapat dikelaskan kepada beberapa bahagian yang boleh dikaitkan dengan kandungan sedimen di dalam air laut dan kedalaman air. Imej yang diproses jelas menunjukkan sebahagian besar sedimen tertabur di sekitar muara utama. Muara Pengkalan Datu terutamanya memper-lihatkan kandungan sedimen yang paling tinggi walaupun pada masa ini sungai ini tidak begitu aktif dan mempunyai kawasan tadahan yang kecil. Fenomena ini berlaku mungkin akibat daripada pengaruh ombak dan arus pasang yang mengepam sedimen ke dalam alur sungai dan meluahkan kembali semasa air surut. Di sekitar muara sungai aktif yang tidak terlindung, seperti di Muara Kemasin dan Muara Pak Amat, sedimen luahannya ditolak lebih ke arah laut dan disebarkan oleh tindakan ombak dan arus. Dengan itu kandungan sedimen di sekitar kawasan tersebut adalah jauh lebih rendah. Pada masa yang sama kawasan-kawasan tersebut pada masa ini merupakan kawasan hakisan yang utama. Muara utama Sungai Kelantan yang terlindung oleh kehadiran anak tanjung menerima sedimen dan mengendapkan sedimen di tempat yang sama.

Pengaruh geologi ke atas prestasi mesin gerekan terowong batuan keras

(The influence of geology on the performance of hard rock tunnel boring machines (TBM))

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Ruangan bawah tanah boleh dibina dengan kaedah penggerudian dan letupan ataupun dengan cara penggalian mekanikal. Walaupun teknik penggerudian dan letupan diutamakan sejak dahulu untuk batuan keras, penggalian mekanikal semakin menarik disebabkan oleh beberapa faktor.

Tidak seperti kaedah penggerudian & letupan, penggalian mekanikal batuan keras sangat dipengaruhi oleh keadaan geologi. Ekonomi penggalian batuan keras dengan mesin gerekan terowong dipengaruhi oleh kestabilan dan sokongan terowong serta ketahanan mata pemotong dan kadar pemotongan. Kedua-dua faktor ini dipengaruhi oleh ciri-ciri fizikal dan mekanikal bahan batuan berserta dengan ciri-ciri jasad batuan, dan seterusnya menentukan kebolehan menggali jasad batuan.

Kemajuan teknologi telah membolehkan mata penciptaan pemotong yang tahan lasak dan mesin gerekan terowong berkuasa tinggi. Kemajuan ini berserta dengan kefahaman geologi telah membolehkan batuan yang lebih kuat digali.

Kertas ini membincangkan secara ringkas pengaruh geologi ke atas prestasi mesin gerekan terowong batuan keras. Ciri fizikal seperti mineralogi, saiz butiran, kekerasan, abrasi dan ciri mekanikal seperti kekuatan mampatan sepaksi, tensi dan ricih, dan ciri jasad batuan seperti kekerapan kekar (bukaan, bahan pengisi, kekasaran dan keterusan), zon sesar, perubahan kimia dan luluhawa didapati mempengaruhi prestasi mesin gerekan terowong batuan keras (Jadual 1).

Rujukan dibuat kepada Terowong Pemindahan Kelinchi, di Seremban yang sedang dibina dengan mesin gerekan terowong Robbins. Spesifikasi utama mesin ini adalah: garis pusat 3.5 m, kuasa 671 kW, RPM 10.08, jumlah mata pemotong 29, saiz mata pemotong 393.7 mm dan 412.75 mm, tekanan maksima setiap mata pemotong 169.8 KN. dan panjang pemotongan 1.2 m.

Purata masa pemotongan untuk 1.2 m di Kelinchi di dapati berubah dari 71 minit untuk batuan masif dan sangat kuat (240 MPa) kepada 50 minit untuk batuan sangat kuat hingga kuat dan berkekar (200 MPa) dan kepada 30 minit dalam batuan lemah hingga kuat, yang telah mengalami perubahan kimia, tericih dan berkekar rapat (150 MPa).

Keberkesanan pemotongan didapati rendah untuk batuan masif dan sangat kuat (163 MJ/m^3) berbanding dengan batuan sangat kuat hingga kuat dan berkekar (104 MJ/m^3) ataupun dalam batuan lemah hingga kuat yang telah terubah atau tericih (71 MJ/m^3). Tenaga yang diguna didapati melebihi 100% untuk penggalian batuan masif dan sangat kuat berbanding dengan batuan terubah dan tericih. Purata penggunaan mesin gerekan terowong di sini di dapati sekitar 48% (purata penggunaan mesin dalam industri penerowongan dengan mesin adalah 40%)

Underground space can be constructed by conventional drill & blast method or mechanical excavation. Though historically blasting techniques have been preferred for hard rock, the adoption of mechanical excavation is increasingly becoming more attractive due to various reasons.

Unlike in drill & blast, mechanical excavation of hard rock is very much dependent on the geology. Apart from ground stability and tunnel support, the economics of the hard rock tunnelling with TBM, depends largely on the cutting tool life i.e. tool consumption and penetration rate. These two factors are governed by the physical and mechanical properties of intact rock and the rock mass properties and hence greatly influence the excavatability or boreability of the rock mass.

Technological advancement has seen the development of more durable cutters and higher capability tunnel boring machines. These developments coupled with the understanding of the geology has enabled harder rock excavation viable.

This paper discusses briefly the geological properties of the hard rock that affects the performance of TBM. The physical properties such as mineralogy, grain size, hardness, abrasiveness, the mechanical properties such as compressive, tensile and shear strength and rock mass properties such as frequency of fracturing/jointing (and its aperture, infill, roughness, persistence), fault zones, chemical alteration, weathering are found to influence the performance of hard rock TBM (Table 1).

Reference is made to Kelinchi Transfer Tunnel, Seremban that is currently being excavated by Robbins TBM. The main specifications of this TBM are: cutter head diameter 3.5 m, cutter head power 671 kW, RPM 10.08, number of cutters 29, cutter sized 393.7 mm and 412.75 mm, max thrust force 169.8 KN. per disc, stroke length 1.2 m.

At the Kelinchi site the average stroke time (1.2 m advance) varied from 71 minutes in massive, very strong granite (240 MPa) to 50 minutes in very strong to strong granite, moderately fractured and fissured (200 MPa), to 30 minutes in weak to strong (150 MPa), altered and sheared, closely jointed granite (150 MPa)

The cutting efficiency is found to be low in very strong, massive ground (163 MJ/m^3) compared to very strong to strong fractured ground (104 MJ/m^3) or weak to strong altered/sheared ground (71 MJ/m^3). The power consumed to excavate a unit volume of rock was more than 100% in massive ground versus altered/sheared ground. The overall TBM availability averaged 48% to date (typical value accepted in industry: 40% availability).

Penggunaan kaedah-kaedah hidrogeokimia dan kerintangan geoelektrik untuk mengesan kemasinan air tanah pada akuifer kedua di pantai utara Kelantan

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Ramai penduduk di negeri Kelantan menggunakan air tanah untuk memenuhi keperluan harian. Di Kelantan utara terdapat empat akuifer. Pada amnya penduduk tempatan menggali perigi daripada akuifer pertama dan Jabatan Bekalan Air mengambil air tanah daripada akuifer ketiga. Air tanah daripada perigi akuifer kedua dilaporkan sebagai payau, maka pada amnya air ini tak diambil untuk kegunaan hari-hari.

Kawasan kajian terletak di sepanjang pantai utara Negeri Kelantan. Pada kawasan pantai daripada kawasan kajian, terdapat aluvium Kuaterner yang terdiri daripada lempung, kelodak, pasir dan kerikil. Aluvium ini berasal daripada sungai dan samudera. Aluvium ini menutupi bahagian atas batuan dasar yang pada amnya ialah granit.

Tujuan utama kajian ini ialah untuk mengesan kemasinan air tanah pada akuifer kedua dan juga untuk menentukan sempadan air masin dengan air tawar. Terdapat beberapa kaedah untuk mengesan kemasinan air tanah. Kaedah-kaedah tersebut diantaranya ialah kaedah hidrogeokimia dan kaedah kerintangan geoelektrik. Dalam melakukan kajian ini digunakan pelbagai data iaitu data yang berupa peta topografi, data lubang gerudi, data hidrogeokimia dan data kerintangan geoelektrik.

Data hidrogeokimia yang digunakan diperolehi berdasarkan pemprosesan sampel air yang diambil daripada perigi pengesanan di Negeri Kelantan. Peta lokaliti perigi pengesan tersebut boleh dilihat pada Rajah 1. Untuk mengetahui jenis air tanah tersebut, data asas itu diproses lebih lanjut iaitu dengan menggunakan gambarajah Piper. Hasil akhir pemprosesan dan penafsiran tersebut boleh dilihat pada Jadual 1.

Pada kajian ini, kaedah kerintangan geoelektrik juga digunakan. Prosidur yang digunakan untuk melakukan cerapan di lapangan ialah kaedah duga dalam dan susunan elektrod yang digunakan ialah susunan Schlumberger. Stesen-stesen kerintangan geoelektrik boleh dilihat pada Rajah 1. Data kerintangan geoelektrik yang diperolehi dengan menggunakan kaedah ini ditafsirkan dengan bantuan data lubang gerudi. Sesudah nilai kerintangan ketara dihitung untuk setiap pembacaan, kemudian data tersebut di proses dalam bentuk grafik. Untuk memproses data tersebut, digunakan perisian RESIX.

Daripada kajian yang telah dibuat, dihasilkan peta tematik yang dilengkapi gambar kawasan air tanah yang mempunyai kepekatan klorid lebih besar dan sama dengan 250 miligram/liter serta gambar kawasan air tanah yang mempunyai kepekatan klorid lebih kecil dari 250 miligram/liter. Berdasarkan gambar-gambar kedua kawasan tersebut, boleh dibuat suatu garis sempadan. Rajah 2 menunjukkan bahawa air tanah pada akuifer kedua tak semua bersifat payau akan tetapi ada juga yang bersifat tawar. Dengan mengukur jarak daripada pantai ke garis sempadan tersebut maka boleh diketahui bahawa air pada akuifer kedua yang mempunyai kepekatan klorid lebih besar atau sama dengan 250 miligram/liter berada hingga jarak 5 kilometer dari garis pantai menuju ke pendalaman. Oleh itu, kawasan yang mempunyai kepekatan klorid lebih kecil daripada 250 miligram/liter, berada pada jarak yang lebih besar daripada 5 kilometer dihitung daripada pantai menuju ke daratan.

Magnetic modelling from a subsurface intrusion in the Yan area, Kedah

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A ground magnetic survey was conducted in the Yan area of Kedah to investigate the source of a prominent aeromagnetic anomaly north of Gunung Jerai detected in the 1956-57 aeromagnetic survey of Peninsular Malaysia. The area covered in the present survey is approximately 18 km x 13 km. A total of 574 observation stations was used in a network of magnetic traverses totalling about 200 km in length. The station spacing was between 150 m and 300 m depending on the locality and modelling requirements.

The resulting magnetic contour map obtained after reduction of the raw data conformed the broad features of the aeromagnetic anomaly but with considerably more detail, as expected. Mathematical modelling of the data indicates the presence of a subsurface igneous intrusion within 300 m of the surface. This interpretation is consistent with the original interpretation of the aeromagnetic anomaly as well as the results of recent gravity surveys in the area. It appears that the intrusion is most probably granitic in composition and associated with, or perhaps even an extension of, the granite of Gunung Jerai.

The Holocene monsoonal storm Pahang River Delta Complex, the Malay Peninsula: Behaviour in space and in time

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The Holocene Pahang River Delta Complex is situated approximately mid-point on the east coast of the Malay Peninsula, Malaysia, and progrades eastward into the monsoonal storm-dominated South China Sea. Current studies and the present day active lobe indicate that the delta complex may be a unique type, jointly and variably influenced and controlled by seasonal coarse-grained fluvial input, mesotidal reorientation of bars, and wave and longshore current redistribution of sediments, and is building out semi-cuspately into a tropical

sea dominated by seasonal storms and waves. It seems not to fit into the classification of Galloway (1975) or Orton & Reading (1993).

Aerial photographs and satellite imagery studies indicate that the Pahang Delta Complex as a whole has been shifting its course and locus of deposition at least twice. The present day lobe progrades eastwards. Prior to this, it prograded northeast ward and now almost abandoned, leaving an estuarine river mouth. Before this, it prograded southeastwards, now totally abandoned, with its delta plain area undergoing subsidence, and its river mouth undetectable.

Sediment supply into the Pahang sedimentary basin comes from a drainage basin of about 25,000 sq km, flowing for a distance of about 300 km long from the west. Water discharge and river flow are not uniform annually. Maximum discharge and swiftest flow are during the Northeast Monsoon, blowing from November to January. During the Southwest Monsoon from May to July, discharge is minimum and flow is at its slowest.

Sediments come from the weathering of Permian schists, phyllite, quartzite and limestone, middle Triassic tuffaceous shales, sandstones and conglomerates and volcanoclastics, late Triassic granitoids, and Jurassic-Cretaceous coarse-grained sandstones, shales and conglomerates, with the latter two being the dominant source rocks. They form side and mid channel bars along the upper reaches, side and point bars along the middle course, and coarse-grained fluvial braid bars along the lowermost course, and the tidal bars, coarse-grained spits and river mouth bars around the river mouth.

Tidal range is 1.5 m to 2.5 m, i.e. mesotidal. Tidal surge is detected some 10 km upstream. The high tidal range and appreciable tidal surge, realign the coarse-grained braid bars.

Strong Northeast Monsoon storms, which blow during the months of November to January, graze over the South China Sea, and generate waves with amplitude up to 2.5 m high, propagating southwesterly against the east coast of the Malay Peninsula, striking at right angles along the coast immediately north of the Pahang River mouth, translating into a weak northwesterly long shore drift, but striking the coast immediately south of the Pahang River mouth at angles of about 40° to 50°, thus generating strong longshore current southerly along the middle part of the east coast of the Peninsula. Prevalent longshore current, especially along the northern and southern parts of the east coast of the Peninsula, is northwesterly.

The marine regimes leave the north coastline of the Pahang Delta rather stable. The river mouth areas, river mouth bars and the southern coastline are however, very dynamic, undergoing deposition and erosion in response to the seasonal change in wind, wave and longshore current strength and directions.

Process model of the Pahang Delta Complex is being work out.

Drilling data indicated the bedrock to range from 130 m to as shallow as 40 m along the coast. Bedrocks crop out about 80 km inland. The valley seems to be structurally controlled.

Permian brachiopods from Maran area, Pahang

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Permian outcrops and fossils including both fauna and flora are very well known from various localities within the vicinity of Maran, Pahang. Among Permian fossils fauna known are fusulinid foraminiferas, corals, brachiopods, bivalves, cephalopods and bryozoans. Brachiopods are abundant in particular horizons in this area. Two Permian brachiopods localities, i.e. Jengka Pass and Sri Jaya were already well established in past literatures. The present paper will incorporate the result of recent revision of the brachiopods from these two localities as well as recording a new brachiopod locality from Timor Oil Palm mill site.

At Jengka Pass, brachiopods are found in both limestone, sandstone and shale, but they are more dominant in the black shale. Several species of brachiopods have been listed in Jones *et al.* (1966), Ichikawa (1966) and Gobbett (1973). The brachiopods from this locality was first described by Nakamura (1973). Recent revision indicates that the fauna was dominated by a single species *Liosotella jaafari* new species (a species which was previously described by Nakamura (1973) as *Spinomarginifera kueichowensis* Huang). Other brachiopods include *Costiferina* sp., *Juresania* sp., *Phricodothyris* sp., *Leptodus* sp. and ?*Dialesma* sp. The brachiopods are associated with some bivalves, cephalopods, bryozoans, crinoids and foraminiferas of late Middle Permian to early Upper Permian age.

The Sri Jaya bed outcropped along the Maran-Kuantan road (the easternmost of the series of Bukit Jaya ridges) yields some rare brachiopods, fusulinid foraminiferas, bivalves and some plant remains. Azhar Husain (1977), Che Aziz Ali (1985) and Lee (1990) have come out with different lists of brachiopods from this locality.

Among brachiopods identified from the present study are *Reticulatia* sp., *Rhipidomella* sp., *Derbyia* sp. and ?*Permundaria* sp.

The Timor Oil Palm refinery site exposed some black shales with some *Liosotella jaafari* new species and some fusulinid foraminiferas.

The brachiopod assemblage in this study shows closer affinity with Cathaysian fauna from Japan and Northern China than any other fauna from this region. This imply that these fauna might have flourished on the East Malaya-Indochina Block which was still quite a distant away from the Sibumasu Block.

Radiolaria from the Lubok Antu Complex, Sarawak

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The Lubok Antu Mélange was introduced by Tan (1979) for a rock unit composed of blocks and fragments of mudstone, sandstone, cherts, hornfels, limestone, basalt, gabbro, and serpentinite of varying size, embedded in a sheared mudstone matrix. This unit was associated with subduction zone. The age of the unit ranges from Late Cretaceous to Middle Tertiary based on planktonic foraminifera (Tan, 1979). The presence of planktonic foraminifera in the matrix indicates that the mélange was originally a sedimentary mélange which had undergone deformations. The term Lubok Antu Mélange cannot be considered as a lithostratigraphic unit and therefore it should be changed to the Lubok Antu Complex.

The occurrence of chert blocks in the Lupar valley has been reported by Hinde (1900), Haile (1957) and Tan (1979). The largest chert block is that forming Bukit Buluk which is approximately 5.5 km in length. The radiolaria from the chert blocks were first studied by Hinde (1900). He concluded that the age of the chert was probably Jurassic, but possibly Early Cretaceous. Davies (in Haile, 1957) suggested the age of the chert between Middle Jurassic and pre-Cenomanian based on some radiolaria, identified from thin sections of twelve chert specimens. With the advent of the hydrofluoric acid technique (Pessagno and Newport, 1972) it is now possible to extract radiolarian specimens from the chert. Pessagno has identified some radiolarian assemblages indicative of Hauterivian to Aptian, Early Cretaceous (in Tan, 1979). Tumanda *et al.* (1993) have reported some late Jurassic and Early Cretaceous radiolaria from the Lubok Antu Mélange and the Serabang Formation. Recently, Basir Jasin and Haile (1993) have recorded some Albian-Cenomanian radiolaria from the chert of Bukit Buluk. The age of the chert in Lubok Antu Complex ranges from Late Jurassic to Cenomanian, Cretaceous

Recently, 14 samples of chert (Samples LA 1-LA 14) were collected from chert blocks exposed along the Lubok Antu and Batang Ai roads. The chert samples were crushed and soaked in hydrofluoric acid for two days. The samples were washed and filtered through filter paper. The samples were dried and picked by using a paint brush. The well preserved specimens were photographed by using a Scanning Electron Microscope.

The cherts are widespread within the Lubok Antu Complex. Some of the large chert blocks form prominent hills i.e. Bukit Melarang, Bukit Buluk, Bukit Tongkat, Bukit Terbalau, and Bukit Rakut. Most of the blocks embedded in the mudstone matrix. The cherts are bedded with thickness ranging from 1 cm to 10 cm. The cherts are interbedded with mudstones. The cherts are folded and some parts are fractured and sheared. The origin of the chert and its relationship with the Pakong Mafic Complex is not fully understood. These cherts were probably associated with the Pakong Mafic Complex which formed an ophiolite sequence.

Radiolarian assemblage and age

Three assemblage were recognised:-

1) **Assemblage 1**:- This assemblage is found in sample LA 14. The assemblage is composed of:

Sphaerostylus lanceola (Parona)
Homeoparonaella gigantea Baumgartner
Angulobracchia sp.
Titrab exotica (Pessagno).
Neotripocyclia sp.
Hsuum cf. cuestaensis Pessagno
Ristola boesii (Parona)
Mirifusus baileyi Pessagno
Spongocapsula sp.
Acanthocircus carinatus Foreman
Paronaella cf. bronnimanni Pessagno
Paronaella sp.
Protonuma sp.
Archaeodictyomitra excellens (Tan Sin Hok)
Ristola altissima (Rust)
Mirifusus mediodilatatus (Rust)
Parvicingula excelsa Pessagno and Blome

The presence of *Ristola altissima* (Rust), *Parvicingula excelsa*, *Homeoparonaella gigantea*, *Neotripocyclia* sp. and *Titrab exotica* (Pessagno) indicates the Tithonian age, Late Jurassic. The assemblage represents the *Ristola altissima* Zone (Zone 4 of Pessagno *et al.*, 1993). This is the oldest radiolarian assemblage found in the area.

2) **Assemblage 2**:– This assemblage is found in samples LA 2 and LA 5. The assemblage is characterised by the occurrence of

Sphaerostylus lanceola (Parona)
Holocryptocanium barbui Dumitrica
"Cenosphaera" boria Pessagno
Cyrtocapsa grutterinki Tan Sin Hok
Stichocapsa altiforamina Tumanda
Dibolachras apletopora Foreman
Archaeodictyomitra lacrimula (Foreman)
Pseudodictyomitra sp.
Thanarla pulchra (Squinabol)
Parvicingula usotanensis Tumanda
Xitus spicularius (Aliev)
Staurosphaera septemporata (Parona)
Alievium cf. helenae Schaaf
Eucyrtis tenius (Rust)
Sethocapsa leiostraca Foreman
Podobursa triacantha (Fischli)
Archaeodictyomitra apiara (Rust)
Pseudodictyomitra carpatica (Lozyniak).
Pseudodictyomitra puga (Schaaf)
Thanarla conica (Aliev)
Ristola boesii (Parona)

This assemblage is indicative of Valanginian- Barremian age.

3) **Assemblage 3**:– The assemblage consists of

Holocryptocanium tuberculatum Dumitrica
Orbiculiforma sp.
Cryptamphorella conara (Foreman)
Stichomitra communis Squinabol
Obesacapsula somphedia (Foreman)
Thanarla elegantissima (Cita)
Ultranapora sp.
Novixitus mclaughlini Pessagno
Novixitus weyli Schmidt-Effing
Holocryptocanium barbui Dumitrica
Cryptamporella sphaerica (White)
Squinabollum fossilis (Squinabol)
Stichomitra sp.
Thanarla praeveneta Pessagno
Archaeodictyomitra vulgaris Pessagno
Pseudodictyomitra pseudomicrocephala (Squinabol)
Xitus spicularius (Aliev)
Rhopalosyringium majuroensis Schaaf

This assemblage indicates Albian-Cenomanian age. The assemblage is found in samples LA 1, LA 3, LA 4, LA 6, LA 7, LA 8, LA 9, LA 10, LA 11 , LA 12 and LA 13.

The age of the chert blocks in the Lubok Antu Complex ranges from Tithonian, Late Jurassic to Cenomanian, late Early Cretaceous.

The occurrence of spore and pollen at km 136 Kuching-Sri Aman Road, Sarawak

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Some outcrop samples were collected from a road-cut at km 136, Kuching-Sri Aman Road which is predominantly of fine to medium grained sandstone, siltstone and shale. These rocks sequence is generally grey to dark grey in colour, with strike and dip of 110°/10°. This area was mapped by previous workers (Haile, 1954; Tan, 1979) as Plateau Sandstone. The Plateau Sandstone is underlain conformably by the Silantek Formation. The base of the Plateau Sandstone is of Upper Eocene age (Tan, 1979). Trough cross-bedding and mud clasts are common structures in the sandstone layers, whilst the argillaceous layers are normally associated with carbonaceous materials of brown to dark brown in colour. This rock sequence is interpreted to be deposited in estuarine environment. It has no red mudstone layer (as reported by Haile, 1954 from other area) to indicate a continental origin.

The Plateau sandstone in the Klingkang Range was reported as practically barren of fossils. This palynological study is an attempt to extract the palynomorphs in the outcrop samples from this locality. All the samples were analysed, from which three of them contain a fairly well-preserved spore and pollen assemblage. Nonetheless, some poorly preserved palynomorphs were also found in the other samples. Several genera were identified such as *Arucariacites*, *Gleicheniidites*, *Triorites*, *Retitriporites*, *Lycopodiacites* and *Echitriporites*. All the identified spore and pollen are shown in Table 1. This assemblage of spore and pollen from this particular outcrop has no resemblance to any palynological zones of Muller (1968). The species of *Retitriporites variabilis*

which characterises the *R.variabilis* zone of Eocene age (the youngest zone proposed by Muller) was only found as a minor constituent and the common species of *Discoidites borneensis*, *Myrtaceidites* sp. and *Pediastrum* sp. in this assemblage were absence in the samples analysed. The spore and pollen assemblage of the present study is also not comparable to the older zone by the absence of the characterising genus such as *Spinizonocolpites* in *Proxapertites* zone.

In the authors' opinion, the age of this assemblage is suggested to be younger than *R.variabilis* zone (Eocene), tentatively of Oligocene-Miocene age.

The nature of Permian-Triassic junction in the rock sequence in Central Pahang: Suggestion from geochemical studies

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This paper presents new results on work on the nature of the Permian-Triassic junction in the rock sequence in central Pahang, which was earlier read at the Seminar On Permo-Triassic of Malaysia on 14 to 17 April 1994.

In the earlier paper, physical lithological characteristics of the lower andesitic soil (Permian?) and the upper turbiditic interbedded shale and tuffaceous sandstone (Triassic Semantan Formation?) at two localities, one near Felda Purun along Triang-Bt. Bertangga road, and the other near Kg. Sungai Jerik, Bandar Jengka were described in detail, apart from the mention of several other occurrences of the andesite/shale junctions. The probable preliminary interpretation of the nature of contact of the andesite and the shale was that was no apparent break in the succession and therefore it could be a continuous, conformable contact.

As a continuation of the work, soil samples were taken from two localities along Triang-Bt. Bertangga road where andesite soil is in contact with weathered shale. Samples were taken at 2 m interval across the contact, and analysed for SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, Na_2O, K_2O and P_2O_5 using X-ray fluorescent technique. The result, as shown in Tables 1 and 2, shows marked, sharp and consistent difference in chemical characteristic of the two soil types. Bivariate plots for the two soil types also reveal consistent difference in their pattern. A plot for SiO_2, Al_2O_3 and Fe_2O_3, superimposed on a field outcrop further portrays the consistent difference in the percentages of the three oxides.

The shape of the curve superimposed, on the outcrop sketch, indicates 'irregular' boundary for the top of andesite, suggesting a pre Semantan erosional surface. The contact could be unconformable, contrary to earlier preliminary interpretation.

Further work on geochemistry from more localities will have to be done, and search for possible fossil occurrence must be tried to really establish the nature of the contact.

Penemuan fosil bivalvia (*Posidonia kedahensis* dan *Posidonia japonica*) di kawasan Sungai Petani dan tafsirannya

(Discovery of the bivalves (*Posidonia kedahensis* and *Posidonia japonica*) in Sungai Petani, and its interpretation)

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Kajian terdahulu menunjukkan bahawa kawasan Sungai Petani terdiri daripada batuan Formasi Jerai, Formasi Mahang, Granit Gunung Jerai serta sedimen kuarterner yang menutupi kawasan bertopografi rendah. Formasi Jerai terdiri daripada batuan kuarzit, honfel dan syis. Formasi ini dijangkakan berusia Kambria Akhir berdasarkan perbandingan litologi dan stratigrafi dengan batuan Formasi Machinchang di Pulau Langkawi (Bradford, 1972). Formasi Mahang yang meliputi sebahagian besar kawasan ini terdiri daripada batuan sabak merah, batu lumpur dan syal berwarna kelabu dan merah. Formasi ini berusia Ordovisi Tengah hingga Devon Awal berdasarkan penemuan fosil graptolit (*Homotecnus* sp. dan *Styliolina* sp.) oleh Bradford (1972) serta fosil *Ortoceras* sp. oleh Yang (1979). Batuan granit yang merejah batuan Formasi Jerai terdiri daripada batuan granit biotit berbutir sederhana.

Selain daripada batuan di atas, dalam kerja pemetaan yang dijalankan baru-baru ini, kami menemui satu singkapan batuan di kawasan Ladang Ong Seng dan Ladang Al Mashoor yang boleh dibahagikan kepada batuan fasis arenit, fasis argilit dan fisis silika. Fasis arenit terdiri daripada subarkos berpebel sokongan lumpur yang berwarna cerah. Juga terdapat batu pasir berbutir halus berselang lapis dengan batu lumpur. Fasis argilit terdiri daripada batu lumpur dan syal, berwarna kelabu dan kelabu cerah, berbutir halus dan berpebel. Dalam fasis ini terdapat struktur sedimen berskala kecil yang terdiri daripada laminasi selari, laminasi silang dan lapisan flaser. Fasis silika yang terletak di bahagian bawah jujukan batuan di sini terdiri daripada batuan rijang dan separa rijang yang berasosiasi dengan batu lumpur. Batuannya berwarna kelabu cerah dan gelap dan sebahagiannya telah mengalami perlipatan.

Dalam batuan syal dijumpai fosil bivalvia: *Posidonia kedahensis* dan *Posidonia japonica.* Diagnosis fosil *Posidonia kedahensis*: fosil yang dijumpai terdiri daripada acuan cangkang, garis tumbesarnya dapat dilihat dengan jelas, umbo kurang jelas berbentuk submedian dan terletak di bahagian hadapan sedikit, cangkang memanjang, garis engsel lurus dan bahagian ventralnya berbentuk membulat. Bagi fosil *Posidonia japonica*, diagnosisnya: umbo terletak di tengah, garis engsel lurus, rib berbentuk elip, garis tumbuh berbentuk subbulat, bahagian dorsal dan ventralnya berbentuk subbulat. Berdasarkan pengelasan usia fosil ini oleh Kobayashi (1964), batuan di singkapan ini berusia Karbon.

Berdasarkan perbandingan litologi, struktur batuan dan kandungan fosil penunjuk antara singkapan batuan di Ladang Ong Seng dan Ladang Al Mashoor dengan batuan lain di kawasan kajian dan juga di kawasan sekitar maka jujukan batuan yang ditemui ini ditafsirkan sebagai sebahagian daripada lanjutan batuan Formasi Kubang Pasu (yang terdapat lebih meluas di bahagian utara Sungai Petani tetapi belum pernah direkodkan kehadirannya di kawasan ini) yang terenap umumnya di sekitaran laut dalam.

Pemprosesan dan pengelasan data Landsat "Thematic Mapper" untuk kegunaan geologi: Satu kajian kes di Sungai Petani, Kedah Darul Aman

(Processing and classification of Landsat "Thematic Mapper" data for geological applications: A case study in Sungai Petani area, Kedah Darul Aman)

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Teknik penderiaan jauh (*remote sensing*) telah terbukti sangat berguna dalam beberapa kajian termasuk geologi, terutamanya di kawasan gersang dan semigersang. Maklumat geologi boleh diperolehi sama ada melalui tafsiran imej secara visual ataupun pengelasan imej dengan bantuan komputer. Oleh sebab tertentu, umumnya pentafsiran imej secara visual sama ada menggunakan imej "standard products" ataupun imej yang diproses secara digit sering digunakan untuk mendapatkan maklumat geologi suatu kawasan berbanding dengan menggunakan bantuan komputer. Kertas ini akan menjelaskan hasil daripada percubaan awal untuk mendapatkan maklumat geologi daripada imej Landsat "Thematic Mapper" (TM) melalui proses pengelasan imej dengan bantuan komputer menggunakan contoh dari Malaysia.

Dalam kajian ini, data Landsat TM bagi kawasan Sungai Petani telah diproses secara digit dan seterusnya dikelaskan dengan bantuan komputer untuk mendapatkan maklumat geologi. Teknik pengelasan yang digunakan termasuklah kaedah analisa pengelompokan (*clustering analysis*) dan juga analisa komponen utama (*principal component analysis*). Maklumat yang diperolehi daripada pengelasan ini telah dikaitkan dengan makluman geologi yang diperolehi di lapangan untuk melihat sama ada (a) maklumat geologi lapangan boleh dikelaskan dengan baik menggunakan kaedah ini, dan (b) terdapat maklumat atau kelas tambahan yang ada kepentingan dan boleh dikelaskan dalam imej satelit.

Menerusi kaedah analisa pengelompokan, 27 kelas maklumat diwujudkan di peringkat awal. Walau bagaimanapun, setelah melalui "proses pengelompokan" didapati hanya 20 kelas maklumat yang boleh disesuaikan dengan 7 kelas bahan permukaan yang terdapat di kawasan kajian berdasarkan data lapangan: terain batuan granit, terain batuan sedimen, aluvium (paya dan sawah), kawasan endapan lumpur, air berlumpur dan air jernih. Taburan kesemua 7 kelas atau jenis bahan permukaan ini boleh dikelaskan dan ditunjukkan dengan baik menerusi kaedah analisa pengelompokan di kawasan ini.

Analisa komponen utama bertujuan untuk mengurangkan korelasi dan matra data asal. Di samping itu, kaedah ini juga mampu untuk memisahkan bahan permukaan yang akan dikumpulkan dalam komponen-komponen tertentu. Dengan melihat imej komponen utama secara saling tindak, akan diperolehi gabungan imej yang sesuai untuk memaparkan atau memisahkan kelas atau bahan permukaan yang berbeza. Didapati gabungan imej komponen utama, terutamanya daripada komponen yang "low rank" telah memaparkan kesemua 7 kelas bahan permukaan di atas di samping memperlihatkan pembahagian yang lebih terperinci dalam satu-satu kelas berbanding dengan imej hasil kaedah analisa pengelompokan.

Imej yang diproses menggunakan kaedah penapisan didapati baik untuk menonjolkan fitur linear (lineamen) seperti sesar dan retakan utama. Beberapa lineamen utama yang dipaparkan dan boleh disurih mungkin mewakili struktur geologi (sesar) yang belum dipetakan di kawasan ini. Lebih menarik, lineamen juga boleh dicamkan di kawasan bertopografi rendah (aluvium). Struktur sebegini mungkin mewakili sesar yang terdapat dalam batuan dasar tetapi keujudannya boleh dicam di permukaan bumi. Maklumat sebegini agak mustahil untuk ditemui di lapangan kerana kedudukannya di kawasan bertopografi rendah.

Keputusan kajian ini memperlihatkan bahawa data Landsat TM mampu untuk memaparkan bahan permukaan yang dikenal di lapangan. Malahan, data satelit menjadikan kerja pemetaan bahan seperti ini menjadi lebih mudah terutamanya aspek persempadanan antara bahan tersebut. Di samping itu, kaedah pemprosesan yang ada termasuk penapisan telah membolehkan beberapa lineamen yang mungkin mewakili sesar di kawasan ini dipetakan. Melalui teknik pemprosesan dan juga pengelasan tertentu, data satelit berpotensi untuk di gunakan di Malaysia terutamanya dalam kerja-kerja pemetaan bahan permukaan dan juga mendapatkan maklumat struktur geologi (sesar) yang mungkin sukar ditemui secara konvensional.

The Subis Limestone: Cement type and paradiagenesis

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Subis Limestone consists of basal deep marine limestones and shallow marine reef limestones. The limestone body forms a localized isolated patch reef developed on a shoaling clastic bank.

As in modern reef sediments, the bulk of the carbonate sediments were composed of metastable aragonite and Mg-calcite. Diagenetic changes into various type of stable calcites, occurred at an early stage in the diagenetic history under surface-related physico-chemical conditions. A variety of diagenetic processes and products have been recognized including early marine cementation, meteoric cementation, neomorphism and deep burial cementation. These diagenetic processes are closely related to depositional environment and are characteristic of certain limestone facies. Basically, deep marine facies underwent extensive marine cementation and late burial fracturing, whilst shallow marine facies were affected by marine and minor meteoric diagenesis. Later stage of diagenesis which took place in a deeper burial environment have tightly cemented the sediments and plagued all the remaining pore spaces with late stage calcite cements.

Investigation of the textures and geochemical analyses of the core material suggest the following sequence and products of diagenetic processes:

1) Early marine diagenesis.

This process involved micritization and early marine cementation that was dominated by the formation of fibrous/bladed circumgranular and circumvoid rim cements.

2) Fresh water stabilization.

This process occurred in the shallow marine facies. This involved stabilization of carbonate including dissolution of metastable grains and precipitation of stable calcite cements.

3) Deeper burial diagenesis.

This process took place in a deeper subsurface environment. The diagenetic process was dominated by compaction, infilling of the remaining porosity by sparry calcite, saddle dolomite and poikilotopic calcite, and neomorphism of micrite. The entire process took place in reducing and iron-rich connate water.

A spore and pollen assemblage in Pueh area, Sarawak

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Nine samples from south of Pueh town, about 10 km west of Sematan, First Division, Sarawak were examined. This area was previously mapped as Serabang Formation in the east and Plateau Sandstone in the west. Some well-preserved spore and pollen were obtained from three siltstone samples of the Serabang Formation. The identified spore and pollen genera from these samples are *Psilatricolporites, Exesipollenites, Apiculatisporis, Acanthotriletes, Distaverrusporites, Spinizonocolpites, Tsugaepollenites, Matonisporites, Microfoveolatosporis, Dictyophyllidites, Reticulatisporites, Biretisporites, Lycopodiacidites, Verrutriporites, Echitriporites, Alisporites, Retitricolpites and Triorites.* Four specimens of dinoflagellate cyst of *Hystrichosphere* sp. were also recorded in these samples.

Some confusion arise in assigning this assemblage to any of the previously described palynological zones by Muller (1968) due to the presence of several long ranging genera. However, after a thorough comparison study, this assemblage shows some similarities with the *Rugubivesiculites* zone (Senonian), and this is supported by the presence of some characterising species of *Spinizonocolpites bacculatus, Psilatricolpites kayanensis* and *Apiculatisporis ferox.* The two former species were described as appearing for the first time and the latter one was considered as a restricted species in this assemblage zone. These three species were fairly common constituents in the assemblage of the present samples. The present assemblage is not comparable to the older zones of *Araucariacites* and *Cicatricosisporites.* The common species of *Triorites minutipori* in *Araucariacites* zone and *Cicatricosisporites* sp. in *Cicatricosisporites* zone were not recorded from the present samples.

The spore and pollen assemblage extracted from the samples studied has to be assigned to the *Rugubivesiculites* zone, not older to *Araucariacites* zone or *Cicatricosisporites* zone because of the absence of *Triorites minutipori* and *Cicatricosisporites* sp. respectively, and not younger than *Rugubivesiculites* zone because of the presence of the *Apiculatisporis ferox.*

Hematite mineralization at Bukit Lop, Chaah, Johor

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Several iron and barite mines were reported by Bean (1969) to have operated in northwest Johor, including the Sri Medan, Bukit Lop, Bukit Kepong and Bukit Tui mines. In 1986, the Bukit Lop iron mine was reopened by the Matahari Mining Sdn. Bhd. The mine which is located on the southeastern spur of Bukit Lop ridge, about 10 km southwest of Chaah Town exposed some details about the geology of the mineralization discussed in this paper. The main iron ore deposit occurs both as primary and secondary deposits.

The primary mineralization occurred in a massive unit of andesitic volcanic unit of the Upper Mesozoic continental deposit known as the Ma'Okil Formation (Loganathan, 1978). The maximum thickness of the ore bodies reaches up to 20 m thick with concordant as well as discordant nature of displacement. From the first (old) adit, the main ore body is discordant to the general strike of the host rock (Bean, 1969; Zakaria Hussain, 1994) while from the second (new) adit the main ore body is concordant to the strike of the host rock.

The secondary iron ore deposit occurred as basal conglomerate of the conglomerate unit overlying the andesite. Mohd Shafeea Leman & Yusri Zakariah (in press) considered that these iron conglomerate beds represent a series of alluvial fans deposited along a faulted andesitic volcanic rocks.

The main ore deposit comprise of hematite with traces of magnetite (Bean, 1969). Minor baryte occurrences were also reported from this locality (Bean, 1969; Zakaria Hussain, 1994). The Bukit Lop mineralization has been related with the ?Ma'Okil wrench fault by Burton (1965). Hutchison (1983) interpreted that this mineralization was injected through faults and bedding planes. This mineralization in many aspect is similar to some other epithermal ore deposits related with subaerial volcanic activities described by Sillitoe (1977).

Petrology and geochemistry of the volcanic rocks associated with the Darvel Bay Ophiolite, Lahad Datu, Eastern Sabah, Malaysia

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Introduction

The uppermost unit of the igneous stratigraphy of ophiolite complexes consists of sequences of volcanic rocks, mainly basaltic lava. The top of this lava pile is commonly covered by extruded rocks, such as tuff and volcanic breccia, and oceanic sedimentary rocks. The Darvel Bay Volcanic Rocks (DBVR) consist mainly of massive basalt, with minor layered basalt, pillow basalt, volcanic breccia and tuff. Volcanic rocks are only sparsely distributed and cover approximately 20% of the total studied area. They mainly crop out along road sections in the southern part of the complex. Some of the volcanic rocks are associated with the mélange outcrop and occur as loose blocks and sometimes are associated with pelagic sedimentary rocks. The DBVR can also be observed in several islands around the Darvel Bay.

The Darvel Bay Ophiolite Complex has been well described in the publications of the Geological Survey of Malaysia (Reinhard & Wenk, 1955; Fitch, 1955; Dhonau & Hutchison, 1966; Koopmans, 1967). The complex has been interpreted as a segment of ocean floor, either of a Proto-South China Sea (Holloway, 1981; Rangin *et al.*, 1990) or of the Celebes Sea (Hutchison, 1988). A wide range of K/Ar age dates have been obtained from the rocks of the Darvel Bay Ophiolite Complex from 210 Ma Early Jurassic (Leong, 1971) to 168 Ma 150 Ma Late Jurassic and 137 Ma Early Cretaceous (Rangin *et al.*, 1990; Aitchison, 1994).

This paper gives an account of the field relations, petrographic description and geochemistry of the DBVR and discusses their origin and significance in the tectonic evolution of Sabah. The work described here was presented as a thesis by Omang (1993) for the award of the PhD. degree of the University of London.

Field and Petrographic Descriptions

Based on field observation, petrography and geochemistry the DBVR are divided into three main groups: (1) Group I Darvel Bay volcanic rocks. (2) Group II Darvel Bay volcanic rocks and (3) Group III Darvel Bay volcanic rocks.

Group I Volcanic Rocks

Group I Darvel Bay volcanic rocks occur mainly as loose blocks in the mélange outcrop. To the south of the study area, they occur along the road section at km 101 of Jalan Silam and to the north of the study area near Kampong Sepagaya, about 6 miles west of Lahad Datu town. Group I Darvel volcanic rock crops out in the Kampong Sepagaya showing pillow structures. These pillows are always brownish in colour and sometimes greenish. Amygdaloidal or vesicular textures are well preserved. Basaltic dykes with size range between 5-10 cm also occur within the pillow basalt outcrop. In thin section, the pillow basalt is fine grained, showing interstitial and amygdaloidal textures. Most of the vesicles have been filled by carbonate and quartz. This rock contains microphenocrysts of plagioclase, clinopyroxene, olivine and Fe-Ti oxides.

Group II Volcanic Rocks

This group is mainly exposed along Jalan Silam (e.g. Localities JS8, JS118.5, JS121, JS123). The other localities are in the Sungai Sabahan (Locality SGB2), south of the study area in a disused quarry along the Jalan Sandakan (Locality JSN3) and in the north of the study area. The main feature of this group is characterized by massive structure. This basaltic rock is greenish and brownish colour. In thin section, the massive basalt is fine to medium grained and commonly shows intersertal textures but sometimes amygdaloidal/vesicular textures and also preserved. The rock consists mainly of plagioclase, clinopyroxene, olivine and Fe-Ti oxides.

Group III Volcanic Rocks

Group III Darvel Bay volcanic rocks consist of layered basalt and volcanic breccia. Layered basalt is mainly exposed on several islands south of Lahad Datu town. In thin section, the rocks consists of plagioclase, amphibole, epidote, chlorite and Fe-Ti oxides. Commonly show intersertal texture as well as amygdaloidal/ vesicular (less than 2%), including those from Pulau Sakar (southern part only) (sample PS9) and its surrounding (Pulau Katung Kalungan) (samples PK2C, PKN).

Volcanic breccia is exposed in one locality along Jalan Silam at km 113 (Locality JS113) and km 129 (sample JS129). Most of the clasts in the volcanic breccia are of basalt fragments. The size of the clasts varies from a few cm up to 5 cm across. In thin section these rocks consist of clasts of mainly basaltic fragments showing vesicular texture.

Whole-rock Geochemistry

Twenty-two samples of volcanic rocks from the Darvel Bay Ophiolite Complex were selected for major and trace element analysis. Five samples of Group I volcanic rocks, seven samples of Group II volcanic rocks, seven samples of Group III volcanic rocks and three samples of Neogene volcanic are rocks from the Dent Peninsula, Sabah were analysed. Several covariation plots of major and trace elements were tested to determine if the volcanic rocks could be subdivided into geochemical compositional groups that might facilitate their genetic interpretation. Considered together, these plots clearly establish the DBVR can be divided into three groups, which do not appear to be related to a single fractionation trend and are therefore not co-genetic.

Tectonomagmatic Setting

Group I volcanic rocks fall in the within-plate basalt (WPB) field and Group II volcanic rocks fall in the MORB field respectively. The Group III volcanic rocks fall within the IAT field and those from Neogene volcanic arc of Sabah (samples TB, SgPgD, SgPgP) suggest an arc affinity.

Tectonic Significance

On the basis of the trace element geochemistry the data suggests the existence of the tectonic environments from major ocean basin to island-arc settings. Group I and II Darvel Bay volcanic rocks may be related to volcanic activity during formation of the oceanic crust. Group II Darvel Bay volcanic rocks (N-MORB affinity) may represent the spreading ridge-axis volcanism whereas the Group I Darvel Bay volcanic rocks (OIB/E-MORB affinity) represent the off-axis volcanism. Darvel Bay Group III volcanic rocks (LAT affinity) may be related to the Oligocene-Middle Miocene volcanic arc activity of the Dent Peninsula, SE Sabah. This magmatic arc formed either due to southeastward subduction of the Proto South China Sea oceanic crust beneath Sabah (Taylor & Hayes, 1983) or due to northward subduction of the Celebes Sea (Bangin *et al.*, 1990; Hutchison, 1992). Later late Neogene (Pliocene to Quaternary) volcanic arc of Sempurna-Tawau are superimposed on the older arc, relating to the southward subduction of the Sulu Sea beneath the Sulu arc (Hutchison, 1975, 1978; Rangin, 1989).

Stratigraphy, sedimentology and structural geology of the Betong-Lepang Nenering border area, Pengkalan Hulu (Keroh), Hulu Perak

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The study area which is located at the northernmost part of Peninsular Malaysia along the border with neighbouring Thailand, displays outcrops of a series of rocks that range nearly the entire Paleozoic Era and Cenozoic Era. They are the Early Ordovician-Early Devonian Kroh Formation; the Carbo-Permian Kati Formation and the Tertiary Nenering Tertiary Beds.

The older Kroh Formation which act as the basement rock for the other two younger formations comprises four distinguishing facies, namely:-

i) Argillaceous Facies
ii) Siliceous Facies
iii) Arenaceous Facies
iv) Calcareous Facies

The strata of the Kroh Formation is extremely folded and deformed. Lying above it are the two younger broadly folded formations, they are the Kati Formation which is only limited to the SE portion of the study area and the Nenering Tertiary Beds to the NW portion of the study area. Both of the younger formations lie above clearly exposed basal planes of unconformity which are angular in nature.

The Kati Formation, which is a turbiditic formation consists of two main facies, namely:-

i) Basal Conglomerate Facies
ii) Rhythmite Facies

The succession starts with a thick layer of intraformational chert conglomerate, followed by a layer of finer conglomerate, and massive sandstone beds and beds of argillaceous material. The thick chert conglomerate layer reoccurs giving rise to the total thickness of approximately 70 meters for the Basal Conglomerate Facies. Succeeding this basal facies is the Rhythmite Facies that consists of an alternating beds of sandstone, siltstone, shale and clay. The total thickness of this formation sums up to approximately 700 meters.

The Nenering Tertiary Beds, which is an alluvial-fluviatile continental deposit comprises of three main units, namely:-

i) The Lower Unit
ii) The Middle Unit
iii) The Upper Unit

The lithology consists of well consolidated to semi-consolidated gravel beds, sandstone and, silt and mud.

Structurally the study area generally, has undergone two periods of tectonic deformation, both of which are subjected to an EW compression force that resulted in the two phases of folding of the strata of the Kroh Formation and the broad folds of the Kati Formation. The area has also gone through an active period of faulting which play an important role in exposing the primary planes of unconformity between the related formations and result in the broad folding of the Tertiary outcrops.

Hubungan genetik syis, gneis, migmatit serta granit ditinjau dari aspek petrografi dan petrokimia

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Pendahuluan

Kajian telah dijalankan di kawasan terpilih Kompleks Igneus Stong dan sepanjang Lebuhraya Timur-Barat. Walau bagaimanapun, perkaitan di antara syis, gneis, migmatit dan granit agak kurang jelas di lapangan, tetapi dipercayai mereka mempunyai kaitan genetik yang amat rapat serta intim. Berdasarkan alasan berkenaan maka kajian awalan ini dijalankan berlandaskan petrografi dan petrokimia. Sejumlah 33 sampel yang mewakili pelbagai jenis batuan telah dijalankan kajian petrografi serta dianalisis untuk unsur utama, minor dan kesan (trace).

Petrografi dan Petrokimia

Syis: Bagi tujuan ini, syis kuarza-mika telah dipilih dan difikirkan ada perkaitan genetiknya dengan migmatit. Ia mempamerkan syistositi yang jelas dengan perulangan di antara kuarza (cerah) dan mika (gelap). Kuarza (70%) wujud sebagai kekanta hasil segregasi serta terpadat sebagai mozek dan bersempadan sutur. Biotit (20%) berbentuk memanjang dengan birefringen yang tinggi (tertib ketiga) serta berkelipan (sparkling). Sebahagian kepingan biotit telah terubah kepada klorit yang mempamerkan warna biru janggal yang jelas. Sementara muskovit (10%) terselit di antara kepingan biotit dan kuarza. Dua generasi muskovit yang wujud bersaiz kasar dan halus (serisit).

Gneis: Batuan bertekstur gneisos dengan susunatur biotit secara memanjang mengepung lensa-lensa kuarza dan feldspar. Kuarza (65%) mengalami segregasi dan berbentuk memanjang serta terpadat dengan sempadan sutur. Ia mempamerkan pemadaman bergelombang yang kuat. Mikroklin (10%) bertekstur poikiloblastik (kuarza sebagai inklusi) dengan kembaran Carlsbad yang jelas. Sementara plagioklas (15%) dari komposisi oligoklas (An_{11}) bersifat subhedron dengan kembaran albit yang jelas. Biotit (10%) merupakan juzuk utama mineral mafik berbentuk kepingan yang beralun akibat tegasan. Zirkon, apatit, epidot dan muskovit (serta serisit) sebagai mineral aksesori.

Migmatit: Singkapan batuan yang tidak homogen menunjukkan perulangan lapisan leukosom (kuarzo-feldspatik atau feldspatik) dan melanosom (mineral mafik) yang jelas. Ciri-ciri schlieren dan perlipatan (sinklinorium dan antiklinorium) sering dijumpai. Secara mikroskop, batuan bertekstur holohabluran hipidiomorf bergranul dengan tentuarahan yang jelas. K-feldspar (50%) bersifat subhedron dengan kembaran polisintetik serta kadang-kadang bertekstur poikiloblastik. Plagioklas (25%) berkomposisi albit-oligoklas (An_{10}) dengan kembaran albit-Carlsbad. Kuarza (15%) sering wujud dengan pemadaman bergelombang yang kuat seta berbentuk mozek (bersempadan sutur). Biotit (10%) mempamerkan birefringen yang tinggi tetapi mengalami canggaan menjadikan kerdutan dan terpintal (kinked). Apatit, zirkon, epidot dan opek sebagai mineral aksesori.

Granit: Pelbagai jenis granit bertekstur samabutiran atau berporfir, serta bersifat leukokrat dan melanokrat wujud bersama-sama dengan kompleks migmatit tersebut, iaitu:-

a) Granit berbutiran halus, samabutiran dan bersifat leukokrat.
b) Granit biotit berbutiran sederhana, samabutiran dan berwarna kelabu cerah.

c) Granit biotit berporfir, berbutiran sederhana dan berwarna kelabu cerah.
d) Granit biotit-hornblend-sfen berporfir, berbutiran sederhana dan berwarna merah jambu.

Analisis kimia menunjukkan bahawa kandungan SiO_2 berada dalam julat yang agak kecil iaitu 62.3 dan 75.9%. Kesemua mereka bersifat kalka-alkali dan dalam domain subalkali berpandukan gambarajah AFM dan alkali-SiO_2 (Irvine dan Baragar, 1971). Korelasi yang dipamerkan oleh plot segitiga AFM amat baik di mana gneis dan syis berasosiasi dengan migmatit dan berlaku pengkayaan alkali membentuk granit. Plot mineral normatif QAP menggambarkan penumpuan gneis dalam domain tonalit dan granodiorit, sementara granit dan migmatit berkomposisi granit hingga granodiorit. Gambarajah AB dari Debon dan Le Fort(1983) menunjukkan kesemua batuan bersifat peralumina dengan mineral mafik utama terdiri daripada biotit dalam pelbagai amaun. Secara amnya, konsentrasi kandungan gneis dan migmatit berada dalam domin pengkayaan biotit. Plot segitiga Rb-Ba-Sr mempamerkan kandungan gneis kaya dengan Sr sebagai bahan sisa (restite) terevolusi ke arah pengkayaan Ba membentuk migmatit dan granit. Penentuan tahap tektonik berpandukan plot variasi Y+Nb-Rb yang diperkenalkan Pearce *et al.* (1984) menunjukkan majoriti mereka berada dalam domain syn-COLG, sementara sebahagian gneis dan syis berada dalam domain VAG.

Brittle fault zone in granite, Pulau Pangkor

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On the western board of Pulau Pangkor, between the beaches of Pasir Ketapang and Pasir Bogak, is a coastal exposure of more than a kilometre wide of coarse-grained porphyritic biotite granite.

The coastal exposure is accessible during low-tide levels on calm-weather days. Its exposure is laced with linear subparallel fracture lines which we suspect are elements of a brittle fault zone.

In the literature very little emphasis have been given to brittle structures in granite as compared to that have been given to the ductile ones.

In the field, the exposure consists of thin fault/fracture planes which strike in the 290°-310° direction and inclined 65°-85° southwestwards. These planes, are separated between a few cm to several cm from one another. On the rock surface these fault planes appear as thin lines. Close observation of surfacial rocks along these fault/fracture lines indicate that many of them do not show evidence that the rocks have translated along them. Granite protolith between these "fault-fractures" also do not show any deformational characteristics.

A sample chosen from one of the few thicker fault ("sheared") planes and another from an intrafault ("unfaulted") zone give ages of 70.2 ± 3.5 and 73.2 ± 4.6 Ma, respectively. As ages for Pangkor granite determined by Bignell are 207, 209 and 215 Ma, we believe the younger age indicate the age of the faulting during late Upper Cretaceous.

What intrigued us about the brittle fault zone is the lack of translational movements along most of the fault lines. The few that we could observe that movements had taken place were found to be left-lateral, and we infer that this is a left-lateral fault zone.

Under the microscope these fine fault planes are observed as thin microfracture zones of thickness from 0.1-0.2 mm to 0.1 mm (anastomised) thick. The translations along these fault/fracture zones also is an image of the megascopic scale. Most do not show that translation had taken place. A few show microscale 1/2 mm translations, both left lateral and right lateral movements were observed.

The microstructure of the protolith adjacent to fault/fracture zones is dominated by intra- and intergranular fractures. Some of the fractures in quartz are healed.

Volcanic breccia is exposed in one locality along the Jalan Silam at km 113 (Locality JS113) and km 129 (sample JS129). Most of the clasts in the volcanic breccia are of basalt fragments. The size of the clasts varies from a few cm up to 5 cm across. In thin section these rocks consist of clasts of mainly basaltic fragments showing vesicular texture.

Structural history of Hinge fault zone of the Malay Basin

LIEW KIT KONG

PETRONAS Research & Scientific Services Sdn. Bhd.

The curvilinear Hinge fault zone demarcates the western boundary of the Malay Basin. This fault zone trends northerly in the north and changes progressively to WNW-ESE in the south. This 10-kilometre wide fault zone represents the sites of pull-apart grabens, and is traceable for more than 450 km. This major fault zone transects several tectonic domains: in the north, this fault runs parallel between the Kerteh Ramp and the Pilong sub-basin; in the centre, this fault zone lies within a flexure zone in which the Terengganu Platform changes into the Kerteh Ramp, and in the south, it runs into the Angsi-Duyong sub-basin.

Based on the trends and structural styles, this fault zone can be subdivided into five major segments: northerly trending Ular-Kuda fault zone that is associated with north-south trending flexures; northwest-southeast trending Kabut-Tembikai fault zone which comprises extensional fault block and associated anticlines; WNW-ESE trending Angsi-Duyong fault zone having symmetrical compressional anticlines and associated fault blocks; Dungun fault zone with its rhombic Dungun graben and associated half grabens; and Sotong fault zone that forms a major boundary between the Tenggol Arch and the Angsi-Duyong sub-basin. The Ular-Kuda, Kabut-Tembikai, and Angsi-Duyong fault zones are interpreted to form the main segment of Hinge fault zone. The Dungun and Sotong fault zones are interpreted as splays from the main Hinge fault zone. The Dungun fault zone trends NNW-SSE and bifurcates in the vicinity of Kuda and Kabut. The other splay is the NW-SE Sotong fault zone which meets the main fault zone in the vicinity of Tembikai-Angsi.

During ?Late Eocene-Early Oligocene, this fault zone experienced right lateral movement. In this wrenching period, strings of rhomboid pull-apart grabens are developed within the fault zone. These faults were probably active until Late Middle Miocene. During Middle Miocene, reversal of wrench movement (left lateral) produced compressional anticlines within the pull-apart grabens in this fault zone.

Sub-ophiolite metamorphic rock in the Tungku area, Lahad Datu, Eastern Sabah, Malaysia: Origin and tectonic significance

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Introduction

In the Tungku region of Dent Peninsula, SE Sabah, approximately 50 miles east of Lahad Datu town, garnet amphibolites abundantly occur as blocks and pebbles in slump and breccia deposit of Middle to late Miocene age along the stream of the Sungai Pungulupi. The pebbles are of various sizes and shapes. In this river, there exists other pebbles such as ultramafic rocks, gabbros. Felsic intrusives, volcanic rocks and sedimentary rocks are also abundant. A few pebbles of garnet amphibolite were collected for petrology and chemistry studies. In this study, these rocks were interpreted as related to the early ophiolite emplacement. However, Morgan (1974) has studied the garnet metapyroxenite pebbles from the same locality and considered that these rocks represented a mantle xenolith.

Good exposures of the metamorphic rocks underlying the allochthonous ophiolite complex are very scarce in Sabah, including the Darvel Bay area. This is due to the nature of the exposure or to the highly tectonized nature of the area, or obscured by the effects of the subsequent tectonism. This paper gives an account of the field relations, petrography, mineral chemistry, whole rock geochemistry and age of the garnet amphibolite and also discusses their origin and significance in the tectonic evolution of Sabah. The work described here was presented as Ph.D thesis by Omang (1993).

Petrography

The rocks are fine to medium grain size and show porphyroblastic and gneissic textures, but sometimes a mylonitic texture is also visible: rounded amphibole and plagioclase, ilmenite and clinopyroxene. The main foliations (S_1) are defined by alternating layers of plagioclase, green hornblende and light grey clinopyroxene. Local cataclasis and brittle fracturing orientated oblique to earlier ductile metamorphic fabrics (the main foliation) characteristic of late D_2 deformation, and are associated with retrograde metamorphism. This D_2 deformation is associated with S_2 foliations.

These metabasites consist mainly of porphyblastic garnet, clinopyroxene, green amphibole, plagioclase and rutile/ilmenite. Mineral assemblage clearly indicates the amphibolite facies which were later replaced by minerals of the greenschist facies (? actinolite + plagioclase + epidote), suggesting a retrograde metamorphic event. Late prehnite/pumpellyite veins cut the fabric of the rock.

Geochemistry

The chemistry of clinopyroxene in garnet amphibolite indicates that this rock is derived from igneous protolith of MORB derivation. Whole rock major and trace elements geochemistry also suggest the garnet amphibolites were also derived from MORB origin. Abundances of incompatible and compatible elements in the garnet amphibolite are close to the Mowomba metamorphic sole and the Peluru Mélange, Central Sulawesi.

Spider diagram patterns (normalised to chondrite data from Sun *et al.*, 1979) for two samples of garnet amphibolites, suggest a MORB deviation (Saunders *et al.* 1980). Most of the tectonic discriminant diagrams indicate the analysed garnet amphibolites always fall within MORB/OFB and WFB fields.

K-Ar age dating

One hornblende separated from garnet amphibolite (Tungku metabasite) yielded an age of 76 ± 21 Ma (55-97 Ma: Early Eocene to late Early Cretaceous). This age may represent the age of metarmorphism.

Tectonic significance

It suggested that the occurrence of the garnet amphibolites may be related to the early stage emplacement of the Darvel Bay Ophiolite which probably took place during Late Cretaceous time. The occurrences of the Tungku metabasites (metapyroxenite and garnet amphibolite pebbles) in the Sungai Pungulupi, Tungku area, provide a record for the formation of the basal mylonitized peridotite and metamorphic soles in Sabah, relating to the subducted and/or obducted Mesozoic oceanic lithosphere of the Proto South China sea.

Genting Sempah Volcanic Complex: Genetic implications for the Main Range Granite

K.R. CHAKRABORTY

Department of Geology, University of Malaya

The Genting Sempah Volcanic Complex is one of the few known examples of acid volcanism that is related, both temporally and spatially, to the Triassic Main Range Granite. The complex comprises units of tuff lavas, lavas and porphyries. They are all peraluminous rhyodacitic in composition, and are generally highly porphyritic with 30 to 60 per cent phenocrysts consisting of plagioclase (commonly andesine), quartz, K-feldspar and biotite. A distinctive porphyry unit (subvolcanic intrusive?) also contains phenocrysts of orthopyroxene which has reaction relationship with biotite. There is a perceptible chemical difference between the orthopyroxene bearing rhyodacite porphyry (OBR) and the orthopyroxene lacking other rhyodacitic rocks (OLR). In the present study, more emphasis has been given to the OBR.

The origin of the phenocrysts, whether magmatic or restitic/xenocrystic, is a critical issue that needs to be resolved for proper understanding of the petrogenetic history of these rocks. Textural and petrographic features such as occurrence of phenocrysts mainly as discrete individual crystals, euhedral to subhedral nature of some phenocrysts, general scarcity of granoblastic crystal clots, provide permissive evidence in favour of magmatic origin. However, the possibility of some deformed biotite phenocrysts and irregular labradoritic cores of some zoned plagioclase crystals being restiteocrysts cannot be completely ruled out. Further support for magmatic origin comes from the chemical composition of the rocks. Neither OBR nor OLR show any significant intragroup chemical variation despite having differing proportion and amount of phenocrysts. Evidently the bulk compositions of the rocks, by and large, represent liquid compositions. The phenocrysts can, therefore, be regarded as products of crystallization at slow rate of cooling prior to rapid undercooling.

The phenocryst assemblage of plagioclase + orthopyroxene + quartz + K-feldspar + biotite in the OBR is quite analogous to the hypersolidus crystallization sequence observed in experimental studies of similar bulk composition at low water content. The OBR magma attained K-feldspar and quartz saturation before complete resorption of orthopyroxene possibly through a reaction like: orthopyroxene + liquid = biotite + quartz. This suggests that the water content of the OBR magma was less than 3 percent and that the temperature was more than 800°C when the rapid undercooling of the groundmass occurred. Since the OBR magma was about 50 per cent crystalline at that stage, it is reasonable to assume that the initial temperature of the magma was much

higher, probably 900°C or more. Such a dry and high temperature magma would require dry source rocks and could have been derived from psammopelitic granulites, charnockite or similar rocks. Although not observed in the present study, granoblastic aggregates of orthopyroxene + plagioclase + cordierite + biotite + quartz has been previously reported from the OBR and has been interpreted as restite. If this interpretation is correct, then it would limit the depth of magma generation to about 20 km. A temperature of 900°C or more, as discussed earlier, at such a depth would require a high geothermal gradient of about 45°C/km. This aspect warrants further study regarding heat source and heating mechanism.

The compositions of both OBR and OLR lie on or very close to the variation trends of the associated Main Range granitic suites, but they are not more felsic or more evolved than the granites. To the contrary, the OBR is compositionally less evolved than most of the granitic suites of the Main Range. Evidently the Genting Sempah rhyodacites and the Main Range granites are not comagmatic; that is they are not complementary fractions of a common parental magma which produced the granites as early differentiates and the rhyodacites as residual liquids.

The Genting Sempah Volcanics is likely to be underlain by the Main Range Granite. This possibility coupled with the fact that they are temporally related would imply that the depth of granite emplacement in this region was probably nor more than the maximum thickness of the volcanic pile.

Evaluating some applications of GIS technology in geological data management and processing methods: A case study from part of Northwest Borneo Basin, Sabah

SIVAJI, S.

Department of Geology, University of Malaya

The Tertiary Northwest Borneo sedimentary basin which extends from the western part of Sabah through Brunei into west-central Sarawak is exposed in the Klias Peninsula and on Labuan Island. Extensive field studies followed by integrated laboratory investigations is being undertaken by the researcher with the aim of reconstructing the depositional environment and sedimentation history of the area in order to assess their implications on the hydrocarbon potential of the area. Data gathered are categorised into different types: sedimentological, stratigraphical, palaeontological, geochemical and petrographical. A data dictionary is being developed and spatiotemporal and the attribute data are being modelled.

For broader qualitative and quantitative analytical purpose the spatiotemporal data sets are being modelled in a GIS using both the vector and the raster data models. Attribute data are modelled by object oriented techniques and the data base is structured by using advance SQL techniques for the easy accessibility for interactive modelling purpose. Advanced isomaps based on characteristics such as geochronological, sedimentological, palynological are being produced and incorporated with digital terrain models for 3-dimensional analytical purposes.

A Graphical User Interface (GUI) is being developed and the optional analytical tools are provided for the interactive simulation modelling. Hypermedia techniques are proposed to enhance the interactivity. Graphics and object attributes and their network relationships are tested. In conclusion the use of GIS is evaluated and illustrated for its analytical as well as spatiotemporal modelling capabilities for geological data management and analysis.

Warta Geologi, Vol. 21, No. 3, May–Jun 1995

222

Australian firm to identify targets in Bau goldfields

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The survey and other ground work will conclude Menzies' commitment to spend about A$5 million over five years to acquire 55 per cent interest of the venture.

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Menzies also has made several new discoveries at its Wullersdorf project in Sabah.

It has estimated that between 200,000 and 500,000 ounces of gold could exist in any of the newly-discovered areas in Sabah.

NST, 14.6.1995

Indon tin giant in gold, diamond ventures

The world's single largest producer of tin, Indonesia's State-owned PT Tambang Timah, has said that it is planning to diversity into gold and diamond mining in a bid to boost earnings.

"Since we have the experimence in mining tin, we see no problems in mining for gold and diaminds," Timah president director Erry Riyana said yesterday.

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The sources said Timah production was expected to rise to about 36,700 tonnes this year, compared with 33,900 tonnes in 1994. Timah accounts for 80 per cent of Indonesia's output.

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BERITA-BERITA PERSATUAN
News of the Society

KEAHLIAN (Membership)

The following applications for membership were approved:

Full Members

1. Khor Peng Seong
   21 Persiaran Perajurit 4, Taman Perak, 31400 Ipoh.
2. Rokiah Bt. Esa
   3-1-2 Waizuri 1, Jalan 11/27A, Wangsa Maju, Section 5, 53300 Kuala Lumpur.
3. Khairul Anuar B. Mohd. Nayan
   Pusat Penyelidikan Geoteknik, Jalan Serdang, 43000 Kajang.
3. Raghubir Rampal
   c/o Constec Sd. Bhd., 98, SS15/4, Subang Jaya.

Student Members

1. Mohamad Zaid Sapii
   2/13 Burbank Avenue, Bedford Pard, SA 5042, Australia.
2. Raguram A/L Bilangwaty
   Jabatan Geologi, Universiti Malaya, 59100 Kuala Lumpur.
3. Wong Mei Leng
   Department of Gecological Sciences, University of S. Carolina, Columbia SC 29208, U.S.A.
4. Wan Zuhairi bin Wan Yaacob, Jabatan Geologi, Universiti Kebangsaan Malaysia, 43600 Bangi.

PETUKARAN ALAMAT (Change of Address)

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

1. Mark Alex-Sanders
   Department of Geological Sciences, University of Plymouth, Drake Circus, Plymouth, Devon PL4 8AA, United Kingdom.
2. Foong Yin Kwan
   11 Amersham Crescent, Carindale, Q4152, Australia.
3. Mohamed Taher A. Tahe
   Schlumberger Surenco, Apartado 63392 (Altamira), Caracas 1062-A, Venezuela.
4. Sahat Sadikun
   UKM Kampus Sabah, Beg Berkunci 62, 88996, Kota Kinabalu, Sabah.
5. Abdul Hadi Abd. Rahman
   Department of Geology, Universiti Malaya, 59100 Kuala Lumpur.
6. Larry S. Grubbs
   c/o Texaco International, 4800 Fournace Place, Bellaitle Texas 77402, USA.
7. Michael C. Friederich
   BHP Minerals, 11th Floor, MIDPlaza Building, Jalan Jend. Sudirman 10-11, Jakarta 10220, Indonesia.

PERTAMBAHAN BAHARU PERPUSTAKAAN (New Library Additions)

The Society has received the following publications:

1. Geoscience & Development (AGID), no. 1, 1994.
2. Bulletin Sukutahun, Jan-Mac 1995.
3. University of Kansas, Paleontological Contributions, no. 6, 1995.
4. Acta Geoscientia Sinica, nos. 1-2, 1994.
5. Bulletin of the Chinese Academy of Geological Sciences, no. 29, 1994.
6. Journal of Hebei College of Geology, vol. 17, nos. 3-5, 1994.
7. Annual Report: Chinese Academy of Geological Sciences, 1993.
8. Acta Palaeontologica Sinica, vol. 33, no. 6, 1994 & vol. 34, no. 1, 1995.
9. Palaeontological Abstracts, vol. 9, no. 4, 1994; vol. 10, no. 1, 1995.
10. Acta Micropalaeontologica Sinica, vol. 11, nos. 3 & 4, 1994 & vol. 12, no. 1, 1995.
11. The Laboratory of lithosphere tectonics and its dynamics (MGMR) Annual Report 1994.
12. Natural History Research, vol. 3, no. 2, 1995.
13. Episodes, vol. 17, no. 4, 1994.
14. Journal of the Natural History Museum & Institute, Chiba, vol. 3, no. 2, 1995.
15. Monthly Statistics on mining industry in Malaysia. Jun-March 1995.
16. IMM Bulletin no. 1023 & 1024, 1995.
17. AAPG Explorer, May & June 1995.
18. AAPG Bulletin, vol. 79, nos. 4 & 5, 1995.
19. Commonwealth Science Council, nos. 5 & 6, 1994 & no. 1, 1995.
20. Annales Academiae Scientiacum Fennicae, no. 158, 1995.
21. SOPAC News, vol. 11, no. 3, 1994; vol. 12, no. 1, 1995.
22. Journal of the Faculty of Science, The University of Tokyo, vol. 22, no. 4, 1995.
23. Tin International, vol. 68, no. 1-3, 1995.
24. Geological Bulletin of Turkey, vol. 37, no. 2, 1994.
25. IMM, Section A, May-August 1995.
26. Annual Report 1992.
27. Museum of Nature & Human Activities, nos. 3 & 4, 1994.
28. Journal of Science, Hiroshima University, vol. 10, no. 1 (1994); no. 2 (1995).
29. Science Reports of the Institute of Geoscience, University of Tsukuba, vol. 16, 1995.
30. BREM, Scientific Report 1992/93.
31. Geological literature of USSR, vols. 1 & 2, 1992 & 1993.
32. Compendio anual de Productividad, 1989 & 1990.
33. Journal of Geology & Mineral Resources (Indonesia), 1994: nos. 35-39, 1995: 40-42.
34. Geosurvey Newsletter, nos. 281-286 (1994), 287-289 (1995).
35. U.S.G.S. Bulletin 1994: 2088, 2114, 2107, 2089, 2108, 2102, 2101, 2097, 1995-F, G, 2106, 2049-A, 2057, 2085-A, 2081, 2023-B, 2092, 1730-E, 1982, 1589-E, 2022, 2061-B, 1939-B; 1995: 2220, 2119, 2079, 2113, 2096, 2084, 1738-E, 1741-H.

USGS Circular 1994: 1116, 1113; 1995: 1108, 1118, 1117, 1123.

BERITA-BERITA LAIN
Other News

Local News

Australian mining firm seeking gold in Lipis

A mining company from the gold-rich Kalgoorlie district in Australia will spend RM4 million this year for exploration work to ascertain the volume of gold deposits in Lipis before commencing with mining.

Valiant Consolidated Ltd. managing director Simon Farrell said the company had spent RM3 million on initial geochemical studies to decide whether it should involve itself in long-term gold exploration in Pahang.

Valiant had identified 10 drilling targets and would be conducting on-going studies to identify more sites.

"To date, we are confident that the sites we have studied have economic potential," he told reporters after a State dinner held for Valiant Share-holders and senior officials.

Farrell said Valiant was taking the *"leap of faith"* because there was no guarantee it was going to hit pay dirt or at least discover economically viable mining sites.

He stressed Valiant's vision of striking another mother lode of the proportion discovered in the Raub mine where 35.4 tonnes (1.25 million ounces) of gold were recovered.

"This is not impossible because Raub is situated along the rich mineral belt which extends from Thailand to Indonesia."

Farrell said the company would be using the latest gold-mining technique which meant better chances of detecting gold deposits and an improved recovery rate of pure gold from the ore excavated.

He said the latest technique would enable the recovery of two grammes of raw gold from every one million grammes of ore while 90 per cent pure gold could be recovered from the two grammes.

Valiant, in its joint venture with local mining and exploration company Damar Consolidated Exploration Sdn. Bhd., has signed a prospecting agreement with the Pahang State Development Corporation over blocks three, four and six in Lipis covering 2,000 square kilometres.

The 20-year-old company had acquired a 55 per cent interest in the exploration blocks plus one million partly-paid shares from Damar Consolidated.

It has an option to acquire a further interest up to a total of 75 per cent, to be exercised on or before April 30, 1996.

Farrell said within the area, Valiant had applied for 31 prospecting licences over a total of 72,000 ha and should an economic gold deposit be found, the company planned to invest a substantially higher amount than the RM7 million to be spent by the end of this year.

He said Valiant had already signed exploration agreements with settlers whose land were within the prospecting area.

Farrell said RM25,000 would be paid over a period of four years for each 0.4 ha taken. The amount payable to each settler whose land is utilised for mining will total RM350,000.

Valiant was among the 70 prospecting licence applicants of which 24 had been approved by the State Government.

The other foreign company whose application was approved was the Canadian company Specific Resources, a subsidiary of Avocet Ventures Incorporated, which applied for 141 ha.

NST, 16.5.1995

Third KL-Klang highway under study

The state government will study a proposal for a third highway linking Kuala Lumpur and Klang by building it parallel to the Klang River, Mentri Besar Tan Sri Muhammad Haji Muhammad Taib said.

He said the highway would complement the Federal Highway, which has shown signs of congestion from Subang Jaya to Kuala Lumpur, and the North Klang Valley Expressway.

However, he said the proposal would be studied by experts from the Works Ministry, and others concerned, before being implemented.

The state government was willing to offer land to those who were interested in the project, he said.

The road, he said, was also a means of developing the squatter areas along the river.

He said this was part of the state's efforts to ensure that proper infrastructure was provided for the expanding economic growth.

Muhammad said restaurants and recreation centres would also be built along the riverbank.

"Once we start keeping our rivers clean, it will become a centre of attraction," he said.

He added that intensive cleanliness campaigns would be launched by the state to educate people not to litter and dispose of rubbish, industrial waste or toxic waste into the rivers.

Selangor, said Muhammad, would stress on keeping the environment clean.

"I will personally call for a special meeting with the excos concerned to organise a campaign.

"We will not hesitate to act against those who litter and pollute the environment," he said, adding that rubbish was thrown all over the place including rivers.

He said the government would also encourage the people to love and protect the rivers.

Besides keeping the environment clean, Muhammad said the state would ensure that green lungs were protected and increased.

Star, 19.5.1995

Switch to clay, tin miners urged

Tin miners in Perak have been encouraged to switch to clay extraction for the ceramics industry.

Mentri Besar Tan Sri Ramli Ngah Talib said some miners still wanted to renew their mining leases while others wanted new sites for prospecting although the cost of production was higher than the price of tin.

The state had abundant deposits of ball clay, kaolin and other types of clay, he said yesterday after opening a symposium on chemical and technological developments of mineral and material resources and their environmental impact.

A Geological Survey report estimated that the state had one billion tonnes of ball clay reserves worth RM200 billion in Bota, Beruas, Sitiawan, Hutan Melintang, Kampung Gajah, Pasir Panjang Ulu, Durian Sebatang, Changkat Jong and Changkat Chermin.

Ramli said clay extraction would be carried out in a more systematic manner to prevent pollution and destruction of land.

Conditions would be imposed to ensure that only high-tech companies are allowed to extract clay to produce high value products.

Export of clay as raw material would be prohibited, he said.

He said the state government and Sirim had established a ceramics laboratory service centre in Pengkalan to provide technical support to the industry.

The Universiti Sains Malaysia branch campus's mineral faculty could also provide support in research and development.

Ramli also said that the state government had taken steps to rehabilitate former mining land by converting them into fruit orchards, poultry farms and housing estates.

The Federal Government has also started a pilot integrated development agriculture project to rehabilitate about 1,200 ha of former mining land near Tanjung Tualang.

Star, 20.5.1995

Australian firm to identify targets in Bau goldfields

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NST, 14.6.1995

States to get maps showing soil erosion danger areas

The Department of Environment (DOE) is drawing up geographical maps containing information on potential soil erosion areas and distribution of natural resources for all States to assist the respective Governments in their development plans.

The DOE hopes to embark on the project, which uses the computer-based technology called geographical information system (GIS), under the Seventh Malaysia Plan beginning next year.

DOE director of environmental impact assessment Hasmah Harun said via the GIS maps the department could advise the State Governments on land use, recommend areas where maximum care must be taken if development is taking place and indicate sites which should best be left alone to avoid dangers resulting from soil erosion.

The maps are to inform the authorities that improper planning resulting in severe soil erosion is dangerous as it could destabilise building structures.

"Our aim is to help States plan their development projects taking into consideration mitigative measures to protect the environment," Hasmah said.

She said the GIS, a resource information database in visual and graphic form, would show the worst case scenario which could occur if total land clearing takes place and measures are not taken to prevent soil erosion.

"We are not trying to scare the public but the GIS maps could be used to avoid dangers and threats from soil erosion," she said.

Using an international classification of soil risks, DOE officials are able to estimate the tonnes of soil lost per hectare per year if preventive measures are not taken.

The areas are divided into high erosion (between 50 and 80 tonnes of soil loss per hectare per year), severe (80 and 150 tonnes/ha/year) and very severe (more than 150 tonnes/ha/year).

Besides showing potential soil erosion areas, the maps also indicate air and water quality and the siting of various industries.

Hasmah said the drawing up of GIS maps for the States would be done in stages due to manpower constraints.

In the interim, DOE is also coming up with GIS maps for the water catchment and water intake sites — areas which are tremendously sensitive to soil erosion and siltation.

These maps would be distributed to the State waterworks departments.

To date, the DOE, with the assistance of several agencies, including the Drainage and Irrigation Department, Malaysian Centre for Remote Sensing and departments of Agriculture, Geological Survey and Meteorology, has already prepared GIS maps of several sites.

These include the upper part of Klang Valley, Hulu Kelang near the Highland Towers area, Bangsar and Damansara residential sites, and the Putera Jaya (Prang Besar) proposed Federal administration centre and Negri Sembilan.

The pilot project took off following the Highland Towers tragedy on December 11, 1993, which created concern among residents staying on or near hill slopes.

According to the GIS map of Hulu Kelang, more than 80 per cent of the area surrounding Highland Towers was categorised as very severe and the rest severe.

NST, 26.6.1995

Shortage of local tin ore this year: Lim

The tin products industry would experience a shortage of local ore this year as a result of consumption exceeding supply, Malaysian Tin Products Manufacturers Association president Lim Cheng Sand said.

"Production of tin concentrate is declining in Malaysia," he said, adding that smelters in Penang were forced to import the ore to meet production capacity.

Last year, tin-based product manufacturers consumed 5,614 tonnes, or 87 per cent, of locally produced tin.

One factor contributing to the surge in imports is the lack of high-grade smelted tin.

Lim said solder producers in Malaysia used higher grades of smelted tin which are not produced locally, resulting in solder manufacturers having to import.

Speaking to reporters after the association's AGM in Kuala Lumpur yesterday, Lim said the main industries that consumed tin were the tin plate and solder manufacturing and pewter industries.

He said efforts should be made to increase tin content in tin-products.

Former president Abdul Rahman Omar called for more research and development into tin consumption to increase the mineral content in the products.

Star, 28.6.1995

KONGRES SAINS DAN TEKNOLOGI MALAYSIA '95

Research & Technology Update '95: Advances in agriculture, medicine, industry, information and environment, including their socio-economic impact

22-25 Ogos 1995

Perdanasiswa University of Malaya
Kuala Lumpur

Anjuran
Kementerian Sains, Teknologi dan Alam Sekitar Malaysia

Dikelolakan oleh
COSTAM & Universiti Malaya

dengan kerjasama
Institusi-Institusi Penyelidikan dan Pembangunan Badan-Badan Ikhtisas Sains dan Teknologi

INTRODUCTION

The Ministry of Science, Technology and Environment sponsors a number of activities as part of its effort to promote a better public understanding of science and technology as well as to help in the development of science and technology in the country. These activities are targeted at all levels of society, namely school children, professionals and the public at large. One of the activities at the professional level is the Malaysian Science & Technology Congress which has been held annually since 1988.

OBJECTIVES

The objectives of the Malaysian Science & Technology Congress are:

1) To disseminate recent R & D results from research being undertaken in Malaysia.

2) To familiarise scientists, planners and industrialists on the R & D being carried out.

3) To allow closer interaction between scientists of different disciplines interested in similar areas of research.

4) To highlight R & D efforts in Malaysia.

5) To provide a forum for scientists to exchange scientific ideas.

6) To focus on the application of science and technology in priority areas.

STRUCTURE OF CONGRESS

The congress will comprise seminars/ symposia in the following sectors:-

- Basic Sciences
- Applied Sciences & Engineering
- Medical Sciences
- Agricultural Sciences
- Information Technology
- Environmental Sciences
- Socio-Economic Impacts

CORRESPONDENCE

All Correspondence should be sent to:-

COSTAM Secretariat,
d/a Pusat Kanak-Kanak Spastik
Selangor & W.P.,
14 Lorong Utara A, P.O. Box 48,
46700 Petaling Jaya.

Tel: 7550296/7582393/7550576
Fax: 7567511/7550576

The 4th ASEAN Science and Technology Week

Science and Technology: The Future of ASEAN

21 August – 1 September 1995

The Central Plaza Hotel, Bangkok, Thailand

Organizer: **ASEAN Committee on Science and Technology (COST)**

Host: **National Research Council of Thailand, and Thailand's National Science and Technology Development Agency;**

Ministry of Science, Technology and Environment, Thailand

The ASEAN Committee on Science and Technology (COST), established in 1970, has its goal to promote scientific and technical development in the Southeast Asian region. With the assistance of its dialogue partners, COST has over the years put much efforts to reach the overall socio-economic development objectives. In order to promote greater awareness of current development in, and application of, science and technology throughout the region and elsewhere, the **ASEAN Science and Technology Week (ASTW)** is held every three years.

The ASTW has, since its inception, been an important regional forum for scientists, technologists, industrialists, academics and key government officials. It provides the opportunity for the meeting between colleagues from ASEAN and dialogue partners namely, Australia, Canada, the European Union, Japan, Korea, New Zealand, U.S.A. and UNDP.

The 4th ASEAN Science and Technology Week will carry the theme *"Science and Technology: The Future of ASEAN"*. The activity will feature a series of conferences, awards for scientists and technologists, and an exhibition to highlight the various achievements and developments of science and technology in the region and elsewhere.

Conference Highlights

Focusing on the theme of ***Science and Technology: The Future of ASEAN***, there will be eight concurrent conferences on:

Biotechnology	28-29 August 1995
Food Science & Technology	29-30 August 1995
Non-Conventional Energy	28-29 August 1995
Marine Science	28-29 August 1995
Materials Science & Technology	28-29 August 1995
Microelectronics & Information Technology	28-30 August 1995
Meteorology and Geophysics	29 August 1995
S&T Infrastructure and Resource Development	28-30 August 1995

For Further Information:

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Dr. Yongyuth Yuthavong
Director, Thailand's National Science and Technology Development Agency
Gypsum Metropolitan Tower, 18th Floor
539/2 Sri-Ayudhaya Road, Rajdhevee
Bangkok 10400, Thailand
Tel. +66 2 248-7541/8
Fax +66 2 248-7549

Strategic Management of HAZARDOUS WASTE In Malaysia

12th-13th September 1995
Hotel Equatorial, Kuala Lumpur

Featuring corporate case studies and insightful analyses from local and international experts

inclusive

A Practical Workshop

Developing An Effective Environmental Management System (EMS) for Hazardous Waste

KEYNOTE ADDRESS: *Understanding the hazardous industrial waste situation in Malaysia*

ISO14000: *A Trade barrier or opportunity? — The implications for international and local business*

Understanding the true cost of waste

CASE STUDY: *Exploring the cost benefits of waste minimisation — the Nissan Industrial Oxygen approach*

CASE STUDY: *Integrating waste minimisation as part of your corporate environmental strategy — The Federal Batteries approach*

CASE STUDY: *Management strategies for progressive reduction of hazardous wastes and discharges*

Making profitable returns from the recycling and reuse of hazardous waste

Treating hazardous waste the cost-effective way

Designing and implementing a cost-effective waste minimisation programme

Waste management in the pharmaceutical industry — An insight into the development and progress of waste minimisation in the industry

Practical and Interactive Workshop

Developing An Effective Environmental Management System (EMS) for Hazardous Waste

The concept of EMS has emerged out of the demand by organisations for a systematic approach to environmental management. This interactive and practical **Workshop** is hence designed to assist organisations develop the procedures and structures for a systematic approach to EMS. Participants can be assured of a practical hands-on session where they are encouraged, step-by-step, to design and develop an EMS for hazardous waste.

The workshop is led by Mr. Derek Low, Manager, New South Wales and Mr. Peter Williams, Manager, Victoria, of Axis Environmental Consultants Pty. Ltd., Australia. Both Derek and Peter have more than 20 years experience in environmental management and have extensive experience at manufacturing, industrial and chemical facilities.

All enquiries and bookings can be made at:

IIR Sdn. Bhd.
Suite 214B, 2nd Floor, Kompleks Antarabangsa,
Jalan Sultan Ismail, 50250 Kuala Lumpur,
Malaysia.
Tel: 03-2410325 Fax: 03-2445935

FEE

Including Lunches, Refreshments and Conference documentation, your investment for attending this conference and full-day workshop is only RM2,295 per person if we receive your registration and payment by 5th August 1995. Thereafter, all delegates will pay the full conference fee of RM2,495.

PAYMENT

Payment must be included with registration. Telephone registration may also be made, but payment is required by 1st September 1995. Attendance is limited and only pre-registered, pre-paid delegates will be guaranteed access to the conference. Walk-in delegates, with payment, will be admitted on a space availability basis.

New Dates for Offshore South East Asia96

Offshore South East Asia (OSEA), the biggest exhibition and conference for the oil and gas industry in the Asia Pacific will next take place from **24 to 27 September 1996.**

OSEA96, originally scheduled to run in its regular early December slot, has now been brought forward to avoid a clash with the inaugural ministerial conference of the World Trade Organisation (WTO).

OSEA has enjoyed strong growth in exhibitor participation and visitor numbers over the past two decades. At its 10th show anniversary last year, OSEA expanded to a record high of 8,719 square metres nett with 1,367 participating companies. A remarkable 11,068 trade visitors, 37% of whom came from the region and abroad, attended the show.

For more information, please contact:

Ms Jean Khoo
Senior Public Relations Executive
SINGAPORE EXHIBITION SERVICES PTE. LTD.
(A Member of The Montgomery Network)
2 Handy Road #15-09
Cathay Building
Singapore 0922
Tel: (65) 338 4747
Fax: (65) 339 9507

The Australasian Institute of Mining and Metallurgy Kalgoorlie Branch and the Western Australian School of Mines

UNDERGROUND OPERATORS' CONFERENCE

Kalgoorlie, Western Australia 13-14 November 1995

The conference will provide a forum for mining practitioners and related professions to discuss the present status and the future of underground mining. The sessions will focus on key issues related to: mining methods, mining technology, mine safety, mine control, automation and communications, economics of mining and mine management. Several visits to major underground operations located in Western Australia will follow the conference.

For further information please contact:

Professor Tad S. Golosinski, Western Australian School of Mines, P.O. Box 597, Kalgoorlie WA 6430. Telephone: (090) 805 152; Fax: (090) 805 151

5th Base Metals Concentrates Conference

For professionals involved in all aspects of one or all base metals.
Covers: copper, lead, zinc, nickel, tin

16 and 17th October 1995
The Conrad Hotel, Dublin, Ireland

Hosted by
Metal Bulletin

Why the base metals industry needs to meet regularly?

In a year which looks to be one of transition for the base metals mining sector worldwide, Metal Bulletin is taking its 5th Base Metals Concentrates Conference to Dublin, Ireland, home to a flourishing lead-zinc mining industry.

For base metals miners the recession of the early 1990's, when much mine capacity was forced to close, has been followed by a period of concentrate deficit in many cases and more favourable treatment charges.

The last couple of years, however, have been extremely buoyant demand for most base metals: Lead and zinc mine production, after hitting historic lows in 1993-4, is now on the increase. New and idled mine capacity is being brought on stream in Canada, Australia and Latin America and the scales are tipping back from deficit into surplus. On the copper front, metal-in-concentrates output is set to rise by over 500,000 tonnes in 1995 with a further 800,000 tonnes increase next year. Tin mine production has shrunk beyond recognition in many traditional tin mining countries, but new or expanded sources of production are starting to offset the decline.

All this makes for an interesting scenario as far as treatment charges are concerned: the lead-zinc mating season has dragged out even longer this year as smelters battle it out. And even where, on paper, there are enough concentrates to meet demand, the grade of material available does not always meet the smelter's criteria.

So, what are the main issues being discussed in 1995 that will interest you?

The 5th Base Metals Concentrates Conference in Dublin will address all current issues that are key to the concentrates producing, trading and consuming industry.

In particular this conference will review:

- Global supply/demand scenarios for lead, zinc, copper and tin mine production: how will these affect spot and term contract treatment charges in the next years?
- Aspects of concentrates shipping and handling: how will freight rates and availability develop? What is new on the mine transportation and port handling front?
- The role of the east bloc today: when will the tide turn in terms of mine production and concentrate supplies?
- Shifts in the type of concentrate produced: what will this mean in terms of smelter technology needs and smelting costs?
- The environmental factor: what compliance challenges lie ahead for the industry? How will these affect mining costs? Will base metal concentrate fall under the scope of the Basel Convention and other such instruments?

These and other issues will be discussed in depth at the Dublin event.

The Conference sessions on October 16 and 17 will be followed by optional field trips on Wednesday October 18. Delegates will be able to choose between a visit to Tara Mines' zinc mining and concentrating facilities just west of Dublin, or a tour of Arcon Mines' Galmoy zinc-lead mine, currently under construction, about 1½ hours drive southwest of the capital. Space on both these trips is limited so delegates who wish to participate are advised to signal their interest as soon as possible.

For further information:

1. **by phone:**
   +44(0)171 827 9977 (international)
   or +1(212) 213 6202 (USA)
2. **by fax:**
   +44(0)181 337 8943 (international)
   or +1(212)213 1870 (USA)
3. **by post:**
   Metal Bulletin Conference Ltd., Park House, Park Terrace,
   Worcester Park, Surrey, KT4 7HY, UK
   or Metal Bulletin Inc., 220 Fifth Avenue, 19th Floor, New York, NY 10001/7781, USA.

The 1995 AAPG International Conference and Exhibition

10-13 September 1995
Acropolis Convention Center, Nice, France

Co-Sponsored by:

The American Association of Petroleum Geologists
An International Geological Organization

The Institut Français du Pétrole (IFP)

The 1995 AAPG/IFP International Conference and Exhibition is returning to the beautiful city of Nice, the capital of the French Riviera, at the base of the Alps and the edge of the Mediterranean Sea. It will be held in the superb Acropolis Art and Convention Center 10-13 September 1995.

The conference theme, *"Managing Change at the Turn of the Century"*, has been chosen to reflect the need for adaptation of our industry to a low-cost-per-barrel world. For this reason, three major areas of interest were identified to discuss key questions:

- What are the main themes and the new rules for upstream industrial and academic research and development?
- What are the new exploration and production opportunities in the area of the Greater Central Tethys, including basins in West and North Africa, the Mediterranean, the Middle East, and the Caspian Sea?
- How will better integration of technologies allow more accurate prediction of reservoirs and enhancement of reservoir performance and prediction?

The program includes 140 oral sessions and 250 poster presentations, with special invited speakers for the Monday, September 11 oral sessions. The invited speakers, who are executives representing the Institut Française du Pétrole, (the conference co-sponsor), major oil companies, research and service firms, will be making presentations on *"Hydrocarbon Research and Development in a Low-Cost-Per-Barrel World"*.

The Technical Program Committee, under the guidance of its chairmen, Dr. Nahum Schneidermann, Dr. David Roberts, and Dr. Peter Homewood, has put together an exciting program addressing the issues mentioned above in oral and poster presentations. These presentations are supplemented by short courses and field trips.

Indeed there is no better place in the world to see geology. The field trip chairman, Alain Mascle, has organized a superb menu of field trips — structural inversion due to Alpine tectonics, providing outcrop examples of classical subsurface geological phenomena that are crucial for petroleum exploration and reservoir delineation. You will have, in addition to France and Spain, the unique opportunity to see the geology of Albania, Hungary, Tunisia and Greece.

The technical exhibits will display a very broad spectrum of products and services, providing the opportunity to conduct in-depth discourse with technical and service companies.

Further information

AAPG International Conference
P.O. Box 979, Tulsa, OK 74101-0979 USA
or
AAPG International Conference
1444 S. Boulder, Tulsa, OK 74119-3604 USA

AAPG Hedberg Research Conference —
Lacustrine Basin Exploration in China, Southeast Asia and Indonesia

15-20 October, 1995
Dongying City, Peoples' Republic of China

You are invited to attend the AAPG Hedberg Research Conference entitled "Lacustrine Basin Exploration in China, Southeast Asia and Indonesia", being held in October 15-20, 1995, in Dongying City, Peoples' Republic of China.

The conveners for the conference are Dr. Barry Katz, with Texaco Exploration and Production Technology Department, and Prof. Liu Xingcai, Vice President of the Shengli Petroleum Administration. The purpose of this international conference is to bring together a group of petroleum researchers and explorationists with interest in lacustrine basins of the region in order to establish a baseline of current knowledge and a regional framework, as well as to determine the technology needs for exploration with these basins.

The conference will include a suite of oral and poster presentations. Presentations will be made in both English and Chinese. Simultaneous translation will be provided. The number of presentations is being limited in order to permit discussion. A one-day visit to the Shengli Petroleum Administration core warehouse is also included in the program on Friday, October 20th. A tentative listing of presentations to be included in the program is attached. There may be some additions and deletions prior to the assembly of the final technical program, so an updated copy will be available at the conference.

The cost of the 5-day conference is $1,150.00. This includes the conference itself, lodging for 5 nights at the conference center, all meals beginning with dinner on 10/15 and ending with lunch on 10/20, and the conference banquet. Partial financial support for the conference is being provided by the Shengli Petroleum Administration and by Texaco Middle East/Far East. **Please indicate your arrival and departure dates on the registration form. All reservations will be made by AAPG at one time using this information.** Additional arrangements will need to be made for those attendees planning on departing on Saturday, October 21st.

Please note that the Shengli Petroleum Administration will provide any necessary letters of invitation required as part of visa applications. It is recommended that attendees plan to fly into Beijing, then make connections to arrive at Jinan airport (or Qingdao airport as an alternate) or Zibo railway station. Shengli Petroleum Administration will provide transportation from these areas to the conference center in Dongying City.

For further information, please send your completed registration form and full payment as soon as possible to the AAPG Education Department, P.O. Box 979, Tulsa, Oklahoma, U.S.A., 74101. We look forward to your participation in this exciting conference, and should you have any questions, please feel free to contact Debbi Boonstra in the AAPG Education Department, at 918-560-2630 (phone), 918-560-2684 (Fax), or debbi@aapg.org (e-mail), or you may contact one of us at the numbers shown below.

Co-conveners:

Barry. J. Katz
Texaco
3901 Briarpark,
Houston, Texas 77042,
U.S.A.
Phone: (713) 954-6093
Fax: (713) 954-6113

Liu Xingcai
Shengli Petroleum Administration,
Dongying City,
Shandong Province 257001,
Peoples Republic of China,
Fax: 86-5461-221359

Australia Mineral Foundation

Career Path Development: Courses for Profession Staff

• Conference & Seminars

928/95	New Generation Gold Mines: Case Histories of Discoveries	27-29 November, Perth

• Management, Economics, Safety & Environment

921/95	Legal Principles of Project Finance	25-29 September, Melbourne
922/95	Mineral Law	23-27 October, Melbourne
906/95	Petroleum Law	6-10 November, Melbourne

• Minerals Geoscience

934/95	Sampling Gold	4-6 September, Kalgoorlie
920/95	Project Generation in Mineral Provinces: Workshop and Field Course	1-8 September, Darwin
923/95	Geology and Exploration for Non-Geologists	3-5 October, Adelaide
925/95	Geology and Exploration for Non-Geologists	16-18 October, Perth
938/95	Engineering Logging of Drill Core	27-29 November, Kalgoorlie

• Mining

934/95	Sampling Gold	4-6 September, Kalgoorlie
922/95	Mineral Law	23-27 October, Melbourne
924/95	Ground Support in Mining	6-9 November, Adelaide
938/95	Engineering Logging of Drill Core	27-29 November, Kalgoorlie

• Metallurgy/Processing

934/95	Sampling Gold	4-6 September, Kalgoorlie
935/95	Sampling Fine Particles and Slurries	11-12 September, Perth
936/95	Sampling Fine Particle and Slurries	18-19 September, Brisbane
937/95	Spreadsheet Modelling of Processes and Their Cashflows	6-7 November, Perth

• Petroleum

923/95	Geology and Exploration for Non-Geologist	3-5 October, Adelaide
925/95	Geology and Exploration for Non-Geologist	16-18 October, Perth
933/95	Interpretation of 3-D Seismic Data	1-3 November, Adelaide
906/95	Petroleum Law	6-10 November, Melbourne

For detailed course outlines please contact AMF.

For further information:

Australian Mineral Foundation
63 Conyngham Street, Glenside, SA 5065
Telephone [08] 379 0444
Facsimile [08] 379 4634

KALENDAR (CALENDAR)

1995

August 1-2

DAM ENGINEERING '95 (International Conference), Kuala Lumpur, Malaysia. (John S.Y. Tan, 150 Orchard Road #07-14, Orchard Plaza Singapore 0923. Phone: (065) 7332922; Fax: (065) 2353530; Tlx: RS 33205 FAIRCO)

August 7-12

6TH INTERNATIONAL KIMBERLITE CONFERENCE, Novosibirsk, Russia. (Dr. N. Pokhilenko, United Institute of Geology Geophysics and Mineralogy, Russian Academy of Sciences, Siberian Branch, 630090 Novosibirsk-90, Russia. Telex: 133123 KORA SU; Telefax: 007 3832 3526 92; E-mail: chief@diamond.msk.su.

August 9-10

TERRESTRIAL CARBON CYCLE CHANGES DURING THE LAST 150 Ky (International Symposium, INQUA), Berlin, Germany. (H. Faure, Luminy Case 907, F 13288 Marseille Cédex, 09, France. Telefax 33 91 26 66 38)

August 13-16

CONGRESS ON SEDIMENTARY GEOLOGY, St. Petersburg, Fla., by Society for Sedimentary Geology. (SEPM, Box 4756, Tulsa, Okla. 74159-0756. Phone: 800/865-9765; Fax: 918/743-2498)

August 13-18

WATER-ROCK INTERACTION (8th International Symposium), Vladivostok, Russia. (Oleg Chudaev, Far East Geological Institute, 690022 Vladivostok, Russia. Phone: 7 4232 3172567; Telefax: 7 5098 512430; Telex: 213212 FEBAS SU; E-mail: fegi@visenet.iasnet.com)

August 21-25

RESEARCH METHODS IN ANCIENT AND MODERN LACUSTRINE BASINS (1st International Limno-geological Congress), Copenhagen, Denmark. (Dr. Nanna Noe-Nygaard, Geological Institute, University of Copenhagen, Øster Volgade 10, Copenhagen 1350 K, Denmark. Phone: 45 35322491; Telefax: 45 35322499)

August 22-September 1

INTERPLATE MAGMATISM IGCP 336, Duluth, Minn. (Penny Morton, Dept. of Geology, University of Minnesota, Duluth, 55812. Phone: 218/726-7962; Fax: 218/726-8275; E-mail: pmorton@ua.d.umn.edu)

August 24-September 5

OROGENIC LHERZOLITES AND MANTLE PROCESSES (2nd International Workshop), Granada, Spain. (H.G. Barsczus, Géofluides GBE/ISTEEM, CP 057, Université de Montpellier 2, 34095 Montpellier Cedex 5, France. Phone: 33 6714 3933; Telefax: 33 6714 4774; E-mail: barsczus@dstu.univ-montp2.fr)

August 27-September 1

GEOLOGY OF THE EASTERN MEDITERRANEAN REGION (2nd International Symposium), Jerusalem, Israel. (P.O. Box 50006, Tel-Aviv 61500, Israel. Phone: 972 3 5140014; Telefax: 972 3 5175674)

August 28-31

MINERAL DEPOSITS: FROM THEIR GENESIS TO THEIR ENVIRONMENTAL IMPACTS (3rd Biennial SGA Meeting), Prague, Czech Republic. (Dr. Jan Pasava, Secretary General, Czech Geological Survey, Klarov 131/3, 118 20 Praha 1, Czech Republic. Phone: (42) 2 537011; Telefax: (42) 2 7980965)

August 28-September 1

TECTONIC AND METALLOGENY OF EARLY/MID PRECAMBRIAN OROGENIC BELTS, Montreal, Canada. (J.A. Percival, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario, Canada, K1A 0E8. Phone: (613) 995-4723; Telefax: (613) 995-9272; E-mail: ipercival@6091C.gsc.emr.ca)

August 28-September 2

CARBONIFEROUS-PERMIAN (13th International Congress), Krakow, Poland. (XIII ICC-P Secretary General, Prof. dr.hab Sonia Dybova-Jachowicz, Panstwowy Instytut Geologiczny, Oddzial Córnoslaski, 1 Królowej Jadwigi, 41-200 Sosnowice, Poland. Phone: 48 32 66 20 36; Telefax: 48 32 66 55 22)

August 28-September 2

ORIGIN OF GRANITES (3rd Hutton Symposium), College Park, Maryland, USA. (Dr. Michael Brown, Dept. of Geology, University of Maryland at College Park, College Park, MD 20742 USA. Phone: 301/405-4082. Telefax: 301/314-9661)

August 31

INQUA, Berlin, Germany. (E. Derbyshire, Royal Holloway and Bedford New College, London University, Egham, Surrey TW20 0EX, UK. Telefax: +44(0)273-748919)

September 1

BRACHIOPODES ACTUELS ET FOSSILES (International congress). Sunbury, Ontario, Canada. (M. Gayet and B. Courtinat. Université Claude-Bernard Lyon 1, Centre des Sciences de la Terre, 27-43, boulevard du 11-nov., F-69622 Villeurbanne Cedex, France. Phone: 72 44 83 98 and 72 44 85 72; Telefax: 72 44 84 36)

September 3-9

RADIOACTIVE WASTE MANAGEMENT AND ENVIRONMENTAL REMEDIATION, mtg., Berlin, by American Society of Mechanical Engineers. (Steven C. Slate, Battelle Pacific Northwest Laboratory, MSIN K1-19, Box 999, 902 Battelle Blvd., Richland, Wash, 99352. Phone: 509/375-3903; Fax: 509/375-5963; E-mail: sc_slate@pnl.gov)

September 4-8

DYKES (3rd International Conferences), Jerusalem, Israel. (Dr. Gideon Baer, Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem 95501, Israel. Telefax: 972 2 3806688)

September 4-9

ASSOCIATION OF EUROPEAN GEOLOGICAL SOCIETIES (9th Meeting), St. Petersburg, Russia. (Dr. A. Kotov, Institute of Precambrian Geology and Geochronology, Marakova Emb. 2, St. Petersburg, Russia. Phone: (812) 218 4701; Telefax: (812) 218 48 01; E-mail: spire@sovamsu.sovusa.com)

September 4-9

DEVONIAN MICROVERTEBRATE BIOCHRONOLOGY (Final Meeting of IGCP 328, followed by field meeting in N. France/ Belgium, 9-25 September), Paris, France. (Dr. Alan Blieck, telefax: 33 2043 6900)

September 4-9

TERRESTRIAL PLANTS IN GEOLOGIC TIME, int'l. mtg., Nanjing, China. (ICTPG, Dept. of Paleobotany, Nanjing Institute of Geology and Palaeontology, Nanjing)

September 5-9

MINERAL RESOURCES OF RUSSIA 1995 (International Forum), St. Petersburg, Russia. (Organizing Committee of the Exhibitions, Congress and Symposium, P.O. Box 215, "MINERALS", 192004, St. Petersburg, Russia. Phone: (812) 355-7952; 218-9224; Fax: (812) 213-5926; E-mail: vsg@sovamsu.sovusa.com)

September 10-13

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGIST, int'l conf., Nice, France, by AAPG and Institut Francais du Petrole. (AAPG, Box 979, Tulsa, Okla. 74101. Phone: 918/584-2555). Call for Papers deadline: Nov. 15.

September 10-14

GEOHAZARDS AND ENGINEERING GEOLOGY, ann. conf., Coventry, England, by the Engineering Group of the Geological Society. (Steve Penn, Coventry University, School of the Built Environment, Priory St., Coventry, CV1 5FB). Abstracts due Nov. 30.

September 10-20

KARST WATER AND ENVIRONMENTAL IMPACTS (5th International Symposium), Antalaya, Turkey. (G. Günay, Karst '95, P.O. Box 357, Kizilay, 06420 Ankara, Turkey. Phone: 90 41312 235 2543; Telefax: 90 41312 235 2862)

September 18-20

REMOTE SENSING FOR MARINE AND COASTAL ENVIRONMENTS, Seattle, by Environmental Research Institute of Michigan, and others. (Robert H. Rogers, ERIM, Box 134001, Ann Arbor, Mich., 48113-4001. Phone: 313/994-1200, ext. 3453; Fax: 313/994-5123)

September 18-23

FROM RIFTING TO DRIFTING IN PRESENT-DAY AND FOSSIL OCEAN BASINS (International Ophiolite Sumposium). Pavia, Italy. (Dr. R. Tribuzio, Dipartimento di Scienze della Terra, Universita di Pavia, via Abbiategrasso, 209, 1-27100 Pavia, Italy. Phone: 382 505874; Telefax: 382 505890)

September 29-October 2

PALEOBIOLOGY AND EVOLUTION OF THE BIVALVIA (5th Canadian Paleontology Conference and International Symposium — Joint Meeting), Drumheller, Alberta, Canada. (Paul A. Johnston, CPC-V, Royal Tyrrel Museum of Paleontology, P.O. Box 7500, Drumheller, Alberta T0J 9Y0. Phone: 403 823 7707; Telefax: 403 823 7131)

October 9-13

GEOLOGY FOR DEVELOPMENT WITHIN A SUSTAINABLE ENVIRONMENT (10th Conference of the Geological Society of Africa), Nairobi, Kenya. (Secretary GSA 95 Organising Committee, P.O. Box 60199, Nairobi)

October 10-14

AMERICAN ASSOCIATION OF STRATIGRAPHIC PALYNOLOGISTS (28th Annual Meeting), Ottawa, Canada. (Ms Susan A. Jarzen, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, Ontario, Canada K1P 6P4. Telefax: 613 954 4724)

October 10-14

PALEOCEANOGRAPHY (International Meeting) Halifax, Nova Scotia. (Larry Mayer, Ocean Mapping Group, Dept. of Surveying and Engineering, Box 4400, Fredericton, New Brunswick, Canada E3B 5A3)

October 16-20

LAND SUBSIDENCE — FISOL '95 (1st International Symposium), La Haye, The Netherlands. (F.H. Schröder, Netherlands Geodetic Commission, P.O. Box 5030, NL-2600 GA Delft, The Netherlands)

October 17-19

SEISMIC ZONATION (5th International Conference), Nice, France. (5th ICZS, AFPS Domaine de Saint-Paul, BP 1, 78470 Saint Remy Les Chevreuse, France. Telefax: (33-1) 30 52 75 75)

October 22-25

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS (International Conference and Exhibition), Cairo, Egypt. (AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101, USA. Phone: (918) 584-2555)

October 29-31

26TH UNDERWATER MINING INSTITUTE, Newfoundland, Canada. (Ms. Karynne Chong Morgan, Underwater Mining Institute, c/o Marine Minerals Technology Center, 811 Olomehani Street, Honolulu, Hawaii 96813-5513, USA. Phone: (808) 522-5611; Fax: (808) 522-5618; Internet: 70673.534@compuserve.com • CompuServe: 70673,534)

November 4-6

GEOLOGY OF SOUTHEAST ASIA AND ADJACENT AREAS (Joint Meeting of IGCP Projects 306, 321 & 359), Hanoi, Vietnam. (Prof. Dang Vu Khuc, Geological Museum, 6 Pham Ngu Lao, Hanoi, Vietnam. Phone: 84.4.266.802, Fax: 84.4.254.734)

November 5-9

SOCIETY OF EXPLORATION GEOPHYSICISTS (Annual Conference), Denver, Colorado, USA. (Society of Exploration Geophysicists. Convention Assistant, P.O. Box 702740, Tulsa, OK 74170, USA)

November 6-10

CURVED OROGENIC BELTS: THEIR NATURE AND SIGNIFICANCE, Buenos Aires, Argentina. (Dr. Jose Selles-Martinez, COB '95, Dpto. de Ciencias Geologicas, Pabellon 2 Ciudad Universitaria, 1428 Buenos Aires, Argentina. Phone: 54 1 781 8213; Telefax: 54 1 788 3439; E-mail: postmast@lpgfcf.uba.ar)

November 7-11

RIVER SEDIMENTATION (6th International Symposium), New Delhi, India, (Shri C.V.J. Varma, Central Board of Irrigation and Power, Malch Marg, Chanakyapuri, New Delhi 110021, India. Phone: 91 11301 5984; Telefax: 91 11301 6347; Telex: 31 66415 CBIP IN)

November 19-22

PACRIM (Congress), Auckland, New Zealand. (Mrs. Charmayne Perera, Congress Secretariat, Australasian Institute of Mining and Metallurgy, P.O. Box 122, Parkville, Vic 3052, Australia. Phone: (03) 347-3166; Telefax: (03) 347-8525; E-mail: j.mauk@auckland.ac.nz)

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Khon Kaen, Thailand. (Assist. Prof. Ladda Wannakao, The Conference Secretariat, Department of Geotechnology, Faculty of Technology, Khon Kaen University, Khon Kaen 4002, Thailand. Phone: (66-43) 242333-40 Ext. 2351-3; Fax: (66-43) 239329; E-Mail: ladda@kkul.kku.ac.th

December 9-11

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1996

CANADIAN INSTITUTE OF MINING, METALLURGY AND PETROLEUM, (98th Annual General Meeting), Quebec City, Quebec, Canada. (John Gaydos, Meetings Manager, Canadian Institute of Mining and Metallurgy, 1 Place Alexis Nihon, 1210-3400 de maisonneuve Boulevard West, Montreal, Quebec H3S 3B8, Canada. Phone: (514) 939-2710; Telefax: (514) 939-2714)

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MYANMAR (BURMA) OIL & GAS EXPO '96 (Downstream & Upstream), Yangon (Rangoon), Myanmar (Burma). (Mr. K.G.E. Kay, CP Exhibition, 2801 Tung Wai Commercial Building, 109 Gloucester Road, Wanchai, Hong Kong. Fax: 852-25119692; Tel: 852-25117427, Tlx: 76270 HX)

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GEOLOGICAL SURVEYS AND SUSTAINABLE DEVELOPMENT (Conference to mark the Centennial of the Geological Survey of Egypt), Cairo, Egypt. (M. El. Hinnawi, Geological Survey of Egypt, 3 Salah Salem Road, Abbassiya, Cairo, Egypt. Telefax: 002 02 820 128)

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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS (Annual Conference), San Diego, California, USA. (AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101, USA. Phone: (918) 584-2555)

May 27-29

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June 2-6

4TH CONFERENCE ON PETROLEUM GEOCHEMISTRY AND EXPLORATION IN THE AFRO-ASIAN REGION, Arusha-Tanzania. (The 4th AAAPG Conference Secretariat, Tanzania Petroleum Development Corporation, P.O. Box 5233, Dar Es Salaam, Tanzania, East Africa. Phone: 255-51-29661/2 & 36086; Fax: 255-51-29663/20775; Telex:

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June 3-7

EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS and EUROPEAN ASSOCIATION OF PETROLEUM GEOLOGISTS (EAEG 58th Annual Assembly and EAPG 8th Annual Congress), Amsterdam, Netherlands. (EAPG, Attention of Mr. E. van der Gaag, P.O. Box 298, NL-3700 AG, Zeist, Netherlands)

June 9-12

NORTH AMERICAN PALEONTOLOGICAL CONVENTION (6th). Washington, DC, USA. (NAPC-VI, c/o Department of Paleobiology, Mail Stop 121, National Museum of Natural History. Washington, DC, 20560, USA)

June 17-21

INTERNATIONAL SYMPOSIUM ON LANDSLIDES (7th), Trondheim, Norway. (Norweigian Geotechnical Society, P.O. Box 40, Taasen N-0801, Oslo, Norway)

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INTERNATIONAL PALYNOLOGICAL CONGRESS (9th), Houston, Texas. (Dr. Vaughn M. Bryant, Department of Anthropology, Texas A & M University, College Station, TX 77843, USA. Phone: 409 845 5242; Telefax: 409 845 4070; E-mail: glwrenn@lsuvm.sncc.lsu.edu)

August 4-14

30TH INTERNATIONAL GEOLOGICAL CONGRESS (30th), Beijing, China. (Prof. Zhao Xun, Deputy Secretary General, 30th IGC, P.O. Box 823, Beijing 100037, P.R. China. Phone: 86 1 8327772; Telefax: 86 1 8328928)

October 28-31

GEOLOGICAL SOCIETY OF AMERICA (Annual Meeting), Denver, Colorado, USA. (Jean Kinney, GSA Headquarters, Box 9140, 3300 Penrose Place, Boulder. CO 80301, USA. Phone: 303/447-2020. Fax: 303/447-1133)

1997

ASSOCIATION OF EUROPEAN GEOLOGICAL SOCIETIES (10th Meeting), Karlovv Vary, Czechoslovakia. (Geological Society, Burlington House, Piccadilly, London W1V 0JU, UK. Phone: +44 (0) 71 -434 9944)

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1998

CANADIAN INSTITUTE OF MINING, METALLURGY AND PETROLEUM (100th annual general meeting), Quebec, Canada. (John Gaydos, Meetings Manager, Canadian Institute of Mining and Metallurgy, 1 Place Alexis Nihon, 1210-3400 de Maisonneuve Boulevard West, Montreal, Quebec H3Z 3B8, Canada. Phone: (514) 939-2710; Telefax: (514) 939-2714)

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August 9-15

INTERNATIONAL MINERALOGICAL ASSOCIATION: IMA '98 (17th General Meeting) Toronto, Canada. (Professor A.J. Naldrett, Department of Geology, University of Toronto, Canada M5S 3BI. Phone: (461) 978 3030; Telefax: (416) 978 3938; E-mail: ima98@quartz.geology.utoronto.ca)

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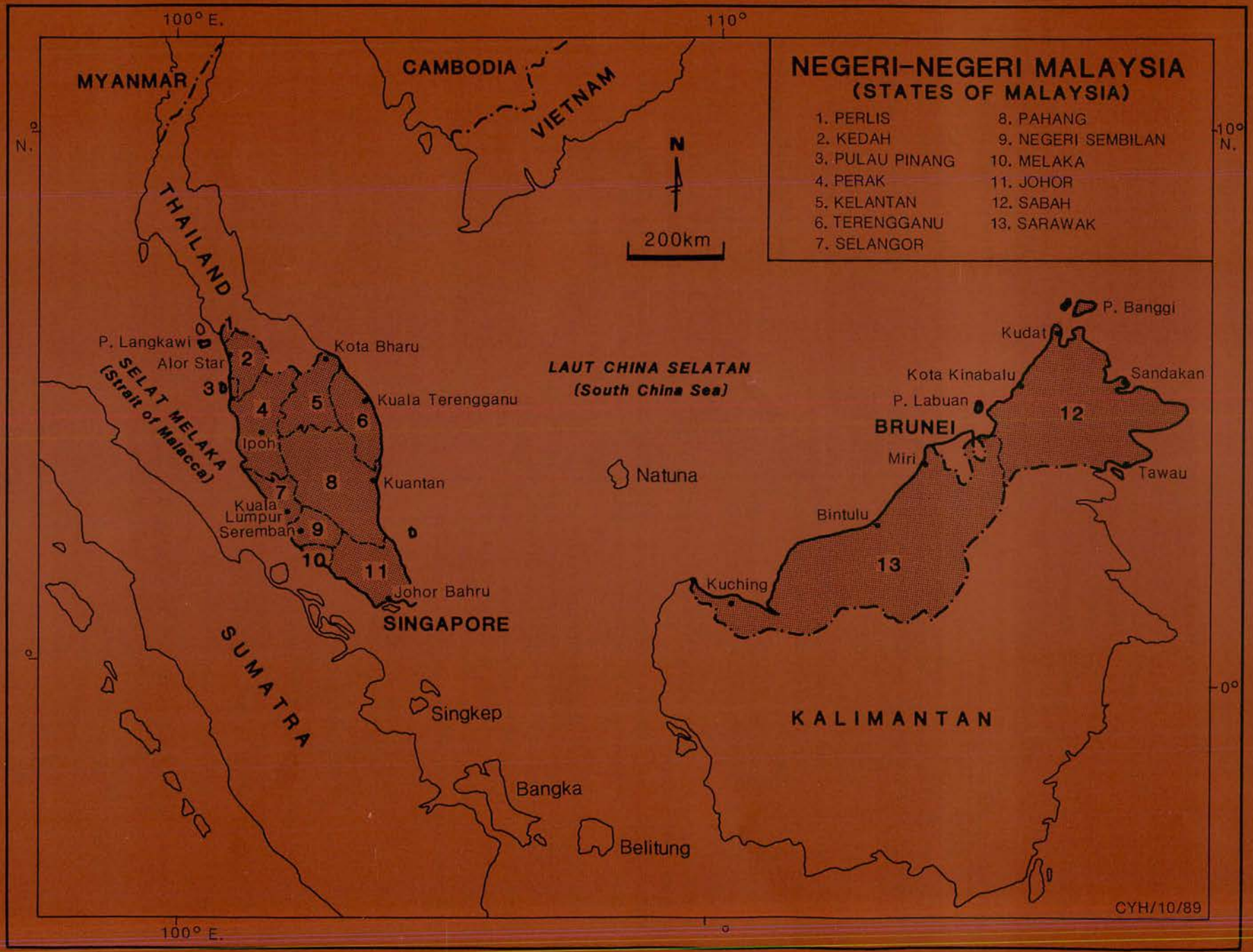
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