

## PERSATUAN GEOLOGI MALAYSIA

# WARTA GEOLOGI

## NEWSLETTER OF THE GEOLOGICAL SOCIETY OF MALAYSIA



GEOLOGICAL  
SOCIETY OF  
MALAYSIA

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# PERSATUAN GEOLOGI MALAYSIA

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### About the Society

The Society was founded in 1967 with the aim of promoting the advancement of earth sciences particularly in Malaysia and the Southeast Asian region.

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

### Modelling of the crystallisation phases of the Bukit Mertajam-Kulim granitic magma

AZMAN A. GHANI, BORHAN M. DOYA AND G.H. TEH

Department of Geology  
University of Malaya  
50603 Kuala Lumpur

**Abstract:** Bukit Mertajam-Kulim granite is an isolated granitic body which lies to the northwest of the Peninsular Malaysia and is part of the Main Range batholith. Modelling of the Bukit Mertajam-Kulim granitic magma show that plagioclase, K-feldspar, biotite, sphene, zircon and magnetite are responsible for the evolution of the magma.

#### INTRODUCTION

Bukit Mertajam-Kulim granite is an isolated granitic body which lies to the northwest of Peninsular Malaysia (Cobbing *et al.*, 1992). The granite is part of the Main Range batholith and consists of coarse grained biotite to muscovite granite and microgranite. Based on field relationships, petrography and geochemical analyses the granite has been divided into three subunits namely (1) Granite Mertajam, (2) Granite Bongsu and (3) Granite Panchor (Borhan Doya, 1995). Detailed field relationships and geochemical characteristic of these granites will be presented and discussed in a separate paper. The purpose of this short note is to document the main precipitation phases in the Bukit Mertajam-Kulim granitic magma.

#### PETROLOGY

The rock contain biotite, plagioclase, quartz, K-feldspar, sphene, garnet, tourmaline, zircon, apatite, chlorite, opaque phases and muscovite. Some of the rocks show porphyritic varieties with the range of phenocrysts from 3 to 6 cm. It consists mainly of euhedral K-feldspar which is usually pinkish in colour. Tourmaline clots rimmed by felsic quartz-feldspathic material (mean diameter: 3 cm) is common in the rock. Thus, in terms of mineralogy the granite is

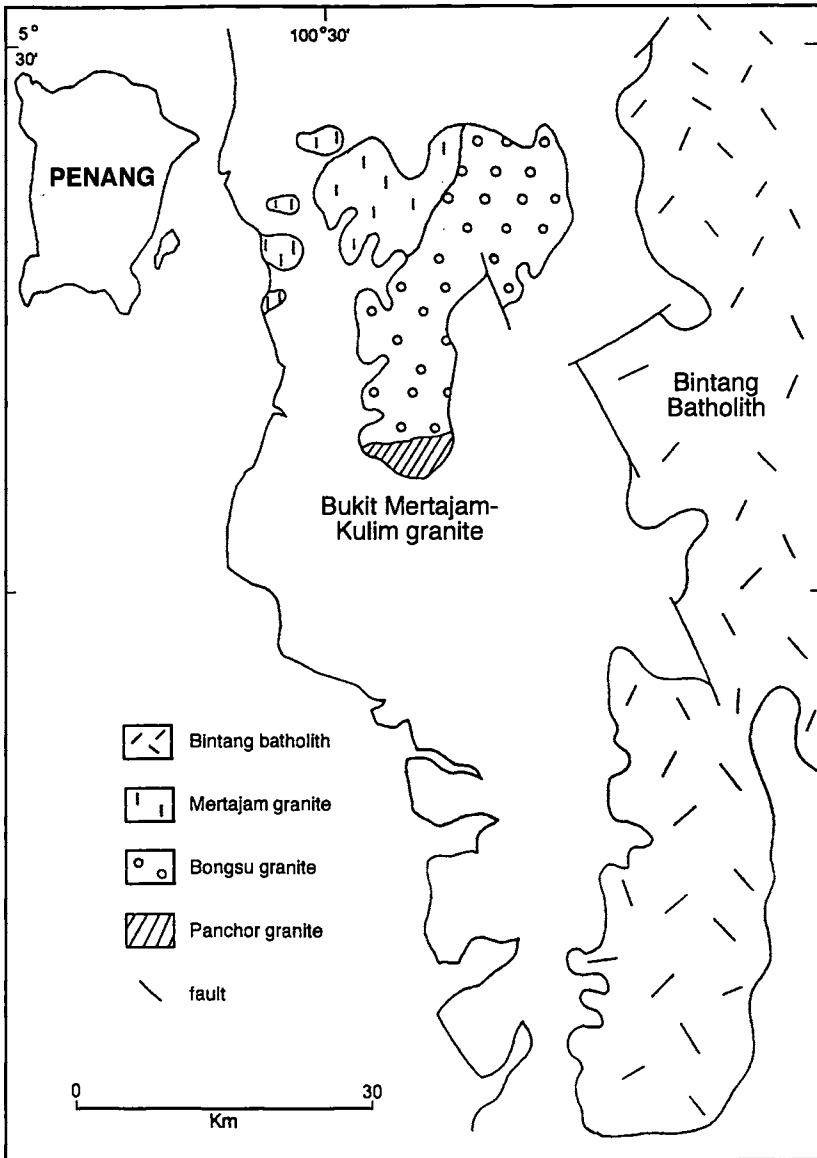
similar to the S-type granite from the Lachlan Fold Belt, Australia (Chappell and White, 1974).

#### GEOCHEMISTRY

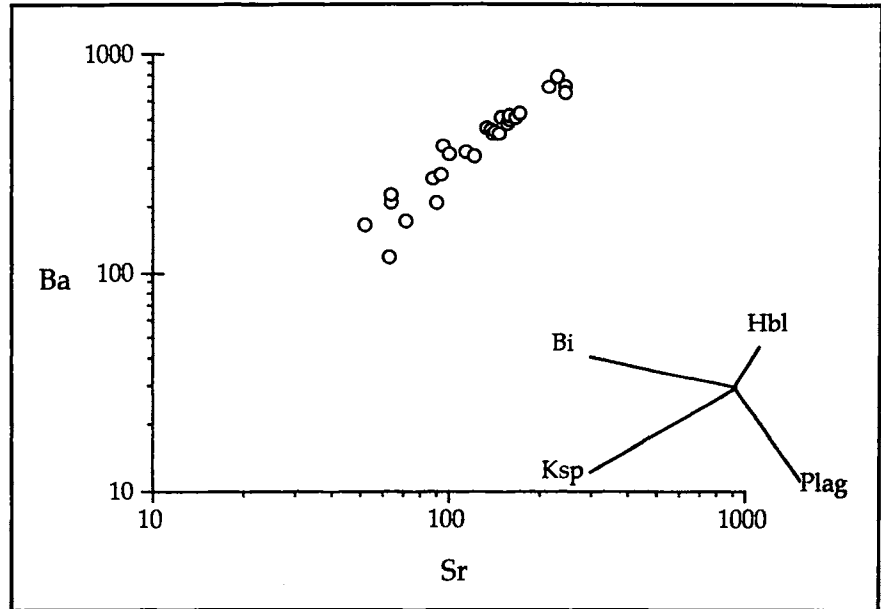
Before discussing the main precipitating phases of the granite, it is necessary to briefly discuss the whole rock geochemistry of the granites. The main Bukit Mertajam-Kulim granite contain 68.7 to 76.3% SiO<sub>2</sub>, 22.9% to 14.8 Al<sub>2</sub>O<sub>3</sub>, 2.4 to 3.4% Na<sub>2</sub>O and 4.6 to 5.9% K<sub>2</sub>O and are peraluminous granites in ACNK values (1 to 1.19). The rocks have high alkali contents, with the Na<sub>2</sub>O + K<sub>2</sub>O ranges from 7.3 to 8.9%. In terms of major and trace elements geochemistry, the Bukit Mertajam-Kulim granite has also many similarities with S-type granites described elsewhere (Chappell and Stephens, 1988). The granites also have distinctive trace elements characteristics in comparison with other granites, for example, the granite has Rb (303 to 578 ppm), Sr (52 to 785 ppm) Ba (118 to 785 ppm) and Zr (12 to 221 ppm).

#### MODELLING OF THE CRYSTALLISATION PHASES

The LIL elements Ba, Sr and Rb are of considerable value in determining the type and amount of major phase fractionation in intermediate and acid rocks because:



**Figure 1.** Simplified geological map of the Bukit Mertajam-Kulim granite (modified from Liew, 1993 and Borhan Doya, 1995).



**Figure 2.** Log Ba-Log Sr plot for the Bukit Mertajam-Kulim granite. Mineral vector indicate the net change in composition of the initial liquid after 30% Rayleigh fractionation of the named phase. Plag = Plagioclase; Ksp = K-feldspar; Bi = Biotite; Hbl = Hornblende.

MODELLING OF THE CRYSTALLISATION PHASES OF THE BUKIT MERTAJAM-KULIM GRANITIC MAGMA

- (a) they are held predominantly in the major phases,
- (b) Kd's for commonly occurring major phases are available,
- (c) each element behaves somewhat differently; for example, Rb is taken up preferentially by biotite, Ba by biotite and alkali feldspar and Sr by plagioclase and K-feldspar.

Using Rayleigh fractionation equation ( $C_1/C_0 = F^{D_a-1}$  where  $C_0$ : concentration of element 'a' in the original melt,  $C_1$ : concentration of element 'a' in residual melt,  $D_a$ : bulk distribution coefficient for element 'a' and  $F$ : weight fraction of melt remaining) and the Kd values for rhyolitic liquid (Arth, 1976), we have calculated the net change in composition of the liquid after 30% Rayleigh fractionation by removing K-feldspar, hornblende, plagioclase or biotite. Figure 2 shows a log-log plot of Sr vs Ba of the sample from Bukit Mertajam-Kulim granite. The Sr value increases with increasing Ba and there is a good positive correlation. Rayleigh fractionation vectors for single mineral phases imply that the crystallisation of alkali feldspar, plagioclase and biotite may have controlled the trends in the granite.

Precipitation of plagioclase is also evidenced

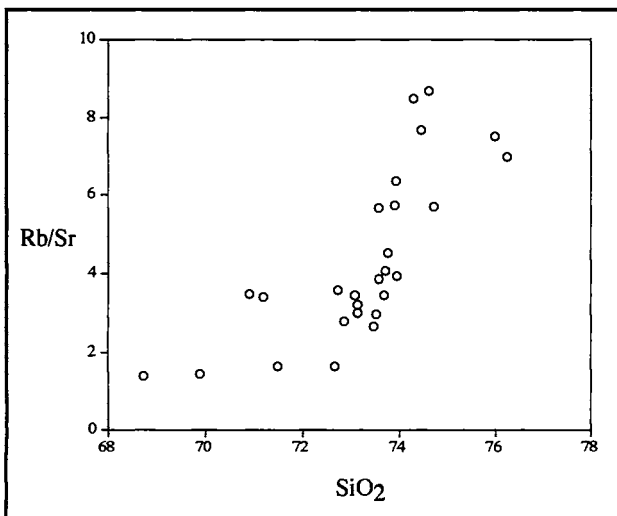


Figure 3. Rb/Sr vs  $SiO_2$  plot for the Bukit Mertajam-Kulim granite showing characteristic form due to fractional crystallisation with plagioclase as the major precipitating phase.

from Rb/Sr vs  $SiO_2$  plot (Fig. 3). The 'J' shaped trend produced by the plot is similar to some superunits of the Coastal Batholith (Atherton, 1993). The plot showing the characteristic form is due to fractional crystallisation with plagioclase as the major precipitating felsic phase.

The  $TiO_2$  vs Zr diagram is important in constraining the role of zircon, magnetite and sphene as well as hornblende and biotite during crystallisation (Mahawat *et al.*, 1990) (Fig. 4). The vector diagram indicates that sphene, zircon and magnetite are more important in determining the trend of the Bukit Mertajam-Kulim granite (modes lack of hornblende). Thus the crystallisation options for the granite are zircon + sphene, zircon + magnetite, zircon + biotite and biotite + sphene or some combination of these minerals.

ACKNOWLEDGEMENT

Mr. Roshdy is thanked for drafting the geological map.

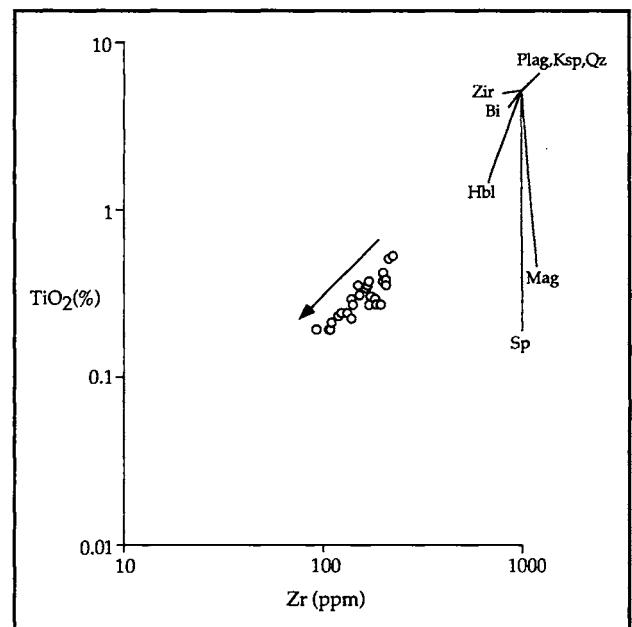


Figure 4.  $TiO_2$  vs Zr plot for the Bukit Mertajam-Kulim granite. Arrow indicate the fractionation trend of the granite. Mineral vectors indicate path of evolved liquids from 15% of mineral precipitating: Plag = Plagioclase; Ksp = K-feldspar; Qz = Quartz; Zir = Zircon; Bi = Biotite; Hbl = Hornblende; Sp = Sphene; Mag = Magnetite (Atherton *et al.*, 1990).

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Manuscript received 11 May 1999

## PERTEMUAN PERSATUAN Meetings of the Society

### Ceramah Teknik (Technical Talk)

### Gemology Night (Malam Gemologi)

#### Origin of sapphires

MAT RUZLIN MAULUD

#### Gemstones of Malaysia

K.N. MOORTHY

#### Laporan (Report)

Mention the magic word 'gemstones' and it will not fail to attract a crowd. This was just what happened at Gemology Night held on Tuesday 30 November 1999 at the Geology Department, University of Malaya. In fact even before tea time the enthusiasts were busy looking at the gemstones and gems testing equipment put up by one of the speakers, Mat Ruzlin Maulud.

When the talks started at 5.30 pm there were about 70 in the audience. Mat Ruzlin spoke on sapphires and their fascinating colours while Moorthy shared his experiences on gemstones of Malaysia. At the end of the evening everyone was trying to get a closer look at Moorthy's fascinating drawer of gemstones of Malaysia, a collection of gemstones put together during his years with the Geological Survey of Malaysia.

G.H. Teh



**MAT DUZLIN MAULUD**

**K.N. MOORTHY**

### Gemology Night (Malam Gemologi)



UIN Ar-Raniry

UIN Ar-Raniry



## Mini Forum — Field Trip

The FESM, special working group of the GSM, held a mini-forum at Shell's offices in Miri, on the afternoon of November 12th 1999. There were 45 attendees representing Shell, BDO, Carigali, Amerada Hess, Murphy Oil, CTOC, the university, Jason Geophysics, Baker Hughes, Schlumberger and several consultants. It was followed by a Field Trip led by Assoc. Prof. Azhar Hussin on November 13th, with 20 participants. Baker Hughes sponsored dinner on the Friday evening. Feedback on the sessions was very positive.

The subject of the forum was: Chasing Channel Sands in S.E. Asia. The speakers each gave a 20 minute presentation, followed by 10 minutes of questions.

### The program:

2:25 : Introduction, Peter Lloyd & Ajit Menon: special thanks to Ajit and Kwang Ha for helping arrange logistics of the Forum. Special thanks to Baker Hughes for coffee break and dinner sponsorship.

2:30 – 3:00 : Jason Geosystems Asia — *Mark Sams*, Senior Geophysicist

Jason Geosystems Asia is specialized in offering advanced reservoir characterization software and services to the international oil and gas industry. Latest developments in the Jason Geoscience Workbench will be presented: elastic inversion, stochastic inversion, and some indication of what type of return on investment clients have achieved in the region.

3:00 – 3:30 : Baker Atlas GEOScience — *Jeremy Prosser*, Chief Geoscientist Asia/Pacific

Borehole image and dipmeter logs provide high resolution data sets, with cm scale vertical resolution. When examined in conjunction with open hole logs, borehole image and dipmeter data allow geoscientists to undertake lithofacies analysis and sequence analysis. Interpretation of alluvial and other channel systems will be addressed.

### Break

3:45 – 4:15 : Schlumberger — *Peter Lloyd*, Lead Geologist, SE Asia and Australia

This paper will describe 4 case studies from SE Asia of how channels have been identified in the subsurface and their orientation determined. This has resulted in optimizing the positioning of production wells, with the improvements that this can bring to development efficiency.

4:15 – 4:45 : Carigali-Triton Operating Company — *Wan Manan*, Petrophysicist

Sands developed within shallow marine and tidal channel settings can be very difficult to interpret from a petrophysical perspective. Thin laminations, bioturbation, and complex silty lithology can result in low resistivity pays and very variable irreducible water saturations and permeabilities. In this paper various examples of these problems will be discussed, and solutions recommended.

On the Saturday Field Trip we visited the discovery well on the Miri Anticline, and Prof. Azhar took us to five more locations to understand the geology of these complex tidal and shoreface settings. The range of potential reservoir problems discussed at the forum by Sams, Prosser, Lloyd and Manan were particularly exemplified at these outcrops.

Peter Lloyd

## **Beyond the sequence stratigraphy paradigm: learning to exploit high-resolution data**

HENRY W. POSAMENTIER

### **Laporan (Report)**

Henry W. Posamentier of Atlantic Richfield Indonesia Inc., gave the above talk to an audience of 25 on 7th December 1999 at the Geology Department, University of Malaya.

### **Abstrak (Abstract)**

Sequence stratigraphy has proven to be a powerful vehicle for analyzing geological data ranging from sedimentological to biostratigraphic to geochemical data and developing robust geologic interpretations. Key to its success is that sequence stratigraphy embodies an approach rather than a set of models. And, as an approach, what originated as a somewhat simplistic model-based tool, has subsequently evolved into a sophisticated first-principles based tool.

Early development of sequence stratigraphy was based largely on relatively low-resolution 2D multichannel seismic observations. The basic framework of lowstand, transgressive, and highstand systems tracts comprising the sequence was developed initially on the basis of these observations. Initially, also, limited tectonic/physiographic settings were considered.

In the years since then, geologists and geophysicists have come to better understand the fundamental driving mechanisms behind the development of sequence architecture, namely, eustasy, sea floor motion (associated with tectonism, compaction, and thermal contraction), sediment flux, and physiography. Improved understanding of these driving mechanisms inevitably led to the conclusion that sequence stratigraphy was relevant not only to seismic data, but also to well log, core, outcrop, geochemical, and biostratigraphic data. As a consequence, there has been a pronounced shift to analysis of high-resolution geologic data, and with this shift came the challenge to learn how to exploit these data within a sequence stratigraphic context.

With these new high-resolution observations, it has become clear that many of the early concepts were lacking precision and ignorant of some significant variations on the general sequence stratigraphic theme. Such fundamental concepts as the expression of key surfaces (e.g., flooding surfaces, maximum flooding surfaces, and sequence boundaries) and the timing of formation and the physiographic settings of key physiographic elements (e.g., deepwater submarine fans, incised valley systems, shelf ridges, and shelf-edge deltas), have in some instances been profoundly influenced, refined, and modified by high-resolution observations. In particular, 3D seismic data, with its potential for imaging detailed three-dimensional views of subsurface paleogeography, when integrated with core sedimentology and detailed biostratigraphy have yielded compelling insights. This has led to awareness of significant variations on the general sequence stratigraphic theme and better prediction of temporal and spatial relationships between different depositional elements. Using these observations, the earth scientist can gain an understanding as never before of how a sedimentary basin fills. Examples of high-resolution data from the Gulf of Mexico and the Java Sea will be used to illustrate the relevancy of such data, with reference to the areas studied as well as to sequence stratigraphic principles in general.



H.W. POSAMENTIER



# PETROLEUM GEOLOGY CONFERENCE '99

## Laporan (Report)

This 24th Petroleum Geology Conference was held at the Shangri-La Hotel, Kuala Lumpur, on 23–24 November 1999. The Conference this year was declared open by Yang Berbahagia Tuan Haji Akhbar Tajuddin Abdul Wahab, Senior General Manager, Petroleum Management Unit PETRONAS. The Conference was attended by over 200 participants, including students from the local universities.

A total of 28 technical papers were presented together with a Keynote Address entitled "*Mergers, acquisitions and alliances: their impact on the petroleum industry in the next millennium*" by Bill Shaeffer, Jr., General Manager, Sante Fe Energy Resources of Malaysia. Besides that, there were 4 participants for the poster session.

The Organising Committee should be congratulated for organising a very successful conference with a good technical programme, informative exhibition booths and more importantly a commendable list of donors and sponsors and a good turnout.

G.H. Teh

# PETROLEUM GEOLOGY CONFERENCE '99



# PETROLEUM GEOLOGY CONFERENCE '99



# PETROLEUM GEOLOGY CONFERENCE '99

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# PETROLEUM GEOLOGY CONFERENCE '99

## Welcoming Address by Prof. Dr. Ibrahim Komoo President, Geological Society of Malaysia

23-24 November 1999, Shangri-la Hotel, Kuala Lumpur

Terima kasih Tuan Pengerusi Majlis,

Yang Berbahagia Tuan Haji Akhbar Tajuddin Abdul Wahab  
Pengurus Besar Kanan, Unit Pengurusan Petroleum PETRONAS,

Yang Berusaha En. Barney Mahendran  
Pengerusi, Jawatankuasa Penganjur Persidangan Geologi Petroleum 1999,

Tuan-tuan dan Puan-puan, para hadirin sekalian,

Assallam mualaikum dan salam sejahtera.

On behalf of the Geological Society of Malaysia (GSM), I would like to welcome all of you to the Petroleum Geology Conference 1999. We are particularly privileged today to have with us Ybhg. Tuan Haji Akhbar Tajuddin Abdul Wahab, Senior General Manager, Petroleum Management Unit PETRONAS, who will officiate our conference shortly.

The (GSM) was established in 1967 with the aim of promoting the advancement of the geosciences, particularly in Malaysia and the Southeast Asian region. Today it has about 600 members and regularly published a bulletin and a newsletter. We convene two conferences annually: the annual geological conference, and the petroleum geology conference. The society encourages specialised group activities and organises talks on various specialised subjects. The working groups on Petroleum Geology and Formation Evaluation are two such groups of direct relevance to your profession. I am aware that many of you are still not members of the Society. I would like to encourage you to join the Society.

While we strongly support our own membership, our involvement with the general public and non-geological related agencies is limited. This weakness, among other factors, had led to a low level of awareness of the important contributions of geologists and, what is worse, there are signs that show that this contribution is being ignored or considered unimportant. This is a challenge to all geologists.

In the early stages of the nation's development there was a very strong demand for geologists, particularly in the field of economic geology, resulting in a strong growth of geological information and knowledge of the whole country. The Geological Survey Department was then established, and departments of geology were set up in universities to provide the human resources needed for the mining industry. Unfortunately when the mining industry shrank, there was a downturn in the demand for geologists.

Fortunately for us, as the demand for economic minerals got smaller, there was a growth in the petroleum industry and petroleum geology expanded in the context of the exploration for this natural resource. Petroleum geology, in fact, provided the stimulus for growth in geophysics and other 'soft-rock' fields. Oil companies and related service industries called for large



members of geologists. Until today this demand remains strong.

But what will happen in 10 or 20 years' time when petroleum exploration activities wind down? Will petroleum geology suffer the same fate as the economic mineral geologists? Will the entire geological community be marginalised? This is an important and urgent issue that needs to be reflected upon by the entire geological community.

To grapple with this problem we geologists must unite. We need to find a way to make geology relevant in the next century. The effort to establish the Geologist Act is a step in the right direction because it is an attempt to give the geologist professional status. This effort desperately needs your support for our own survival. We have no doubt whatsoever in our minds that the daily work of the petroleum geologist is an extremely professional one. We should therefore fight for this professional status.

While we recognize the importance of petroleum geology as the forerunner of the geological fraternity, the geological community should also make themselves continuously relevant in the future. To be able to achieve this, we need to continuously explore new fields in new industries and find new niches for ourselves. Only a consolidated effort will yield this and help us to move into other fields, while at the same time strengthening our roles in established fields.

Indeed, the petroleum industry is not only an established field, but also a major revenue earner for the country, particularly as we overcome the current economic slowdown. For example, the export value of the petroleum industry is in the region of almost 17 billion ringgit in 1997. We are all proud of the contribution of our fellow geologists from the petroleum industry in the development of our nation. And, we look forward to more active participation and support from all petroleum geologists in increasing the relevance of our profession in the next century.

In closing I would like to thank Ybhg. Tuan Haji Akhbar Tajuddin Abdul Wahab to be with us today, and the organising committee for a job well done. On behalf of GSM, I would also like to take this opportunity to thanks to sponsors, donors, paper presenters, and to all of you. And wish all the participants a meaningful and constructive 2 days of deliberation. Thank you.

# PETROLEUM GEOLOGY CONFERENCE '99

## Opening Address by Tuan Haji Akbar Tajudin Abdul Wahab Senior General Manager, E&P Business, PETRONAS

23-24 November 1999, Shangri-la Hotel, Kuala Lumpur

Yang Berbahagia, Datuk Professor Dr. Ibrahim Komoo  
President of Geological Society of Malaysia,

En. Barney Mahendran  
Organising Chairman of the 1999 Petroleum Geology Conference,

Distinguished Guests,  
Participants,  
Ladies and Gentlemen,

First of all, I would like to wish a very good morning and a warm welcome to all. To our foreign guests, I wish you "Selamat Datang ke Malaysia". I am sure you would enjoy the warm weather with clear blue skies offered by our country. It is indeed my pleasure to be present here amongst prominent geoscientists and experts of the oil and gas industry and to deliver the opening address in the 24th Petroleum Geology Conference organised by the Geological Society of Malaysia.

The work put in by the Geological Society of Malaysia to organise this annual petroleum geology conference to promote new exploration ideas and geological concepts and even to just share the experiences within the petroleum fraternity is commendable indeed. I hope the aim of this conference is also to transform a good geologist into an astute oil finder that can see much wider, deeper and clearer in the geological subsurface. It is noteworthy that more than 200 participants including students from the local universities are attending this year's conference where 24 technical papers will be presented. I am sure participants will also get the opportunity to listen to the latest technology being used in the search for hydrocarbons which is now extremely necessary in view of the diminishing size of our prospects to be explored.

Ladies and gentlemen,

PETRONAS has accomplished much in attracting oil companies to invest in our basins. We want to ensure that they will also receive a reasonable rate of return. Since 1997, our export duty for crude oil has been reduced to merely 10% and PITA has been cut to 38%. In 1997, we have also introduced the more liberal R/C terms into our PSCs for the continental shelf areas and we have already signed 13 new PSCs with seven oil companies based on the new terms. In fact, four of the oil companies are new players in this region. That is an indication that our new terms are not only attractive to both the current oil companies operating in our basins but also to outside oil companies who have an eye for our oil and gas-prolific basins.

Ladies and gentlemen,

The challenges facing the oil industry have become more global in nature. Oil prices continue to be the main driving factor. Happily, it is constant in the long term but unpredictable in the short term. Global competition for exploration and production is increasing as basins become more mature. All these are occurring within a background of increased environmental awareness by the exploration companies as environmental considerations are integrated into all operations. As we go into the new millennium, the concept of global teamwork with the mega mergers of former rivals has resulted in the pooling of resources, funds and capabilities to give these giants a competitive advantage over all others. The new oil companies would definitely retain the best geoscientists and dismiss the less efficient ones. The geoscientists in Malaysia are not spared either. They too much always be on their toes to add new reserves to their respective oil companies. Otherwise they might see their names on the retrenchment list.

Ladies and gentlemen,

In order to maximise our profits, we much attempt to reduce cost in our E&P operations as far as possible. On our part, PETRONAS has initiated CORAL, the acronym for Cost Reduction Alliance in 1995 for the upstream oil industry with the aim of reducing the 1995 cost base by 30% by Yr 2000. The sharing of seismic vessels and drilling rigs are but some important examples of CORAL projects in the exploration and development phase of our operations. I am delighted that a paper will be presented in this conference to give the participants an overview of what CORAL aims to achieve.

Ladies and gentlemen,

In the wake of unstable oil prices, technical innovation and the application of leading edge technologies remain the key success factors in commercialising our projects. In Malaysia the implementation of new seismic acquisition and processing techniques such as Pre-stack Depth Migration (PSDM), 4-component (4C) and ocean bottom cable (OBC), have helped us gain better data and more accurate evaluations of our assets. More exciting technologies awaits us in the new millennium with the steady progress of innovative IT technology that will give us realistic 3D visualisations of our subsurface geologies. Advances in communications and databases will enable us to remotely evaluate and explore prospects from anywhere in the world. In the new millennium, much of this can also be done from the comfort (and safety!) of our homes. Not forgetting peaceful by-products of recent high tech air wars that include airborne aeromagnetic surveys, satellite imagery and terrain mapping radars as they are also being utilised for oil and gas exploration purposes. Similarly, improvement in the drilling technology with multilateral drilling and completions, we can reap full benefit from our production reservoirs.

Ladies and gentlemen,

As mentioned, our basins are getting into a mature stage with the opportunity for exploring those obvious structural traps almost closed. We know there is still substantial amount of hydrocarbons but they are reseroired in subtle, illusive and deep plays. I believe that innovative ideas and the application of leading edge technologies will enable companies to successfully explore and produce these assets. The service sector is increasingly playing a more important role in providing the required technology.

I am proud to say that the geoscientists in PMU have also helped to shape the views of oil companies regarding our basins. We have drilled in the open acreage in the North Malay Basin to prove that indeed there is deep reservoir potential below the overpressure zones. In the SW Sarawak Shelf, PMU's geoscientists have also discovered a new gas play thereby upgrading the prospectivity in this area.

Ladies and gentlemen,

We have acquired plenty of 3D seismic data and in the near future we are acquiring some more not only for development but exploration as well. The question that is posed to the oil companies is: can we add value to our huge volume of 3D seismic data? I am glad to note that new 3D seismic data interpretation techniques has emerged that include coherency technique, 3D visualization technique, 3D AVO technique, 3D inversion technique and 3D amplitude slice, some of which are to be presented here. With these techniques, we can image the extent of single sand channel filled with hydrocarbons thereby influencing our decisions to place our wells more accurately and ultimately bringing a healthy return of investments. The recent successful drilling by some of the operators here are cases in point.

Ladies and gentlemen,

I would like to conclude by reminding my respected audience of geoscientists of that saying “oil is found in the minds of men” and to step up the pace of hydrocarbon exploration by using constructive new concepts coupled with technology and synergistic alliances between oil and service companies to ensure success. This conference, I trust, will provide sufficient opportunities to review all these. Lastly, I would like to take this moment to congratulate the members of the Organising Committee for their efforts in bringing about this Conference.

It is with great pleasure that I declare the 24th Petroleum Geology Conference open.

Thank you.

# PETROLEUM GEOLOGY CONFERENCE '99

## PROGRAMME

Tuesday, 23 November 1999

- 08.00 : **Registration**
- 08.50 : **Arrival of Invited Guests**
- 09.00 : **Welcoming Address by President of GSM, Professor Dr. Ibrahim Komoo**
- 09.10 : **Opening Address by Tuan Hj. Akbar Tajudin Abdul Wahab, Senior General Manager, PMU, PETRONAS**
- 09.30 : **Coffee Break**

### Session 1 : Morning Session

#### Session Co-Chairmen:

**David Mackertich** (XM, Amerada Hess)

**Azhar Hj. Hussin** (Head, Geology Dept., University of Malaya)

- 10.00 : **Keynote Address:** Mergers, acquisitions and alliances: their impact on the petroleum industry in the next millennium  
*Bill Schaefer, Jr. (GM, Santa Fe Energy Resources of Malaysia)*
- 10.30 : **Paper 1:** Natural gas opportunities in Malaysia  
*Mohd. Sabri Mohamed (PMU)*
- 11.00 : **Paper 2:** A new geological/geophysical framework for SE Asia  
*Karsten M. Storetvedt (Univ. of Bergen)*
- 11.30 : **Paper 3:** Global wrench tectonics and its consequences for the tectonic evolution of the NW Borneo continental margin  
*Leong Lap Sau et al. (USM)*
- 12.00 : **Paper 4:** Stress domains in the Sarawak and NW Sabah basins  
*H.D. Tjia (PRSS)*
- 12.30 : **Lunch** (sponsored by Landmark Graphics)  
*20-minute presentation by Landmark Graphics*

**Tuesday, 23 November 1999**

**Session 2 : Afternoon session**

**Session Co-Chairmen:**

**Yusoff Johari** (*Manager, PMU, Petronas*)  
**Jose Alcover-Santos** (*Manager, Geological Review,  
 New Business Development Unit, SHELL*)

- 14.00 : **Paper 5:** Seligi depletion management  
*S.T. Goh et al. (EPMI)*
- 14.30 : **Paper 6:** Simple and effective method for quality control of seismic amplitudes during marine seismic acquisition  
*Lee-Chui Swee & Chiaw-Oi Kuek (EPT-GPA, SSB/SSPC)*
- 15.00 : **Paper 7:** Borneo: plays that work and plays that don't  
*Richard Murphy (UK)*
- 15.30 : **Coffee Break**
- 15.50 : **Paper 8:** Seismic stratigraphy and turbidite depositional systems of deep water Block E, offshore Sarawak  
*J. Jong & L.P. Sha (SSB)*
- 16.20 : **Paper 9:** Seismic attributes associated with thin channel and crevasse splays sand identification  
*Ng Tong San & Redhani (PCSB)*
- 16.50 : **Paper 10:** A 3D pre-stack depth migration case history from the South China Sea  
*Refik Oezsen et al. (Paradigm Geophysics)*
- 17.20 : **Paper 11:** Some insights into the source rocks of Central Luconia and the West Baram Delta area, Sarawak  
*Mike Scherer et al. (PRSS)*
- 17.50 : **Paper 12:** Integration of newly acquired aerogravity data in the exploration work of the Tinjar Province, onshore Sarawak  
*Othman Ali Mahmud et al. (PMU)*
- 18.20 : **Paper 13:** New plays offshore Sabah: low stand stratigraphic traps in the Champion Delta  
*Colin J. Grant (SSPC)*
- 19.00 : **Evening Cocktail** (*sponsored by Baker Atlas*)

## Wednesday, 24 November 1999

### **Session 3 : Morning Session**

#### **Session Co-Chairmen:**

**Ted Zakarakis** (XM, Murphy Oil)

**Grant Gilchrist** (XM, CTOC)

- 08.30 : **Paper 14:** 3D Post-stack Depth Migration: a step towards enhanced subsurface imaging  
*Idrus M. Shuhud (PMU) & M. Firdaus A. Halim (PRSS)*
- 09.00 : **Paper 15:** Integrated Amplitude versus Offset (AVO) approach for delineating stratigraphic traps  
*M. Azuddin M. Yusof (PCSB)*
- 09.30 : **Paper 16:** Lithofacies sorting of organic matter and its implications for source rock potential  
*Ouzani Bachir et al. (Univ. of Malaya)*
- 10.00 : **Paper 17:** AVO analysis in Block SB305, offshore East Sabah, Malaysia  
*Idrus M. Shuhud (PMU) et al.*
- 10.30 : **Coffee Break**
- 10.50 : **Paper 18:** Improved hydrocarbon prospectivity and new play concepts in inboard Block SB301, Sabah  
*Charlie Lee et al. (SSPC)*
- 11.20 : **Paper 19:** 'H' and 'T' groups truncation play in PM309 — SE of Malay Basin  
*Muzammal A. Ghani and Mansor Ahmad (PRAD, PMU Petronas)*
- 11.50 : **Paper 20:** Identifying and evaluating producing horizons in fractured basement  
*Peter Majid Tandom et al. (Petronas Carigali, Vietnam Sdn. Bhd.)*
- 12.20 : **Lunch** (sponsored by Schlumberger)

## Wednesday, 24 November 1999

### **Session 4 : Afternoon Session**

#### **Session Co-Chairmen:**

**Rocky Becker** (XM, EPMI)

**Hoh Swee Chee** (Senior Manager, PRAD, PMU, Petronas)

- 13.30 : **Paper 21:** Seismic processing of Ocean Bottom Cable and streamer data over Seligi field  
*Lye Yue Choong and Abdul Razak Mohd Nurin (EPMI)*
- 14.00 : **Paper 22:** The prospectivity of the Dungun Graben — Block PM304, Malay Basin  
*Tan Bee Hoon et al. (Amerada Hess)*

- 14.30 : **Paper 23:** Application of pre-stack migration techniques in SSB/SSPC to improve seismic imaging and reduce exploration uncertainties  
*Jan Douma (SSB/SSPC)*
- 15.00 : **Paper 24:** Elastic impedance inversion for enhanced reservoir characterisation  
*Mark Sams (Jason Geosystems)*
- 15.30 : **Coffee Break**
- 15.50 : **Paper 25:** The role of sedimentology and sequence stratigraphy in the stochastic modeling of a carbonate reservoir  
*David Evans (Roxar)*
- 16.20 : **Paper 26:** Gravity anomalies, subsidence history, and tectonic evolution of the Malay and Penyu basins, offshore Peninsular Malaysia  
*Mazlan B. Hj. Madon (PRSS)*
- 16.50 : **Paper 27:** The use of fast-track 3D streamer and OBC data in the development drilling of Seligi  
*Pauline Wong (EPMI)*
- 17.10 : **Paper 28:** Kamunsu East-1: Shell Malaysia's first step into deep water — designing and executing an exploration test in a challenging deep water environment  
*Stephen Hart & Ha Kwong Tak (SSPC)*
- 17.40 : **Closing of Conference and Closing Remarks by Organising Chairman**

### **POSTER SESSION**

1. Oil families of eastern offshore Sarawak  
*Peter Abolins & Mike Scherer (PRSS)*
2. Petrography and organic geochemistry of Tertiary coals from Mukah-Balingian, Sarawak  
*Wan Hasiah & Nur Sharliza Mohd Rapi'an (University of Malaya)*
3. Biomarker distributions of the Upper Paleozoic sediments from East Pahang, Peninsular Malaysia  
*Amer Mohamed Ibrahim et al. (University of Malaya)*
4. Evidence for the origin of the West Baram Delta oils: marine versus terrigenous  
*Azlina Anuar & Abdul Jalil Muhamad (PRSS)*



# PETROLEUM GEOLOGY CONFERENCE '99

## Abstracts of Papers

### **Mergers, acquisitions and alliances: their impact on the petroleum industry in the next millennium**

BILL SCHAEFER, JR.

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Professor Dr. Ibrahim Komoo, Dato' Mohd. Idris Mansor, distinguished guests, fellow geologists, ladies and gentlemen. Good morning, and welcome to the 1999 Petroleum Geological Conference. First, I want to thank the Geological Society of Malaysia for inviting me to give the keynote address. I consider it an honor to be standing here before such a distinguished group of geologists.

This morning, I would like to explore with you the impact of Mergers, Acquisitions and Alliances on the Petroleum Industry in the next millennium.

With the discovery of the first commercial hydrocarbons in 1856, Colonel Drake changed the World. Without hydrocarbons and the Petroleum industry that was born from their commercial development, we would not have the fuel to drive automobiles, to fly planes, or to have propelled the industrial revolution out of the steam era. We would not have plastics, synthetic rubber, certain cosmetics and medicines and man would not have landed on the moon. We are part of one of the most important industries on earth. And it starts with you, the explorationist that finds that very valuable, though often under-priced, commodity called Oil and Gas.

Over the last 25 years we have seen our industry go through tremendous change. We've seen the technical evolution of seismic from a 2D exploration tool to a 3D exploration and development tool to a 4D development and engineering tool. We have used our enhanced technology and understanding of the earth to successfully unlock tremendous amounts of oil and gas reserves. Some may argue that we have been too successful. More on that later.

At the same time we have seen independent and major oil companies disappearing through mergers and acquisitions; the weaker companies being taken over by the strong ..... an industrial version, if you will, of Charles Darwin's biological thesis on the "survival of the fittest". Who would have guessed that such name brands as Gulf Oil, one of the original seven sisters, Sinclear, Getty, Union Texas and now, Mobil, Amoco and ARCO, to name just a few, would no longer be a part of our petroleum landscape. What, if anything, does this tell us about the petroleum industry's future. That's what I hope to explore with you this morning. The impact of Mergers, Acquisitions and Alliances on the Petroleum Industry during the New Millennium. And let me add, this is an Independent oil-mans perspective on the subject. Although I will not address the impact of mergers on academia, mining, nor the petroleum services industries, I believe that in most cases you will see a direct correlation.

Before we dust off our “collective” crystal ball to look at the future, let's take short journey back into the past. Let's find out what has driven our industry into an era referred to by the media as “Merger Mania!”

As reported by Ralph Nelson, “the Great Consolidation of the '90's cites as main factors, the generally favorable conditions of business combined with a rising, buoyant securities market at a time of too much productive capacity”. Sound familiar? Interestingly enough, this quote refers to the 1890's, not the 1990's! Mergers and Acquisitions have always been part of industry. During the late 19<sup>th</sup> century John D. Rockefeller built the Standard Oil Empire by acquiring oil fields and merging refineries. The Royal Dutch Company, the company that successfully found oil in Sumatra in 1885, was merged with Shell in 1907.

Later, driven by the energy needs of World War I, oil prices increased and remained strong through the 1920's industrial “boom” years giving the cash flow needed to support the petroleum industries growth. During the 1930's, we saw a dramatic increase in oil reserves, lead by Pop Joiner's discovery of the giant East Texas Oil Field, drive oil prices down to then unprecedented lows, and, as a result, drive many companies out of business or into the arms of competitors.

Were these early consolidations of our industry different than what we are seeing today? Were they the struggles of a new industry finding its feet, or were they the harbinger of things to come. During the late 19<sup>th</sup> and early 20<sup>th</sup> Century, most of the world was experiencing strong industrial growth as a result of the increased availability of cheap hydrocarbon energy. In the Petroleum Industry, independent and “major” oil companies of the day were consolidating to build larger, stronger companies to better provide the “new energy” required by a very competitive and very fast growing industrial world. Later, in the 1930's, with too much oil on the market resulting in lower oil prices, these same companies were consolidating to stay in business.

As you can see, mergers are not only a part of our petroleum industry, but arguably, gave it birth. Now let's fast-forward to more modern times and an event in the late 20<sup>th</sup> century that changed the energy business forever. From the 1940's until 1973 oil prices remained relatively stable at around US\$2.50–3.50/bbl. During 1973, as a result of the Yom Kippur War, Arab states called for an oil embargo on the United States, a defining event that lead to unprecedented high oil prices and a 13 year boom for the petroleum industry that makes earlier oil booms pale in comparison. With significantly increased cash flow from higher oil prices, the petroleum industry experienced increased exploration activity and production levels. And not unnoticed, increased number of personnel. The looming Oil Price Crash of 1986 was an unforeseen event to those oil-men of the 1970's and early '80's. There were, however, many hints of its inevitability as early as 1982 as oil prices began to drop from their 1980 peak, increased cost cutting measures such as layoffs began to emerge and the drilling rig count dropped dramatically. The radical growth of the petroleum industry driven by unprecedented high oil prices during the late 1970's and early 1980's was in 1986 about to come to an abrupt halt. It was time for a reality check. And reality was not a pretty picture.

Although cost-cutting measures had emerged in the early '80's as necessary for the industry, when the oil crash of 1986 arrived oil companies found themselves with high production costs, bloated staffs, excess production and low oil prices. Increased cost cutting measures had to be taken to survive. And as is characteristic of our industry, our performance was stellar. We brought down our collective finding and development costs from over \$20/boe in 1981 to less than \$5/boe in 1995. But, as you can see, most of these reductions were accomplished during the 1980's. By the turn of the decade we had squeezed just about all of the significant cost savings out of our companies possible. But oil prices remained volatile and except for special events such as the sinking of the Valdez and the gulf war crisis, prices seemed forever to stay on the low side. More had to be done to survive.

As a result, during the early 1990's major oil companies began to rationalize their non-core assets, and majors and independents alike began to expand overseas in an effort to find the large reserves that eluded them in the mature oil basins of the United States and Europe. There was an increase in Alliances to pool resources in order to cut costs and to enhance profitability. Innovation such as 3D seismic was helping find more hydrocarbons at less cost and mergers among independents and mini-majors were starting to get our attention.

Today it's hard to pick up a newspaper, trade journal or magazine without reading about some company being reorganized, restructured, re-engineered, merged, acquired or joining in an alliance. Why is this? What drives these companies to such measures and what are the benefits and negative aspects of such decisions? What impact will these decisions have on the next millennium? To find the answer, let's look at what drives mergers, acquisitions and alliances of the 1990's. And let's see what the benefits and negatives are for such strategies.

Although every merger, acquisition and alliance has its own rationale and dynamics, most have common drivers. One of the most important of which is the need for companies to continue to grow. As noted by Douglas Terreson, managing director for Morgan Stanley, the petroleum industries recent record is not good: "In recent years," he says "the energy industry has failed to generate the risk-adjusted returns that investors can get in other sectors of the S&P 500. This has led to slower earning growth, lower valuation and under-performance in the stock market." There are many reasons for this poor performance, foremost of which, is that the petroleum industry has been too successful at finding oil. There is just too much of the stuff around and too many companies producing it. Even with today's higher oil prices there is still a large "oil Bubble", as illustrated here by the Cambridge Energy Research Associates, of excess production capacity and there will be for several years to come.

Companies can no longer make an impact on their bottom line by continuing to cut costs. It's a process, at this point, of diminishing returns. One way, however, for oil companies grow and, at the same time cut costs, is to merge and then cut redundant costs. It has been announced that the mergers of Exxon/Mobil and BPAmoco/Arco will save the two combined companies US\$4.8 billion dollars/ year.

A barometer, if you will, showing the state of the consolidation of the petroleum industry is seen in the Oil and Gas Journal's annual report of the largest US companies. In 1985, 400 companies qualified for the listing. In 1990 the group was reduced to 300 and in 1995 only 200 companies could be found to qualify for the list. In September, the Oil and Gas Journal speculates that next year the list may drop to 150 companies!

As an example of just how fragmented the petroleum industry is, did you know the Exxon-Mobile combination will create the world's largest publicly traded oil company, but still will have only have 4% of the worlds oil production. This according to David Moore of Andersen consulting in an article in the July 23, 1999 edition of the Wall Street Journal. And, as you can see from the slide, it will take a combination of at least three or more of the majors to approach the size of even the smallest of the four Super-majors. Of course, as the largest companies get larger, it puts pressure on the smaller companies to do the same.

Globalization is another important driver. As larger and more expensive projects such as ultra-deepwater drilling and production and the exploration and development of such remote areas as the Former Soviet Union become available, only the larger companies will have the resources to pursue them.

Growth, production over-capacity and its resultant instability of prices, a fragmented industry and globalization are the key drivers of mergers, acquisitions and alliances, but they are not the only drivers.

Another force for merger is the competition from National Oil Companies, which at first diversified into downstream but have increasingly become more aggressive in the upstream sector, and not just within their nation's borders. For example, Petronas, one of the most successful National Oil Companies in the world, has since 1990 developed upstream presence in 12 countries outside of Malaysia and recently formed an Alliance with Premier adding Indonesia and Australia to its portfolio.

Other important drivers are deregulation, which is especially important in the refining and marketing business and gas and power utilities, the need for portfolio enhancement, the desire to increase market share, and the costs of environmental regulation, especially considering the Kyoto accords.

The benefits of Mergers, Alliances and Acquisitions can be significant. Increased size means more revenues, more capital and better access to capital, long term financial stability, more cost-cutting opportunities, larger pool of experts, bigger data bases, and access to larger upstream projects, to name a few. And not un-noticed by the service industry, bigger oil companies have more clout to squeeze the-hell-out of them for even more cost reductions.

But mergers and alliances are not all roses, there are thorns hidden in those bushes. As David Moore, Andersen Consulting, points out, "Mergers in general have a surprisingly high failure rate. About 44% of all large mergers completed between 1994 and 1997 fall short of their corporate parents initial financial and strategic expectations. As in a marriage, I suggest that you be very careful about that urge to merge, a bad partner can sometimes be deadly! Mr. Moore continues, "oil mergers are particularly mediocre, about 70% of them haven't achieved the benefits they sought to accomplish". The reason "synergies are difficult to obtain and take more time and effort to capture than companies expect."

A report from Mckinsey puts it this way, "buying a company is the easiest way to get bigger faster, but only 23% of acquisitions earn their cost of capital." Why such low rates of success? The main reasons are that the premiums paid are often too high, the joining of two disparate company cultures can be extremely difficult and disruptive, management indecision during the transition stage, project delays, lost time from re-organization, staff insecurity and the ill-well of employees, and government regulation.

Now, are you ready to look into that crystal ball? What will the impact of Mergers, Acquisitions and Alliances have on the next Millennium?

As you know, oil and gas are commodities and, as the last quarter century has shown us, the price of oil and gas is subject to a variety of pressures. As a result, the price of oil has been volatile and will most likely remain so in the future. Even if OPEC manages to control production, in the long term higher oil prices will cause OPEC to lose market share to non-OPEC countries and to alternative fuels, something they will most likely not allow to happen.

The industry will continue to have trouble raising funds during periods of low oil price, and even during periods of higher oil prices if capital markets don't believe price stability. Mergers and acquisitions allow for growth, for the larger entity to attract capital for larger projects and, at the same time, it provides an avenue for additional cost-cutting, an area where there is very little "self-help" left for companies.

As we've seen, Mergers, Acquisitions and Alliances have been a part of the oil industry from the beginning, and I suspect they will continue to be an important part of the industry's future. My crystal ball says, hang on, we are in for a bumpy ride. But I also see a light out there ..... it's called "demand". With the recovery of Asia in progress and the Former Soviet Union not far behind, with the energy needs of emerging nations and the ever increasing needs of an ever expanding world population, and as you can see by this slide, the earth's population growth will be a significant factor, the longer

term outlook for oil companies is good. For sure, it will be a future with fewer independents, fewer mini-majors and fewer major oil companies and, as a result, fewer employees. The companies with the best management teams, brightest and most talented staffs, strongest financial balance sheets and best resources will emerge as the successful and healthy oil companies of the next millennium. I should add, the survivors will also have successfully incorporated Mergers, Acquisitions and Alliances into their strategic thinking.

Will there be only half the number of niche E&P oil companies remaining in 10 years as predicted by Jack Taylor in a recent issue of *Oil and Gas Investor*? I don't know. But a recent article in *Forbes Magazine* points out that even in merchandizing, the most cutthroat industry of all, there is still room for the specialized boutiques to be profitable while working next door to mega-giant department stores. I believe this analogy is good for the petroleum industry as well. The independents, mini-majors, majors and super-majors will all find their place in the industrial "pecking order" and they will find a way to be profitable. The process will be enlightening for some and painful for others. As I said earlier, it will be a bumpy road but, in the end, we will have a healthier, stronger industry. The future is out there, and so will be the answers. In the meantime, as Captain John Luke Picard of *Star Trek* would say, "Engage, we are going where no person has gone before." I would add, you'd better tighten your seat belt!

With that, I conclude my presentation and I thank you for your kind attention.

## **Natural gas opportunities in Malaysia**

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The natural gas history in Malaysia started very much later than the oil. While the first oil production started way back in 1910, the first commercial sales of natural gas only started in 1983 with the commencement of the LNG project in Bintulu, Sarawak. This was later followed by the Peninsular Malaysia Gas Utilisation (PGU) and Sabah Gas Projects in 1984.

Malaysia is fortunate to have abundant natural gas resources. Natural gas is one of the resources that provide major contribution to the national economy. It has a major role to meet energy requirement and generate substantial export earning for the country. In coming years, its role is becoming more important as the currently being constructed and planned petrochemical plants rely heavily on gas for the feedstock.

The paper will review the status of upstream gas industry in Malaysia which covers gas resources, planned and future upstream gas development projects, outlook on gas utilisation as well as opportunities in the industry. Since the last decade, the industry has seen significant opportunities being created in the support and service industries as well as in fabrication industry. Sustainable exploration and development effort is vital for the growth of these industries. Thus, challenges in the gas development and efforts undertaken to ensure sustainable gas supply to the gas projects are also discussed.

## A new geological/geophysical framework for SE Asia

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Triggered by the great confusion pertaining to global geology today a completely new system of Earth evolution has recently been launched (Storetvedt, 1997). The new theory envisages that the Earth originally had a relatively thick pan-global sialic (continental type) crust, but that subsequent planetary cooling has rendered this surface layer chemically unstable, gradually replacing it by the much thinner basaltic crust of the deep oceans. The suggested internal mass reconstitution is consistent with modern seismic mantle tomography which shows that there exists a significant compositional difference between sub-oceanic and sub-continental mantles. On this new basis global tectonics becomes intimately linked to Earth's rotation, and, based on the classical physical principles of rotating planetary bodies Earth history becomes a chain of interrelated phenomena. Plate tectonic principles have no place in the new geological worldview.

By the end of the Cretaceous the present mosaic of variegated continental blocks and intervening oceanic basins was largely in place, and with the concomitant build-up of upper mantle low velocity layers the scene was set for a tectonic revolution on Earth. The time of the Alpine climax (late Cretaceous-early Tertiary) was a time of acceleration in Earth's rate of rotation (eastward) which triggered the classical inertia effects: a general westward wrenching of crust and topmost mantle (the 'lithosphere') within which the northern paleo-hemisphere was twisted clockwise and the southern paleo-hemisphere anti-clockwise. At that time the palaeoequator passed along the southern rim of the Mediterranean, continuing eastward just south of Sumatra/Java.

The counterclockwise rotation (and associated wrench deformation) of the southern Upper Cretaceous-Lower Tertiary palaeo-hemisphere produced extensive and curved tectonic lineaments across the Indian Ocean. It is envisaged that the broad 'N-S' striking shear belt along the Central Indian Basin (a major paradox for plate tectonics) came into existence through this global 'lithospheric' wrenching. The greater mid-ocean left lateral shearing also produced considerable under-thrusting (of the thin Indian Ocean crust) beneath the Indonesian Archipelago.

In the northern palaeo-hemisphere the corresponding phase of global westward wrenching brought about considerable shearing within the attenuated crust of Eastern Asia, producing the penetrative NE-SW structural grain along the NW Pacific margin. Continued loss of continental crust to the mantle, presumably through sub-crustal eclogitization processes, has had its most significant development along the prevailing deep faults, producing the narrow and deep NE-SW trending sedimentary basins as well as the horsts and half-graben structures characterizing the South China Sea. Further, the predominantly NE-SW shearing would be prone to produce rifting perpendicular to this structural grain, and therefore the NW-SE trending embayments/basins of Eastern Asia (Malay Basin, South Mekong Basin etc.) can be explained by crustal thinning ('oceanization') along such perpendicular fracture zones.

In addition to the more direct tectonic effects provided by global wrench deformation in Alpine time a 70 degrees of Neogene anticlockwise rotation of Australia and surrounding insular regions added considerable structural complications to SE Asia. The interacting regional stress fields led the way to a significant counterclockwise rotation of Borneo giving rise to major bending of the extensive Rajang Group (NW Borneo). Within localised transtensive regimes upper mantle material (ophiolites) were squeezed to the surface as

solid state intrusions, but the overall transpressive conditions led to significant regional tectonization and structural tightening of pre-existing strata not least in NW Sabah. The linear pattern of major oil and gas fields in SE Asia, and their close association with deep fracture zones, reiterates the discussion to which extent petroleum has a non-biological origin. The implications for hydrocarbon exploration may be significant.

## **Global wrench tectonics and its consequences for the tectonic evolution of the NW Borneo continental margin**

LEONG LAP SAU<sup>1</sup>, MUHAMMAD ADIB<sup>2</sup> AND KARSTEN M. STORETVEDT<sup>3</sup>

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Based on Storetvedt's new theory of Global Wrench Tectonics a reinterpretation of the structural history of the NW Borneo continental margin is proposed. The new evolutionary scheme has significant consequences for the tectonic development of Borneo and adjoining regions, including questions of formation of the NW Sabah Trough, clastic source areas, folding and thrusting, ophiolite occurrences, heat flow history, Tertiary uplift, and hydrocarbon potential.

According to variations in structure and depositional history the NW Sabah continental margin can be sub-divided into 6 units (Hazebroek and Tan, 1993) which in seaward direction are: 1, the mostly onshore Rajang Group Fold-Thrust Belt, forming a 1,000 km long and arcuate tectonic belt in NW Borneo; 2, Inboard Belt, a deep basin with more than 12 km of Neogene-Recent siliciclastic sediments with main deformation in late Miocene/early Pliocene; 3, Outboard Belt, a structurally complex NE-SW trending late Miocene-Pliocene basin with a western thrust front; 4, Baram Delta, depocenter with thrust front to the west (adjacent to the NW Sabah Trough); 5, NW Sabah Trough, a down-faulted, relatively narrow, part of the NW Sabah Platform reaching water depths of up to 2,800 m; and 6, NW Sabah Platform, the southern portion of the attenuated continental crust underlying the South China Sea basin. The offshore Luconia Province on the Sarawak shelf is characterised by numerous carbonate buildups upon a stable horst and graben basement. West of the Lupar Line lies the crystalline Sunda Shield.

To explain this tectono-stratigraphic sequence subduction of hypothesised South China Sea oceanic crust beneath NW Sabah (Haile, 1973; Hamilton, 1979) and diachronous collision of the NW Sabah Platform (Hazebroek and Tan, 1993) have been invoked, but we regard such plate tectonic thinking both unnecessary and untenable. Based on the new geological/geophysical framework of SE Asia (Storetvedt, this volume) we propose instead the following three-step development model for the NW Borneo continental margin:

1. Normal continental crust is thought to have originally occupied the present marginal seas of SE Asia, and extensive Alpine age sub-crustal 'chemical' thinning is held responsible for the variably attenuated crust presently observed in the region of the South China Sea. Worldwide

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H.D. TJIA

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Borehole breakout data, published and unpublished structural information of onshore outcrops and from offshore hydrocarbon exploration, and newly interpreted radar images



term outlook for oil companies is good. For sure, it will be a future with fewer independents, fewer mini-majors and fewer major oil companies and, as a result, fewer employees. The companies with the best management teams, brightest and most talented staffs, strongest financial balance sheets and best resources will emerge as the successful and healthy oil companies of the next millennium. I should add, the survivors will also have successfully incorporated Mergers, Acquisitions and Alliances into their strategic thinking.

Will there be only half the number of niche E&P oil companies remaining in 10 years as predicted by Jack Taylor in a recent issue of Oil and Gas Investor? I don't know. But a recent article in Forbes Magazine points out that even in merchandizing, the most cutthroat industry of all, there is still room for the specialized boutiques to be profitable while working next door to mega-giant department stores. I believe this analogy is good for the petroleum industry as well. The independents, mini-majors, majors and super-majors will all find their place in the industrial "pecking order" and they will find a way to be profitable. The process will be enlightening for some and painful for others. As I said earlier, it will be a bumpy road but, in the end, we will have a healthier, stronger industry. The future is out there, and so will be the answers. In the meantime, as Captain John Luke Picard of Star Trek would say, "Engage, we are going where no person has gone before." I would add, you'd better tighten your seat belt!

With that, I conclude my presentation and I thank you for your kind attention.

## **Natural gas opportunities in Malaysia**

MOHD. SABRI MOHAMED

PETRONAS-PMU

Level 28, Tower 1, PETRONAS Twin Towers  
Kuala Lumpur City Centre  
50088 Kuala Lumpur

The natural gas history in Malaysia started very much later than the oil. While the first oil production started way back in 1910, the first commercial sales of natural gas only started in 1983 with the commencement of the LNG project in Bintulu, Sarawak. This was later followed by the Peninsular Malaysia Gas Utilisation (PGU) and Sabah Gas Projects in 1984.

Malaysia is fortunate to have abundant natural gas resources. Natural gas is one of the resources that provide major contribution to the national economy. It has a major role to meet energy requirement and generate substantial export earning for the country. In coming years, its role is becoming more important as the currently being constructed and planned petrochemical plants rely heavily on gas for the feedstock.

The paper will review the status of upstream gas industry in Malaysia which covers gas resources, planned and future upstream gas development projects, outlook on gas utilisation as well as opportunities in the industry. Since the last decade, the industry has seen significant opportunities being created in the support and service industries as well as in fabrication industry. Sustainable exploration and development effort is vital for the growth of these industries. Thus, challenges in the gas development and efforts undertaken to ensure sustainable gas supply to the gas projects are also discussed.

## A new geological/geophysical framework for SE Asia

KARSTEN M. STORETVEDT

Institute of Geophysics  
University of Bergen  
Alleg. 70, N-5007 Bergen, Norway

Triggered by the great confusion pertaining to global geology today a completely new system of Earth evolution has recently been launched (Storetvedt, 1997). The new theory envisages that the Earth originally had a relatively thick pan-global sialic (continental type) crust, but that subsequent planetary cooling has rendered this surface layer chemically unstable, gradually replacing it by the much thinner basaltic crust of the deep oceans. The suggested internal mass reconstitution is consistent with modern seismic mantle tomography which shows that there exists a significant compositional difference between sub-oceanic and sub-continental mantles. On this new basis global tectonics becomes intimately linked to Earth's rotation, and, based on the classical physical principles of rotating planetary bodies Earth history becomes a chain of interrelated phenomena. Plate tectonic principles have no place in the new geological worldview.

By the end of the Cretaceous the present mosaic of variegated continental blocks and intervening oceanic basins was largely in place, and with the concomitant build-up of upper mantle low velocity layers the scene was set for a tectonic revolution on Earth. The time of the Alpine climax (late Cretaceous-early Tertiary) was a time of acceleration in Earth's rate of rotation (eastward) which triggered the classical inertia effects: a general westward wrenching of crust and topmost mantle (the 'lithosphere') within which the northern paleo-hemisphere was twisted clockwise and the southern paleo-hemisphere anti-clockwise. At that time the palaeoequator passed along the southern rim of the Mediterranean, continuing eastward just south of Sumatra/Java.

The counterclockwise rotation (and associated wrench deformation) of the southern Upper Cretaceous-Lower Tertiary palaeo-hemisphere produced extensive and curved tectonic lineaments across the Indian Ocean. It is envisaged that the broad 'N-S' striking shear belt along the Central Indian Basin (a major paradox for plate tectonics) came into existence through this global 'lithospheric' wrenching. The greater mid-ocean left lateral shearing also produced considerable under-thrusting (of the thin Indian Ocean crust) beneath the Indonesian Archipelago.

In the northern palaeo-hemisphere the corresponding phase of global westward wrenching brought about considerable shearing within the attenuated crust of Eastern Asia, producing the penetrative NE-SW structural grain along the NW Pacific margin. Continued loss of continental crust to the mantle, presumably through sub-crustal eclogitization processes, has had its most significant development along the prevailing deep faults, producing the narrow and deep NE-SW trending sedimentary basins as well as the horsts and half-graben structures characterizing the South China Sea. Further, the predominantly NE-SW shearing would be prone to produce rifting perpendicular to this structural grain, and therefore the NW-SE trending embayments/basins of Eastern Asia (Malay Basin, South Mekong Basin etc.) can be explained by crustal thinning ('oceanization') along such perpendicular fracture zones.

In addition to the more direct tectonic effects provided by global wrench deformation in Alpine time a 70 degrees of Neogene anticlockwise rotation of Australia and surrounding insular regions added considerable structural complications to SE Asia. The interacting regional stress fields led the way to a significant counterclockwise rotation of Borneo giving rise to major bending of the extensive Rajang Group (NW Borneo). Within localised transtensive regimes upper mantle material (ophiolites) were squeezed to the surface as

solid state intrusions, but the overall transpressive conditions led to significant regional tectonization and structural tightening of pre-existing strata not least in NW Sabah. The linear pattern of major oil and gas fields in SE Asia, and their close association with deep fracture zones, reiterates the discussion to which extent petroleum has a non-biological origin. The implications for hydrocarbon exploration may be significant.

## **Global wrench tectonics and its consequences for the tectonic evolution of the NW Borneo continental margin**

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<sup>1</sup>Geophysics Program, School of Physics  
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<sup>3</sup>Institute of Geophysics  
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Based on Storetvedt's new theory of Global Wrench Tectonics a reinterpretation of the structural history of the NW Borneo continental margin is proposed. The new evolutionary scheme has significant consequences for the tectonic development of Borneo and adjoining regions, including questions of formation of the NW Sabah Trough, clastic source areas, folding and thrusting, ophiolite occurrences, heat flow history, Tertiary uplift, and hydrocarbon potential.

According to variations in structure and depositional history the NW Sabah continental margin can be sub-divided into 6 units (Hazebroek and Tan, 1993) which in seaward direction are: 1, the mostly onshore Rajang Group Fold-Thrust Belt, forming a 1,000 km long and arcuate tectonic belt in NW Borneo; 2, Inboard Belt, a deep basin with more than 12 km of Neogene-Recent siliciclastic sediments with main deformation in late Miocene/early Pliocene; 3, Outboard Belt, a structurally complex NE-SW trending late Miocene-Pliocene basin with a western thrust front; 4, Baram Delta, depocenter with thrust front to the west (adjacent to the NW Sabah Trough); 5, NW Sabah Trough, a down-faulted, relatively narrow, part of the NW Sabah Platform reaching water depths of up to 2,800 m; and 6, NW Sabah Platform, the southern portion of the attenuated continental crust underlying the South China Sea basin. The offshore Luconia Province on the Sarawak shelf is characterised by numerous carbonate buildups upon a stable horst and graben basement. West of the Lupar Line lies the crystalline Sunda Shield.

To explain this tectono-stratigraphic sequence subduction of hypothesised South China Sea oceanic crust beneath NW Sabah (Haile, 1973; Hamilton, 1979) and diachronous collision of the NW Sabah Platform (Hazebroek and Tan, 1993) have been invoked, but we regard such plate tectonic thinking both unnecessary and untenable. Based on the new geological/geophysical framework of SE Asia (Storetvedt, this volume) we propose instead the following three-step development model for the NW Borneo continental margin:

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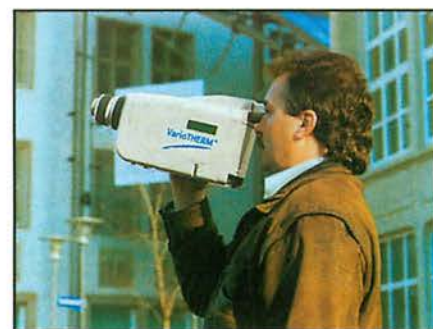
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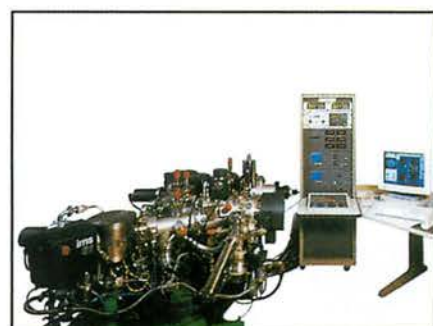
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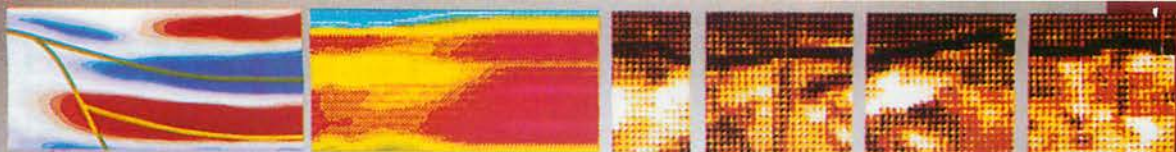


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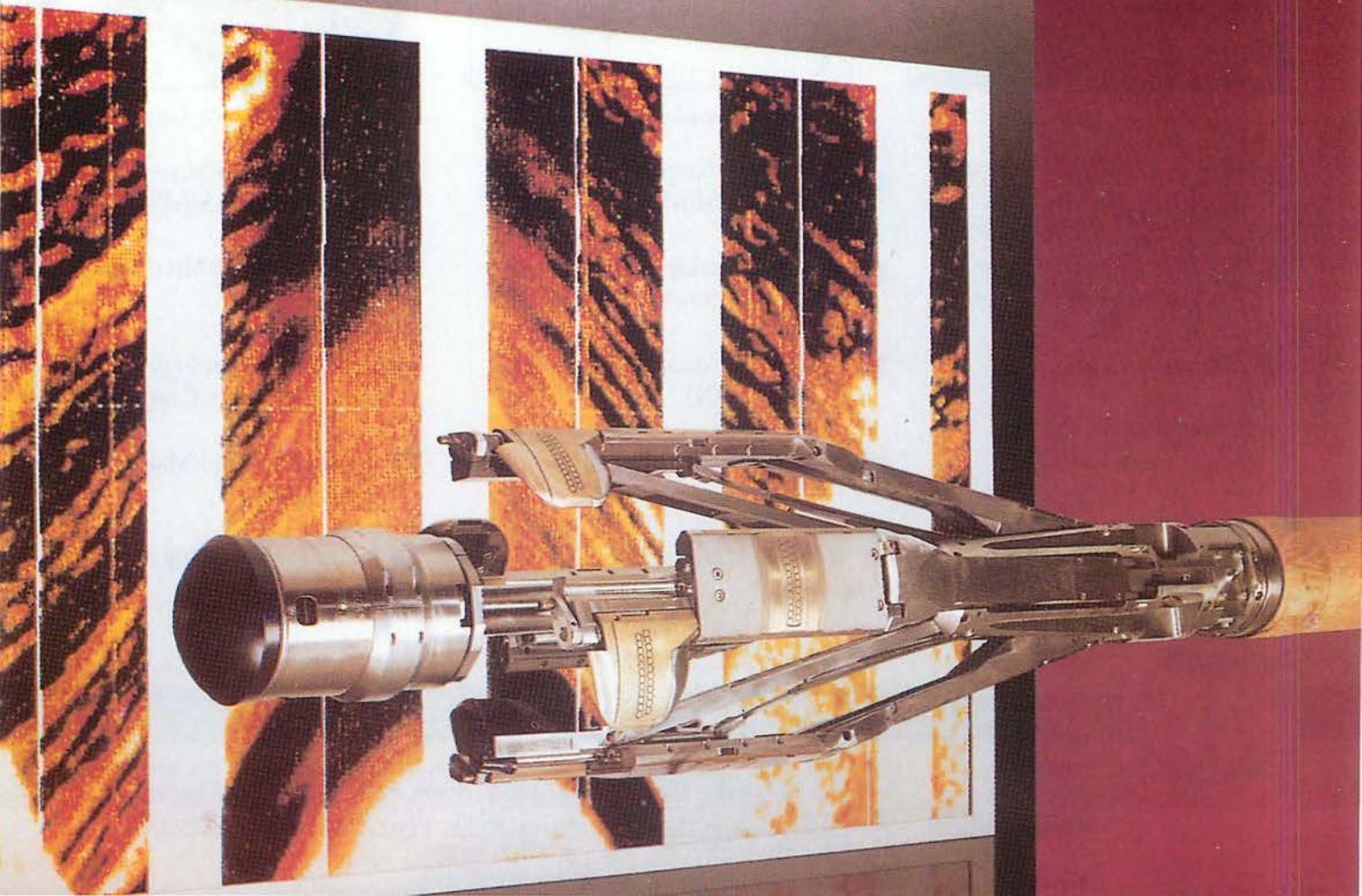
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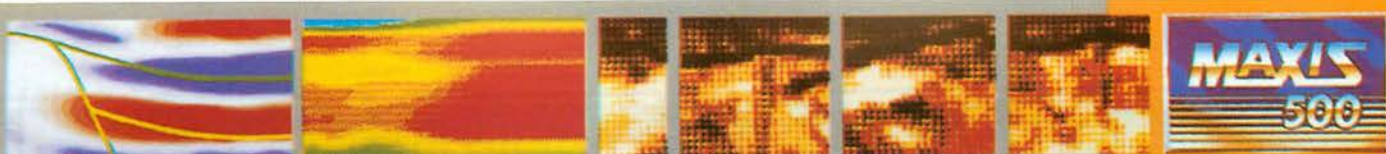
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HUTCHISON, C.S., 1989. *Geological Evolution of South-east Asia*. Clarendon Press, Oxford. 368p.

SUNTHARALINGAM, T., 1968. Upper Paleozoic stratigraphy of the area west of Kampar, Perak. *Geol. Soc. Malaysia Bull. 1*, 1-15.

TAYLOR, B., AND HAYES, D.E., 1980. The tectonic evolution of the South China Sea basin. In: D.E. Hayes (Ed.), *The Tectonic and Geologic Evolution of Southeast Asian Sea and Islands, Part 2. Am. Geophys. Union Monograph 23*, 89-104.

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Shallow marine topset environments are classic hunting grounds for stratigraphically enhanced traps. Offshore Sabah, eustasy and tectonics combine to provide a tantalising array of potential stratigraphic plays. In this presentation conceptual models of stratigraphic traps will be developed and applied to the subsurface seismic expression of the stratigraphy surrounding the TB3.4 sequence boundary. Seismic examples of complex truncation and detached shoreface traps will be described. The use of high density seismic in combination with AvO analysis will be shown as the best means of evaluating the hydrocarbon potential of these plays, but the key to prospect identification and ranking is understanding the complex geology inherent in low-stand and transgressive system tracts.

### **3D Post-stack Depth Migration: a step towards enhanced subsurface imaging**

**IDRUS MOHD SHUHUD<sup>1</sup> & M. FIRDAUS A. HALIM<sup>2</sup>**

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43000 Bangi

One of the emerging technologies that leverages more information from 3D data is the depth imaging technique. Prestack Depth Migration is widely accepted as a more accurate technique than the time domain techniques for solving imaging problems in complex structure.

Considering the voluminous amount of prestack data in a 3D survey and the intense computational nature of prestack depth algorithms, the costs involved for such project is inevitably high. Therefore, a balanced decision have to be made which takes into account the degree of improvement made on the data versus the economics of the project.

In this paper, we will present a case study which uses the Poststack Depth Migration technique to improve the image of the deeper exploration targets and as a tool to help to decide for the next step. The result shows quite significant improvements in terms of reflection continuity and structural delineation. Technically, it is concluded that, there is a high probability that the Prestack Depth Migration will deliver much better enhanced subsurface image.

## **Integrated Amplitude versus Offset (AVO) approach for delineating stratigraphic traps**

M. AZUDDIN M. YUSOF

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### **Introduction**

Amplitude versus Offset (AVO) effect can be explained as increase (or decrease) in seismic amplitude as offset increases. This could be related to lithology or hydrocarbons and should be viewed as a detail interpretation of seismic amplitudes (or attributes) which is based on migrated stacked data. High amplitudes that are seen on migrated seismic data could be caused by shale or coal and could be easily misinterpreted as Direct Hydrocarbon Indicator (DHI).

Exploration for stratigraphic trap is of higher risk but the reward can be spectacular since the closure is not limited to structural spill point. Specialized exploration tools such as 3D seismic have become economically feasible and the use of super computers has resulted in improvement in data quality and interpretation. 3D marine seismic data acquisition has become more efficient and even 3D AVO is becoming cheaper.

### **Integrated AVO analysis**

As a prerequisite, seismic processing steps need to be evaluated carefully to preserve amplitudes but commonly seismic data are processed to improve fault images and reflectors continuity, disregarding minute changes in seismic amplitude. Integration of well data or nearby well information is highly recommended to reduce risk since high amplitudes visible on seismic data do not necessarily related to DHI.

This paper will not emphasize much on the theoretical aspect of AVO but rather focus on the interpretation or analysis of AVO. The most common method of AVO analysis is to compare near angle (or near offset) migrated stacked data against far angle (or far offset) migrated stacked data at a particular seismic reflector to distinguish amplitude changes.

This near and far angle stack method, however, has a serious limitation. If we have a zone of interest that ranges from very shallow to very deep (for example from 0.5 to 3 km), the angle ranges from the shallow zone are different from the deeper zone. For example, at 0.5 km depth we might have angle ranges from 5 to 30 degrees but at 3 km depth the angle ranges from 1 to only 15 degrees. Sometimes, a middle angle range has been introduced in addition to the near and far angle ranges to remedy this situation, but from a seismic interpreter point of view, this would only result in more seismic data of poorer signal-to-noise ratio. Imagine if we have a 3D AVO cube for the near, middle and far angle migrated/stacked data; the disk space required for storing the seismic data alone could be huge.

Analysis of the normal move out (NMO) corrected common depth point (cdp) gathers should be conducted on lines with well control since this method is the most precise even though it consumes a lot of disk space.

### **Case Story — Field A in Malay Basin**

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first well (A1) was located close to the crest and penetrated numerous gas columns and based on the structural closure concept and Gas-Down-To, limited oil rim was modeled.

However in 1995, 3 more wells (A2, A3 and A4) were drilled downdip and encountered several oil legs. In the same year a 3D seismic survey was also conducted. The analysis of attribute maps and horizon slices indicated that thick meandering channels with high amplitudes are present at the flank of the structure. High amplitude blobs were also present and they were prognosed to be crevasse splays.

In 1997, two more wells (A5 and A6) were drilled further down dip to appraise remaining potential. The A5 well was drilled at structural spill point where oil-water-contact was prognosed but instead encountered full oil column at different pressure. The OWC could not be defined from well data.

AVO analysis was conducted on the 3D inline that passed through that well and produced encouraging results. At that particular reservoir, high amplitudes are noticed from the far angle stacked data. Even some coal beds could be differentiated from reservoirs.

## Conclusion

Results from the test line processing and interpretation have broadened in-house expertise on the AVO technique. The AVO analysis could also be used to upgrade the probable or possible reserves to proven reserves and delineating stratigraphic traps.

## Lithofacies sorting of organic matter and its implications for source rock potential

OUZANI BACHIR, WAN HASIAH ABDULLAH & AZHAR HJ. HUSSIN

Department of Geology  
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50603 Kuala Lumpur

The Nyalau Formation (Oligocene-Miocene) was deposited in a coastal deltaic environment. In the north of Bintulu, it has been recognised that the ideal sequence of the Nyalau Formation is a progradational tide dominated sequence, which coarsens upwards from offshore muds to sandstones. The sorting of the coal in the Nyalau Formation into different lithotypes is observed to be related to the associated lithology and is interpreted as the consequence of the processes in the depositional environment. The lithologic diversity is expressed by the maceral composition; coal seams associated with shales are liptinite-rich and those interlayered in the sandstones are vitrinite-rich. However, coal seams interstratified in the thinly bedded sandstones-muds facies show similar maceral composition as the coal associated with shales and sandstones. These variations are seen at different (microscopic and macroscopic) scales, suggesting that conditions of deposition controlled the coal lithotype sorting. This is attributed to the energy of the operating processes within the peat-forming environment. If the deposition occurred during high-energy events such as floods, tides, and wave action the liptinites are flushed and redeposited in the surrounding environments. Subsequently, if the energy of deposition is low, the flushing is inhibited allowing the deposition of a liptinite-rich *in situ* coal seam. The flushing of the organic deposits by the hydrodynamic agents such as floods and tides in lower coastal plain may strongly govern the coal liptinitic contents and consequently its source rock potential.

## **AVO analysis in Block SB305, offshore East Sabah, Malaysia**

**IDRUS MOHD SHUHUD<sup>1</sup>, M. FIRDAUS A HALIM<sup>2</sup> & SHAIDIN ARSHAD<sup>2</sup>**

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Kawasan Institusi, Bandar Baru Bangi  
43000 Bangi

Block SB305 is located in the southern part of Sandakan Basin in offshore East Sabah in water depth of 200 m. Initial hydrocarbon exploration was carried out by Aquitaine, which between 1965 to 1976, acquired approximately 1,072 km of 2D seismic data and drilled eight (8) exploration wells. The result was three gas discovery wells. Later, WMC shot 2,865 km of 2D seismic and drilled two wells within 1990 to 1995. Both wells had minor oil and gas discovery. Finally, an oil and gas well was discovered and drilled in the Nymphe-Benrinnes complex of a highly faulted structure.

AVO (Amplitude Variation with Offset) analysis was carried out on the Nymphe-Benrinnes complex to enhance the understanding of the potential of the area to assist in further efforts of commercial hydrocarbon exploration. Selected 2D seismic lines over the structure were reprocessed using prestack time migration as input for AVO analysis.

Based on the reconnaissance analysis (AVO attribute stacks), crossplotting and modelling using available sonic and density data, the results reveal several AVO anomalies at various locations. These anomalies define possibilities of occurrence of several different classes of AVO (Class I, II, III and IV) indicative of hydrocarbon presence.

## **Improved hydrocarbon prospectivity and new play concepts in inboard Block SB-301, Sabah**

**CHARLIE LEE, C. GRANT, F. OPRINSEN, N. MAT FIAH, P. GEORGE,  
TAN S.M. & WONG K.L**

Sabah Shell Petroleum Company  
Locked Bag No. 1  
98009 Miri, Sarawak  
Malaysia

Sabah Shell Petroleum Company (SSPC) acquired Block SB-301 in July 1997 and has since carried out an extensive regional evaluation to assess the hydrocarbon potential of the 'Inboard' area. Results to date have indicated a better hydrocarbon prospectivity than hitherto believed.

Hydrocarbon exploration activity in the Inboard area of Block SB-301 dates back as early as 1866 when a land well was drilled at "Raffles Anchorage", on the northern tip of Labuan Island. Since then a total of 22 land and 17 marine exploration wells have been drilled in the Block SB-301 Inboard area, resulting in five sub-commercial discoveries (SE Collins, Lokan, Raffles Anchorage, Klias and Tindak).

Shallow marine topset environments are classic hunting grounds for stratigraphically enhanced traps. Offshore Sabah, eustacy and tectonics combine to provide a tantalising array of potential stratigraphic plays. In this presentation conceptual models of stratigraphic traps will be developed and applied to the subsurface seismic expression of the stratigraphy surrounding the TB3.4 sequence boundary. Seismic examples of complex truncation and detached shoreface traps will be described. The use of high density seismic in combination with AvO analysis will be shown as the best means of evaluating the hydrocarbon potential of these plays, but the key to prospect identification and ranking is understanding the complex geology inherent in low-stand and transgressive system tracts.

### **3D Post-stack Depth Migration: a step towards enhanced subsurface imaging**

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One of the emerging technologies that leverages more information from 3D data is the depth imaging technique. Prestack Depth Migration is widely accepted as a more accurate technique than the time domain techniques for solving imaging problems in complex structure.

Considering the voluminous amount of prestack data in a 3D survey and the intense computational nature of prestack depth algorithms, the costs involved for such project is inevitably high. Therefore, a balanced decision have to be made which takes into account the degree of improvement made on the data versus the economics of the project.

In this paper, we will present a case study which uses the Poststack Depth Migration technique to improve the image of the deeper exploration targets and as a tool to help to decide for the next step. The result shows quite significant improvements in terms of reflection continuity and structural delineation. Technically, it is concluded that, there is a high probability that the Prestack Depth Migration will deliver much better enhanced subsurface image.

## **Integrated Amplitude versus Offset (AVO) approach for delineating stratigraphic traps**

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### **Introduction**

Amplitude versus Offset (AVO) effect can be explained as increase (or decrease) in seismic amplitude as offset increases. This could be related to lithology or hydrocarbons and should be viewed as a detail interpretation of seismic amplitudes (or attributes) which is based on migrated stacked data. High amplitudes that are seen on migrated seismic data could be caused by shale or coal and could be easily misinterpreted as Direct Hydrocarbon Indicator (DHI).

Exploration for stratigraphic trap is of higher risk but the reward can be spectacular since the closure is not limited to structural spill point. Specialized exploration tools such as 3D seismic have become economically feasible and the use of super computers has resulted in improvement in data quality and interpretation. 3D marine seismic data acquisition has become more efficient and even 3D AVO is becoming cheaper.

### **Integrated AVO analysis**

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The poor exploration success rate in the Inboard area has routinely been attributed to two main factors: the lack of hydrocarbon charge and a lack of seal. However, recent evaluations, involving well data review, satellite slick detection, sea bottom sampling and field work have shown that hydrocarbon charge is not a problem. Instead, hydrocarbon retention is believed to be the main risk. Previous exploration wells in the Inboard area targeted structural plays, with Stage IVA topsets as the primary objective. The wells were usually located on structural highs and ridges, which show complex deformation and therefore had a high risk for seal breach.

The hydrocarbon potential of the Block SB-301 Inboard area lies in the nine identified mini basins. These are relatively undeformed and contain a thick succession of Miocene siliciclastics. The hydrocarbon prospectivity of the mini basins remains largely unknown and untested.

Detailed interpretation of reprocessed and new 2D seismic lines in the Inboard area, together with results of a well review, has allowed the Inboard area to be systematically mapped. A number of new plays have been identified, and these are grouped into 3 age and objective related categories: Pre-DRU Plays, Inter-DRU-SRU Topset Plays and Inter-DRU-SRU Turbidite Plays. The major play types are further subdivided into 16 sub-play types based on the structural and stratigraphic configuration: Buried Hill/Reef, Pondered/Channelised Turbidites, Base of Slope/Slope Fans, DRU Subcrop, Basal Stage IVA Onlap, Transpressional Pop-up/Thrust, Truncation against Shale Injection, SRU Subcrop, Basin Margin Footwall Closure, Up-dip Shelf Edge Pinch-out, Shelf Edge Failure Truncation Trap, Crestal Footwall Closure, Inversion Induced Dip Closure, Wrench Induced Faulted Anticline, Distal Onlaps, Pondered Fan Systems, Channel-fill Deposits and Slump Induced Closure.

Selected examples of these plays will be presented.

## **'H' and 'I' groups truncation play in PM309 — SE of Malay Basin**

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The interpretation of the H and I groups truncation was carried out in the eastern part of Block PM309, SE of Malay Basin with the aim of identifying new hydrocarbon play.

PM309 of the southeastern part of Malay Basin lies in the prolific oil and gas province whose structures were formed during the Early to Middle Miocene time. The tectonic movement during this time which resulted the folding and uplift of the eastern portion of the Malay Basin gave rise to high relief anticline which now form the major producing trend. The axial region of this anticline became exposed and were eroded with the greatest amount of sediment stripping occurring in the most easterly portion of PM309 where the section, down to middle of Lower Miocene, mainly H and I groups has been removed. This is followed by a period of major marine transgression where the transgressive shale acts as effective seal in this group D formation. The truncated H and

I formations abutting against the overlying group D formation hence form good stratigraphic trap. This study is therefore, to identify any stratigraphic trap with relation to this unconformity.

The H and I Petroleum System is sourced from intraformational coals and coaly shales (type II/III) deposited in a coastal/delta plain environment. The source beds are high in T.O.C., up to 78% in the coals and show good oil source potential. Hydrocarbon is expected to be generated from the deep mature source and migrated laterally and updip into the stratigraphic trap/s.

This study has identified possible hydrocarbon trap/s in the H and I truncation play. Some amplitude anomalies could be observed at the reservoir level which could be related to hydrocarbon occurrence.

With the existence of favourable hydrocarbon system and with the help of distant hydrocarbon migration into the trap/s, this stratigraphic play may be a viable prospect to be explored in the future.

## **Identifying and evaluating producing horizons in fractured basement**

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<sup>3</sup>Schlumberger, Malaysia

This paper will describe the results of development drilling to date in the basement reservoir of the Ruby Field in the Mekong Basin, Offshore Vietnam.

The results of joint research on the Ruby discovery wells and onshore basement exposures (Peter M. Tandom *et al.*, 1997) were used to develop an interpretation model for the fractured and weathered granite reservoir. This model has proven very robust, and has now been further enhanced by applying more quantitative formation evaluation techniques to determine fracture aperture and porosity. Various acquisition techniques and computation algorithms have been tested to come up with an optimized (single trip in the hole) logging program; giving consistent results compared with core analysis and production data.

Having developed a geological model for the field, and carefully matched well data with reprocessed 3D seismic, it has been possible to identify faults and fracture zones across the field. Fracture zones can be recognized by their lower acoustic impedance, and by the generation of characteristic diffraction patterns. These effects are often quite subtle, however, but with the help of Coherence Cube techniques, and after detailed comparison with the fracture properties where we have well control, we feel that not only faults, but also zones of fracturing can be identified with some confidence.

Directional wells drilled towards the NE and SW (perpendicular to the direction of maximum horizontal geostress), and penetrating sections where there is evidence of both faulting and fracturing on the seismic, have indeed proven to be the best producers.

It is now possible to predict with some certainty the most prospective hydrocarbon

bearing intervals, and work is currently being focused on the estimation of likely production rates. Failure to meet the expected well deliverables provides a criteria for identifying candidates for stimulation. These techniques will also be reviewed.

As more wells are drilled, it has become possible to better correlate and map the producing horizons. This clearly allows better planning of the location of future wells, and the thickness of the reservoir section which needs to be penetrated, so optimizing field economics.

## **Seismic processing of Ocean Bottom Cable and streamer data over Seligi field**

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In 1998 EPMI initiated a new 3D seismic survey over Seligi field where seven platforms are presently active. The main objective of this project is to obtain a very high quality data set for development drilling and for identification of infield opportunities. A total of 14,700 km of seismic data was shot using a combination of Ocean Bottom Cable (OBC) and conventional marine streamer techniques. The main reasons for using two acquisition techniques are to collect data near to or underneath the platforms and to minimize the cost of acquisition. This dual mode of acquisition involves a higher level of technical difficulties both in acquisition and processing of the data, as care had to be taken to ensure the compatibility of the two data sets.

The two-component OBC data were recorded using a hydrophone and a geophone. The first step in OBC processing is to calibrate the geophone data to the hydrophone data in terms of phase and amplitude. The calibrated data is then summed together to remove the receiver ghost that is inherent in OBC data. After summing, the OBC data was processed using the conventional marine streamer processing sequence. A proprietary PHIFAR filter was applied to both the OBC and streamer data to dephase and convert the data into zero phase. OBC data were found to be very sensitive to velocities. A velocity error of 2% or more will produce scalloped reflections on the crosslines. Considerable time and effort was spent in velocity analysis and quality control.

The OBC and streamer data were stacked separately. The signal to noise ratio and the bandwidth of both data sets were exceptionally good with the usable frequency up to 110 Hz. The next challenge in processing was to match the OBC data to the streamer data. Analysis of the data shows that there is less than 20 degrees difference in phase and less than 2 ms time difference between the two data sets. The bandwidth of the two data sets was also very similar and matching filter was found to be unnecessary. However, a 12dB constant gain was applied to the OBC data to bring its RMS amplitude up to the level of the streamer data. The amplitude difference is due to different instrument response between the OBC cable and the solid marine streamer. The OBC data matches seamlessly into the streamer data.

Detailed quality control at every step of the processing sequence and working closely with the processing contractor is the key to producing a very high quality OBC data set for the interpreter.

## **The prospectivity of the Dungun Graben — Block PM304, Malay Basin**

TAN BEE HOON<sup>1</sup>, MOHAMMAD JAMAAL HOESNI<sup>2</sup> & DAVID MACKERTICH<sup>1</sup>

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The Dungun Graben lies on the south-western margin of the Malay Basin some 50 km due east of the town of Dungun on the east coast of Peninsular Malaysia. In outline the graben is rhombic in shape, elongate in NNW-SSE orientation, the same as the Malay Basin. It is 35 km in length reaching a maximum of 10 km in width. Sediment infill is interpreted to have changed from lacustrine to deltaic and ultimately to fluvial. The basement is probably entirely of metamorphic or crystalline origin and thought to be of Lower Cretaceous age.

The Dungun Graben lies entirely within Block PM304, operated by Amerada Hess (Malaysia) Ltd. Following 2D seismic acquisition in 1998, a geochemistry study was undertaken one of the aims of which was to assess the hydrocarbon potential of the graben. No wells have been drilled in the graben and subsequently seismic facies analysis was utilised in basin modelling and source rock prediction.

Critical factors in formation of hydrocarbons in the Dungun Graben are the source rock maturity and, to the lesser extent, the source quality. Maturity modelling show most of the section in the graben is immature, with the exception of late Oligocene sediments (Group M). Given the size and depth of the graben (< 3,200 m) it is unlikely that source rocks will have been buried deep enough to generate and expel significant quantities of hydrocarbons. Similar pull apart features are likely to exist further north along the western margin of the basin or possibly on the eastern side of the basin. If these were to be buried deep enough they could constitute a viable hydrocarbon play in this region.

### **Application of pre-stack migration techniques in SSB/SSPC to improve seismic imaging and reduce exploration uncertainties**

JAN DOUMA

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A crucial step in seismic processing is the application of migration techniques. An optimum migration ensures proper imaging and positioning of seismic events. In conventional processing post-stack time migration is the most commonly applied migration technique. For geological settings with mild velocity variations this technique gives satisfactory results. However, for more complicated structures with strong velocity variations post-stack time migration results are sub-optimum and more advanced migration methods such as pre-stack time migration and pre-stack depth migration should be applied.

These pre-stack migration methods are generally CPU and labour intensive, especially in pre-stack depth migration which requires velocity model building. Although the turnaround time is relatively long and costs are generally high for processing projects with pre-stack migration, the improvement in imaging and positioning of seismic events can significantly reduce exploration and production risks, thus leading to large cost savings and improved financial performance of an E&P company.

This paper describes the successful application of 2D and 3D pre-stack migration techniques in the in-house processing centre in SSB/SSPC.

## **Elastic impedance inversion for enhanced reservoir characterisation**

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Inversion of seismic data generates an impedance volume. The impedance volume contains all the information in the seismic data and removes the deleterious effects of the wavelet. Impedance, which is an absolute property of the rock layers, is usually related to parameters that characterise the important properties of hydrocarbon reservoirs. Impedance volumes are therefore used as the basis for static and dynamic models of reservoirs. Typically inversion is carried out on stacked seismic data. It is assumed that the stacked seismic data represent a zero offset response and that the output from inversion is acoustic impedance. The acoustic impedance contains information about the rock density and compressional velocity.

These days many more different types of seismic data are becoming available: angle stacked, offset stacked, mode converted and multiple component. All these seismic types can also be inverted to generate impedance. The impedance generated from these seismic data types is elastic impedance. The elastic impedance contains information about the rock density, compressional and shear velocity. These rock properties are the same as those that determine the seismic AVO response. Elastic impedance therefore combines the benefits of AVO analysis and inversion. That is giving quantitative information on the lithology and fluid distribution within the reservoir volume.

In one case study, a far angle stack was inverted for elastic impedance. The elastic impedance was able to delineate a Class II gas sand that would have been missed by acoustic impedance inversion. The elastic impedance allowed rapid gas sand delineation for a variety of sands and volumetric analysis. In a second case study, a mode converted seismic data set was inverted for elastic impedance. The elastic impedance was able to discriminate between good and poor quality reservoir. This was not possible from the acoustic impedance. The elastic impedance allowed rapid reservoir delineation and interpretation of individual sand bodies within the reservoir.

Elastic impedance inversion permits fast, accurate, quantitative analysis of reservoirs enhancing the interpretation from acoustic impedance inversion.

## **The role of sedimentology and sequence stratigraphy in the stochastic modeling of a carbonate reservoir**

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In the late 90's progressive exploration and production companies are embracing new technologies including computer software in order to help them better understand reservoir architecture and to develop the resources contained in these reservoirs.

Roxar as a major supplier of geological modeling software via its IRAP RMS 3D geological modeling package often sees 3D geological models being constructed with little real geological data. Any geological model be it deterministically or stochastically derived must have good basic geological data to condition it. The old adage "garbage in garbage out" is very relevant to 3D geological modeling.

Carbonate models on the whole require a greater geological understanding than clastic models and are often over simplified. An E&P company collects millions of dollars worth of geophysical, geological and engineering data during appraisal drilling. The consequences of not coupling this data with an understanding of the sedimentology and sequence stratigraphy prior to model building will result in a flawed 3D stochastic reservoir model being generated. This translates into frustration with the software, and wasted man-hours and dollars.

Achieving a good understanding of sedimentology and sequence stratigraphy will enable the modeling of facies and petrophysical attributes to be done in a consistent manner, therefore resulting in accurate facies patterns both spatially and in depth.

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## **Gravity anomalies, subsidence history, and the tectonic evolution of the Malay and Penyu basins, offshore Peninsular Malaysia**

MAZLAN B. HJ. MADON

PETRONAS Research & Scientific Services Sdn. Bhd.  
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Bandar Baru Bangi, 43000 Kajang  
Malaysia

The tectonic subsidence and gravity anomalies in the Malay and Penyu basins, offshore Peninsular Malaysia, were analysed using gravity, well, and thermal history data. These extensional basins contain up to 14 km of sediment fill which implies that the crust beneath them had been thinned significantly during basin development. Gravity data were used to investigate the isostatic compensation mechanism of these basins. The basins are characterised by broad negative free-air gravity anomalies of between -20 and -30 mGal. Gravity modelling results show that they are underlain by a relatively thinned crust, indicating some form of crustal stretching, but the Moho depth calculated based on the free-air gravity data is about 25% deeper than that predicted by Airy

isostasy (Backstrip Moho). This suggests that the Airy model overestimates the compensation and that the basins are probably undercompensated isostatically. The discrepancy between the gravity-derived Moho and the Backstrip Moho suggests that there is an extra amount of tectonic subsidence that is not compensated by crustal thinning. This uncompensated or anomalous tectonic subsidence is interpreted to be due to thin-skinned crustal extension that did not involve the mantle lithosphere. These results appear to be consistent with the strike-slip tectonic history of the basins.

## **The use of fast track 3D streamer and OBC data in the development drilling of Seligi**

PAULINE WONG

Esso Production Malaysia Inc.  
Menara ESSO  
Off Jalan Kia Peng  
50450 Kuala Lumpur

A comprehensive depletion management study for the Seligi field in 1997 identified the need for a new 3D study. Since 7 active platforms are present over the field, a combination of Ocean Bottom Cable (OBC) and conventional streamer 3D techniques were deployed to ensure full fold coverage. Objectives of the new survey were to define the current fluid distribution over the field and thus to identify infill drilling opportunities. Streamer data over the Seligi-F area was fast-track processed in order to optimize development drilling which was on-going during that period. This fast-track cube enabled a number of major improvements to the interpretation and resulted in a very successful development drilling program. Similarly, OBC data over the Seligi-H area was fast-track processed for input into the ongoing North Seligi Development Plan.

In the Seligi-F area, three main areas of improvement were identified in the new fast-track survey. Higher resolution within the group K section has allowed more accurate identification of the DHI response for the K-10 reservoir. Improvements in the data quality and resolution can be attributed to using solid streamers for reducing noise, 4 times smaller inline spacing (25 m) and higher frequencies of 100 Hz vs. 70 Hz (at 2 secs) on the older 1985 3D survey. Additionally, inversion of this higher resolution dataset has enabled reservoir quality changes within the J-20 reservoir to be delineated on the basis of acoustic impedance. Finally, higher quality, denser spatial sampling coupled with more optimal line orientation has resulted in a better imaged fault network. Integration of this improved structural and stratigraphic framework with reservoir depletion management techniques has aided the completion of the 32 well Seligi-F development drilling program. Seismic input resulted directly in the drilling of 4 additional wells and added a further 6.7 MBO EUR to the going-in Seligi-F reserves.

In the Seligi-H area, the higher resolution and greater bandwidth of the OBC dataset has given a better delineation of the amplitude anomaly and stratigraphic events associated with the J-15/16 reservoir. Analysis of this anomaly and comparison with the older survey is being used to investigate 4D time lapse effects over the Seligi field.

Seamless integration and merging of the streamer and OBC datasets over the entire field is now enabling the improvements seen and interpreted on the fast-track cubes to be extrapolated to the entire field. Integration of this high quality seismic dataset with production data is currently being utilized to further optimize the Seligi field reservoir management.

## **Kamunsu East-1: Shell Malaysia's first step into deep water — designing and executing an exploration test in a challenging deep water environment**

STEPHEN HART & HA KWONG TAK

Sabah Shell Petroleum Company  
Locked Bag No. 1, 98009 Miri  
Sarawak Malaysia

Shell Malaysia's first deep water well, Kamunsu East-1 (KME-1, -S1), was drilled in 1998 off north-west Sabah in a water depth of 2,417 feet. The exploration success has increased the gas reserve base in a very prospective area. KME-1 was drilled and abandoned in 49 days, including 10 days rig move and with an extensive coring and logging programme. The final well cost of US\$12 Million was US\$7 Million below budget, and has shown that drilling in this deep water area need not be prohibitively expensive. This has had a major positive impact on the economic viability of the Sabah deep water acreage. The discovery has given added impetus to commercialise Sabah gas and future work will concentrate on developing the Keabangan-Kamunsu area.

Sarawak Shell Berhad/Sabah Shell Petroleum Company's (SSB/SSPC) Keabangan-Kamunsu Asset stretches from the shelf edge (water depths around 460 ft) into the deep water basin (around 5,600 ft). The area has a high prospectivity for gas within a sand-rich Miocene turbidite fairway. Prior to KME-1, SSPC's main asset was the Keabangan gas discovery. Exploration assessments indicate geophysically well-defined prospects with gas scope volumes in the Tcf range. Significant Oil/NGL volumes have not yet been proven, though oil charge in the area has been demonstrated by sea bottom sampling and satellite slick detection. In the cluster of prospects, Kamunsu East was drilled as the best-defined geophysically, with the highest POS and the highest volumetric potential. The well was, however, economically 'strategic' in that the prospect was likely gas-bearing and would be a challenge to commercialise in the short-term.

The exploration highlights of the well will be discussed, and the main learning points from the planning and operations, specifically:

- Integrated well planning, tapping into Shell Group experience of deep water operations.
- 2D vs 3D well proposals and optimisation of the well trajectory.
- 3D location selection and Visualisation/Body checking.
- Pre-Stack Depth Migration (PSDM).
- Pressure prediction using seismic velocities.
- Logging and coring, but NOT testing.
- No Site Survey.
- Calculated risk-taking: use of an upgraded rig and drilling during the monsoon.



# PETROLEUM GEOLOGY CONFERENCE '99

## Abstracts of Posters

### Oil families of eastern offshore Sarawak

PETER ABOLINS<sup>1</sup> & MIKE SCHERER<sup>2</sup>

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Bandar Baru Bangi, 43000 Kajang

<sup>2</sup>Sarawak Shell Berhad

<sup>2</sup>Sarawak Business Unit, Exploration EPK-SUP  
Locked Bag No. 1, 98009 Miri, Sarawak

The eastern side of offshore Sarawak marks the meeting place of three geological provinces: Central Luconia, Balingian, and the Baram Delta. Each of these provinces are proven petroliferous (sub)basins with fields presently producing appreciable amounts of oil and gas.

This geochemical evaluation of oils and condensates from eastern offshore Sarawak is based upon geochemical characterisation using numerous advanced geochemical techniques, such as GCMS and stable carbon isotope analysis. The geochemical characteristics thus gathered can be used to group oils and condensates into families and to correlate identified oil families with specific source rock environments.

In many parts of the study area, source rocks were not encountered. All that is known of their existence is the hydrocarbons that they generated. An example of such a situation is the B11/B12 area in the eastern sector of the Central Luconia province. An important objective of this study, therefore, was to obtain information on the effective source rock types from the geochemical characteristics (predominantly biomarker distributions) of the oils and condensates that were generated.

Maturity studies dictate that only Cycle I/II/III sequences can be effective source rocks over much of the study area. There has been a long-standing belief that the lower coastal plain land-plant derived coaly sequences have been responsible for the majority of hydrocarbons encountered offshore Sarawak. Biomarker and isotope studies discussed here indicate that this is not always the case. The more easterly hydrocarbons clearly have a marine signature (e.g. B11 and B12). It is only in western areas of Balingian and Central Luconia that fully lower coastal plain biomarker signatures are displayed (e.g. D35, D18). In central regions (between D35 and B11), changes in the geochemical characteristics of oils and condensates indicate a gradually changing source facies which mirrors the changing depositional setting at the time of source rock deposition. These gradational changes are most enigmatically displayed in the Jintan/M4 area where overlying condensates have distinctly different biomarker distributions from those of the underlying oil rims.

In the extreme east of the study area, on the offshore part of the Baram Delta proper, the source facies of the oils revert back to lower coastal plain, with only limited marine input.

## Petrography and organic geochemistry of Tertiary coals from Mukah-Balingian, Sarawak

WAN HASIAH ABDULLAH & NUR SHARLIZA MOHD RAPI'AN

Department of Geology  
University of Malaya  
50603 Kuala Lumpur

A total of ten coal samples collected within the southern part of the Mukah-Balingian area, between the Batang Mukah in the west and Batang Balingian in the east, were subjected to detailed organic petrological and organic geochemical study. The aim of this study is threefold: to determine the thermal maturity of the coals, their depositional environments, and their hydrocarbon generating potential.

The coals analysed are low in rank, that is lignite to sub-bituminous C with mean vitrinite reflectance (% Ro) values in the range of 0.3 to 0.4%. On average they contain 56% vitrinite, 32% liptinite (exinite), 3% inertinite, and 9% mineral matter. All of these coals are of a humic type. Based on the TPI (Tissue Preservation Index) versus GI (Gelification Index) plot that was derived from the maceral analysis data, all of the samples studied were deposited in limnic and limno-telmatic regimes of a lower delta plain setting. Some of the samples may have been deposited under the influence of lagoonal brackish water conditions. The maceral-based interpretation of the environment of deposition is to a certain extent supported by palynological data as suggested by the presence of *Calophyllum* and *Palaquium* species that are commonly associated with wet peat swamp condition of deposition. XRD analysis performed on a clay sample that was beneath the coal deposit is shown to be rich in kaolinite: an association commonly observed within peat swamp depositional environments.

Based on the organic geochemical data, a high yield of extractable organic matter (EOM) of more than 2,000 ppm and hydrocarbon yield of more than 500 ppm were recovered. The average aliphatic hydrocarbon yield is 8%, aromatic yield 23%, and NSO compounds 69%. Triterpanes occur in high abundance relative to steranes. The hopane distribution is generally dominated by C<sub>29</sub> or C<sub>31</sub> hopane. C<sub>30</sub> hopane occurs in low relative abundance compared to C<sub>29</sub> hopane. The predominance of R isomers compared to S isomers of the C<sub>31</sub> homohopane supports the immature nature of these coals as suggested by vitrinite reflectance data. At greater depth or upon reaching sufficient thermal maturity, good oil and gas generating potential can be expected from these coals owing to their high liptinite content. Based on coal facies interpretation, it is apparent that the coals possessing the greatest oil-generating potential were deposited within a limno-telmatic marsh sub-environment mostly under fluvial influence.

## **Biomarker distributions of the Upper Palaeozoic sediments from East Pahang, Peninsular Malaysia**

AMER MOHAMED IBRAHIM, WAN HASIAH ABDULLAH & AZHAR HJ. HUSSIN

Department of Geology  
University of Malaya  
50603 Kuala Lumpur, Malaysia

A number of organic-rich sediments of the Upper Palaeozoic Kuantan Group of East Pahang were analysed for their biomarker distribution. These sediments consist of shales and coaly shales from the Charu and Sagor Formation, and a Panching Limestone sample. The TOC content varies from trace amounts in the limestone to about 9 wt % in the coaly shales. Although negligible in TOC, the organic origin of the limestone is evidenced by the presence of shell debris and algal fragments within the sample. The thermal maturity of all the samples analysed is in the range of 1.08–1.13% mean vitrinite reflectance, indicating that these sediments have reached a high level of thermal maturity (late oil window).

The biomarkers analysed include n-alkanes, isoprenoids, terpanes, and triterpanes. The gas chromatograms of the saturated hydrocarbon fractions of the Charu and Sagor samples display a smooth high end-member distribution of n-alkanes extending beyond n-C<sub>30</sub>. A relatively lower abundance of n-alkanes is displayed by the limestone sample. Most of the samples show evidence of slight biodegradation as suggested by the presence of unresolved complex compounds and the loss of some of the lower molecular weight n-alkanes. The strong predominance of high molecular weight n-alkanes in the shales/coaly shale of the Charu and Sagor formations suggest significant input of higher land plant organic matter into these sediments.

The Panching limestone sample is dominated by nC<sub>17</sub>–nC<sub>19</sub> alkanes suggesting significant contributions of algal-derived organic matter. The even n-alkane predominance commonly associated with limestones is apparent within the medium range (nC<sub>14</sub>–nC<sub>19</sub>) of the Panching limestone analysed. The possible presence of C<sub>21</sub> highly branched isoprenoid is noted in this limestone sample but is not observed in the other samples. The lack of higher land plant-derived organic matter within the Panching limestone sample is evident from the low concentration of higher molecular weight n-alkanes compared to the Charu and Sagor sediments.

No distinct variation is observed for the Ts/Tm ratio (generally considered to be associated with higher land-plant organic matter) among the samples studied, suggesting this ratio may not be indicative of source input but are strongly influenced by the high thermal maturity attained by all of these samples. The 22S/22S+22R C<sub>32</sub> hopane has reached equilibrium and therefore supports the high maturity level indicated by the vitrinite reflectance data. The high abundance of C<sub>24</sub> tetracyclic terpanes could be associated either with higher land-plant, algae or microbial sources. The presence of significant marine influence is suggested by the high abundance of tricyclic terpanes in all of the samples studied.

## **Evidence for the origin of the West Baram Delta oils: marine versus terrigenous**

AZLINA ANUAR & ABDUL JALIL MUHAMAD

PETRONAS Research & Scientific Services Sdn. Bhd.  
Lot 3288 & 3289, Off Jalan Ayer Itam, Kawasan Institusi Bangi  
43000 Kajang, Selangor Darul Ehsan

Conclusive evidence pertaining to the origin of the West Baram Delta oils were obtained from bulk property data and biological marker studies. Results from the analyses of 31 oils collected from 7 fields in the western part of the Baram Delta indicate that they were generated and expelled from source rocks containing principally land-derived Type III kerogen that were deposited and preserved in oxidising environments. Their general characteristics are as follows :

- sulphur contents < 0.15 wt %
- Pr/Ph ratios: 3.5–7.0 (oxidising depositional environments)
- high occurrence of oleanane
- low to moderate abundance of C<sub>24</sub>-tetracyclics
- low to moderate abundance of bicadinanes
- low abundance of taraxastane
- the predominance of C<sub>29</sub> regular steranes relative to their C<sub>27</sub> and C<sub>28</sub> counterparts

Some minor contribution from a marine source is reflected by the trace amounts of tricyclics. The trace to low abundance of C<sub>29</sub> and C<sub>30</sub> 4-methylsteranes signify only secondary input from either marine algae or freshwater lacustrine dinoflagellates.

Aromatic hydrocarbon-based biological marker maturity parameters, particularly the Methylphenanthrene Index (MPI) and the Triaromatic ratio (TA), proved to be more useful for determining the oil generation window of these oils. Results from these maturity estimations suggest that the West Baram Delta oils were generated from source rocks at peak oil window (VRo 0.8–1.0%) maturities.

In general, the West Baram Delta oils can be considered as light, paraffinic and low to moderately waxy oils with low sulphur contents. However, this general description may change slightly due to the observed differences in their bulk properties. Wide variations in API gravities (19.4° to 45.3°), wax contents (1.8 to 14.8 wt %) and pour point temperatures (–25° to 24°C) are attributed to biodegradational effects. As such, the bulk properties of the West Baram Delta oils are deemed to be primarily the result of in-reservoir bacterial alterations and not due to source facies differences.

## BERITA-BERITA PERSATUAN News of the Society

### PETUKARAN ALAMAT (Change of Address)

The following member has informed the Society of his new address:

1. Mohamed Taher A. Taha  
Schlumberger Oilfield Services, Av.  
Presidente Wilson 231, 20 Andar, Rio de  
Janeiro 20030-021, Brazil.

GSM

### PERTAMBAHAN BAHARU PERPUSTAKAAN (New Library Additions)

The Society has received the following publications:

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. AAPG Explorer, Nov. 1999.</li> <li>2. Episodes, vol. 22, no. 3, 1999.</li> <li>3. Monthly statistics on mining industry in Malaysia, Aug 1999.</li> <li>4. AAPG Bulletin, vol. 83/9, 1999.</li> <li>5. Scripta Geologica, no. 118, 1998.</li> <li>6. SOPAC, vol. 16, nos. 1 &amp; 2, 1999.</li> <li>7. Acta Palaeontologica Sinica, vol. 38, no. 2 &amp; 3, 1999.</li> <li>8. Acta Micropalaeontologica Sinica, vol. 16, nos. 2 &amp; 3, 1999.</li> </ol> | <ol style="list-style-type: none"> <li>9. Palaeontological Abstracts, vol. 14, nos. 2 &amp; 3, 1999.</li> <li>10. National Council for Scientific Research &amp; Development annual report 1998.</li> <li>11. Oklahoma Geology Notes, vol. 59, nos. 1-3, 1999.</li> <li>12. American Museum Novitates, nos. 3275 &amp; 3276, 1999.</li> <li>13. USGS Circular: 1999: nos. 1181, 1190, 1187.</li> <li>14. USGS Prof. Paper: 1999, no. 1565-C.</li> <li>15. USGS Bulletin: 1999: No. 2162.</li> </ol> |
|---|---|

GSM

# Common Rocks of Malaysia

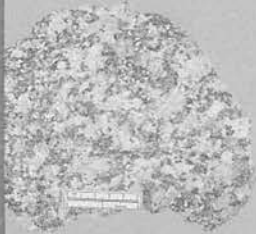
A full colour poster illustrating 28 common rocks of Malaysia. With concise description of the features and characteristics of each rock type including common textures of igneous, sedimentary and metamorphic rocks.

## Laminated

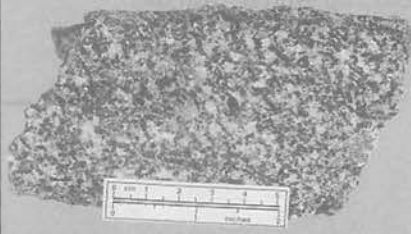
**Size:** 94 cm x 66 cm (42" x 26")

**Price:** Student members RM7.00 (one copy per member, subsequent copies RM10.00 each)  
 Members RM8.00 (one copy per member, subsequent copies RM10.00 each)  
 Non-members RM10.00 per copy

# COMMON ROCKS



Granite (Tampin, Negeri Sembilan)



5. Diorite (Kg. Kemahang, Kelantan)



6. Basalt (Segamat, Johor)



Serpentinite (Raub, Pahang)



12. Pegmatite (Bukit Mor, Johor)



13. Conglomerate (Pulau Redang, Terengganu)



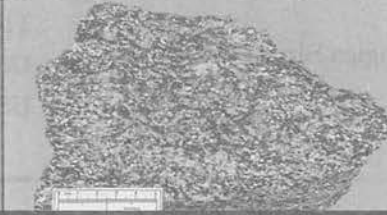
Mudstone (Kg. Laloh, Kelantan)



19. Chert (Nenering, Kedah)



20. Coal (Batu Arang, Selangor)



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## ORDERS

The Hon. Assistant Secretary  
 GEOLOGICAL SOCIETY OF MALAYSIA  
 c/o Dept. of Geology, University of Malaya  
 50603 Kuala Lumpur, MALAYSIA

## BERITA-BERITA LAIN

### Other News

## Local News

### A master map of Malaysia

A master map of Malaysia is being prepared, one which identifies every square inch of land which can and cannot be developed.

To be called the National Spatial Plan (NSP), the map will identify all environmentally-sensitive areas in the country, such as water-catchment areas, wetlands and hill-slope areas unsuitable for development.

The map will also identify land specified for the planting of certain types of crops.

Two years in the making, the NSP is being prepared by the Town and Country Planning Department, Survey and Mapping Department, Land and Mines Department and the Agriculture Ministry.

*"The map will enable us to specifically outline the areas in which development is forbidden and will tell the kinds of development each square inch of land is planned for,"* Town and Country Planning Department director-general Prof. Datuk Zainuddin Muhammad told a Press conference at his office today.

Scheduled for completion "sometime in the middle of the Eighth Malaysia Plan", the NSP, added Zainuddin, "will be made public so that the people can immediately know when their local or State authorities approve development projects in areas forbidden".

Projects which encroach into environmentally-sensitive areas can be stopped much quicker with the NSP in place.

Zainuddin said the map would merge all of Malaysia's various policies like the Industrialization Policy and the National Agriculture Policy into a single map.

*"It translate all our policies into the actual landscape of our country."*

He said the use of high technology like satellite imaging and the Computerised Geographical and Land Information System in the creation of the NSP would make it a relatively speedy affair.

NST, 5.11.1999

### Malayan Cement to improve operations — plant to be premier Asian exporter

Malayan Cement Berhad, part of the United Kingdom-based Blue Circle Group Industries Plc., plans to position its plant in Langkawi as a premier Asian exporter by consolidating its product (cement quality) and customer service.

The group wants to improve cost competitiveness of the Langkawi operations first, managing director Alistair R. Cox said yesterday after acquiring a 77 percent stake in the plant which recently changed its name from Kedah Cement to Malayan Cement.

Its recent successes include production of low-alkali cement which won the local environmental competition, Cox said in a briefing on the plant's operation during a royal visit from the Sultan and Sultanah of Kedah.

The plant is the biggest in the group and could become the flagship in the company's stable of three cement production plants in Malaysia.

The plant has a production capacity of 7.9 metric tonnes and employs 490 workers. The company's other plants in Kanthan and Rawang

employ 368 workers and 476 workers respectively.

*"Our production efficiencies will be enhanced with a capital boost of RM95 million allocated over the next three years,"* Cox said.

The Langkawi plant, which was accorded ISO 9002 certification last September and aims to achieve ISO 14001 certification by the end of 2000, is poised to penetrate a larger market such as in Australia with the Sirim Award.

Cox said 90 per cent of the langkawi plant output is exported to countries such as Nigeria, Singapore and Bangladesh.

Mauritius is forecast to be the largest importer of cement and Singapore the largest for clinker (fused coal ash) this year.

Malayan Cement, through the Blue Circle holding arm, believes the country has strong fundamentals for sustained recovery in the

infrastructure field, which is the reason for its continued investment in the cement manufacturing sector.

It also dominates the country's cement industry with a 50 per cent market share.

Cox said the 77 per cent stake in the Langkawi plant represents an investment of RM835 million apart from a substantial pre-takeover debt it has to absorb.

Blue Circle is among the 100 largest UK-listed companies with over 20,000 employees worldwide and is the fourth largest cement producer in the world with a global capacity of 50 million tonnes. Its three Malaysian plants account for eight million tonnes.

Blue Circle has operations in 18 countries and, apart from Malaysia, recently made major investments in Singapore, the Philippines and Greece.

*NST, 11.11.1999*



## KALENDAR (CALENDAR)

### 2000

#### January 24-28

*OCEAN SCIENCES* (Meeting sponsored by AGU), San Antonio, Texas, USA. (Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1 202 462 6900; Fax: +1 202 328 0566; E-mail: meetinginfo@kosmos.agu.org; Website: <http://www.agu.org>)

#### February 1-5

*INDIAN GEOLOGICAL CONGRESS (12TH) AND NATIONAL SEMINAR ON "GROUNDWATER RESOURCES"*, Udaipur, India. (Contact: Dr. Vinod Agrawal, Organising Secretary IGC-2000, Department of Geology, M.L. Sakhadia University, 51 Saraswati Marg., Udaipur 313002, India. Tel: +294-413955 ext. 417; Fax: +0294-412459; E-mail: psranawat@yahoo.com)

#### March 6-9

*SOCIETY FOR MINING, METALLURGY, AND EXPLORATION* (Annual Meeting), Salt Lake City, Utah, USA. (Contact: SME, 8307 Shaffer Parkway, P.O. Box 625002, Littleton, CO 80162-5002, USA. Tel: 1 303 973 9550; E-mail: smenet@aol.com)

#### March 8-9

*THE NATURE AND TECTONIC SIGNIFICANCE OF FAULT ZONE WEAKENING* (International Research Meeting, sponsored by UK Tectonic Studies Group), London, UK. (Contact: R.E. Holdsworth, Department of Geological Sciences, University of Durham, Durham DH1 3LE, UK. Fax: +44 0191 374 2510; E-mail: R.E. Holdsworth@durham.ac.uk; Website: <http://www.dur.ac.uk/~dglms/reh.htm>; abstract deadline: 30 September 1999)

#### April 16-19

*AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS* (Annual Meeting), New Orleans, Louisiana, USA. (Contact: AAPG Conventions Department, P.O. Box 979, 1444 S. Boulder Ave., Tulsa, OK 74101-0979, USA. Tel: +1 918 560 2679; Fax: +1 918 560 2684; E-mail: dkeim@aapg.org)

#### April 22-24

*15TH HIMALAYA-KARAKORAM-TIBET WORKSHOP*, Chengdu, China. (Contact: Dr. Deng Bin, 15th HKT Affairs Office, Chengdu University of Technology, No. 1, Erxianqiao, Dongsan Road, Chengdu, 610059, P.R. China. Tel: +86-28-4 079 488, -28-4 079 887; Fax: +86-28-4 077 099, -28-4 077 163; E-mail: 15hkt@cdit.edu.cn; Website: <http://www.cdit.edu.cn/15hkt/>)

#### April 24-28

*ENVIRONMENTAL GEOCHEMISTRY* (5th International Symposium), Cape Town, South Africa. (Contact: Department of Geological Sciences, University of Cape Town, Private bag, Rondebosch 7701, South Africa; Fax: +27-21 650 3783; E-mail: 5iseg@geology.uct.ac.za)

#### April 29-30

*MODERN & ANCIENT ICE-MARGINAL LANDSYSTEMS* (International Symposium), Keele, Staffs, UK. (Contact: Dr. Andrew J. Russell, Dr. David J.A. Evans, School of Earth Sciences & Geography, Keele University, Staffs, ST5 5BG, UK. E-mail: a.j.russel@keele.ac.uk or devans@geog.gla.ac.uk)

#### May 7-11

*SALT SYMPOSIUM*, The Hague, The Netherlands. (Contact: Secretariat Organizing Committee, 8th World Salt Symposium, P.O. Box 25, 7550 GC Hengelo Ov, The Netherlands. Tel: 31 74 244 3908; Fax: 31 74 2443272; E-mail: Salt.2000@inter.NL.net)

#### May 15-16

*PERMO-CARBONIFEROUS CARBONATE PLATFORMS AND REEFS* (A Research and Field Conference jointly sponsored by SEPM and IAS), El Paso, Texas, USA. (Contact: Judy Tarpley, SEPM 1731 E, 71 Street, Tulsa, OK 74136, USA. Tel: +1 918 493 33 61; Fax: +1 918 493 20 93; E-mail: jtarpley@sepm.org; Website: <http://www.sepm.org/research/conferences/permcarb2000.html>)

#### May 15-18

*GEOLOGY AND ORE DEPOSITS 2000: THE GREAT BASIN AND BEYOND* (Conference), Reno-Spark, Nevada, USA. (Contact: Geological Society of Nevada, P.O. Box 12021, Reno, Nevada

89510, USA. Tel: +1-702 323 3500; Fax: +1-702 323 3599; E-mail: [gsnsymp@nbgm.unr.edu](mailto:gsnsymp@nbgm.unr.edu); Website: <http://www.seismo.unr.edu/GSN>)

#### May 15-19

*EARLY VERTEBRATES-LOWER VERTEBRATES* (International Meeting), Flagstaff, USA. (Contact: Dr. D.K. Elliot, Department of Geology, Box 4099, Northern Arizona University, Flagstaff, Arizona 86011-4099, USA. Tel: +1 520 523 7188; Fax: +1 520 523 9220; E-mail: [David.Elliot@nau.edu](mailto:David.Elliot@nau.edu))

#### May 23-25

*TRACERS AND MODELLING IN CONTAMINANT HYDROLOGY* (International Conference), Liege, Belgium. (Contact: TraM'2000, LGIH, University of Liege, B19 Sart-Tilman, 40000 Liege, Belgium. Tel: +32 4 366 2216; Fax: +32 4 366 2817; E-mail: [adassarg@lgih.ulg.ac.be](mailto:adassarg@lgih.ulg.ac.be))

#### May 29 - June 2

*62ND EAGE CONFERENCE & TECHNICAL EXHIBITION, GLASGOW*, Scotland, UK. (Contact: EAGE Conference Dept., P.O. Box 59, 3990 DB Houten, The Netherlands. Tel: +31 30 6354055; Fax: +31 30 6343524)

#### May 30 - June 3

*AMERICAN GEOPHYSICAL UNION* (Spring Meeting), Washington, DC, USA. (Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1 202 462 6900; Fax: +1 202 328 0566; E-mail: [meetinginfo@kosmos.agu.org](mailto:meetinginfo@kosmos.agu.org); Website: <http://www.agu.org>)

#### June 4-8

*GSA PENROSE CONFERENCE "GREAT CASCADIA EARTHQUAKE TRICENTENNIAL"*, Seaside, Oregon, USA. (Contact: John Clague, Department of Earth Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6 Canada. E-mail: [jclague@sfu.ca](mailto:jclague@sfu.ca))

#### June 4-9

*INTERNATIONAL SYMPOSIUM ON THE BIOGEOGRAPHY OF SE ASIA 2000*, Leiden, The Netherlands. (Contact: Rienk de Jong, Nationaal Natuurhistorisch Museum, Department of Entomology, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands. Tel: +31 71 516 26 52; Fax: +31 71 513 33 44; E-mail: [jong@nmm.nl](mailto:jong@nmm.nl))

#### June 14-16

*MANAGEMENT INFORMATION SYSTEMS, INCORPORATING REMOTE SENSING*, Lisbon, Portugal. Organised by Wessex Institute of Technology, UK. (Contact: Gabriella Cossutta. Tel: +44 (0)238-029-3223; Fax: +44 (0) 238-029-2853; E-mail: [gcossutta@wessex.ac.uk](mailto:gcossutta@wessex.ac.uk); Website: [www.wessex.ac.uk/conferences/2000](http://www.wessex.ac.uk/conferences/2000))

#### June 24-30

*INTERNATIONAL PALYNOLOGICAL CONGRESS* (10th), Nanjing, China. (Contact: Secretary of the Organizing Committee for 10th International Palynological Conference, Nanjing Institute of Geology and Palaeontology, Academis Sinica, 39 East Beijing Road, nanjing 210008, China. Website: <http://members.spree.com/sip/spore/index.htm>)

#### June 27-30

*PETROGRAPHY ON THE VERGE OF THE XXI CENTURY: RESULTS AND PERSPECTIVES* (The Second Russian Petrographic Meeting), Syktyvkar, Komi Republic, Russia. (Contact: Dr. Irina Golubeva, Institute of Geology of Komi Sc. Centre UD RAS, Pervomaiskaya st., 54, Syktyvkar, 167610, Russia. Tel: +7(8212)447262; Fax: +7(8212)425346; E-mail: [petr@geo.komo.ru](mailto:petr@geo.komo.ru))

#### July 3-7

*GEOLOGICAL SOCIETY OF AUSTRALIA (Biennial Meeting), 15TH AUSTRALIAN GEOLOGICAL CONVENTION* (Theme: Understanding Planet Earth — Searching for a sustainable future), University of Technology, Sydney, Australia. (Contact: Misha Frankel, Geological Society of Australia, Suite 706, 301 George Street, Sydney, NSW, Australia. Tel: +61 2 92902194; Fax: +61 2 9290 2198; E-mail: [15thagc@gsa.org.au](mailto:15thagc@gsa.org.au); Website: [www.science.uts.edu.au/agc/agchome.html](http://www.science.uts.edu.au/agc/agchome.html))

#### July 3-7

*18TH COLLOQUIUM OF AFRICAN GEOLOGY* (Hosted and organized by the Austrian Geological Society and the Austrian Mineralogical Society), Graz, Austria. (Contact: Institut für Geologie und Paläontologie, Karl-Franzens-Universität Graz, Heinrichstraße 26, A-8010 Graz, Austria. Tel: +43-316-380-5587; Fax: +43-316-380-9870; E-mail: [cag18@bimn22.kfunigraz.ac.at](mailto:cag18@bimn22.kfunigraz.ac.at))

**July 9-12**

*INTERNATIONAL CONFERENCE ON CATASTROPHIC EVENTS AND MASS EXTINCTIONS: IMPACTS AND BEYOND*, Vienna, Austria. Sponsored by: University of Vienna, Lunar and Planetary Institute, European Science Foundation IMPACT Program, Federal Ministry of Science and Transport, Austria, and the Geological Survey of Austria. (Contact: Elizabeth Waggner, Impact 2000 Conference, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113. Tel: (281)486-2177; E-mail: waggner@lpi.jsc.nasa.gov; Website: <http://cass.jsc.nasa.gov/meetings/impact2000/>)

**July 11-15**

*APC-2000, COMBINED AUSTRALIAN PALAEOONTOLOGICAL CONVENTION; 3RD INTERNATIONAL SYMPOSIUM ON THE SILURIAN SYSTEM; AND 2ND AUSTRALIAN CONODONT SYMPOSIUM*, New South Wales, Australia. (Contact: George Wilson, Department of Earth and Planetary Sciences, Macquarie University, Sydney, NSW 2109, Australia. Website: <http://www.es.mq.edu.au/MUCEP/auscos/auscos.htm>)

**July 12-14**

*GEOFLUID-III 2000* (The third international conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts), Barcelona, Spain. (Organized by the University of Barcelona and Instituto Jaime Almera. Website: [www.ub.es/geoquimi/geofluids](http://www.ub.es/geoquimi/geofluids))

**July 16-22**

*APPLIED MINERALOGY — ICAM 2000* (6th International Congress), Göttingen & Hannover, Germany. (Contact: ICAM 2000 Office, P.O. Box 510153, D-30631 Hannover, GERMANY. Tel: +49-511 643 2298; Fax: +49-511 643 3685; E-mail: [ICAM2000@bgr.de](mailto:ICAM2000@bgr.de); Website: [www.bgr.de/ICAM2000](http://www.bgr.de/ICAM2000); abstract deadline: September 1, 1999)

**July 16-22**

*"GEO-INFORMATION FOR ALL"* (19th International Congress of the International Society for Photogrammetry and Remote Sensing), Amsterdam, The Netherlands. (Contact: Prof. K.J. Beek, P.O. Box 6, 7500 AA Enschede, The Netherlands. Tel: +31 (0) 53

4874214; Fax: +31 (0) 53 4874200; E-mail: [beek@itc.nl](mailto:beek@itc.nl))

**July 18-23**

*INTERNATIONAL ASSOCIATION OF VOLCANOLOGY AND CHEMISTRY OF THE EARTH INTERIOR (IAVCEI) GENERAL ASSEMBLY 2000*, Bandung, Indonesia. (Contact: Secretariat, Volcanological Survey of Indonesia, Jalan Diponegoro 57, Bandung 40122, Indonesia. Tel: +62-22 772606; Fax: +62-22 702761; E-mail: [iavcei@vsi.dpe.go.id](mailto:iavcei@vsi.dpe.go.id); Website: <http://www.vsi.dpe.go.id/iavcei.html>; abstract deadline: February 29, 2000)

**July 31 - August 4**

*JOINT WORLD CONGRESS ON GROUNDWATER*, Fortaleza, Brazil. (Contact: ABAS, Ceara Chapter, Avienda Santos Dumont, 7700 Papicu, Fortaleza, CEP 60 150-163, Brazil. Tel: +55 85 265 1288; Fax: +55 85 265 2212)

**August 6-17**

*31ST INTERNATIONAL GEOLOGICAL CONGRESS, Geology and Sustainable Development: Challenges for the Third Millennium*, Rio de Janeiro, Brazil. (Contact: 31st IGC Secretariat Bureau, Av. Pasteur, 404-ANEXO 31 IGC, Urca, Rio de Janeiro RJ, CEP 22.290-240 Brazil. Tel: +55 21 295 5847; Fax: +55 21 295 8094; E-mail: [3ligc@crystal.cprm.gov.br](mailto:3ligc@crystal.cprm.gov.br); Website: [www.3ligc.org](http://www.3ligc.org). To request current Circular, send e-mail to <mailto:address@3ligc.org>)

**September 3-8**

*GOLDSCHMIDT 2000* (International Conference), Oxford, UK. (Contact: P. Beattie, Cambridge Publications, Publications House, P.O. Box 27, Cambridge UK CB1 4GL. Tel: +44-1223 333438; Fax: +44-1223 333438; E-mail: [Gold2000@campublic.co.uk](mailto:Gold2000@campublic.co.uk); Website: <http://www.campublic.co.uk/science/conference/Gold2000/>)

**September 11-15**

*8TH INTERNATIONAL NANNOPLANKTON ASSOCIATION CONFERENCE*, Bremen, Germany. (Contact: Prof. Helmut Willems, FB-5-Geowissenschaften, Universität Bremen, Postfach 330 440, 28334 Bremen, Germany. Tel: +49 421 21 82 198; Fax: +49 421 21 84 451; E-mail: [willems@micropal.uni-bremen.de](mailto:willems@micropal.uni-bremen.de); Website: <http://uni.bremen.de/~micropal/ina8.html>)

**September 17-21**

*7TH INTERNATIONAL CONFERENCE ON PALEOCEANOGRAPHY*, Sapporo, Japan. (Contact: Prof. Helmut Weissert, Geological Institute, ETH-Zurich, CH-8092 Zurich Switzerland. Tel: +41 (0)1 632 37 15; Fax: +41 (0)1 632 10 30; E-mail: helmi@erdw.ethz.ch; Website: <http://www.ijnet.or.jp/jtb-cs/icp7/>)

**September 17-26**

*KARST'2000: 6TH INTERNATIONAL SYMPOSIUM AND FIELD SEMINAR ON PRESENT STATE AND FUTURE TRENDS OF KARST STUDIES*, Marmaris, Turkiye. (Contact: Hacettepe University, International Research and Application Centre for Karst Water Resources (UKAM), Beytepe Campus, 06532 Ankara, Turkiye. Fax: 90 312 299 213; E-mail: ukam@naim.jeo.edu.tr)

**September 25-29**

*12TH INTERNATIONAL SYMPOSIUM ON PLACER AND WEATHERED ROCK DEPOSITS*, Moscow, Russia. Pre-congress and post-congress workshops and field excursions. Abstract deadline: May 1, 2000. (Contact: Prof. Patyk-Kara N.G., Secretary General, Igem RAS, 35. Staromonetny Per., 109017 Moscow. Tel: 7 (095) 230-8427; Fax: 7 (095) 230-2179; E-mail: rkv2000@igem.ru; Website: <http://www.igem.ru/symp/rkv2000/>)

**October**

*INTERNATIONAL MILLENNIUM CONGRESS ON GEOENGINEERING*, Melbourne, Australia. (More information soon)

**October 11-13**

*RISK ANALYSIS 2000, Second International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation*, Bologna, Italy. Organised by Wessex Institute of Technology (WTT), Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK. (Contact: Karen Savage, RISK 2000/1479. Tel: +44(0)238 029 3223; Fax: +44(0)238 029 2853; E-mail: ksavage@wessex.ac.uk; Website: [www.wessex.ac.uk/conferences/2000](http://www.wessex.ac.uk/conferences/2000))

**October 15-18 (Provisional)**

*AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS* (International Meeting), Bali, Indonesia. (Contact: AAPG Conventions Dept., P.O. Box 979, Tulsa, OK 74101-0979, USA. Tel: 1 918 560 2679; Fax: 1 918 560 2684)

**October 23-27**

*9TH INTERNATIONAL CORAL REEF SYMPOSIUM*, Bali, Indonesia. (Contact: Secretariat of the International Coral Reef Symposium, c/o COREMAP, Jl. Raden Saleh 43, Jakarta 10330, Indonesia. Tel: +62 21 314 30 80; Fax: +62 21 327 958; E-mail: coremap@indosat.net.id; Website: <http://www.coremap.or.id>)

**October 23-27**

*INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS* (30th Annual Meeting), Cape Town, South Africa.

**November 13-16**

*GEOLOGICAL SOCIETY OF AMERICA* (Annual Meeting), Reno, Nevada, USA. (Contact: GSA Meetings Dept., P.O. Box 9140, Boulder, CO 80301-9140, USA. Tel: +1 303 447 2020; Fax: +1 303 447 1133; E-mail: meetings@geosociety.org; WWW: <http://www.geosociety.org/meetings/index.htm>)

**November 19-24**

*GEOTECHNICAL AND GEOLOGICAL ENGINEERING — GEOENG 2000* (International Conference), Melbourne, Australia. (Contact: GeoEng2000, ICMS Pty. Ltd., 84 Queensbridge Street, Southbank, Vic 3006, Australia. Tel: +61 3 9682 0244; Fax: +61 3 9682 0288; E-mail: geoeng2000@icms.com.au; Website: <http://civil-www.eng.monash.edu.au/discipl/mgg/geo2000.htm>)

**December 3-6**

*DEEP WATER RESERVOIRS OF THE WORLD (Gulf Coast Section of Society of Economic Paleontologists and Mineralogists Foundation Research Conference)*, Houston, Texas. (Contact: GCSSEPM Foundation, 165 Pineburst Rd., West Hartland, Conn. 06091-0065. Tel: 800/436-1424; Fax: 860/738-3542; E-mail: gcssepm@mail.snet.net; Website: <http://www.gcssepm.org>)

**December 11-16**

*INTERNATIONAL SYMPOSIUM AND FIELD WORKSHOP ON GEODYNAMIC EVOLUTION OF HIMALAYA-KARAKORAM-EASTERN SYNTAXIS (INDO-BURMA RANGE)-ANDAMANNICOBAR ISLAND ARC AND ADJOINING REGION*, Lucknow, India. (Contact: Prof. A.K. Sinha, Director/Dr. Anil Chandra, Organizing Secretary, Birbal Sahni

Institute of Palaeobotany, 53 University Road, Lucknow 226 001, India. Tel: 0091-0522-333620/32491/323206/325822/325945; Fax: 0091-0522-381948/374528; E-mail: bsip@bsip.sirnetd.ernet.in)

#### December 15-19

**AMERICAN GEOPHYSICAL UNION (FALL MEETING)**, San Francisco, California, USA. (Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1 202 462 6990; Fax: +1 202 328 0566; E-mail: meetinginfo@kosmos.agu.org; Website: <http://www.agu.org>)

## 2001

#### May 11-21

**MID-PALAEOZOIC BIO- AND GEODYNAMICS: THE NORTH GONDWANA-LAURUSSIA INTERACTION**, Joint meeting of the 'International Geological Correlation Program (IGCP) 421' and the 'Subcommission on Devonian Stratigraphy (SDS)' hosted by the 'Senckenbergische Naturforschende Gesellschaft', Frankfurt am Main at the 'Forschungsinstitut und Naturmuseum Senckenberg' Frankfurt am Main, Germany. (Contact: G. Plodowski, Forschungsinstitut Senckenberg, Senckenberganlage 25. D-60325 Frankfurt am Main. Tel: ++49-69-97075127; Fax: ++49-69-97075137; E-mail: gplodows@sngkw.uni-frankfurt.de)

#### June 3-6

**AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS** (Annual Meeting), Denver, Colorado, USA. (Contact: AAPG Conventions Department, P.O. Box 979, 1444 S. Boulder Ave., Tulsa, OK 74101-0979, USA. Tel: +1 918 560 2679; Fax: +1 918 560 2684; E-mail: dkeim@aapg.org)

#### June 11-16

**63RD EAGE CONFERENCE & TECHNICAL EXHIBITION**, Amsterdam, The Netherlands. (Contact: EAGE Conference Dept., P.O. Box 59, 3990 DB Houten, The Netherlands. Tel: +31 30 6354055; Fax: +31 30 6343524)

#### July 30 - August

**INTERNATIONAL ASSOCIATION OF ENGINEERING GEOLOGY AND THE**

**ENVIRONMENT (IAEG)**, "Engineering Geological Problems of Urban Areas" (International Symposium), Ekaterinburg, Russia. (Contact: Secretariat, "EngGeolCity-2001, UralTISIZ 79, Bazhov str., Ekaterinburg, Russia 620075. Tel: +7 3432 559772; Fax: +7 3432 550043; E-mail: UralTIS@etel.ru)

#### August 23-28

**INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY (5th)**, Tokyo, Japan. (Contact: Prof. K. Kashiwaya, Dept. of Earth Sciences, Kanazawa University, Kanazawa, 920-1192 Japan. E-mail: kashi@kenroku.kanazawa-u.ac.jp)

#### September 6-12

**IAMG2001 (THE ANNUAL CONFERENCE OF THE INTERNATIONAL ASSOCIATION FOR MATHEMATICAL GEOLOGY)**, Cancún, Mexico. (Contact: IAMG2001 Conference Secretariat, c/o Jorgina A. Ross, Kansas Geological Survey, 1930 Constant Avenue, Lawrence, KS 66047-3724, USA. Tel: +785-864-3965; Fax: +785-864-5317; E-mail: aspiazu@kgs.ukans.edu; Website: <http://www.kgs.ukans.edu/Conferences/IAMG/index.html>)

#### November 5-8

**GEOLOGICAL SOCIETY OF AMERICA** (Annual Meeting), Boston, Massachusetts, USA. (Contact: GSA Meetings Dept., P.O. Box 9140, Boulder, CO 80301-9140, USA; Tel: +1 303 447 2020; Fax: +1 303 447 1133; E-mail: meetings@geosociety.org; WWW: <http://www.geosociety.org/meetings/index.htm>)

## 2002

**INTERNATIONAL ASSOCIATION ON THE GENESIS OF ORE DEPOSITS (11th International Symposium)**, South Africa. (Contact: Dr. Erik Hammerbeck, Geological Survey, Department of Mineral and Energy Affairs, 280 Pretoria Street, Private Bag X112, Silverton, Pretoria 0001, South Africa. Tel: +012 841 1130; Fax: +012 841 1203; E-mail: ehammerb@geoscience.org.za)

#### April 7-10

**AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS** (Annual Meeting), Houston,

Texas, USA. (Contact: AAPG Conventions Department, P.O. Box 979, 1444 S. Boulder Ave., Tulsa, OK 74101-0979, USA. Tel: +1 918 560 2679; Fax: +1 918 560 2684; E-mail: dkeim@aapg.org)

### July 7-12

**16TH INTERNATIONAL SEDIMENTOLOGICAL CONGRESS**, Auckland Park, Gauteng, South Africa. (Contact: Bruce Cairncross, Department of Geology, Rand Africans University, P.O. Box 524, Auckland Park, 2006, South Africa. Tel: +27 11 489 23 13; Fax: +27 11 489 23 09; E-mail: bc@na.rau.ac.za; Website: <http://general.rau.ac.za/geology/announcement.htm>)

### September 16-20

**INTERNATIONAL ASSOCIATION OF ENGINEERING GEOLOGY AND THE ENVIRONMENT (IAEG)**, "Engineering Geology for Developing Countries" (9th International Congress), Durban, South Africa. (Contact: The Technical Committee, 9th IAEG Congress, P.O. Box 1283, Westville 3630, South Africa)

### October 28-31

**GEOLOGICAL SOCIETY OF AMERICA** (Annual Meeting), Denver, Colorado, USA. (Contact: GSA Meetings Dept., P.O. Box 9140, Boulder, CO 80301-9140, USA; Tel: +1 303 447 2020; Fax: +1 303 447 1133; E-mail: [meetings@geosociety.org](mailto:meetings@geosociety.org); WWW: <http://www.geosociety.org/meetings/index.htm>)

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- Proceedings of the Workshop on Stratigraphic Correlation of Thailand and Malaysia Vol. 1.** (1983). Technical Papers. 383 p. Price: RM25.00 (Members: RM12.00).
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