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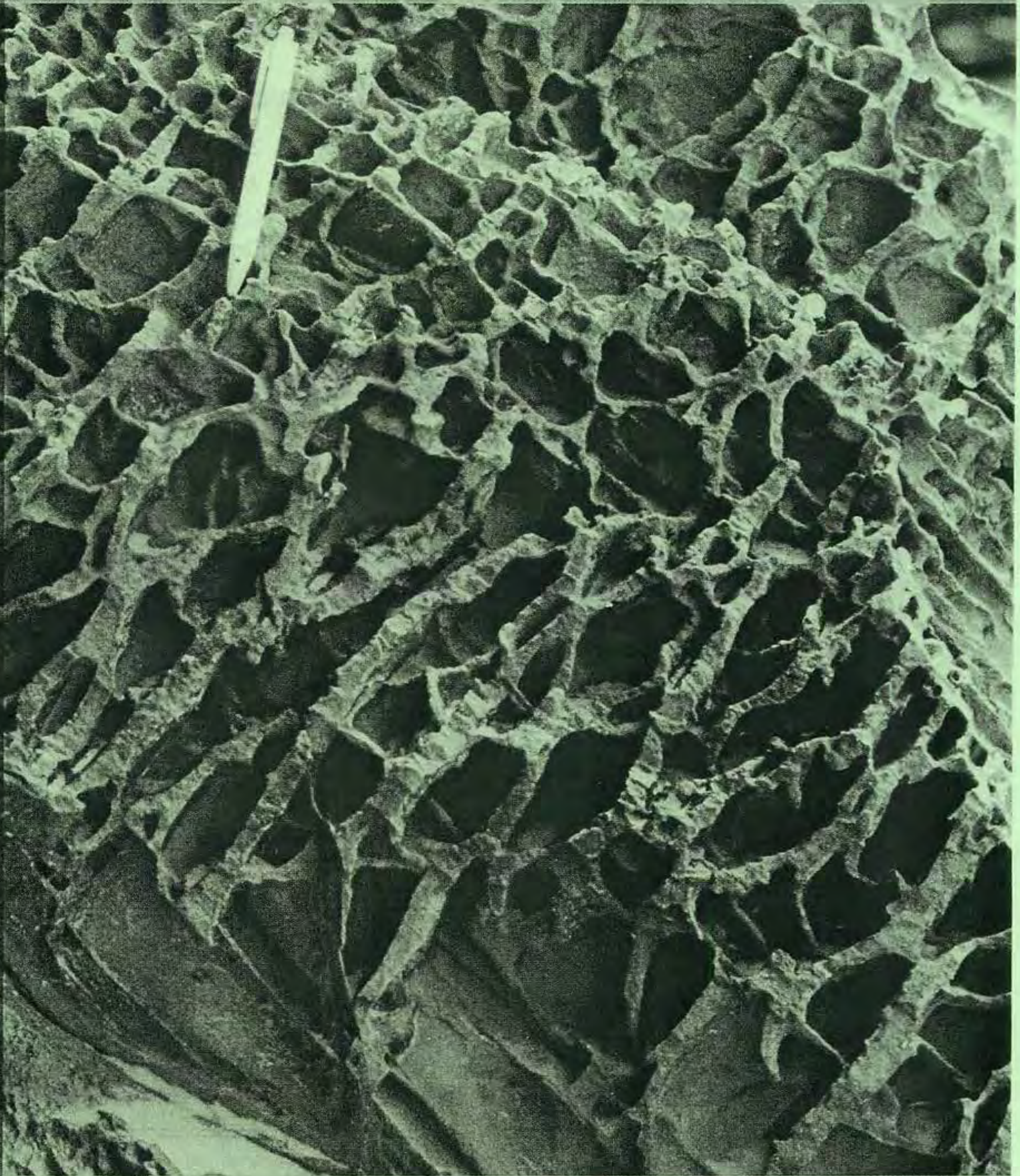
## PERSATUAN GEOLOGI MALAYSIA

# WARTA GEOLOGI

## NEWSLETTER OF THE GEOLOGICAL SOCIETY OF MALAYSIA





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# PERSATUAN GEOLOGI MALAYSIA
# Geological Society of Malaysia



## 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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# Mainstreaming geoscience inputs for sustainable development: prospects for the Malaysian scenario

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43600 UKM Bangi

## INTRODUCTION

The concept of sustainable development as it is known today was articulated by the Bruntland Commission in 1987. The Commission provided the most simple and widely used definition for sustainable development; development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). In this concept, societal well-being, environmental integrity as well as intra and inter-generational equity are simultaneously possible while a nation achieves its full economic potential and enhances its resource base. The concept was given currency at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, and reinforced at the World Summit on Sustainable Development (WSSD), hosted by Johannesburg in 2002.

In Malaysia, elements of sustainability have been incorporated in federal policy documents such as the 20-year Outline Perspective Plan and the five-year Malaysia Plans since the 1970s (GoM, 1971, 1976). The quest then was to balance human activities with the environment, in the effort to eradicate poverty and correct social and economic disparity. Environmental considerations have become increasingly important over the past two decades. For example, the recent Eight Malaysia Plan (2001–2005) reinforced the need for environmentally sustainable development, in addition to economic, social and cultural progress, for long-term advancement of the country. The government also identified ten key strategies to be implemented for the duration of the Plan (GoM, 2001). Of these, five were predominantly economic in nature, four related to social sustainability and one related to natural resources and sustainability of the environment.

Geoscience has always played an important but unheralded role in helping the nation achieve its development aspirations. Previously, its main application was for the development of metal, mineral and energy resources for economic and social development. In this function, applied geology such as economic geology, mining geology and petroleum geology predominated. The application of geoscience has since expanded to include engineering geology, hydrogeology and environmental geology. Unfortunately, non-geoscientists particularly the policy and decision makers, are unaware of its contribution to social well-being, economic growth and environmental protection i.e. the three pillars of sustainable development.

This paper describes briefly the changing role of geoscience in Malaysia, with particular reference to geology and its associated disciplines. The changes are traced through its traditional applications in natural resource utilisation for national development and subsequent expansion to meet environmental requirements. Potential applications for geoscience in support of sustainable

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development, particularly with respect to environmental integrity and societal well-being as well as the mainstreaming of such inputs are discussed in this context.

## TRADITIONAL APPLICATIONS

Historically, the impetus for geology as an applied science came from the demand for metals and minerals during the industrial revolution. Many of the Geological Surveys worldwide were established to explore and evaluate the potential of metals and minerals. The Geological Survey in Malaysia was established in 1907 to develop tin and gold resources in the Malay Peninsular (Gobbett and Hutchison, 1973). The role of geology as an applied science became even more important when the need for fuel minerals such as coal and petroleum became acute. In order to support mineral exploration activities, branches of geology such as mineralogy, petrology, structural geology, geochemistry, sedimentology, stratigraphy, paleontology and geophysics evolved distinctly into disciplines in their own right.

The onslaught of infrastructure development in the early 1970's resulted in the introduction of engineering geology. This branch of geology supports the construction industry, particularly with respect to site suitability, safety and optimisation, for infrastructure such as roads, tunnels, dams and bridges, among others. The 1980's saw the expansion of hydrogeology to meet increased demand for groundwater, particularly in certain areas of Peninsular Malaysia and Sarawak (Chong and Tan, 1986). A growing population and limited surface water required the exploitation of more groundwater resources to meet the demand for water in these areas.

Rapid development in the early 1990's resulted in expansion of growth centres onto areas such as hilly terrain, karstic bedrock, former mines as well as peat and soft sediment zones that are prone to geological hazards (Chand, 1999). This brought to fore the importance of geological inputs for urban planning and development, in the form of urban geology. Unfortunately, the general public is still quite unaware of the importance of these inputs in preventing loss of lives and property due to occurrences of geological hazards.

Environmental geology was introduced to address current issues related to pollution control and environmental conservation. Environmental geology is the study of the non-living physical environment that is impacted by natural earth processes and anthropogenic activities. In recent years it's contribution has become more important due to the emphasis on sustainable development as articulated by the government (Pereira, 2001; Pereira and Ibrahim, 1998, 2003; Ibrahim and Pereira, 1998). However, much need to be done to make its application more widespread.

## EMERGING ISSUES

### Environmental Integrity

Elements of integrity as a concept can be traced to early writings on the ethics of landuse (Leopold, 1949). Ecological integrity, which is synonymous to environmental integrity in this paper, relates to the ability of the environment to withstand and recover from perturbations caused by either natural or anthropogenic sources (Karr and Dudley, 1981). There has been no consensus on the constituents of environmental integrity, and the debate is still ongoing (Botkin, 1990, Pickett *et al.*, 1992). However, this has not hampered research on the application of the concept. Indicators of environmental integrity were first developed for aquatic ecosystems (Karr and Chu, 1999). This was followed by development of more holistic indicators for terrestrial ecosystems based on characteristics such as sustainability, naturalness and resilience (Andreasen *et al.*, 2001).

Policy and decision makers as well as the public are concerned now about the need to ensure environmental integrity. The unprecedented rate of industrial development has impacted the earth on a scale as never seen before in recent geologic time. Basic necessities such as food, water, clean air and a healthy environment are becoming increasingly under threat. Geoscientists have to align themselves to focus on this issue.

In Malaysia, the importance of environmental integrity demands a shift from traditional modes of operation. There is need to take a proactive and holistic view of the Earth in meeting the demand for national development. For example, provision of geological services to the mining, energy and construction sectors should be expanded to take the environment into account. Efforts should be made to ensure that activities in these sectors are conducted in a way that does not compromise environmental integrity.

In addition, an inventory of groundwater resources should be established in the country, particularly around urban areas with high population density. Groundwater is a reliable alternative source to surface water, which is increasingly subject to pollution and may become a scarce commodity in the future. The socio-economic benefits and environmental consequences of development over groundwater resources and its recharge areas by competing landuse such as buildings, infrastructure and agriculture should be understood and taken into account in the planning and decision-making process.

The rapidly deteriorating atmospheric condition is another emerging issue. Geosciences have the potential to contribute much to interdisciplinary research in this arena. Among these include aspects such as the effect of global climate change on surface processes, the effect of air pollution on agriculture and food production and the impact of fossil fuel extraction on the global carbon cycle, among others. The need for systematic multidisciplinary programmes with sound geoscience inputs, on local environmental impacts of global changes should be given serious consideration.

## Societal Well-being

The conditions of the environment in which a community resides as well as the characteristics of the community itself reflect societal well-being (Pacione, 2003). Conditions of the environment refer to environmental integrity as discussed in this paper, and include quality of air, water and the immediate surroundings. Characteristics of the community include aspects such as level of health, education and safety.

Societal well-being is not guaranteed by material wealth, a high level of economic growth or achievement of "developed status". In the haste to achieve vision 2020 there is need to ensure that both the environment and the community are given adequate emphasis and that a wide range of social, economic and environmental needs are satisfied. There is also need to ensure equitable access to resources and fairness in distribution of societal risk, for both the present and future generations.

One source of societal risk comes in the form of geological hazards. Examples of such hazards include landslides, subsidence and erosion. In the Klang Valley alone, about 21 landslides, eight subsidence events, 102 flood and flash-floods and 22 riverbank erosion cases were reported, due to rapid and excessive urban development between 1990 and 1996 (Pereira and Ibrahim, 1998). Much has been done to improve inter-agency coordination to address this issue. But more research and development is required to improve understanding as well as develop and conduct geological hazard assessments for planning, particularly in the preparation of development plans for urban areas.

There is mounting evidence that significant health effects have ensued from the interactions that humans have had with the physical environment. Medical Geology is an emerging discipline that examines links between geological material and processes, and spatial and temporal distributions of incidences of human diseases (Berger, 2003). This discipline, which brings together geoscientists and public health professionals, has yet to be introduced in the country. To ensure long-term societal well-being, research and development is required to improve understanding of the links between human health and local geological processes.

The placement of waste disposal sites that is largely determined by locational criteria such as land availability rather than land suitability creates a landscape of risk and threatens the health and safety of its surrounding community.

It is not known how many of these disposal sites have received toxic waste at some point during operations. This situation threatens the well-being of both the present and future generations. In this respect, geoscience has much to contribute particularly in the determination of geological controls and remediation of such sites.

## MAINSTREAMING GEOSCIENCE INPUTS

### Bridging the Geoscience — Policy Interface

Generally, implementation of activities for industrial development can be categorised into several hierarchical levels. These include levels of policy development, urban and regional planning and policy implementation (Ibrahim, 1997).

Policy development entails the formulation of development policies and guidelines. This level involves various government Ministries and departments in particular the national and state economic planning units. In this level, geoscience inputs are essential for ensuring sustainable utilisation of mineral and groundwater resources as well as optimum usage of land and the subsurface. Long-term plans that take into account the well-being of the present and future generations require critical inputs. There is much need to strengthen the generation of appropriate inputs at this level, to bridge the gap in the geoscience — policy interface.

Urban and regional planning involves the process of translating development policies and guidelines into master plans or spatial plans in the form of structure plans and local plans. Such translation requires multisectoral inputs, covering economic, social and environmental dimensions. Geoscience inputs at this level include among others, aspects such as site suitability, management of metal, mineral and groundwater resources, identification and management of natural geological processes that may endanger humans, and prediction and management of geological hazards. The focus is to ensure equitable access to resources and fair distribution of societal risks to both the present and future generations. Although there is a certain degree of geoscience inputs taken into account at this level, there is much to be done to expand its application.

Policy implementation involves the execution of development policies and plans. Various government agencies are either directly involved in or oversee the implementation of such policies and plans in various industrial sectors. The government sectors directly and indirectly drives, manages and oversees the private sector in industrial development. The focus is generally on equitable access to resources and fair distribution economic prosperity for the present generation. At the policy implementation level, traditional applications of geoscience flourished over the years, particularly in the mining, energy and construction sectors. Notwithstanding this, there is much that geoscience can contribute to other sectors of industrial development.

Clearly, geoscience has an important role to play in national development. It can provide inputs derived from research and development to ensure environmental integrity and societal well-being in the quest for development. However, it is critical that such inputs be channelled to the appropriate levels to ensure effective application. Furthermore, the type of inputs would vary depending on the scale of the issue, technological factors and the end-user of such information.

### Strategic Reorientation

In order to bring geoscience into the mainstream of industrial development, several aspects of capacity building and knowledge generation have to be addressed. These include a revision of geoscience curriculum, fulfillment of end-user demands, information dissemination as well as strategic research and development for all hierarchical levels of industrial development.

Currently, geoscience curriculum is designed to fulfill needs at the policy implementation level of industrial development. This has resulted in prolonging the narrow understanding of geoscience among generations of policy and decision-makers. Thus, the geoscience curriculum should be revised to highlight its multidisciplinary nature in providing solutions for environmental problems and ensuring social well-being. In this context, policy and planning tools as well as management tools designed for all hierarchical levels of industrial development should be incorporated into the curriculum. Although, the impact of geoscience curriculum revision to policy and decision-makers may not be immediately felt, it has to be embarked upon as soon as possible, for long term benefits.

In addition, systematic and practical effort should be made to package information regarding geoscience inputs specifically for policy and decision-makers. Information packages should be designed for all hierarchical levels of industrial development, with particular emphasis on policy development as well as urban and regional planning. This will directly benefit policy and decision-makers and lead to information-based decisions to ensure that geoscience inputs are well applied for environmental integrity and societal well-being.

Another aspect of importance is public awareness regarding the role of geoscience in ensuring environmental integrity and societal well-being. The general public is still quite unaware of the importance of geoscience inputs in this matter. A campaign should be embarked upon to sensitise the public on the role of geoscience. The information provided should be packaged in non-technical language suitable for both the non-geoscientist and the public. In the short and medium terms, increased knowledge of geoscience applications among the public will inadvertently create a demand for more information-based policy and decision-making.

Research and development is critical to generate knowledge for all hierarchical levels of industrial development. Geoscience has much to contribute to enable equal access to natural resources and enhance fair distribution of societal risks to both the present and future generations, particularly at the policy development as well as urban and regional planning levels. At the policy implementation level, there is much scope for geoscience to be expanded into the non-traditional sectors. For example, in the manufacturing sector, local sources of strategic industrial minerals can be identified and exploited. This will help realise goals of the industrial master plan and promote economic prosperity. In the tourism sector, conservation geology can yield additional attractions while conserving high quality geological heritage to promote geotourism, and complement current demand for ecotourism products (Ibrahim, 2003). Research in emerging disciplines such as medical geology can shed light on links between natural processes and incidences of human diseases among local populations, which is hitherto unknown. The generation of such knowledge and its systematic and continuous translation into forms appropriate for all hierarchical levels of industrial development will benefit environmental integrity and societal well-being in the medium and long-term.

## CONCLUSION

Geocience has an important role to play in national development to ensure environmental integrity and societal well-being. In order to ensure effective application, it is critical that geoscience inputs be channelled to the appropriate hierarchical level of industrial development. Such levels include the policy development, urban and regional planning and policy implementation levels. The type of geoscience inputs would vary depending on the scale of issues, technological factors and end-user of such information. Aspects of capacity building and knowledge generation such as revision of geoscience curriculum, fulfillment of end-user demands, information dissemination as well as research and development are critical for this purpose.

## REFERENCES

ANDREASEN, J.K., O'NEILL, R.V., NOSS, R. AND SLOSSER, N.C., 2001. Considerations for the Development of a Terrestrial Index of Ecological Integrity. *Ecological Indicators, 1(2001),* 21–35.

BERGER, A.R., 2003. Linking Health to Geology. *In:* Skinner, H.C.W. and Berger, A.R. (Eds.), *Geology and Health — Closing the Gap.* Oxford University Press, Cary.

BOTKIN, B.B., 1990. *Discordant Harmonies.* Oxford University Press, New York.

CANADELL, J. AND NOBLE, I., 2001. *Trends in Ecology* *and Evolution, 16(12)*, 664–666.

CHAND, F., 1999. Environmental Geology in Urban Development. *Bull. Geol. Soc. Malaysia, 43*, 329–335.

CHONG, F.S. AND TAN, D.N.K., 1986. Hydrogeological Activities in Peninsular Malaysia and Sarawak. *Bull. Geol. Soc. Malaysia, 20*, 827–842.

GOBBETT, D.J. AND HUTCHISON, C.S., 1973. *Geology of the Malay Peninsula*, Geol. Soc. Malaysia, Kuala Lumpur.

GOVERNMENT OF MALAYSIA (GOM), 1971. *Outline Perspective Plan (1971–1990)*. Government Press, Kuala Lumpur.

GOVERNMENT OF MALAYSIA (GOM), 1976. *Third Malaysia Plan (1976–1980)*. Government Press, Kuala Lumpur.

GOVERNMENT OF MALAYSIA (GOM), 2001. *Eight Malaysia Plan (2001–2005)*, Economic Planning Unit, Prime Minister's Department, Kuala Lumpur.

IBRAHIM KOMOO, 1997. Geology in the Context of National Development for the Next Millennium (Abstract). *Warta Geologi, 23(3)*, 155–156.

IBRAHIM KOMOO, 2003. *Conservation Geology — Protecting Hidden Treasures of Malaysia*. LESTARI Publishers, Bangi.

IBRAHIM KOMOO AND PEREIRA, J.J., 1998. Urban Planning: Challenges in Integrated Approaches. *In:* Ibrahim Komoo and Pereira, J.J. (Eds.), *Planning Responses for Geohazards Management*. Round Table Dialogue Series No. 5, Institut Alam Sekitar dan Pembangunan, Bangi, 3–13.

KARR, J.R. AND CHU, E., 1999. *Restoring Life in Running Waters: Better Biological Monitoring*. Island Press, Washington D.C.

KARR, J.R. AND DUDLEY, D.R., 1981. Ecological Perspective on Water Quality Goals. *Environ. Manage. 5(1)*, 55–68.

LEOPOLD, A., 1949. *A Sand County Almanac*. Oxford University Press, New York.

PACIONE, M., 2003. Urban Environmental Quality and Human Wellbeing — A Social Geographical Perspective. *Landscape and Urban Planning, 65*, 19–30.

PEREIRA J.J AND IBRAHIM KOMOO, 2003. Addressing gaps in ecosytem health management: the case of mineral resources in the Langat Basin. *In:* D.J. Rapport, W.L. Lasley, D.E. Rolston, N.O. Nielsen, C.O. Qualset, and A.B. Damania (Eds.), *Managing for Healthy Ecosystems*. Lewis Publishers, Boca Raton, Florida USA, 905–916.

PEREIRA, J.J., 2001. Environmental Geoscience in Southeast Asia: Current Trends and Future Challenges. *Episodes, 24(2)*, 115–117.

PEREIRA, J.J. AND IBRAHIM KOMOO, 1998. Using geological information as planning tools for urban centers — The Case of Klang Valley, Malaysia. *In:* Moore D.P. & Hungr O. (Eds.), *Engineering Geology: A Global View from the Pacific Rim — 8th Congress of the IAEG (Vol. IV)*, Balkema, Rotterdam, 2573–2578.

PICKETT, S.T.A., PARKER, V.T. AND FIEDLER, P.L. *ET AL.*, 1992. The New Paradigm in Ecology: Implications for Conservation above the Species Level. *In:* Fiedler, P.L. and Jain, S.K. (Eds.), *Conservation Biology: The Theory and Practice of Nature Conservation, Preservation and Management*, Chapman and Hall, New York.

WCED, 1987. *Our Common Future. World Conference on Environment and Development*. Oxford University Press, Oxford.

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# PERTEMUAN PERSATUAN
# MEETINGS OF THE SOCIETY

## Ceramah Teknik (Technical Talk)

## Forum

## MEDICAL GEOLOGY

***Jointly organized by:***

Institute of Geology Malaysia (IGM)
Geological Society of Malaysia (GSM)
Institute for Environment and Development (LESTARI)

***Jointly sponsored by:***

Geology Department, University of Malaya
Department of Minerals and Geoscience Malaysia
Commission on Geological Sciences and Environmental Planning
U.S. Geological Survey
Geological Survey of Sweden
International Union of Geological Sciences
International Association for Medical Geology
United Nations Educational, Scientific, and Cultural Organization
International Geological Correlation Programme IGCP#454
International Council of Scientific Unions

The above forum was held at 5.15 pm on December 10, 2003 at the Geology Department, University of Malaya and attended by about 40 participants.

Medical Geology is an emerging discipline that examines links between geological materials and processes and the incidence and spatial/temporal distribution of human (and other animal) diseases. New techniques such as remote sensing and optical emission atomic spectroscopy are enabling researchers to dissect and quantify aspect of environmental health with greater clarity. In partnership with public health professionals, geoscientists today are beginning to understand the role of earth materials and systems in the spread of infectious diseases. The objective of this forum on Medical Geology was to introduce medical geology to geologists in Malaysia and to provide information on medical geology as applied to the study of toxic metal species and trace elements.


FORUM ON MEDICAL
GEOLOGY


FORUM ON MEDICAL
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U.S. Geological Survey
Geological Survey of Sweden
International Union of Geological Sciences

## Forum Speakers

Dr. Robert B. Finkelman is currently the coordinator of coal quality activities at the U.S. Geological Survey (USGS) is Reston, VA. Over the last decade he has focused attention on health impacts of geologic materials and conducted research in Yugoslavia, Romania, China and New Zealand. Among his 370 publications are several papers dealing with human health impacts of coal and on mercury in coal.

Dr. Olle Selinus is a geologist working with the Geological Survey of Sweden (SGU). His research work has been focused on environmental geochemistry and geostatistical methods, including research on medical geology. He serves as officer of Commission on Geological Sciences and Environmental Planning and as chairman of its international Working Group on Medical Geology, and co-chairman of the IGCP Project#454 Medical Geology.

## Forum Conveners

Dr. Joy Jacqueline Pereira
Environmental Geology Technical Committee
Institute of Geology Malaysia

Dr. Zakaria Mohamad
Environmental Geology Working Group
Geological Society of Malaysia

# Ceramah Teknik (Technical Talk)

## The quest for energy

PETER M. LLOYD

### Laporan (Report)

Peter M. Lloyd, Business Development Manager, Network of Excellence in Training, Middle East and Asia Pacific, Abu Dhabi (UAE), who was in town to attend the Petroleum Geology Conference & Exhibition 2003 was kind enough to give the above talk targetted mainly for students on Friday, 19 December 2003 at 5.30 pm at the Geology Department, University of Malaya. He also took the opportunity to inform students of the role and benefits of the local AAPG Student Chapter which he and his wife have helped to establish.

### Abstrak (Abstract)

This comprehensive introductory treatment of the Oil & Gas industry starts off by looking at world energy needs, worldwide oil and gas reserves and the challenging careers that are offered as those reserves are found and developed. The importance of technology advances is highlighted.

Different inter-related disciplines in the oil and gas industry will be discussed; geophysics, stratigraphy, sedimentology, geochemistry, petrophysics and reservoir engineering.

Petroleum Systems will then e examined with a discussion of source rocks, reservoirs, seals and traps as well as the processes of O&G generation, migration and entrapment. The drilling and production of hydrocarbon accumulations will also be presented.

The presentation concludes with a review of the importance of professional society involvement in one's career. Technical Careers in the O&G Business can be discussed as part of the Q&A session.

G.H. Teh

# Petroleum Geology Conference & Exhibition 2003

*17 - 18 December 2003*

*Shangri-La Hotel, Kuala Lumpur, Malaysia*

## LAPORAN (Report)

The 25th Petroleum Geology Conference & Exhibition 2003 was held on 17–18th December 2003 at the renovated Shangri-La Hotel. It was declared open by YB Datuk Tan Chai Ho, Deputy Minister, Ministry of Energy, Communications and Multimedia.

In his speech Datuk Tan noticed that the oil and gas business has become more competitive and more global in nature. With global energy demand to increase by more than 50% by 2020, there was the need to replenish current resources with new and commercially viable discoveries. Thus the pace of hydrocarbon exploration should be stepped up using constructive and innovative concepts and to alleviate cost, more strategic alliances and preferred partnerships fostered to ensure success.

This 25th Petroleum Geology Conference & Exhibition attracted a record crowd of 521, a total of 31 exhibition booths were taken up and to accommodate the 59 papers, parallel sessions were introduced for the first time for 44 oral presentations while the remaining 15 were put up as posters.

The Organising Chairman of PGCE 2003, Dr. Jaizan Hardi Mohamed Jais and his Organising Committee should be heartily congratulated for organising such a successful Conference and being responsible for introducing a number of new innovations to the Society's Petroleum Geology Conference & Exhibition to make it even more rewarding and memorable to the participants.

G.H. Teh

# Petroleum Geology Conference & Exhibition 2003

*17 - 18 December 2003*
*Shangri-La Hotel, Kuala Lumpur, Malaysia*

## WELCOMING ADDRESS

## Welcoming Address by Prof. Madya Dr. Abdul Ghani Mohd Rafek, President of Geological Society of Malaysia

***Yang dihormati Tuan Pengerusi Majlis,***

***Yang Berhormat, Datuk Tan Chai Ho,***
***Timbalan Menteri, Kementerian Tenaga, Komunikasi dan Multimedia***

***Yang Berusaha Dr. Jaizan Hardi Mohamed Jais,***
***Pengerusi, Jawatan Penganjur Persidangan Geologi Petroleum 2003***

***Para Jemputan,***

***Ahli-Ahli Persatuan Geologi Malaysia yang dihormati,***

***Rakan-rakan Geosaintis,***

***Tuan-tuan dan Puan-puan para hadirin yang dihormati sekalian,***

Assalamualaikum dan Salam Sejahtera,

Izinkan terlebih dahulu memanjatkan kesyukuran kepada Allah SWT, kerana dengan limpah kurniaNya dapat kita bertemu sekali lagi di Persidangan Geologi Petroleum 2003 pada pagi yang indah ini. Mengambilkira penyertaan daripada beberapa pelusuk dunia, saya memohon kebenaran meneruskan ucapan pagi ini dalam Bahasa Inggeris.

***Distinguished guests,***
***Fellow Geoscientists,***
***Ladies and gentlemen,***

It gives me great pleasure to extend a very warm welcome to all present here on this beautiful morning with *"Selamat Datang"* on behalf of the Geological Society. A very special thank you to Yang Berhormat, Datuk Tan Chai Ho, Deputy Minister, Ministry of Energy, Communications and Multimedia, who has so kindly taken time off from his many duties to be with us here today morning and to officiate this morning's Conference.

***Ladies and Gentlemen,***

This year's Petroleum Geology Conference & Exhibition is the 25th of the series and with each year, the response has grown continuously. As already mentioned last year, due to the overwhelming response, this year parallel session will be conducted, thus enabling over 40 oral presentations. In addition, over 20 papers will be presented in the form of posters. This response shows the intensity of research and development, as well as exploration and innovation that is taking place in the petroleum industry. I would like to take this opportunity to thank all paper presenters for their support and contributions. The wide range of papers also reflects the international nature of our gathering with presentations on the Mekong Basin, Vietnam, Zambezi Delta and southern Poland.

***Ladies and Gentlemen,***

Such a gathering would not be possible without the involvement, contributions, and assistance of various individuals and parties. Please allow me this opportunity to thank:

- Yang Berhormat, Datuk Tan Chai Ho, Deputy Minister, Ministry of Energy, Communications and Multimedia
- the organisations and companies that have contributed to this Conference
- the organisations that have taken up the exhibition booths
- the authors and presenters of the technical papers
- Dr. Jaizan Hardi Mohamed Jais and his Organising Committee
- and, to all participants of this Conference

Lastly, ladies and gentlemen, please accept my most humble apologies for any shortcomings during the course of this Conference. It is also my sincere hope that you do also find the time to enjoy some of the sights and pleasant experiences that Malaysia has to offer, in particular for those who are here for the first time or are back after some years.

Thank you very much,
Wabillahitaufik Walhidayah
Wassalamulakum w.b.t.

# Petroleum Geology Conference & Exhibition 2003

*17 - 18 December 2003*
*Shangri-La Hotel, Kuala Lumpur, Malaysia*

# OPENING ADDRESS

## Opening Address by YB Datuk Tan Chai Ho, Deputy Minister of Energy, Communications & Multimedia

***Yang Berbahagia, Prof. Madya Dr. Abdul Ghani Rafek,***
***President of Geological Society of Malaysia***

***Yang Berusaha, Dr. Jaizan Hardi Mohamed Jais,***
***Organising Chairman of the 2003 Petroleum Geology Conference and Exhibition***

***Distinguished Guests,***

***Ladies and Gentlemen,***

Salam Sejahtera and a very good morning.

First of all, I would like to wish you "Selamat Datang" or "Welcome to Malaysia". I am sure you would enjoy the warm weather here in Malaysia. It is indeed my pleasure to be present here amongst prominent geoscientists and expert of the oil and gas industry and to deliver the Opening Address in the 25th Petroleum Geology Conference & Exhibition.

The work put in by the Geological Society of Malaysia to organise this annual 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 geoscientist into an astute oil finder that can see much wider, deeper and clearer in the subsurface. I also wish to commend the geoscience and oil and gas community here and abroad for supporting this event and your contributions would leverages our understanding of the sub-surface geology of our basins. 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 and as we expand to the deeper waters to search for bigger prize.

***Distinguished Guests,***
***Ladies and Gentlemen,***

As oil and gas business is becoming competitive, the challenges facing the oil industry have become more global in nature. Oil prices continue to be the main driving factor. Global energy demand is expected to increase by more than 50 percent by 2020. Asia will continue to remain the fastest growing energy consuming region in the world. It is likely that most of this demand for energy may have to be met through imports.

As such, besides addressing the threats to the industry, the biggest questions facing the oil and gas producers in this region, particularly the N.O.Cs, are how, where and when to expand their oil and gas production to meet the higher demand. Indeed, the N.O.Cs are quite preoccupied with the problems of depleting domestic and regional oil reserves. In the longer term, there is an urgency to replenish current reserves with new and commercially viable discoveries.

However, prospecting for new reserves if proving to be an arduous task, owing to depletion trends. I have been told that today, deep and ultra-deep water exploration and production are the norms in the upstream business. Malaysia does offer attractive prospects and is opening up its deep water areas. Deep water exploration requires the application of sophisticated and superior technological capabilities, something which would undoubtedly be a barrier to most Asian oil and gas companies, majors and smaller participants alike.

To overcome this, the pooling of resources almost becomes a necessity. While the waves of industry mega-mergers continued, we hope to see more strategic alliances and preferred partnerships. As a host country, we would welcome the opportunity to learn and build capability in this field with the help of the experienced oil companies. This will alleviate some of the high costs of prospecting, as well as reduce the cost-to-serve and enhance the effectiveness of serving some of the market segments.

***Ladies and Gentlemen,***

Since the discovery of Miri-1 in 1910, oil and gas exploration in Malaysia has come a long way. As of 1 January 2003, we have acquired a total of more than 1.4 million line-km of seismic data. We have also drilled more than 1,000 wells resulting in the discovery of 134 oil fields and 178 gas fields. Of which 20 wells were drilled in the deepwater acreages based on the deepwater PSC terms. Based on an average success ratio of 1 in 5, our domestic exploration efforts can be considered enviable. Our country total remaining reserves stands at 3.5 billion barrels of oil and 89 trillion cubic feet of gas.

In 2002, we have discovered five new oil fields and nine gas fields from thirty-one exploration wells with an additional reserves of 400 million STB oil and 2.4 trillion SCF gas. Currently, we are producing around 600,000 barrel oil per day and 5.8 billion std cu. ft gas per day from 47 oil fields and 14 gas fields.

2002 was an exciting year in our domestic deep water. The major deep water discoveries made in offshore Sabah has opened up a new chapter in deep water potential and has generated a great deal of interest amongst international E&P companies, including new players.

We know there is still substantial amount of hydrocarbons to be found but these are trapped in more challenging conditions such as subtle stratigraphic plays or in deeper sections below overpressure zones or in frontier onshore and deepwater areas.

The phenomenon of maturing fields is not unique to Malaysia, the challenge is in fact common to the other major producing regions in the world as well. These mature fields can have much hidden potential as many of them may never been characterized adequately from a reservoirs standpoint. The Baram Delta Province is a classic example where we are discovering more of the hidden potential.

I am absolutely confident that the reserves in our basins can be comprehensively explored and effectively exploited by innovative ideas and latest state-of-the-art technology. The service sector is increasingly playing a more important role in providing the required technology. I understand that there are more than 20 booths on display outside by these companies that have proven commendable record of providing excellent technologies to our success.

I hope more exploration success shall prevail in the near future with good technological alliance amongst all parties. With the technological advances shall continue in exploration, development and production, I think we all can tap the possibility of finding future discoveries not just coming from new frontier areas, but also from proven areas as evolving technology improves our ability to see and distinguish the oil and gas before we drill and will ultimately bring a healthy return of investments. This has been proven with the recent successful drilling by our operators here.

In the domestic development scene, we are moving into more challenging development environments which will make the task more complex. Remaining fields are located in remote locations and are geologically more difficult, such as highly channelised, highly faulted and compartmentalized reservoirs. We will have to be at our best to develop these fields, in particular the geoscientists. The engineers may come up with the most cost efficient design but if the geoscientists are unable to locate the reservoirs, the project is bound to fail and destroy value.

We hope with more oil developments coming on stream, Malaysia will sustain its production as long as possible by way of new field reserves addition and new hydrocarbon discoveries in near future.

***Ladies and Gentlemen,***

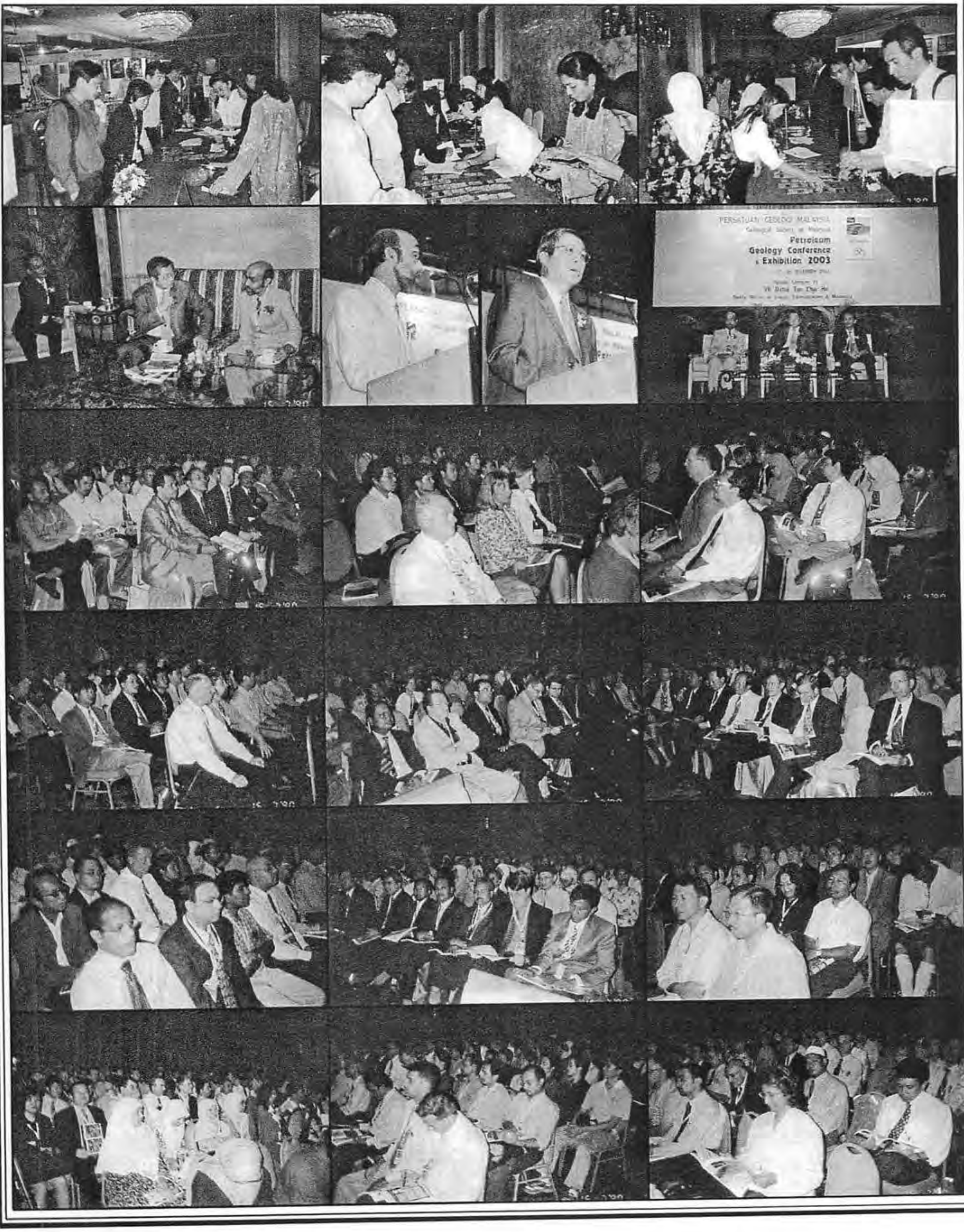
I would like to conclude by reminding my respected audience of geoscientists to step up the pace of hydrocarbon exploration by using constructive and innovative concepts, new aggressive technology and synergistic alliances between oil and services companies and most of all your astuteness to ensure success at every turn. I trust this Conference will provide sufficient opportunities to discuss 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.

On that note, it is with great pleasure that I declare the 25th Petroleum Geology Conference & Exhibition open.

Thank you.

# Petroleum Geology Conference & Exhibition 2003

*17 - 18 December 2003*
*Shangri-La Hotel, Kuala Lumpur, Malaysia*



# Petroleum Geology Conference & Exhibition 2003

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## PROGRAMME

## DAY 1

**Wednesday, 17 December 2003**

**Opening Ceremony**
**(Grand Ballroom)**

| | | |
|---|---|---|
| 08:00 | : | ***Registration*** |
| 08:50 | : | ***Arrival of Invited Guests*** |
| 09:00 | : | ***Welcoming Address by Prof. Madya Dr. Abdul Ghani Mohd Rafek, President of Geological Society of Malaysia*** |
| 09:10 | : | ***Opening Address by YB Datuk Tan Chai Ho, Deputy Minister of Energy, Communications & Multimedia*** |
| 09:30 | : | ***Keynote Address 1:*** A strategy for successful small field and cluster developments in Malaysia — Talisman's perspective<br>*Nick Walker (General Manager, Talisman Malaysia Limited)* |
| 10:00 | : | ***Coffee Break*** *(Sponsored by Geoeast (M) Sdn. Bhd.)* |

# PROGRAMME

## DAY 1

### Wednesday, 17 December 2003

**Session 1**
**(Grand Ballroom)**

**Session Chairman : M Izham Ismail**
*(Exploration Manager, ExxonMobil Exploration & Production Malaysia Inc.)*

10:30 : ***Paper 1:*** Exploring the Sabah Trough — Block K Exploration 1999–2002
*Jack L. Kerfoot (Murphy Oil)*

11:00 : ***Paper 2:*** Irong Barat B multiple scenario analysis — application at EMEPMI
*Diana Abdul Rahman, Lim Hock Kuang, Jason Borg, Nik Ima Dayana Nik Mohamed and Ramli Muhamad (ExxonMobil Exploration & Production Malaysia Inc.)*

11:30 : ***Paper 3:*** North Sabah exploration: new play potential in a mature area
*Dorine Terwogt – de Jonge, Li Pengzhen, Phlemon George, Lourdes Sanchez Rodriguez and Norzita Mat-Fiah (SMEP, Sarawak Shell Berhad)*

12:00 : ***Paper 4:*** Advanced seismic imaging application of Common Reflection Surface Stack (CRS) technology on 3D seismic data of Tembungo Field, offshore Sabah, Malaysia
*Ahmad Riza Ghazali, Nor Azhar Ibrahim and M. Firdaus A. Halim (PETRONAS Research & Scientific Services Sdn. Bhd.)*

12:30 : ***Lunch*** *(Sponsored by Landmark Graphics (M) Sdn. Bhd.)*

# PROGRAMME

## DAY 1

### Wednesday, 17 December 2003

**Session 2**
**(Perak Room)**

**Session Chairman : Peter Brittingham**
*(Manager Deepwater Development, Sarawak Shell Berhad/Sabah Shell Petroleum Company)*

| | | |
|---|---|---|
| 10:30 | : | ***Paper 5:*** Optimisation of deepwater fiscal systems in the context of geological prospectivity<br>*Mark Purdy and Andy Springs (IHS Energy)* |
| 11:00 | : | ***Paper 6:*** A geochemical evaluation of the West Crocker Formation — clues to deepwater source rock facies?<br>*Azlina Anuar, Peter Abolins (PETRONAS Research and Scientific Services Sdn. Bhd.), Paul Crevello (Petrex Asia Sdn. Bhd.) and Wan Hasiah Abdullah (University of Malaya)* |
| 11:30 | : | ***Paper 7:*** Full anelliptic time processing<br>*Charles Zeltser (CGGAP)* |
| 12:00 | : | ***Paper 8:*** Surface geochemistry methods and applications in deepwater exploration<br>*Bernie B. Bernard and James M. Brooks (TDI-Brooks International, Inc.)* |
| 12:30 | : | ***Lunch*** *(Sponsored by Landmark Graphics (M) Sdn. Bhd.)* |

# PROGRAMME

## DAY 1

### Wednesday, 17 December 2003

**Session 3**
**(Grand Ballroom)**

**Session Chairman : Abu Samad Nordin**
*(General Manager, PETRONAS Carigali Sdn. Bhd.)*

14:00 : ***Paper 9:*** Potential of impact-structure plays in Continental Southeast Asia
*H.D. Tjia (PETRONAS Carigali Sdn. Bhd.)*

14:30 : ***Paper 10:*** High resolution facies description from vintage dipmeter logs, a case-study from the Betty Field, offshore Sarawak
*Tanwi Basu and Debnath Basu (Schlumberger Data & Consulting Services)*

15:00 : ***Paper 11:*** The Upper Miocene deepwater fans of NW Borneo: new insights on stratigraphy and palaeogeography from basin-wide 3D seismic data and well control
*C. Grant, T. Chisholm, Yong Boon-Tek, Matthew Choo, Gary Ingram and John Voon (SMEP, Sarawak Shell Berhad)*

15:30 : ***Paper 12:*** Surface geochemistry as an exploration tool in frontier, deep water areas: a case study from the Atlantic Margin
*Malvin Bjorøy (Surface Geochemical Services AS) and Ian L. Ferriday (Geolab Nor AS)*

16:00 : ***Tea Break*** *(Sponsored by Geoeast (M) Sdn. Bhd.)*

**Session 5**
**(Grand Ballroom)**

**Session Chairman : Jack Kerfoot**
*(Senior Exploration Manager, Murphy Oil)*

16:30 : ***Paper 17:*** Pay sands prediction in Baram Delta through rock properties and 3D simultaneous inversion study
*Hesham Hendy, Haslina Mohamed and Vincent W.T. Kong (PETRONAS Carigali Sdn. Bhd.)*

17:00 : ***Paper 18:*** Primaries at last — an innovative technique suppresses severe seismic multiples in the Kutei Basin, Indonesia
*Douglas McKee, Budi Sulistiyo, Dadi Sugiat (Unocal Indonesia Company), Bob Estill (Unocal Corporation) and Dan Heinze (Applied Geophysical Services)*

17:30 : ***Paper 19:*** The sedimentology of the Mio-Pliocene clastic deposits of eastern Sabah, and implications for offshore hydrocarbon potential
*Jon Noad (Shell International)*

18:30 : ***Icebreaker*** *(Sponsored by PGS Exploration (M) Sdn. Bhd.)*

# PROGRAMME

## DAY 1

### Wednesday, 17 December 2003

**Session 4**
**(Perak Room)**

**Session Chairman : Dimyati Mohamed**
*(Manager, PETRONAS Research & Scientific Services Sdn. Bhd.)*

14:00 : ***Paper 13:*** High-resolution stratigraphy of the alluvial-coastal succession of the D and E group (Middle Miocene) of a gas-field in the northern Malay Basin, offshore Peninsular Malaysia
*Mohd Rapi Mohamed Som (PETRONAS Research & Scientific Services Sdn. Bhd.), Abdul Hadi Abd. Rahman (Universiti Sains Malaysia) and Moh'd Nurein Bushara (PETRONAS Carigali Sdn. Bhd.)*

14:30 : ***Paper 14:*** Advances in visualization technologies: a case study, Laho Field, offshore Peninsular Malaysia
*Christianne M. Gell (Landmark Graphics Malaysia Sdn. Bhd.), Douglas E. Meyer, Rosemawati Abdul Majid and David J. Carr (PETRONAS Carigali Sdn. Bhd.)*

15:00 : ***Paper 15:*** Time-Depth Conversion using wells calibrated seismic velocities
*Zakaria Hj Marzuki (Brunei Shell Petroleum Sdn. Bhd.), Jeffry Gunawan (Brunei Shell Petroleum Sdn. Bhd.) and Mark Sams (Fugro-Jason)*

15:30 : ***Paper 16:*** Developing a facies-based 3D geological model of a stacked coastal-deltaic reservoir succession: Bokor Field, West Baram Delta Province, offshore Sarawak
*M. Mulcahy (Schlumberger DCS), F. Zainudin, Hj. W. Musbah (PETRONAS Carigali Sdn. Bhd.), S. Flew, A. Boitel (Schlumberger DCS) and H.D. Johnson (PETRONAS Carigali Sdn. Bhd.)*

16:00 : ***Tea Break*** *(Sponsored by Geoeast (M) Sdn. Bhd.)*

**Session 6**
**(Perak Room)**

**Session Chairman : Dave Richert**
*(Talisman Malaysia Ltd.)*

16:30 : ***Paper 20:*** Tectonostratigraphy of the half-graben sub-province in Western Luconia
*Donald Sim and Guenter Jaeger (Sarawak Shell Berhad)*

17:00 : ***Paper 21:*** Borehole image, CMR* and core calibration for cataloging facies and depositional features: an example from NW-Sabah Basin
*Debnath Basu (Schlumberger Data & Consulting Services), Azli Abu Bakar (PETRONAS Carigali), Michel Claverie (Schlumberger Data & Consulting Services), Isham Fariz B. Ishak (PETRONAS Carigali), Tanwi Basu and Azlina Habibullah (Schlumberger Data & Consulting Services)*

17.30 : ***Paper 22:*** Evaluation of formation fluids from surface gas measurements
*N. Frechin (Geoservices S.A)*

18:30 : ***Icebreaker*** *(Sponsored by PGS Exploration (M) Sdn. Bhd.)*

# PROGRAMME

## DAY 2

### Thursday, 18 December 2003

**Session 7**
**(Grand Ballroom)**

**Session Chairman : Paul Ebdale**
*(Exploration Manager Southeast Asia, Amerada Hess)*

07:45 : Second day convenes

08:15 : ***Paper 23:*** High density simultaneous picking of moveout parameters velocity and anellipticity
*Adam Betteridge (CGGAP Sdn. Bhd.)*

08:45 : ***Paper 24:*** Measuring the success of innovative technology solutions for petroleum exploration and development
*Abbas Mehrabian and Jess Kozman (Schlumberger Information Solutions)*

09:15 : ***Paper 25:*** Rock properties for prediction — uses and abuses
*Timothy E. Johnson (Sarawak Shell Berhad)*

09:45 : ***Paper 26:*** Hydrocarbon potential of pre-Tertiary sediments (Cretaceous/Jurassic?) on Tenggol Arch, West Malay Basin
*Ramlee Abdul Rahman and H.D. Tjia (PETRONAS Carigali Sdn. Bhd.)*

10:15 : ***Coffee Break*** *(Sponsored by Fugro-Jason & Veritas DGC (M) Sdn. Bhd.)*

**Session 9**
**(Grand Ballroom)**

**Session Chairman : Hoh Swee Chee**
*(General Manager, CS Mutiara Petroleum Sdn. Bhd.)*

10:45 : ***Paper 31:*** Wrench-faulting and compressional features in an extensional basin: the Mekong Basin, Vietnam
*Mastura Abd Malik, N.H. Ngoc, M. Jamil Said, M. Nasir Abd Rahman (PETRONAS Carigali Vietnam) and H.D. Tjia (PETRONAS Carigali Sdn. Bhd.)*

11:15 : ***Paper 32:*** Geological well reporting and well data management — a journey through time
*Rien Corstanje (Cambrian Consultants Ltd.)*

11:45 : ***Paper 33:*** Shell's integrated approach to 3D basin modelling
*L. Sánchez Rodríguez, K.K. Liaw, A. Bray (SMEP, Sarawak Shell Berhad) and H.D. Wang (SIEP, Sarawak Shell Berhad)*

12:15 : ***Paper 34:*** Imaging beneath gas — a Prestack Depth Migration case study
*Osman Khan, Uwe Klein-Helmkamp, Peter Whiting (Veritas DGC Asia Pacific Ltd.) and Tim Chapman (Murphy Oil Corporation)*

12:45 : ***Lunch*** *(Sponsored by PETRONAS)*

# PROGRAMME

## DAY 2

### Thursday, 18 December 2003

**Session 8**
**(Perak Room)**

**Session Chairman : Christi Gell**
*(Business Development Manager, Landmark Graphics (M) Sdn. Bhd.)*

| | | |
|---|---|---|
| 07:45 | : | Second day convenes |
| 08:15 | : | ***Paper 27:*** Greenfield in a Brown field — a method to look for untapped potentials<br>*Vincent W.T. Kong, Ngadni Temon and Faizal Zainuddin (PETRONAS Carigali Sdn. Bhd.)* |
| 08:45 | : | ***Paper 28:*** Sampling of mud gas using Isotubes in NW Borneo deepwater<br>*Kim-Kiat Liaw (SMEP, Sarawak Shell Berhad)* |
| 09:15 | : | ***Paper 29:*** Off-shore Mediterranean sea oil potential, Egypt<br>*Heidar Osman (Egyptian General Petroleum Corporation)* |
| 09:45 | : | ***Paper 30:*** South China Sea bathymetry and interpretation<br>*Charles S. Hutchison* |
| 10:15 | : | ***Coffee Break*** *(Sponsored by Fugro-Jason & Veritas DGC (M) Sdn. Bhd.)* |

**Session 10**
**(Perak Room)**

**Session Chairman : Jawaid Saeedi**
*(Operation Manager, Schlumberger Data & Consulting Services)*

| | | |
|---|---|---|
| 10:45 | : | ***Paper 35:*** Structural style of Kudat Peninsula, Sabah<br>*F. Tongkul (Universiti Malaysia Sabah)* |
| 11:15 | : | ***Paper 36:*** Stochastic inversion as a part of static model building<br>*Miltos Xynogalas (Sarawak Shell Berhad)* |
| 11:45 | : | ***Paper 37:*** Genetic unit and prediction of petrophysical parameters — a case study<br>*Mohd Azizi bin Ibrahim (PETRONAS Carigali Sdn. Bhd.)* |
| 12:15 | : | ***Paper 38:*** Surface detection of reservoir hydrocarbons through vertical migration<br>*David G.R. Goold and Holger Stolpmann (W.L. Gore & Associates)* |
| 12:45 | : | ***Lunch*** *(Sponsored by PETRONAS)* |

# PROGRAMME

## DAY 2

### Thursday, 18 December 2003

**Session 11**
**(Grand Ballroom)**

**Session Chairman : Kurujit Nakornthap**
*(Chief Executive Officer, Malaysian-Thailand Joint Authority)*

14:00 : ***Keynote Address 2:*** E&P industry performance improvements require process and technology changes
*Sid Williams [General Manager, Asia Pacific, Landmark Graphics (Malaysia) Sdn. Bhd.]*

14:30 : ***Paper 39:*** Reservoir Connectivity Analysis: understanding of fluid distribution within productive intervals in Tabu and Tapis fields, Malay Basin
*Mohd Rohani Elias (ExxonMobil Exploration & Production Malaysia, Inc.), Bill James, Peter Vrolijk and Rod Myers (ExxonMobil Upstream Research Company, Houston, Texas)*

15:00 : ***Paper 40:*** Oil discovery in the Sepat Field
*Hamdan Mohamad and Idris Mohamed (Petroleum Management Unit, PETRONAS)*

15:30 : ***Paper 41:*** Carbonate Build-Ups in Central Luconia: new Insights from 3D
*Guenter Jaeger, Piet Lambregts, Laurent Bourdon and Andrew Chan (Sarawak Shell Berhad)*

16:00 : ***Paper 42:*** An integrated approach to pore pressure prediction in an exploration setting, Deepwater Sarawak Block F
*R. Courel, D. Goulding, P. Desegaulx [Amerada Hess (Malaysia-Block F) Limited], M. Bayly (WesternGeco), P. Abolins (PETRONAS Research & Scientific Services Sdn. Bhd.), C. Sejourne, L. De Walque, G. Pouliquen (Total) and F. Dartois (Beicip-Franlab)*

16:30 : ***Closing Remarks and Closing of Conference***

17:00 : ***Tea*** *(Sponsored by Fugro-Jason & Veritas DGC (M) Sdn. Bhd.)*
***Adjourn***

# PROGRAMME

## POSTER SESSION

1. A sequence stratigraphic perspective of the Dent Group, Eastern Sabah
*Mohd Razali Che Kob, Mohd Fauzi Abdul Kadir (PETRONAS Research & Scientific Services Sdn. Bhd.) and Awalludin Harun (Petroleum Management Unit, PETRONAS)*
2. Facies and sedimentary cycles within the D and E Group in the north-eastern sector of the Malay Basin, Malaysia
*Abdul Hadi Abd. Rahman (Universiti Sains Malaysia), Mohd Rapi Mohamed Som (PETRONAS Research & Scientific Services Sdn. Bhd.) and Moh'd Nurein Bushara (PETRONAS Carigali Sdn. Bhd.)*
3. Application of Shell volume interpretation software in fast-track 3D seismic interpretation
*Chee-Hau Hoo, Chit-Meng Ooi, Boon-Teck Yong, Matthew Choo, Harry Germs, Chin-Tiong Ling and John W.K. Voon (Sarawak Shell Berhad)*
4. The application of quantitative interpretation technology to offshore Sarawak and Sabah, Malaysia
*Chi-Chin Feng, Hua Zhu, Harry Germs, Chit-Meng Ooi, Miltos Xynogalas, Tai-Ming Ting, Yip-Cheong Kok, Chee-Hau Hoo, Agnes van Bruggen, Sean Dolan and Chin-Leong Ling (Sarawak Shell Berhad)*
5. 4D seismic forward modeling in offshore Sarawak fields
*Kok Yip Cheong and Hua Zhu (Sarawak Shell Berhad)*
6. Application of probabilistic inversion in Sarawak gas fields
*Tai-Ming Ting, Hua Zhu and Agnes van Bruggen (Sarawak Shell Berhad)*
7. Fluid inclusion screening of 16 Carbonate wells from Central Luconia, offshore Sarawak — final results
*Piet Lambregts (Sarawak Shell Berhad)*
8. Challenges of developing a stacked clastic gas field
*Navpreet Singh, Graham Cocksworth, Frank David, Gerco Janssen, Kumareson Paranthaman, Chandra Velu, Leong Hon Voon and Hua Zhu (Sarawak Shell Berhad)*
9. Volume interpretation in the Malay Basin: how to leverage the value of 3D data by using state of the art technologies to better understand stratigraphical plays
*Christophe Gonguet (Sarawak Shell Berhad) and Mike Ainsworth (Carigali Shell Mutiara Petroleum)*
10. Reservoir heterogeneities of lower coastal plain estuarine sands, West Patricia Field, offshore Sarawak
*Teguh Prasetyo, Mohd. Khalid Jamiran, Andy Firth and Mohd. Reza Lasman (Murphy Sarawak Oil Co. Ltd.)*

# PROGRAMME

## POSTER SESSION

11. Technology integration for reservoir characterisation and optimized well planning at Larut Field — offshore Malay Basin
*Melanie J. Ryan and Christopher E. Harris (ExxonMobil Exploration & Production Malaysia, Inc.)*

12. Improved reservoir characterisation from inversion of high resolution 3D seismic data
*Sagar Ronghe, Mark Sams (Fugro-Jason), Sriyanee de Silva (Amerada Hess) and Julian Sherriff (Robertson Research)*

13. Insights on prospectivity of disputed zones, South China Sea
*Janice M. Christ (J-SEA Geoscience), William G. Dickson (DIGs) and James W. Granath (Granath & Associates)*

14. Technology changes supporting improved performance of E&P industry processes
*Dylan Mair (Landmark Graphics (M) Sdn. Bhd.), Nancy Benthien, Kandy Lukats and Scot Evans (Landmark Graphics Corporation)*

15. Prioritising exploration leads in the Sudan using magnetic alteration seepage signatures recognised in high resolution aeromagnetic data
*Vaughan C.A. Stone [Geophysical Exploration Technology Limited (GETECH)], W. Heiko Oterdoom [PETRONAS Carigali White Nile (5B) Ltd.] and J. Derek Fairhead [Geophysical Exploration Technology Limited (GETECH)]*

16. Measurement of sediment surface heat flow and its application in deep water exploration
*Bernie B. Bernard and James M. Brooks (TDI-Brooks International Inc.)*

17. Deformation styles in the Northwest Borneo and North Makassar Basins
*Peter Baillie (TGS-NOPEC Geophysical Company) and Herman Darman (Brunei Shell Petroleum Co. Sdn. Bhd.)*

18. Comparison of source rock geochemistry of selected organic-rich rocks from the New Airport Site and Tg. Kidurong, Bintulu, Sarawak: implication for oil generation from Terrestrial-derived organic matter
*Ismail Elforjani Shushan, Wan Hasiah Abdullah (University of Malaya) and Abdul Hadi Abdul Rahman (University of Science Malaysia)*

19. The Late Miocene Sandakan Formation, East Sabah: facies, depositional environments and relative sea level change
*Tarek Abu Bakar (University of Malaya), Abdul Hadi Abd. Rahman (University of Science Malaysia) and Wan Hasiah Abdullah (University of Malaya)*

20. Sedimentary facies development of breccia dominated sediments in Tanjung Sekakap-Tanjung Murau area, Mersing, Johor
*Sugeng S. Surjono (Universiti Kebangsaan Malaysia, Gadjah Mada University), Mohd. Shafeea Leman, Kamal Roslan Mohamed and Che Aziz Ali (Universiti Kebangsaan Malaysia)*

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# ABSTRACTS OF PAPERS

*Keynote Address 1*

## A strategy for successful small field and cluster developments in Malaysia — Talisman's perspective

NICK WALKER

Talisman Malaysia Limited
Level 31, Menara Citibank
165, Jalan Ampang
50450 Kuala Lumpur

Talisman Energy Inc. is a large diversified international exploration and development company with operations in North America, the North Sea, Southeast Asia, the Caribbean & Latin America and Africa & the Middle East. We operate defined strategies for value creation and growth, which are based on North American style core areas, operatorship and high working interest. Talisman has a successful 10 year track record of growing production and adding value. Since the Company started in 1992 we have grown production eight fold to around 400 mboe/d in 2003. We have utilized our "North American" style strategy to grow internationally and are active in 11 countries.

Talisman entered Malaysia two years ago through the acquisition of Lundin Oil. Our strategic rationale for entry to Malaysia was the opportunity to buy into and develop a new core production area with the major PM-3 CAA project, recognized good growth opportunities within existing acreage, and the potential to expand our business through exploration and access to undeveloped small field growth opportunities. Two years on we feel that we have made good progress towards delivery of our strategy.

Our UK North Sea business provides a good example of Talisman's strategy in action and provides a good template on how to add value in a mature hydrocarbon basin. The success of our North Sea business provides many pointers on how to develop our Malaysian business and the talk will discuss the key lessons from our successful North Sea strategy.

The presentation will cover the key factors behind the success of the PM-3 CAA Phase 1 small field development and the second phase of the block development with the major PM-3 CAA Phase 2 & 3 cluster development, involving production from some 7 fields. The presentation will also cover details of our "fast track" PM-305 South Angsi small field development which we will bring on production within two years from discovery. The presentation will wrap up by discussing Talisman's views on the key factors for successful small field and cluster developments in the offshore environment.

*Paper 1*

# Exploring the Sabah Trough — Block K Exploration 1999–2002

JACK L. KERFOOT

Murphy Sarawak Oil Co; Ltd.
Murphy Sabah Oil Co; Ltd.
Murphy Peninsular Malaysia Co; Ltd
Level 26 & 27, Tower 2
PETRONAS Twin Towers
Kuala Lumpur City Center

The Sabah Trough is located off the Northwest coast of Borneo and covers an area of approximately eighteen million acres. In 1998, the Sabah Trough was one of the last unexplored deepwater provinces in the world. In January 1999, Murphy and Carigali signed the Block K Production-Sharing Contract. The paper addresses the basin assessment, exploration strategy and actual exploration program, which resulted in the discovery of the Kikeh Field in July 2002.

*Paper 2*

# Irong Barat B multiple scenario analysis — application at EMEPMI

DIANA ABDUL RAHMAN, LIM HOCK KUANG, JASON BORG, NIK IMA DAYANA NIK MOHAMED AND RAMLI MUHAMAD

ExxonMobil Exploration & Production Malaysia Inc.
Menara ExxonMobil
Kuala Lumpur City Centre (KLCC)
P.O. Box 10857
50728 Kuala Lumpur

Irong Barat Field, located offshore Peninsular Malaysia, is an east-west trending complexly faulted anticline covering an area of 8,000 acres. The field was discovered and appraised by 13 exploration wells. The initial development of the Irong Barat A drilling program took place in 1984, followed by an infill-drilling program in 2000.

This paper describes the application of multiple scenario analysis to mitigate risks and challenges associated with the Irong Barat B drilling program.

The Irong Barat B drilling program is a 6-well program, which began in May 2003. The primary objective reservoir in the program is thin and highly laminated. Geologic risks include structural and OWC uncertainties, reservoir heterogeneity and the potential for water-bearing sandstone to be present beneath the objective reservoir. Key challenges in the program included the need to confirm the position of the OWC in the thin reservoir sand and the need to maximize the length of completion in a laminated reservoir in order to achieve high $k_h$ to ensure optimum production rates. Multiple scenario concepts including responsible use of batch completion were utilized in both well design and completion strategy in order to optimally address these challenges, enable additional cost optimization and to maximize program economics.

# North Sabah exploration: new play potential in a mature area

DORINE TERWOGT – DE JONGE, LI PENGZHEN, PHLEMON GEORGE,
LOURDES SANCHEZ RODRIGUEZ AND NORZITA MAT-FIAH
SMEP, Sarawak Shell Berhad
Locked Bag No. 1
98009 Lutong, Sarawak, Malaysia

## THE NORTH SABAH INBOARD AREA

Shell has had an active E&P presence in the offshore Sabah Inboard area (generally defined as < 200 m Water Depth) for more than 30 years. Currently Shell operates 5 oil fields with the most recent being SF 30, which started production in 2001. Shell currently holds three exploration PSC's in the Sabah Inboard area (SB301, 96PSC SB303), with all fairly similar PSC terms. Today's exploration efforts in the Sabah Inboard focus on finding new oil reserves to take advantage of available ullage in existing facilities.

Historically exploration was based on 2-D seismic data with generally structural traps as the objective. The current trend is toward exploration with 3-D seismic and an increased focus on traps with a key stratigraphic trapping element. Supported by the recent Shell Northwest Borneo Framework Study the emphasis in the North Sabah area (SB303/96PSC) is on Late Miocene to Early Pliocene TB3 turbidite plays and Early to Middle Miocene Deep Overpressured plays.

The relatively high value that can be derived from the plays that are being pursued is driven by low commercial cut off volumes and PSC terms that generally favour small field development. The base development model is a tie-back structure to existing Shell operated oil infrastructures in the 96PSC and immediate access to available market.

## SF-30 DISCOVERY AND CANYON SLOPE TURBIDITE PLAY

In the Turbidite Play, the Tembungo field is the only success to date in Inboard Sabah in a conventional structural closure. Turbidites on flank structures were identified on 2D seismic in the early 80's, but due to their complex and uncertain trapping geometries often seen as too risky to explore.

With the discovery of a thin oil bearing sand by the SF-28 development well in 1998 and subsequent appraisal in 2000, the SF-30 field in this canyon/slope turbidite setting became the latest Sabah discovery. The discovery was rapidly developed and monetised (in less than 18 months from discovery to first oil). The field is currently producing using state of the art smart well technology.

The success of this new play opened up new exploration opportunities for Sabah inboard, and the chase for a new TB3 turbidite play along the assumed regional trend of the shelf edge started. The trend was extended from the South Furious and Barton fields to the north east. As a result, several slope channels were identified in the Tiga Papan and Kindu-Mangayau sub-basins and this formed the basis for SB303 license application and award in October 2000.

It should be pointed out that this new play, although stopping short of the 200 m waterdepth line, is of the same stratigraphic age as some of the plays that Shell is pursuing in the Sabah deepwater. Future finds in the North Sabah area are expected to have a mean UR of the same order of magnitude or larger than the SF-30 field. Yet to find oil potential for all Inboard TB3 Turbidite sub-plays is about xxx Mmboe. Of particular interest are the Landok and Lidah prospects located in the Tiga Papan sub-basin, less than 5 km from the existing Tiga Papan discovery.

## 3D SEISMIC DRIVEN EXPLORATION

Historically, exploration in Sabah has been based on 2D seismic data with structural traps being the main objective. Because of the complex nature of these slope turbidites, which show intensive channeling of intercutting nature and subtle stratigraphic components, evaluation on 2D seismic is not seen as a viable option. Moreover, Amplitude versus Offset effects, Direct Hydrocarbon Indicators, trapping geometry and reservoir distribution need to be thoroughly evaluated with 3D seismic and its supporting technologies to better quantify volumetrics and to mature these leads to drillable opportunities with acceptable risk and uncertainty levels.

A good example of this is the surprising sequence of Tiga Papan competitor drilling results on 2D seismic, and their current location on 3D seismic: all wells are on the edge of seismic anomalies, and seismic to well tie and prediction of reservoir quality and distribution is extremely difficult.

Hence in 2001, an exploration seismic acquisition campaign was kicked off, and over 1,000 sq. km were acquired. The data was processed in-house with Shell Proprietary ePSI processing technique. 3D seismic acquisition for exploration purposes is now becoming a standard for Shell in Sabah Inboard, and further 3D acquisition is planned for 2004.

## RECENT REGIONAL GEOLOGICAL ANALYSIS AND NEW PLAY AND PROSPECT IDENTIFICATION

A thorough regional analysis of the North Sabah area was kicked off mid 2001, coinciding with arrival of historic SB303 data. Updated (bio)stratigraphic analysis of wells and extensive regional mapping has resulted in updated structure maps for seven TB sequences. These maps, together with well results and qualitative seismic reservoir characterization have been used to construct Gross Depositional Environment maps for the main TB sequences. 3D Basin modelling has been done to analyze source rock distribution, maturation, migration pathways and timing of structuration wrt HC expulsion models.

Integration of all this data have led to the thorough definition of five major plays in the SB303/96PSC area. Plays with currently highest estimated remaining potential are TB3 Turbidites and TB2.1–2.3 Deep Overpressured Play. Other more conventional and creamed plays are TB3 Topsets (St. Joseph) TB2.4–2.6 Topsets (South Furious, Barton) and the less successful TB3 Carbonate Play.

Several new prospects and leads have been identified confirming and the latest state of the art evaluation technology has been applied. 3D seismic is a key enabler for addressing play and prospect critical success factors: it has been used extensively for detailed structural and amplitude (including AVO) mapping, reservoir prediction and characterisation, hydrocarbon prediction techniques and pressure evaluation from seismic.

Whilst the learnings are many, it is clear that exploration in this area still offers commercially attractive opportunities that can be rapidly developed and monetised using the existing North Sabah infrastructure. Some of the most attractive prospects are currently being further matured, and two exploration wells are planned for 2004.

***Paper 4***

# Advanced seismic imaging application of Common Reflection Surface Stack (CRS) technology on 3D seismic data ofTembungo Field, offshore Sabah, Malaysia

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The Tembungo 3D seismic generally exhibits an anticlinal structure in Miocene stage IV-C basin slope fan system. The illumination of the structure was impaired by near-surface reef carbonates that strongly scatter and weaken the seismic wavefield. The imaging problem in the central area was even more aggravated by strong refracted energy in the sedimentary layers at the flanks of the anticline. This is worsen by gas wipeout, multiples, low signal-to-noise (S/N), and complex faulting at the reservoir level. To solve these problems, an integrated approach of 3D Common Reflection Surface (CRS) and Depth Imaging was applied. This new approach of combining specific seismic technologies has proven that it focused better reflections and reduced uncertainties in positioning error. Additional information to approximate traveltimes by CRS technique are emergence angle and wavefront curvatures to increase S/N ratio. Therefore, it does not rely on accurate velocity model to focus images and made them appear on a section. Iterative depth imaging was used to collapse diffractions and migrate the data to correct lateral positioning via 3D Post Stack Depth Migration (PoSDM) method.

*Paper 5*

# Optimisation of deepwater fiscal systems in the context of geological prospectivity

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This paper examines the challenge governments' face in setting fiscal terms that are appropriate to the established and perceived geological prospectivity of basin in order to attract the investment required for high cost and potentially high risk exploration.

Worldwide deepwater activity is concentrated in a small group of countries which are characterised by both geological prospectivity and attractive fiscal terms. Most of the deepwater reserves added in the last 10 years have been in countries which actively seek deepwater investment. The primary driver of deepwater drilling activity is a proven commercial reserve base, but appropriate fiscal terms are required to stimulate initial activity. Many countries and basins do not have the activity in deepwater exploration that they might otherwise have received due to inappropriate levels of government take. Governments can encourage investment and raise activity levels by adjusting fiscal terms to a suitable level in the context of the prospectivity of their deepwater areas.

Not only determining the appropriate level of government take is important in the context of the geological potential of the basin but also the structure. The structure of the fiscal regime should relate to a realistic assessment of the field size that could be discovered and should ensure that a potential stand-alone development can be profitability developed.

*Paper 6*

# A geochemical evaluation of the West Crocker Formation — clues to deepwater source rock facies?

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Recent exploration activity in the present day deepwater areas of offshore northwest Sabah have resulted in varied successes in the targetted turbidite sands; results ranging from dry wells to considerable oil discoveries. These mixed results have raised some issues regarding the hydrocarbon charge in a turbidite setting, particularly concerning the source rock distribution, quality and maturity (Walker, 1978).

Almost all published geochemical studies to date have focussed on the shallow water (present day and ancient) areas of offshore Sabah and have discussed source facies dominated by dispersed terrigenous organic matter (Azlina Anuar, 1994; Leong *et al.*, 1999). However, are these source facies appropriate models for deepwater depositional settings? To try to address this issue, a field study and subsequent geochemical characterisation study, of an onshore deepwater analogue — the West Crocker Formation — were carried out. The West Crocker was selected by virtue of geographic and temporal proximity to the current exploration turbidite targets. In this way, source facies variations were minimised. Furthermore, the West Crocker has been well described sedimentologically, with several turbidite elements recognised and described in the field (Crevello, 1998; Crevello, 2001).

A total of 92 samples, predominantly shales, were collected from 6 localities around the Kota Kinabalu area, each of which represents one or more turbidite depositional elements: channel margins, channel levees, interchannel overbank, slumps, distal lobe, and basin plain. The collected samples were subjected to a detailed geochemical work programme. The sedimentological work (Crevello, 1998; Crevello, 2001) provided accurate positioning of the analysed samples within a sequence stratigraphic and depositional framework. This allowed comparisons to be made between shales having a predominantly reworked shelfal provenance, and shales of a pelagic, generally transgressive, origin. The geochemical analyses comprised basic source rock screening (TOC, Rock-Eval, and VR) with more advanced characterisation (visual kerogen typing and biomarker studies) of selected samples.

The intimate arrangement of shales and reservoir sands observed at the studied localities is very conducive for direct primary migration into carrier and/or reservoir beds.

The shales studied can be categorised into three main types: *pelagic basin plain shales*, as typified in the Seen Seen Section; *turbiditic shales*, representing either the fine tails of turbidity currents or levee/overbank shales, as observed at the Junkyard section; and *slumped shales/debris flows,* as strikingly displayed at the Papar–Beaufort highway quarry.

The basin floor shales are pelagic in nature and tend to be very thick, with a correspondingly very low sand to shale ratio. The organic richness of these shales tends to be very low, generally less than 0.50 wt%. The biomarker distributions of these shales have a predominantly marine signature, typified by an even C27, C28, C29 sterane distribution and the presence of C30 steranes, an absence of higher plant indicators such as 18a(H)-oleanane and bicadinanes, and low Tm/Ts and Pr/Ph ratios. The low organic richness of the basin floor shales suggests they do not represent a likely source rock facies.

The fine turbiditic shales represent either levee/overbank deposits or the fine tails of turbidity currents. The former consist of either thinly bedded levee system shales with a moderately high sand shale ratio, or of thicker overbank shales. The organic richness in these shales is very variable, ranging from as low as 0.11 wt% to as high as 2.52 wt% with shales separated by a single sandstone bed possessing very different organic richness. The organic richness of some of these turbiditic shales suggests that this is a promising source facies, although the variation in organic richness emphasises the need for close sampling when evaluating turbidite sequences as possible source facies. The biomarker distributions of these shales possess a predominantly marine signature, not too dissimilar from those of the basin plain shales: an even C27, C28, C29 sterane distribution and the presence of C30 steranes, an absence of higher plant indicators such as 18a(H)-oleanane and bicadinanes, and low Tm/Ts and Pr/Ph ratios.

The third type of shale studied are those associated with slumps and debris flows. These are observed at the Papar – Beaufort highway quarry which displays some excellent examples of slumps and a striking debris flow. The organic richness of the slump shales appears to be variable, ranging from a poor 0.42 wt% to a promising 2.75 wt%. The debris flows can be very carbonaceous, with TOC values of up to 68.62 wt% being observed. The biomarker distributions of the slumps and debris flows contrast markedly with those of the basin plain and levee/overbank shales. The slump/debris flow shales display a strong terrigenous, higher plant signature. They are characterised by a marked C29 sterane preference, a lack of C30 steranes, and can contain high amounts of higher plant derived compounds such as 18a(H)-oleanane. The organic rich nature of the slump/debris flow shales suggests that they are a promising source rock facies, although the key question is: *how common are they in a typical deep water sedimentary sequence?* At the Papar – Beaufort highway quarry they are very common and represent quite a prospective source. However, elsewhere they are more scarce, perhaps due to the distal depositional settings involved.

Vitrinite reflectance analysis has revealed considerable variation in the maturity of the West Crocker formation from locality to locality. This maturity variation is considered to be due to the thrusted nature of the formation, in which adjacent slices could have been thrusted up from very different depths. Vitrinite reflectance values range from as high as Ro 2.0% or higher to as low as Ro 0.65%. It is often assumed that the West Crocker is invariably overmature. This study has shown that this is not the case, the full implications for which are, as yet, unsure.

*Paper 7*

# Full anelliptic time processing

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Conventional seismic processing is based on the hypothesis that seismic wave velocities vary in space, but are independent of the propagation direction. An assumption is also made that the travel times of seismic events follow hyperbolic behaviour. Of course neither is true, the velocity of propagation within a seismic layer can vary between horizontal and vertical directions (VTI — vertical transverse anisotropy) and with different azimuth of propagation, seismic layering causes ray-bending and increasingly non-hyperbolic behaviour with increasing offset and dip. Lateral velocity variations and the nature of the overlying structures can also break these initial assumptions.

Anellipticity (or effective h) is a term that takes into account the vertical transverse anisotropy and the non-hyperbolic moveout due to long offsets.

This anellipticity can be estimated from the seismic data at an early stage in the processing sequence and taken into account during the subsequent processing steps such as normal moveout (NMO), dip moveout (DMO), and pre-stack time migration (PSTM).

Anelliptic time processing improves focusing at far offsets and of steep dips, results in meaningful interval velocities, improves amplitude preservation for AVO products, and with analysis of the anellipticity field can indicate anisotropic layers.

*Paper 8*

# Surface geochemistry methods and applications in deepwater exploration

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Surface geochemical prospecting is a petroleum exploration tool based on the premise that upward migrated petroleum from deep source rocks and reservoirs can be detected in near-surface sediments and used to evaluate exploration potential. Surface geochemical exploration studies (piston coring and chemical analysis) are cost effective means of obtaining information ahead of the drill bit. The high cost of offshore exploration has made the identification of sea floor micro- and macro-seeps a well-accepted risk assessment methodology. The advantages of surface exploration are that the presence of macro-seepage and/or micro-seepage of oil and gas in near-surface seafloor sediments provides evidence of active oil generation and migration, it allows assessment of most prospective areas, and it provides an integrated seep signal over time. In addition, samples are available to characterize oil properties, maturity and source rock type. In addition, the spatial coincidence of seepage and geologic structure allows for the identification of the loci of natural hydrocarbon seepage and to infer possible migration pathways from the reservoir to the sea floor.

The authors have been involved in the collection of nearly 15,000 piston cores and over 1,000 surface heat flow measurements over the last twenty years as part of deepwater surface geochemical exploration (SGE) studies in frontier regions worldwide. We will discuss current methods and provide case studies and comparison of seepage hit rates from deep water coring programs in the northern and southern Gulf of Mexico, Trinidad, Angola, Nigeria, NW Africa/Nile Delta, NE Canada and SE Asia. The authors will show the increase in seepage hit rates as more recent coring studies have benefited from the increased use of 3-D seismic data over previous 2-D based site selection.

The first part of this paper will describe the current methods used in surface geochemical studies. Typically, geophysical surveys (2D or 3D) have been used to select coring locations based on surface expression of faults and other features related to conduits for upward migration of hydrocarbons. In order to correlate the seabed or sub-bottom feature to be cored with the available seismic records, survey lines are typically executed with the Chirp sub-bottom profiler to collect acoustic graphical data prior to core acquisition. The purpose of this effort is to obtain the best core location and information of sub-bottom structure and bottom hardness for each site. These survey lines are run at the same heading as the seismic line for the station (or its opposite heading), and at a ship speed to give the best image. Ship speed during surveys is typically 6 to 8 knots. Typically, the particular feature on the seabed is identified and matched against the 2-D seismic record. These matches with the seismic records are usually very consistent for most sites. This consistency adds validation to the location calibration data already generated, and eliminates any question as to whether the proper location or datum was specified.

***Paper 9***

## Potential of impact-structure plays in Continental Southeast Asia

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Craters abound on the surfaces of the Moon, of the solid planets and of their satellites. Prior to the manned Apollo missions, views that the craters of the Moon were products of volcanism or of meteorite impacts were about equally strong. The collected Moon rocks show definitive features of high pressure but relatively low-temperature metamorphism that overwhelmingly favour impact origin. On Earth, the suspected impact depression in the Southwestern United States known as Meteor crater, was found associated with high-pressure quartz, or coesite. Currently some 300 terrestrial structures are considered products of impacts by extraterrestrial objects. Almost two hundred of these have been proven as such by the presence of arcuate-circular surface morphology, circular gravity anomaly patterns, shatter cones, poly-megabreccias containing cleaved quartz, quartz and feldspars with mosaicism (patchy extinction), the high-pressure quartz polymorphs of coesite and stishovite, anomalously high Iridium, diaplectic glass, and sometimes microdiamonds. The comparatively low density of terrestrial impact craters on the Earth's surface is attributable to reworking by exogenous processes of weathering, erosion, organic activity, burial by younger deposits, and to the fact that 70 per cent of the surface is covered by water.

In other words, impact craters should be as common on Earth as on the solid extraterrestrial bodies. Calculations suggest a mean probability of over 15,000 significant impact craters having hit land. On land the average depth to diameter ratio of an impact crater is 1:0.2, while rim height is about 4 per cent of the total diameter. Also on land, the dimensions of simple, bowl-shaped impact craters probably do not exceed 4 km in igneous rocks and about 2 km in sedimentary rock. Beyond these limits, complex crater morphologies develop as result of flattening through gravity.

Renewed attention to impact structure plays is relatively recent and was fueled by the 1991 single-strike discovery (25 MMBO, 15 BCFG recoverable reserves) in the vicinity of Ames, Oklahoma, U.S.A. About twenty years earlier other significant discoveries were made at Red Wing Creek, North Dakota (20 MMBO, 25 BCFG), and at the world-famous Chicxulub, Yucatan Peninsula, Mexico (30 BBO, 15 TCFG). However, the structures of these earlier finds were not identified as astroblèmes and at the time of their discoveries the respective reservoirs were considered ordinary fractured carbonates and fractured granite-and-carbonates.

An impact structure creates a local, closed lacustrine or marine depression for source rock to develop and also assist in trapping. Reservoirs are sandstones, carbonates and crystalline rocks whose porosity became enhanced by the impact event. Oil and gas are typically entrapped in and above the encircling rim anticline and in the central rebound peak.

*Paper 10*

# High resolution facies description from vintage dipmeter logs, a case-study from the Betty Field, offshore Sarawak

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The upper cycle V sediments of Betty Field comprise of clastic reservoirs that are primarily homogeneous shoreface deposits. However, there are heterogeneities primarily related to biogenic structures and rip up clasts in a few poor quality sandstones. High-resolution log data and borehole azimuthal coverage from dip meters and image logs facilitates identification of small-scale depositional heterogeneity and is essential for a precise three-dimensional geological model that predicts true reservoir behaviour. This study illustrates an approach to improve the reservoir characterization of the field by quantifying small-scale heterogeneities using dip meter data. Old dipmeter data such as High Resolution Dipmeter (HDT) and Stratigraphic high Resolution Dipmeter (SHDT) commonly logged prior to the introduction of image logs namely FMS, FMI or OBMI have the potential to provide in-depth textural and fabric information. Textural analyses derived from micro-resistivity variations have been used for one well in the Betty field to demonstrate the methodology and to emphasize the optimized use of the dipmeter data in extracting detailed sedimentary information in a quantified way. Fine scale heterogeneities in some of the clastic lithofacies of Betty reservoirs generated by the presence of intense bioturbation, rip up clasts, heterolithic bedding, or massive/homogeneous characters could be detected from these dipmeter logs without any associated images. This valuable information could be obtained through the application of a new suite of Geology software developed for the exploration and production industry which comprises of the fabric/texture analysis module BorTex*.

In a field-wide perspective calibration with cores, however, is essential to validate the dipmeter signatures with actually observed sedimentary features. This was done as a case-study in the Betty Field where vintage dipmeter logs were digitized, and analyzed to detect fine textural heterogeneity, which was later calibrated with the core-description.

The formation heterogeneities are extracted quantitatively based on conductivity variations using BorTex where the dense features are detected as resistive anomalies, and argillaceous features are detected as conductive anomalies. Based on the high resolution dip meter micro-resistivity channels from the key well, Betty-5, the proportion of conductive and resistive heterogeneities was mapped around the borehole wall which when compared to the core image and description correlated very well with observed sedimentary characteristics. The lack of any heterogeneity, i.e., intervals with least active HDT logs matched very well with homogeneous structure-less to very poorly stratified amalgamated sandstone lithofacies representing shoreface deposits. Intervals with high proportion of conductive anomalies with highly active HDT logs, relates to intensely bioturbated sandstone as seen in the core. Higher proportion of conductive heterogeneity as calculated by the textural analysis also correlated well with storm related event beds, which has clay rip-up clasts at the base of the units. The last two lithofacies represent deposition in lower shoreface to an offshore transitional environment. Conductive heterogeneity proportions are also high in bioturbated mud dominated heterolithics, which represents deposition in open marine inner neritic/shelfal environment. Positive resistive anomalies from the textural analysis, on the other hand, correlated well with open-marine massive shales with siderite nodules, which mark flooding events or end of deposition of individual parasequences.

This novel technique has great potential to bring added value from old dipmeter logs which otherwise are nearly forgotten. Fine-scale near wellbore geological heterogeneity is reflected as electrical heterogeneity and is recognizable in these dipmeter and image logs. The specific domain to benefit would be the asset-teams looking for additional data to constrain their facies models and facies geometries. The insights gained from similar dipmeter analysis has the potential for providing quantitative information that can directly be used in property or facies modeling in a fieldwide context. The dipmeter based log motifs have to be calibrated, however, with core observations before populating the information fieldwide. Because of the large vertical resolution contrast between cores and conventional logs, extrapolation of fine depositional heterogeneity into uncored wells using a traditional approach would be unconstrained. The availability of textural analyses in a multi-well scenario and their subsequent use in lithofacies estimation would reduce model uncertainties before up-scaling. The degree of improvement in the ability to identify and quantify geological heterogeneity will have significant implications for future coring, logging programs, and reservoir characterization efforts especially in marginal fields.

*Paper 11*

# The Upper Miocene deepwater fans of NW Borneo: new insights on stratigraphy and palaeogeography from basin-wide 3D seismic data and well control

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Upper Miocene submarine fan deposition across NW Sabah has been influenced strongly by tectonic (as well as eustatic) events. Uplift and erosion across the inboard shelf and mountainous hinterland regions of Sabah have shed large volumes of sand into the NW Borneo basin. Because of limited accommodation space along a narrow shelf, sand cascaded over the shelf edge through a system of upper slope feeder channels or canyons and was deposited in a system of fan lobes on the deepening floor of the NW Borneo trough. Today these fans are folded and thrust within the NW Borneo active margin fold belt. Deformation within this fold belt commenced around 9.5 Ma. Prior to this, gravitational delta tectonics was the dominant deformation mechanism within the basin.

Shell Malaysia-EP has been exploring its deepwater acreages of Blocks J and G, offshore NW Sabah, since 1995. In this 8-year period, the company has amassed a significant deepwater database comprising basin-wide 3D seismic data and 6 exploration wells that have been drilled to test a number of plays and fan intervals. These data have enabled SM-EP to de-risk the NW Borneo deepwater play, to understand the complexity of the deepwater fan stratigraphy, to reconstruct the basin-wide palaeogeography through time, and to establish the spatial and temporal controls on deepwater fan deposition in this active margin setting, namely, basin inversion, delta progradation, and fold belt development.

"Carpet" 3D seismic data provide a broad and detailed canvas on which to evaluate and illustrate the morphology of sand-rich deepwater fan systems. 3D framework mapping of key sequence boundaries on each individual 3D survey allows individual fan units to be isolated seismically. Traditional methods for unravelling fan morphology use combinations of horizon slicing and amplitude extraction to identify depositional characteristics. New interpretation workflows are being developed to rapidly screen 3D seismic data to highlight the main sand fairways in a more automated, less user intense fashion. For example, neural net seismic facies analysis and voxel body extractions are used to recognize and assess depositional elements. AVO data are also incorporated into reservoir facies analysis and can be used to screen for sand sweet spots particularly in the younger, shallower fans.

For the future, SM-EP is reprocessing post-stack its entire 3D dataset and will migrate the data into one large "mega" 3D survey of more than 8,000 sq. km. Once complete this amalgamated 3D seismic dataset will further enhance our ability to evaluate consistently the deepwater play without concern for edge effects, processing artefacts or data gaps.

*Paper 12*

# Surface geochemistry as an exploration tool in frontier, deep water areas: a case study from the Atlantic Margin

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In surface geochemistry the sample collection and preservation aspects are paramount not only for getting the most meaningful data but also for cost. The correct techniques must be used according to the area to be sampled, the most expensive techniques not necessarily being the best regarding sample quality. Ignoring these aspects can lead to an expensive survey, at worst with poorer quality samples. An overview of the sampling criteria are presented and demonstrated in a case study from the Færoes-Shetland area on the North East Atlantic Margin.

The Færoe-Shetland headspace- and occluded gas data indicate mainly only biogenic hydrocarbons, while the adsorbed gas data show greater detail for the heavier, oil-associated hydrocarbons, highlighting definite areas of thermogenic interest. A large area of wet thermogenic gas is shown forming a NE-SW belt in UK quadrants 176 and 204 and Færoes quadrants 6004 and 6005, extending into 6104. To the north of this there occurs a larger, more dispersed and almost fan-shaped spread of dry thermogenic gas in Færoes quadrants 6105, 6104 and 6103 and UK 213.

The liquid hydrocarbon data (GC and GC-MS) similarly highlight areas of seepage which generally coincide with the above. In addition there is shown the presence of two basic source types of oil, together with high maturity condensates of possible mixed origin. The oils comprise a well mature (?U. Jurassic) marine type and a less mature more terrestrial (?M. Jurassic) type.

The greatest concentration of seeping marine type oil is shown within an area in quadrants UK 204 and Færoes 6004 to the west and north of the Foinaven and Schiehallion fields that also have dominantly 'marine' oils. Otherwise there are more scattered occurrences in the central part of the survey area in Færoes quadrant 6104. The greatest concentration of the more terrestrial oil occurs in the central parts of the area, quadrants 6104, 6105 and northernmost 6004. However there appears also to be a belt offset to the north from the marine seepages, close to the Færoes/UK border in quadrants 6005 and 6004.

Regarding drilling, in the UK sector, apart from the fields shown, the wells have returned practically only gas according to available information. Virtually all these wells occur eastward of the survey area, apart from in UK 213, where the dry well shown is in biogenic territory according to the gas data; and in UK 204 where the recent 10-1 oil/gas discovery well is in Type E oil seepage territory according to the extract data. In the Færoes sector, only three wells have been drilled and reported, all since the completion of the surface geochemical survey. Of these, that in 6005 occurs in an area of biogenic hydrocarbons according to both the gas and liquid HC data, and this returned dry. In 6004, the 12-1 well is located in an area with wet thermogenic gas and close to significant Type D oil, this well having shows. In the same quadrant, the 16-1z well, close to the UK-Færoes boundary, is in an area with both abundant wet thermogenic gas and abundant seeps of both Type D and E oils. This well returned with a 170 m oil column, of marine type, similar to the Type E of this study.

The Færoes-Shetland surface geochemical data are therefore so far in good agreement with the drilling results. In addition, some localities to the north in Færoes quadrant 6104 are shown by the geochemical data to have seeped oil-associated hydrocarbons. Only future drilling will show whether these sites contain oils from as yet undiscovered commercial deposits.

***Paper 13***

# High-resolution stratigraphy of the alluvial-coastal succession of the D and E group (Middle Miocene) of a gas-field in the northern Malay Basin, offshore Peninsular Malaysia

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Detail sedimentological analysis and core-log facies calibration of the Middle Miocene succession of a gas-field in the northern Malay Basin identified facies associations which reflect deposition in a coastal-estuarine or coastal-deltaic floodplain environment. The presence of the trace fossils *Diplocraterion* and *Teichicnus* within the floodplain facies, in the upper section of the E Group, and the basal part of the D Group indicate brackish-water conditions, and signify marine incursions into the coastal floodplain areas.

Interpreted log facies of the E, D and B Group successions in the field exhibit three major intervals. These are:

I. **Interval I**: The basal coal-bearing successions of the E Group. Two sub-intervals — a lower floodplain-dominated sub-interval and an upper, sand-prone succession. The lower sub-interval comprises multi-stacked successions of coal-capped floodplains cycles, punctuated by single-story and multi-story fluvial channel sandstones. The upper sand-prone interval is marked by the presence of thick, multi-story, fluvial channel sandstones (10–30 m thick).

II. **Interval II**: Brackish/tidal/marine sand-shale succession, marked by the absence of coal-bearing floodplain cycles, and the presence of *Diplocraterion* and *Teichicnus*. This is essentially the D Group. The lower sub-interval display deltaic sandy, muddy and mixed tidal flats and sand bars, and fluvial channel sandbodies. The upper sub-interval comprises a thick, mud-dominated succession, with minor thin sandy/silty layers, and capped by a 2.0 m thick coal. This muddy unit is interpreted to represent a prograding, prodelta succession.

III. **Interval III**: Thick, coarsening-upward deltaic succession. This interval is represented by a basal lowstand fluvial facies, a transgressive prodelta mud succession, and capped by a sandy, delta-front and fluvial channel highstand deposits. The stacking pattern of the deltaic cycle indicates an overall transgressive episode.

This stratigraphic interpretation indicate that the E-D-B Group sediments form an overall thick, retrogradational succession.

***Paper 14***

# Advances in visualization technologies: a case study, Laho Field, offshore Peninsular Malaysia

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A typical problem facing oil company asset teams today is the integration of new information into existing fields. Recently acquired 3D seismic for example, can add much needed detail to the understanding reservoirs from producing wells. The key step of interpreting faults and surfaces, on which many other results depend, can often be time consuming and delay efforts to bring additional production on-line. However, using a volume-based approach to seismic interpretation using today's visualization technology can lead to more accurate results produced up to four times faster than traditional line-by-line methods.

Over the last four years, visualization technologies have advanced to the point where utilizing these new techniques allow for a faster and more geologically correct interpretation and evaluation of potential reservoirs in a shorter amount of time. These advanced techniques include, but are certainly not limited to: multiple attribute voxel detection; interpreting fault planes (versus fault sticks); real-time volume rendering and the ability to create geobodies; quick reconnaissance work in volume; and the ability to combine workflows using non-3D volume tools such as wave-form classification with volume interpretation.

This paper gives an example of a field from offshore Peninsular Malaysia where two wells were already producing and the operator, Petronas Carigali Sdn. Bhd. (PCSB), acquired 3D data to evaluate the possibility of drilling additional locations. GeoProbe®, a Magic Earth Inc. proprietary visualization program, was used to create the figures for this article.

# Time-Depth Conversion using wells calibrated seismic velocities

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## INTRODUCTION

Time-depth conversion (TDC) has been a debated topic for decades in terms of the methodology and the accuracy of the end product: the depth map or depth volume. There are several ways to transform seismic reflection data, recorded in time, into depth data. All current options can be reduced to 5 routes.

Accurate depth prediction is important for:

- Well targeting and casing design to manage subsurface hazards
- Reliable trap integrity assessments for prospect risking
- Predictable well ties, more reliable reservoir models and fluid contacts
- Transferring seismically derived reservoir models to simulators

A robust volume TDC methodology categorized under Route C of the TDC methods above was established and used for monitoring drilling of wells and reservoir depth prediction. Brunei Shell Petroleum applies all parts of this workflow within the Jason Geoscience Workbench.

## METHODOLOGY

The success of the complete TDC process hinges on the calibration of locally derived well velocities to their corresponding seismic derived Pre-Stack Depth Migration (PreSDM) velocities and the subsequent interpolation and extrapolation of this calibration factor in 3D based on the geological framework model. With the calibrated seismic velocity cube, time horizons/faults and also seismic/impedance/reservoir property/lithology volumes can be easily converted to depth, thus making interpretation in depth possible. The highlight of this methodology is the use of a "geological" framework model in guiding the inter/extrapolation of seismic velocity (step 2) and calibration factor (step 4) volumes. Establishing a good seismic-to-well tie (step 1) and having "sufficient" well control are two key factors to the success of this TDC technique.

The workflow can be applied to interval or average velocities. Average velocities are often used as this overcomes many of the difficulties associated with deviated wells. The first step is to tie the wells to the seismic data volume through matching of synthetics to the seismic. Once the tie has been established at each well and the time to depth relationships compared and checked for reliability, the average velocity is calculated at each point along the well track. The second step is to produce a volume of average velocity from the input velocity model. This step involves conditioning, velocity conversion, interpolation and quality control. The conditioning normally consists of editing, frequency filtering and lateral smoothing. The latter processes may be applied several times at different stages. The lateral smoothing and interpolation should be applied conformably to the structure observed in the velocity model. This may be conformable to geological structure or sea surface or sea floor. Next, the average velocity from the volume is extracted along the well track and compared with the average velocities calculated in the wells. A calibration factor log is then calculated that adjusts the seismic average velocity to the well average velocity. These calibration factor logs can be extended beyond the logged interval and filtered back to the frequency bandwidth of the seismic average velocity volume. The calibration factor logs derived at each well location are then interpolated within the geological model and applied to the average velocity volume to create a calibrated average velocity volume. This volume can then be converted to interval velocity to check for realistic values, as the process does not guarantee this.

## CASE STUDY 1

The described TDC procedure was applied to a brown field in support of an in-fill drilling campaign. Previously a Vo-K TDC method was used to depth convert the time horizons. The depth-converted horizons were then corrected to match well markers using the CPS mapping software. Since there were a very large number of wells in the field, the latter TDC procedure was thought good enough to predict formation tops at new well locations. However, the seismic impedance volume remained in time and the need to use impedance data to monitor well depth while drilling required the impedance volume to be correctly depth converted. In this case, the impedance cube was converted to depth using the advocated volume TDC methodology and used in monitoring the drilling of well 296ST3. The resultant impedance depth volume was instrumental in helping the asset unit to optimally place the well horizontal section and in the end saved at least one day of rig time.

### CASE STUDY 2

This TDC study was conducted over a green field in support of an on-going development drilling campaign. Previous TDC in the field was based on "uncalibrated" seismic PreSDM velocities. Depth horizons were then corrected to well marker using third party geological modeling software (Petrel). Due to limited well control, there was still a lot of uncertainty in the corrected depth maps especially away from well controls. By applying the described volume TDC methodology the asset unit was able to narrow the uncertainty and successfully drilled the development well-10 with targets coming in on the predicted depth.

*Paper 16*

## Developing a facies-based 3D geological model of a stacked coastal-deltaic reservoir succession: Bokor Field, West Baram Delta Province, offshore Sarawak

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The aim of this paper is to illustrate the method used for incorporating the results of detailed sedimentological studies, based on limited spot cores (totaling 898 ft but covering only 13% of the gross reservoir interval), into a detailed 3D geological model of the Bokor Field, which comprises a multiple, stacked reservoir succession with a gross thickness of 7,000 ft.

An earlier sedimentological analysis had established the main facies and sand body types, which were deposited in a range of coastal and deltaic sedimentary environments within the mixed energy (wave- and tide-influenced), Late Miocene (Lower Cycle VI) interval of the West Baram Delta. A total of 11 sub-facies had been identified in the core study, which were calibrated with their well log response and porosity permeability characteristics. This provided a genetic framework for an electrofacies classification scheme, which allows the interpretation of similar sand bodies and facies successions in uncored wells. The results of this electrofacies analysis established six key facies types, which have a widespread occurrence, reflect the range of depositional environments and possess a distinct set of poroperm and wireline log properties.

Multi-well electrofacies classification and estimation was performed using an artificial neural network technique. The data was trained using the six key facies, and the resulting estimated electrofacies were re-checked against original core descriptions to ensure the technique was robust. Results proved very successful and allowed confident and timely extrapolation of electrofacies across a sixty-five well dataset.

As the core defines the electrofacies it was then possible to use these in conjunction with log shape analysis, seismic attributes and production history characteristics to interpret depositional environments and thus define geobody types for geomodelling purposes. Geobodies were then populated with electrofacies using both direct and sequential indicator simulation techniques, and finally populated with petrophysical properties defined for each electrofacies.

The combined sedimentological, electrofacies and geomodelling studies provides additional insight into the depositional characteristics of this part of the West Baram Delta.

*Paper 17*

# Pay Sands prediction in Baram Delta through rock properties and 3D simultaneous inversion study

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The ***Bario West*** prospect is located some 7 km northeast of the oil producing Baram field and 2.5 km west of the ***Bario-1*** oil and gas discovery. This prospect is a fault intersection trap created by the intersection of the ***Bario/ Faridah*** growth fault and the ***Bario*** splay fault. The prospect objective interval is of Late Miocene age, fluviomarine inner-neritic (inner shelf) environment. The main risk associated with the prospect is lateral seal failure of the ***Bario/ Faridah*** main growth fault (small throw at the tip end of the fault and the possibility of sand to sand juxtaposition). Results from fault seal analysis at this growth fault indicate that the active sealing mechanism is not working as most of the sands are juxtaposed. The only sealing mechanism along the ***Bario/Faridah*** growth fault plane is clay smearing. The chances of having hydrocarbon charge, good reservoir quality and favorable hydrocarbon timing are high, as the prospect location is only some 2.5 km west of the ***Bario-1*** oil and gas discovery. Seismic inversion study was then conducted to increase the confidence level of the sealing capability of the ***Bario/Faridah*** growth fault at **Bario West** prospect.

***Bario-1*** well logs displays and cross-plot analyses have been assessed to decide a feasible type of seismic inversion. A clear discrimination of hydrocarbon bearing reservoirs was observed from the cross-plots of acoustic impedance versus shear impedance and acoustic impedance versus $V_p/V_s$. This analytical conclusion necessitates a "Simultaneous Inversion" study over the study area to be able to identify hydrocarbon-bearing reservoirs.

The Well log data, geological interpretation, angle seismic sub-stacks and seismic DMO velocities were algorithmically integrated through simultaneous inversion to generate acoustic impedance and $V_p/V_s$, rock property volumes as well as Lambda-Rho and Mu- Rho derivatives.

The lateral distribution and connectivity of the O4 hydrocarbon reservoir was captured and discriminated from non-reservoir rocks using the 3D visualization and body checking technique. Two sets of analysis were carried out; the first was using the $V_p/V_s$ versus acoustic impedance volumes cross-plotting while the second made used of the Lambda-Rho versus Mu-Rho volumes cross-plotting. A number of different scenarios were analyzed based on a variation of time gates and cut-off values.

The simultaneous inversion results show that both ***Bario*** field and ***Bario West*** prospect have connected hydrocarbon-bearing geobodies. The absence of connected geobodies on the up-thrown side of the main growth fault indicates the growth fault is sealing. The integrity of the "Simultaneous Inversion" results was successfully validated by a blind test of the ***Faridah-1*** dry hole (located to the east of ***Bario's*** structure) which was not disclosed or used in the course of the study. As a conclusion, simultaneous inversion study enables PCSB to reduce the uncertainties of fault seal at ***Bario West*** prospect.

*Paper 18*

# Primaries at last — an innovative technique suppresses severe seismic multiples in the Kutei Basin, Indonesia

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An innovative new technique is effective at attenuating severe seismic multiples in the deepwater Kutei basin, Indonesia. Prior to this, primary reflections in the upper and middle Miocene zones of interest were completely obscured by a complex multiple wavefield.

Severe seismic multiples are generated by gas hydrate accumulations in the subsurface, by lithology variations in the sediments just below mud-line, and by free-gas trapped within these sediments. These multiples are 3D in nature, have significant diffraction components, are often non-hyperbolic, and can have an apex not located at the near-offset trace. A very difficult problem! Conventional multiple suppression techniques are not effective at attenuating these multiples. Advanced techniques such as High Resolution Radon and SRME have been largely ineffective.

An innovative new technique has proven to be effective at attenuating these multiples. The technique involves: 1) wavefield decomposition to separate all wavefield components; 2) raytracing to identify and flag components which are primary events; and 3) migration of the flagged primary events only. This technique excludes all non-primary events, regardless of complexity. Examples from the deepwater Kutei Basin Indonesia show the degree of improvement which has been achieved using this innovative technique.

*Paper 19*

## The sedimentology of the Mio-Pliocene clastic deposits of eastern Sabah and implications for offshore hydrocarbon potential

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Five exploration blocks remain open in the onshore and nearshore of eastern Sabah, and overall the area is relatively under-explored in terms of hydrocarbons. Potential reservoirs include structural and stratigraphic traps within the sandstones of both Tanjong and Sandakan Formations, and more significantly structural traps in the Ganduman Formation to the South and in the offshore. Extensive fieldwork, undertaken between 1995 and 2001, has led to an in depth understanding of the sedimentology of these Miocene and Pliocene clastic deposits onshore, and facilitated detailed palaeogeographic reconstructions. This knowledge can be used to assess the implications for hydrocarbon potential in the nearshore Sulu Sea.

*Paper 20*

## Tectonostratigraphy of the half-graben sub-province in Western Luconia

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The West Luconia Province is located in the western part of offshore Sarawak. It is bounded by the Central Luconia Province to the east and the Natuna Ridge/Platform to the west. Under a Technical Evaluation Agreement (TEA) Shell is evaluating the prospectivity of this little explored region. The result of Shell's Regional Basin Framework Study in 2003 covering the whole of Northwest Borneo and the acquisition of 1,400 line-km of 2D seismic under the TEA in 2002 provides the basis for a detailed study on the Hydrocarbon potential of the Half-Graben sub-province.

The Half-Graben sub-province is characterised by a series of NNW trending, SW dipping extensional faults, creating significant sub-basins that were later filled by Middle to Late Miocene fluviomarine sediments.

Structural extension is interpreted to have taken place during Early to Middle Miocene. The observation of tilted syn-rift Middle Miocene carbonate wedges within the deeper parts of the half-grabens provides substantial evidence for the timing of the half-graben formation. The extension and subsequent rapid subsidence of the half-grabens

would eventually lead to conditions that stalled the growth of carbonates.

Cessation of carbonate growth was followed by clastic sediment influx into the half-grabens, although the latter process could also have contributed to the cessation of the growth of the carbonates. Middle to Late Miocene sediments of up to 2 seconds (some 2,000 m) thick has been observed to fill the sub-basins. The post-rift clastic half-graben fills are differentiated by two main phases of hiatus in sedimentation. The Late Miocene (SB3.1) and Early Pliocene (SB3.4) lowstands are consistently observed throughout the study area; typified by erosional truncations, incised channels and thick, seismically transparent transgressive shales above the unconformity. The fluvio-marine sediments of the Middle Pliocene to recent are dominated by sea-level fluctuations; evidence for the latest lowstand is still preserved in form of the proto-Rajang channel.

At the same time, the West Luconia Rim in the northern part of the study area underwent another phase of major structural deformation during the Late Miocene to Early Pliocene. Large highly faulted, anticlinal structures of significant sizes formed where the Half-Grabens intersect with the West Luconia province. Origin of these can be attributed to wrench-related inversion on some of the extensional faults in association with basement highs.

The sedimentological and structural history of the area produced a variety of trapping configurations. These include structural rollover traps, footwall traps, inversion traps and stratigraphic carbonate traps. This variety, together with the possibility of source rock development within the deeper part of the half-grabens, results in a diverse portfolio of leads.

*Paper 21*

# Borehole image, CMR* and core calibration for cataloging facies and depositional features: an example from NW-Sabah Basin

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Well Sumandak Tepi–1, from NW-Sabah Basin has core, borehole image, and CMR* data available in addition to standard open-hole logs. An exercise was undertaken to integrate and calibrate core observations with the FMI* image and CMR analysis to gain insights into the depositional characteristics of the reservoir section. In this study, images and logs with the highest vertical resolution, i.e. FMI and CMR data, were used for calibration with the core in preference to standard open-hole logs. The objective was to document and catalogue the various depositional facies characterized by features, events and trends seen on the FMI image and T2 distribution/ bin-porosity from the CMR analysis. The cores represent various depositional styles — tidal channels, tidal-flats, interdistributary bay-fills and deltaic depositional elements.

Core coverage is usually very limited and efforts like the current should be employed to calibrate and catalogue all available depositional facies to their image and log responses, as represented in a field. This catalogue can then be used as a knowledge database to facilitate analysis of newly acquired data when cores are not available.

*Paper 22*

# Evaluation of formation fluids from surface gas measurements

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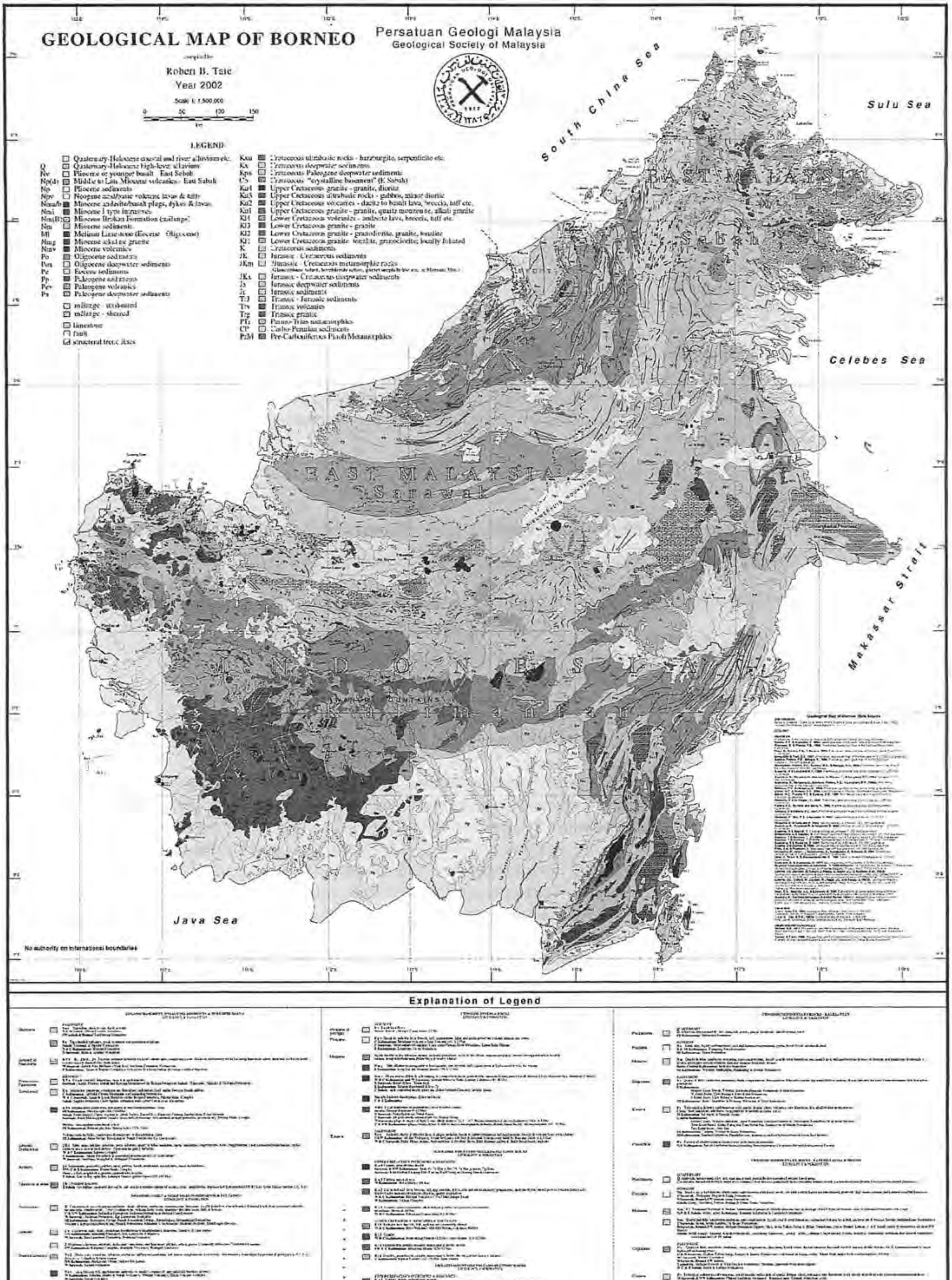
Paris

The analysis of downhole well data (LWD / Wire Line) for the purpose of identifying and locating hydrocarbon fluids is now widely practiced, and current interpretation methods are perfectly adapted to this. These methods do


GEOLOGICAL MAP OF BORNEO
compiled by
Robert B. Tate
Year 2002
Scale 1:1,500,000
0 50 100 150
km
Persatuan Geologi Malaysia
Geological Society of Malaysia
LEGEND
Quaternary-Holocene coastal and river alluvium etc.
Q Quaternary-Holocene high-level alluvium
Nv Pliocene or younger basalt - East Sabah
Np(d) Middle to Late Miocene volcanics - East Sabah
Np Pliocene sediments
Npv Neogene andesitic volcanic lavas & tuffs
Nma/b Miocene andesite/basalt plugs, dykes & lavas
Nmi Miocene I type intrusives
Nm(B) Miocene Broken Formation (mélange)
Nm Miocene sediments
Ml Melinau Limestone (Eocene - Oligocene)
Nmg Miocene alkaline granite
Nmv Miocene volcanics
Po Oligocene sediments
Pos Oligocene deepwater sediments
Pe Eocene sediments
Pp Paleogene sediments
Pev Paleogene volcanics
Ps Paleogene deepwater sediments
mélange - unsheared
mélange - sheared
limestone
fault
structural trend lines
Kuu Cretaceous ultrabasic rocks - harzburgite, serpentinite etc.
Kx Cretaceous deepwater sediments
Kps Cretaceous Paleogene deepwater sediments
CS Cretaceous "crystalline basement" (E. Sabah)
Ku4 Upper Cretaceous granite - granite, diorite
Ku3 Upper Cretaceous ultrabasic rocks - gabbro, minor diorite
Ku2 Upper Cretaceous volcanics - dacite to basalt lava, breccia, tuff etc.
Ku1 Upper Cretaceous granite - granite, quartz monzonite, alkali granite
Kl4 Lower Cretaceous volcanics - andesite lava, breccia, tuff etc.
Kl3 Lower Cretaceous granite - granite
Kl2 Lower Cretaceous granite - granodiorite, granite, tonalite
Kl1 Lower Cretaceous granite - tonalite, granodiorite; locally foliated
K Cretaceous sediments
JK Jurassic - Cretaceous sediments
JKm Jurassic - Cretaceous metamorphic rocks
JKs Jurassic - Cretaceous deepwater sediments
Js Jurassic deepwater sediments
Jr Jurassic sediments
TrJ Triassic - Jurassic sediments
Trv Triassic volcanics
Trg Triassic granite
PTr Permo-Trias metamorphics
CP Carbo-Permian sediments
PzM Pre-Carboniferous Pinoh Metamorphics
South China Sea
Sulu Sea
Celebes Sea
Makassar Strait
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Explanation of Legend

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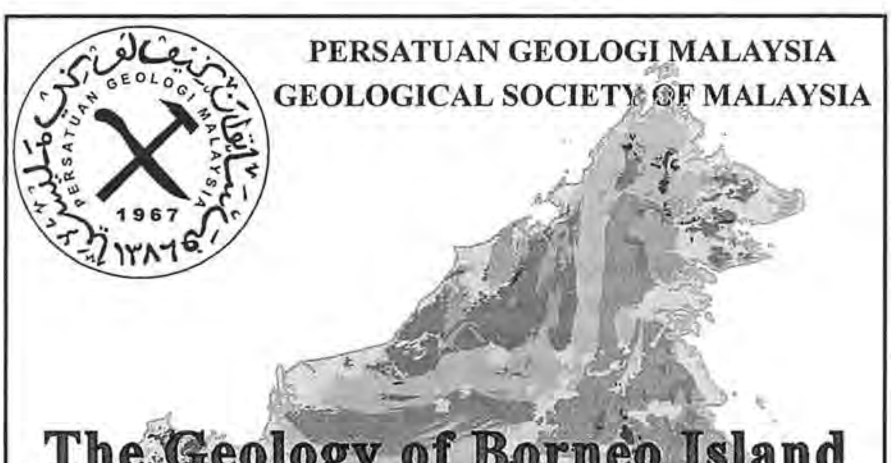


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have their limits, however, the most common being the way the measurement itself is performed.

Some oil companies and a few mud logging companies have been looking at an alternative type of measurement, one that has been available for years but never before used for reservoir interpretation - surface gas readings.

Despite some setbacks on the first attempts, persistent effort has finally paid off. Working on the project since 1996, and using a combination of a new type of gas trap linked to a more accurate, more reliable and faster hydrocarbon gas analyser, Geoservices has been able to develop an interpretation method based on this direct and independent measurement.

In 2001, Geoservices introduced equipment for continuous measurement in the C1 to C8 range, including BTX (benzene, toluene, xylenes) as well as non hydrocarbon gases such as $CO_2$, $H_2S$, methanol, acetic acid, etc. This innovative concept, called FLAIR (FLuids Analysis In Real time), was developed with assistance from the French Petroleum Institute, and consists of a mass spectrometry analyser associated with a volumetric heated gas trap and specific gas transport line.

FLAIR has been successfully tested in wells in different geological environments and has dramatically improved the quality of gas data, notably in deep offshore wells drilled with OBM. The new data have proven their usefulness at the wellsite level, in allowing early evaluation of the fluids encountered and the consequent optimisation of the final well program. Investigations are in progress concerning the input of such new data on the post well synthesis (integration of non HC gases, heavier components, etc.).

The benefits of this new generation of service have already been significant, even though much of the method's potential remains largely unexplored due to it's relatively recent introduction. This paper seeks to present the applications currently used for reservoir characterisation, hydrocarbon fluid differentiation, inter-fluid contact determination, identification of leak or diffusion phenomena, seal efficiency, compartmentalisation, lateral extensions etc.

***Paper 23***

# High density simultaneous picking of moveout parameters velocity and anellipticity

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The focusing process for time imaging is improved drastically when high-density parameter fields are used. Large offsets, steep dips and finally the anisotropy of the data require the estimation of two parameters: velocity (V) and anellipticity (h). Picking V and h using two-pass techniques cannot be a long-term solution. The estimation of both parameters is very sensitive to the mute function separating near to far offsets. Picking both parameters simultaneously using dense bi-spectral picking analysis overcomes this situation.

CGG are proposing an original parameterization of the non-hyperbolic moveout, which increases the sensitivity of the analysis and allows static moveout corrections, necessary for automatic dense pickings.

An intelligent QC sorting of the raw V and h fields, based on lateral coherency of the semblance and the Dix inversion ability of local V and h functions, prepares skeleton fields for simultaneous geostatistical filtering of both parameters. The filling of both V and h fields is done simultaneously using 3D ordinary kriging on the uncorrelated parameters. In order to preserve the moveout resolution, the uncorrelated parameters are filtered using 3D factorial kriging. Different kinds of noise patterns are removed.

The back projection of the uncorrelated filtered fields to V and h allows the required simultaneous filtering.

*Paper 24*

## Measuring the success of innovative technology solutions for petroleum exploration and development

ABBAS MEHRABIAN AND JESS KOZMAN
Schlumberger Information Solutions

Technology has helped reduce finding and lifting costs from $20 per barrel in the early 1980s to about $5 in recent years (Gould, 2003). But one of the biggest challenges in oil and gas exploration is accurately measuring the financial return on investments in technology. Metrics are evolving that allow the rigorous calculation of value added and the effect on ensuring discoveries. Innovative technology solutions streamline key elements of process, tools, and data, and consist of workflow optimization, technology mastery, and data ownership initiatives. Impacts on business objectives are calculated in reduced cycle time, improved quality of strategic decisions, and the value of standardized processes. Measures are provided of barrels of oil added to proven reserves, documented cost savings, and verifiable calculations of the value of time saved for geotechnical personnel working on exploration projects. The pressure will increase as producing fields mature and require more complex processes, tools, and data to be effectively managed.

The value of innovative technology solutions can be measured and demonstrated for exploration and development operations by objectively measuring reductions in cycle time due to workflow optimization, barrels of oil added as a result of technology mastery, and cost reductions from data ownership initiatives.

*Paper 25*

## Rock properties for prediction — uses and abuses

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Understanding of rock properties is essential to all disciplines in the upstream industry. Rock properties are of direct interest to the explorer, developer or producer in helping to predict the acoustic response expected under different pore-fill conditions with varying lithologies. This prediction is aided and sometimes complicated by natural variation in stress regime, burial history, pressure, temperature, depositional facies, rock type, depth, diagenetic history and hydrocarbon fill history. All of these conditions are interrelated through the plate tectonic setting, climatic conditions and therefore geological history. Without understanding the nature of the inter-relationship and how it is expressed in *in-situ* rock properties there is a large possibility of misinterpreting and misusing rock properties. With an understanding, or at least appreciation, of these high-level controls, rock properties can be used to predict acoustic response in areas of sparse well control for exploration purposes, development well planning and production drilling. The only difference is the scale of the variation in the primary controls and their spatial rate of change. Examples of applications and potential pit-falls are given from the local region.

*Paper 26*

# Hydrocarbon potential of pre-Tertiary sediments (Cretaceous/Jurassic?) on Tenggol Arch, West Malay Basin

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The pre-Tertiary basement structures onshore Peninsular Malaysia are dominated by three NW-SE trending tectonic zones: Western, Central and Eastern belts. Immediately offshore to the east is another parallel, tectonic zone whose top is marked by granitic-metamorphic rocks forming the island groups of Perhentian, Redang, Kapas and Tenggol islets. The latter cap the SE end of this tectonic zone that is known as Tenggol Arch. This is a 100-km wide basement platform and ramp separating the Malay Basin to its east from the Penyu Basin. The Arch is separated from the platform/ramp by the north-trending Tembikai Graben Complex.

At basement level, the regional Tenggol fault downthrows 2.5 km towards the Malay Basin. The eastern side of the Arch consists of (?)Triassic-Jurassic granitic rocks, while on the west are metamorphics whose top surface descends about 6 km via normal step faults to form the basement floor of the Penyu Basin. The basement surface of the Arch is part of the Southeast Asian, Cretaceous-Palaeocene peneplain surface that remained elevated throughout the Tertiary structuration of the adjacent Malay and Penyu basins. Only a kilometre of Tertiary sediments overlie the Tenggol Arch, while the basins contain at least 10 km and 6 km Tertiary strata, respectively.

The exploration for hydrocarbon in Malay Basin began when Esso and Conoco were awarded the first concessions in 1968 followed by Mobil in 1971. The first commercially exploitable oilfield, the Tapis field was discovered by Esso in 1969. After that is a history when significant amounts of hydrocarbon were discovered and the petroleum industry has contributed most to the wealth of the nation. All the discoveries were within the Tertiary sediments ranging from seismic Group M to Group D. To date two hydocarbon complexes have been discovered on the Tenggol Arch namely Malong and Bertam. Both fields found significant amounts of hydrocarbon within the Early Mid Miocene reservoirs.

Deeper potentials of the pre-Tertiary basement overlying the Tenggol Arch has not been tested. Early exploration efforts did not focus on the deeper plays due limited understanding of the tectonic framework and seismic data. Recent efforts by PCSB have resulted in additional exploration potential within the 'deeper play' pre-Tertiary sediments. Seismic evidence indicates distinct stratification that possibly represents pre-Tertiary sediments.

The interpreted seismic was acquired as regional lines in 1993 and reached depths of 12 seconds. Special processing yielded meaningful responses from much deeper levels than were routinely penetrated.

New 3D data of the western PM306 block acquired by PCSB have also indicated distinct stratification that possibly represents pre-Tertiary sediments as observed in the PM307 block.

One of the critical elements of such a pre-Tertiary petroleum system is the distance of hydrocarbon migration.

*Paper 27*

# Greenfield in a Brown field — a method to look for untapped potentials

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The ***Betty*** field, within the prolific petroleum-bearing Baram Delta province, has been in production for more than 15 years. The prospective sequence is of Late Miocene age, fluviomarine inner-neritic environment. Static and Dynamic modeling have indicated that there could be more oil in place than initially assessed. Recent drilling

campaign on a slightly deeper satellite structure some 11 km east of the field yielded observable differences in hydrocarbon-water contacts apparently within the same sequence as that in the main *Betty* field. These observations suggest the possibility of stratigraphy trapping mechanism present in this geological setting.

The successes of a couple of wells at the eastern satellite of the main field prompted efforts to investigate the prospectivity and connectivity of the intermediate area between the main producing field and its eastern satellite structure.

Seismic data interpretation efforts commenced in tandem with fundamental reservoir characterization study. The reservoir characterization study was conducted using a Constrained Sparse-spike inversion technique incorporating available well information and the full fold stack seismic data to yield an acoustic impedance data volume.

Well curves calibration of the volume data value range identified a number of connected geo-bodies which are potentially hydrocarbon bearing along the flank of the *Betty* structure. These geo-bodies are not reached by any of the existing wells in the main field or the satellite structure to its east. The presence and shapes of these identified geo-bodies lend credence to the model of stratigraphic play in this deltaic environment. Following this phase of prospect identification further detail reservoir characterization work by means of multiple independent parameter interactions (such as $V_p/V_s$ responses) would be necessary to increase the possibility of success and compute definitive volumetrics.

***Paper 28***

## Sampling of mud gas using Isotubes in NW Borneo deepwater

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Isotube sampling of mud gas was first introduced by SMEP in 2001 during the drilling of deepwater wells Ramin-1 and Ubah-1. It proved to be a cheap and reliable means of obtaining gas data throughout the complete stratigraphy, from the mud returns. This enables a better understanding of the retention and hydrocarbon migration mechanism with respect to regional and local seals and possible fault conduits.

The Isotube technique has since been adopted as a standard well practice in SMEP deepwater exploration. To date, six deepwater wells across NW Borneo have been studied. The benefit from this method is briefly discussed.

The key advantages of the Isotube sampling are:

- acquisition of mud gas information to complement the PVT dataset
- provision of a back-up to PVT study in case of aborted PVT sampling
- continuous gas sampling throughout the stratigraphy

The relatively low cost makes it possible to acquire a continuous log of gas composition with depth. In non-reservoir sections, a 90 ft interval is used. In objective reservoir sections, a 30 ft interval is preferred. This provides a good means to understand the plumbing system of the deepwater hydrocarbon habitat. Abrupt changes in gas composition and major jumps in gas maturity indicate presence of effective seals. Minor step changes imply weaker retention capacity from partial or local seals. A gradual variation means a very leaky overburden hence very poor top seal capacity. Correlation between wells further helps to distinguish major regional seals from the local ones.

It has been acknowledged that Isotube samples tend to capture the lighter (more volatile hence movable) hydrocarbons compared with the PVT samples that represent a more complete compositional range. It must also be noted that Isotubes are by no means a possible replacement for standard PVT studies.

***Paper 29***

## Off-shore Mediterranean sea oil potential, Egypt

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The off-shore Mediterranean area is the most active exploration province in Egypt and predominantly considered as a gas province. Undeveloped oil and condensate were found in a number of wells (e.g. Mango-1, Tineh, West Abu Qir, Abu Qir, Marakia-1 and El King).

The majority of the developed gas discoveries are from the Pliocene reservoirs and the rest are from the Miocene. The undeveloped oil and condensate discoveries which were found in some wells are from older (Miocene and Pre-Miocene) and deeper reservoirs compared to the proven gas discoveries.

The presence of active sea floor oil seeps, the trend of heavier API hydrocarbon with increasing reservoir depth, increasing of condensate/gas ratio with increasing depth and most of the discovered gas pools are of thermogenic origin, all these indicate the possibility for the presence of liquid hydrocarbon in the deeper reservoirs.

The latest geochemical studies carried out on some of the deeper wells in the off-shore Mediterranean area indicate the presence of mature oil prone source rocks preserved in this area. In addition, the well known and proven oil prone source rocks (Jurassic coal, Cretaceous, Oligocene and Miocene) in the on-shore Nile Delta and Western Desert should be preserved in the off-shore Mediterranean.

Extending and focusing the seismic and geologic studies on the Pre-Pliocene sections may indicate possible traps for commercial liquid hydrocarbon.

***Paper 30***

# South China Sea bathymetry and interpretation

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*"All the rivers run into the sea; yet the sea is not full"*

[Ecclesiastes, Ch.1, v.7].

I wish to address the question of the sea-floor bathymetry and its turbidite rivers. They behave similarly to terrestrial rivers but with the ultimate goal of the abyssal plain. We can understand their courses only if we have an accurate bathymetric map. Terrestrial rivers may reach the intermediate goal of a lake and its sedimentary load is then ponded. Once the dam is breached, a new river seeks the ultimate goal of the sea. So it is with turbidite rivers. Ponds of sediments are analogous to lakes, but once full, the onward journey is ultimately the abyssal plain. To understand the turbidite channel courses, we need a more accurate bathymetry map than currently exists, but it is adequate to allow an understanding of the South China Sea.

## GENERALISED MODELS OF CONTINENT/OCEAN TRANSITION

A universal standard for continent–ocean transition does **not** exist, but the following subdivisions are to be found in most introductory geology textbooks: Continental Shelf < 200 m, Continental Slope, Continental Rise and Abyssal Plain at > 4 km water depth. The idealised model is wholly based on the passive margin of the Atlantic Ocean offshore New York. It is that of an Atlantic-type rifted continental margin, and cannot be applied to the active margin of the Pacific Ocean. The dimensions are significantly different in the South China Sea, but the sequence and depths are identical. The term appropriate for the South China Sea is *passive or rifted continental margin.*

## BATHYMETRY

The most accurate bathymetric model is the Topographic Polished Image V5.2 (TPI 5.2), which is freely available from the Internet website

ftp://topex.ucsd.edu/pub/global_topo_2min

This digital bathymetric map combines available depth soundings with high-resolution marine gravity information from GEOSAT and ERS-1 satellite altimeters. The grid has cell dimensions of 2 minutes x 2 minutes on a Mercator projection. Worldwide, only 12% of the grid cells are constrained by ship measurements, 88% estimated. Any resulting map has an estimated minimum resolution ranging from 1 to 12 km. Obviously such a map is acceptable *only* for a regional study such as this paper.

Marine navigational charts offer the highest resolution, but only of selected regions of the South China Sea. Even the best charts contain warnings of the low reliability of the region of the Spratly Islands.

## CRUSTAL NATURE AND THICKNESS

The satellite gravity data set has been recalculated into a map of depth to the Mohorovičić Discontinuity (Holt, 1998). The Moho rises from an average depth of ~ 29 km under the Sunda Shelf to a minimum of ~16 km below the South China Sea marginal basin. A smooth horizontal Moho lies beneath the Sunda Shelf.

A ß (stretching factor) value of 3.0 defines the outline of the South China Sea marginal basin. The Dangerous Grounds (continental rise) have stretching factors ranging from 1.3 to 3.0. Rather high values >3.5 characterise the central deeper parts of the Malay Basin, the Song Hong-Yinggei Hai and parts of the Baram Delta basins. This indicates highly stretched localised regions within the continental shelf. Otherwise, the Sunda Shelf has monotonous ß values between 1.0 and 1.2.

## GEOLOGICAL FRAMEWORK

The South China Sea is subdivided into contrasting morphology by the West Baram Line. To the west is a passive continental rifted margin. The Sunda Shelf is the continental shelf of East Asia, **not** of Sarawak. To the east is a now inactive convergent margin.

The passive margin resulted from rifting of the Sundaland continental crust beginning in the Eocene. A marginal basin began spreading at anomaly 11. Crustal attenuation ceased in the early Middle Miocene (anomaly 5c); recognised throughout as the Mid-Miocene Unconformity. The continental crust of the Sunda Shelf is a uniform ~30 km thickness except in localised deep basins, and extends to a water depth of ~200 m. The slope is narrow; its foot lies at ~500 m water depth. The continental rise, also known as *Dangerous Grounds*, is covered by water ranging from 500 m to 3.5 km depth.

The muddy Rajang River drains interior Borneo; flows over the shelf and continental slope. Its post-rift strata drape over the rifted topography of the continental rise. Elsewhere, the drape is thinner and has not completely buried the half-graben cuestas. The sea floor contains Recent entrenched turbidite channels and ponded sediments. The sea floor cuestas probably were elevated enough to support the carbonate build-up infrastructures of the Spratly Islands, whose slopes rise abruptly from a sea-floor of 2–3 km depth. They could alternatively be built upon Pliocene basalt edifices, Miocene sub-volcanic plugs, or Upper Cretaceous granites.

The Sabah and Brunei offshore area is an extinct convergent margin. There is no continental slope and rise and the on land geology indicates a Mesozoic ophiolitic basement. Features of former convergence are notably the 2 km deep Northwest Borneo Trough and the Western Cordillera, constructed of sandy Oligocene to Lower Miocene West Crocker Formation turbidites, uplifted episodically throughout the Upper Miocene and Pliocene. The rivers are short and reach the sea over a narrow coastal plain. The oil-prolific Baram Delta, resulting from post-rift uplift, has built out as far as the Northwest Borneo Trough. Tectonic models necessitate that the passive margin continental rise (Dangerous Grounds) has been underthrust beneath the Western Cordillera of Sabah. The West Baram Line accordingly abruptly separates the formerly convergent margin from the western passive margin; and was a powerful right-lateral fault.

***Paper 31***

# Wrench-faulting and compressional features in an extensional basin: the Mekong Basin, Vietnam

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The granites of southern Vietnam, including those in the basement of the Mekong Basin were mainly emplaced in the Cretaceous and during the transition time into the Palaeocene were subjected to physical weathering under semi-arid conditions. The Mekong Basin is a Tertiary extensional rift basin located at the eastern edge of the Southeast Asian continental Plate. The oldest known strata are Upper Oligocene sediments that lie at depths of about

10 km. Pre-Middle Miocene deposition comprised lacustrine, fluvial to coastal sediments and gave rise to the Middle Tra Tan source rocks. In the Langhian, significant reorganisations of plate motions changed the originally transtensional stress environment into transpressional that caused strike-slip reversals on some of the regional transcurrent faults and structural inversions in parts of the basin. There is evidence of change of compression direction into a near-orthogonal trend. Regional sea-level also rose, causing the deposition of shallow, holomarine sediments.

NNW-strikes predominate among Topaz North - 1X basement fractures. Other fracture strikes are easterly with moderate dips towards North or South. The granitic basement top of the Topaz North prospect imaged by the VoxelGeo software was shown to consist of four major lineament (fracture) directions. Three of these fracture directions neatly correspond with those predicted to develop as second-order structures produced by right-lateral wrenching along the N060°E elongation of the Topaz basement horst block.

Seismic sections across the Topaz Prospect show local reverse faulting but at other locations normal faulting is clearly evident along the strike of its Northwestern boundary fault. We interpret that the established right-lateral, strike-slip boundary fault generates compression at restraining and extension at releasing bends, and attribute reverse or normal faulting to those respective locations. Seismic sections across the Azurite prospect and published illustrations of the Bach Ho field also indicate occasional reverse faulting (compression) and normal (extensional) faulting along their westerly facing boundary faults. Su Tu Den, the major field of which Azurite is its eastern extremity, strikes East-Northeast and its prominent NE-striking, en echelon fractures indicate left-lateral wrenching of this basement high. The Ruby field strikes Northeast and en echelon, large sigmoidal fracture system across its granitic basement top also indicates that the entire horst experienced dextral wrenching.

Prominent structural inversion of an Oligocene unconformity surface and the Middle Miocene marker is observed at the west end of a regional E-W line across the northern ends of the Mekong and Nam Con Son basins and strongly suggest that genuine tectonic compression exists.

Analyses of slickenside patterns on fault planes, well-bore elongations in over a dozen basement-penetrating wells in Carigali's acreage, orientation of drilling-induced fractures, and en echelon fault patterns on structural maps support the following structural development of the northern Mekong Basin. Throughout the Palaeogene, regional compression had been dominantly NW-SE, possibly associated with Southeast-ward extrusion of the Indosinian Plate, but more than once it temporarily alternated with NE-SW regional compression. The latter direction may have been associated with N-S spreading of the East Vietnam (or South China) Sea Basin that according to the known magnetic stripes occurred between 32 and 17 Ma. Alternation of dominance between these almost orthogonally orientated regional compressions probably resulted from interaction of plate-movements in this part of Southeast Asia. Throughout most of the Cenozoic, its neighbouring plates have been converging onto Southeast Asia. The Indian Ocean-Australian Plate encroaching from the West and from the South, the Pacific Plate westward thrust becoming effective after cessation of spreading of the Philippine and East Vietnam basins at about the Langhian, while as result of the collision between the Indian Subplate and the Eurasian Plate, crustal slabs of Indosinia have been differentially extruded Southeast-ward. After the Langhian, the greater Mekong Basin area was only subjected to relatively slight crustal movements.

*Paper 32*

# Geological well reporting and well data management — a journey through time

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This presentation will outline the significant changes that have taken place over the last decades in the acquisition, organisation, presentation and distribution of data recorded during well drilling operations. The impact of these changes has been significant and has changed the roles and responsibilities of those involved in well operations.

In a space of just 25 years we have gone from a situation where drilling operations could only be reported back to an operations base by means of radio communications, to the situation we find ourselves in today where multidisciplinary office based teams are able to follow drilling operations in real time. Decisions can now be made in minutes rather than the hours or days required just a few years ago.

We should, however, not lose sight of the fact that as oft quoted "oil and gas is found in the minds of men". No amount of technology or computing power will ever replace the keen analytical minds of those tasked with finding and developing the worlds oil and gas reserves. The modern professional has to utilise the latest technology to free up the time required to allow him to make the most of the fundamental decision making skills that ultimately make the difference between success and failure in our increasingly competitive industry.

***Paper 33***

# Shell's integrated approach to 3D basin modelling

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Modeling of key factors involved in the generation, migration, accumulation and retention of hydrocarbons is critical to understanding a petroleum system. The major components which need to be understood to unravel the history of a basin include its thermal and burial evolution, the characteristics and distribution of source-rocks, the pore pressure, migration pathways and trap retention. Using Shell's sophisticated forward basin modeling software (Cauldron) it is possible to examine the interaction and, most importantly, the relative timing of these components. Analysis of results allows a more informed assessment of the volume and composition of hydrocarbon fill within identified traps.

Successful basin modeling is an iterative process with key parameters varied within acceptable ranges and results compared to well and field data. Of special importance in this process is the integration of all possible pieces of information to derive a geologically robust story for a given area. Important calibration data from wells includes Bottom Hole Temperatures, vitrinite reflectance, fission track analysis, pore pressures, fluid analysis etc. However, use of other data is also critical to refinement of the models. For instance:

- sonic and density logs may be used to constrain the magnitude of uplift events
- HC-shows maps and fluid inclusion screening (FIS) analysis can be used to constrain HC-migration paths
- Modelled traps can be validated against DHI's (and vice versa!)
- Sonic and density logs can be used to calibrate1D pressure modeling
- location of oil-slicks, gas-chimneys and mud volcanoes can help to constrain low trap-integrity areas from the model
- integration of pressure prediction from seismic velocities will help to validate and constrain overpressure modelling results.

Furthermore, a regional perspective is prerequisite to the full understanding of a hydrocarbon habitat. With this in mind, SMEP has recently focused on producing a regional model covering the whole of the NW Borneo shelf. As a result, smaller (higher resolution) models can now be examined and interpreted in a regional context.

This paper focuses on Shell's integrated basin modeling workflows, and illustrates it with examples from the regional NW Borneo shelf model, as well as from smaller, higher-resolution models covering various areas of the inboard and outboard Sabah regions.

*Paper 34*

# Imaging beneath gas — a Prestack Depth Migration case study

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Imaging below gas has always been a problematic issue in conventional seismic processing. Not only does gas cause deterioration in imaging of the sediments below, it can also introduce strong structural deformation that can create difficulties for interpretation and reserve estimation. Presence of gas-induced sags presents a classic case meriting the use of prestack depth migration (PreSDM) because of its ability to comprehend local lateral velocity variations, and interpretation of seismic data in the depth domain. This paper presents a case study from offshore Malaysia for seismic data processed employing Kirchhoff PreSDM to resolve the structural imaging of an oil field severely affected by shallow gas.

The structure under investigation is the Kikeh Oil Field, which is a thrust related fold in Miocene deepwater clastics offshore Sabah. Lying in water depths of 1,350 m, the Kikeh structure is an asymmetrical fold with dips on the fore limb as high as 70 degrees. The crestal area of this fold suffers from significant velocity push downs which are interpreted to be due to disseminated gas, possibly locally trapped beneath a gas hydrate layer at a depth of about 250 m below the seabed and associated with a shallow high amplitude seismic anomaly. The low velocity zones are more than 500 m in thickness and 4 sq. km in areal extent, producing considerable ray path distortion that severely impacts our ability to image the reservoir section in the crestal area of the Kikeh structure. As a result of the failure of PreSTM to address the issue of gas sags, it was felt that a PreSDM approach was necessary to get a better solution to this problem. A sub-volume was, therefore, selected for detailed hi-resolution velocity analysis followed by PreSDM.

A hybrid approach incorporating manual velocity updating and 'Residual Curvature Analysis' tomography updates was used to develop a velocity field for prestack depth migration. As a result of this approach, substantial improvements were observed in the overall structural integrity of the data as well as dramatic improvements in image quality with respect to mitigation of gas sags, fault delineation and continuity of reflectors, thereby greatly enhancing the interpretability of the data.

*Paper 35*

# Structural style of Kudat Peninsula, Sabah

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The Northern Sabah Province, which includes the Kudat Peninsula, exhibits a complex structural style. Offshore, NE-striking structural grain changes sharply to E-striking. The E-striking structural grain changes further to SE-striking onshore Kudat Peninsula. A better understanding of the geological structures onshore Kudat Peninsula can benefit hydrocarbon exploration activities offshore.

Kudat Peninsula, consisting of sedimentary and ophiolitic igneous rocks experienced polyphase deformation. Folds trending approximately NW-SE are refolded along NNE-SSW trend. The polyphase deformation produced different structural pattern on three major imbricate thrust slices located at the northern, middle and southern part of the peninsula. A major fault zone, characterised by the presence of a melange deposit, separates the northern and middle thrust slices. The northern thrust slice shows a huge drag fold plunging steeply to the southeast. The middle thrust slice shows wavy fold pattern whereas the southern thrust slice shows a nappe-like fold pattern.

The polyphase deformation was possibly related to progressive N-S transpression generated during the opening of the South China Sea Basin. It is envisaged that early N-S directed deformation produced several E-W trending thrust slices on the Kudat sediments and underlying ophiolitic basement. Each thrust slice was separated by detachment zones. Within each thrust slice, repetition of rock units occurred due to the presence of folds (F1) and thrust faults. Later NW-SE directed deformation oriented oblique to the previous one caused dextral horizontal movement along each of the major detachment/slip zones producing second generation folds (F2) within each of the thrust slice. The type of folds developed within individual thrust slices were possibly related to the competency of the sedimentary sequence.

***Paper 36***

## Stochastic inversion as a part of static model building

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A stochastic inversion was carried out in a producing gas field, offshore Sarawak. The output of this inversion work was used as an input to the field static model and subsequently tested by the reservoir dynamic simulators. Although, the field was aerially extensive, only three wells with good quality logs were available. Another well drilled within the field was left out for verification purposes. Density, P-Sonic, Porosity and Lithology logs were used for this project. An interval with a thickness of approximately 200 ms (about 600 ft) was inverted using the Statmod module of the Jason software package. The entire inversion interval was divided into three zones, the shales above the reservoir, the gas filled reservoir and the water filled part of the reservoir. Three different lithofacies, shale, gas sands and water sands, were defined. Lithology probability density functions were built for each lithology type within each zone using the input well logs. Within the gas reservoir, the probability density functions of the two lithology types, gas sands and shales showed limited separation, increasing the uncertainty of the results. In addition to building the probabilities, the well logs were used to define the variograms for the Lithology, P-Impedance and Porosity distribution. Various horizontal ranges were tested in an effort to optimise the variogram shape given the limited number of wells. Additionally, seismic data and an extracted wavelet were used for inversion purposes. Finally 60 realisations each including lithology, porosity and P-Impedance volumes were generated together with residual seismic traces. The residuals were used only for QC purposes. Sand volume and average porosities within the gas reservoir zone were calculated for each realisation. Net porosity volumes were estimated for ranking purposes. The median, low and high cases were extracted and were exported to the static model building tool. The results of this inversion became an integral part of the static model and by reducing the uncertainties enabled the asset team to decide on future activities in the field with greater confidence.

***Paper 37***

## Genetic unit and prediction of petrophysical parameters — a case study

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The *"genetic petrophysics"* concept that is used to predict petrophysical parameters using genetically focused neural nets (GFNN) simulator has only been introduced recently. It only requires a minimum number of Special Core Analysis data from a chosen representative genetic unit (RGU).

Combinations of wireline logs and core data from a short 7 m RGU interval in PEGASUS Well 2 were used to train the genetically focused neural network predictors which were then applied to predict the residual *Sw* throughout the whole logged section in the well and adjacent well (PEGASUS Well 2b) in the same field. Traditional hydraulic unit analysis or global hydraulic element grids provided the basis for selecting the training plugs. Only 4 core plugs were finally required to represent the hydraulic units in the RGU elements and provide good results. This approach is very cost effective in terms of core material and computing time.

The result of this study shows that the neural network *Sw* predictor is capable of predicting residual *Sw* in the training well and adjacent well. In this particular case, the application of genetic petrophysics approach to predict residual *Sw* is a reliable technique and has potential for a wider scope of application such as full field review or asset evaluation where data, costs and time are normally limited.

However, it was only tested in oil bearing shoreface reservoirs. Thus, it is recommended that this approach be tested in other environments.

***Paper 38***

# Surface detection of reservoir hydrocarbons through vertical migration

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Passive (adsorbent-based) surface geochemical samplers are commonly used to detect a wide range of volatile organic hydrocarbon compounds in soil. Many of these compounds are likely to be thermogenic in origin from underlying petroleum reservoirs. Such compounds are thought to migrate vertically through the stratigraphic column according to microbuoyancy theory. Heavy saturated compounds are detectable in minute amounts ($10^{-9}$ gm).

GORE® Modules were used to collect surface geochemical signatures from a variety of petroleum and dry well sites, during the course of numerous surface geochemical surveys. The module consists of engineered hydrophobic sorbents contained in a permeable membrane made from expanded polytetrafluoroethylene (ePTFE). The hydrophobic character of the adsorbents is an important feature, in order to maintain high sensitivity levels for detecting minute quantities of organic compounds. Modules are placed in the soil to depths of ~60 cm for a period of usually 2–3 weeks, and collect vertically migrating volatile and semi-volatile organic compounds.

Exposed modules were analyzed, by thermal desorption GC-MS, for up to 87 organic compounds, from ethane ($C_2$) to octadecane ($C_{18}$), and including pristane (2,6,10,14-tetramethylpentadecane) and phytane (2,6,10,14-tetramethylhexadecane). The analytical list includes several compound classes: aliphatics (normal, branched, cyclic alkanes, olefins), aromatic and polyaromatic hydrocarbons, aldehydes, terpenes, and a few miscellaneous compounds (see Table 1).

Control samples are often collected near producing petroleum and dry well sites when such sites are available. The recorded geochemical signatures from control sites assist the interpretation of survey sample data through a process of "geochemical modeling" (comparing grid samples to control site signatures). The passive surface geochemical method provides direct detection data for reservoir hydrocarbons, which when integrated with other G&G information may significantly reduce exploration risk.

An example of one control site signature is given as an illustration of reservoir hydrocarbon detection at the surface. Other examples are available for discussion, including a discovery through thick anhydrite sequences. The interpretation and use of this form of geochemical data is not without its pitfalls however; proper geochemical modeling is critical for success of the technique. Recent drilling results indicate that the technique correctly predicts petroleum presence at a rate of ~88%, and has a false negative rate of ~7%.

The paper will highlight some recent project successes from both onshore and offshore sites and will reference other projects from the SE Asian region.

*Keynote Address 2*

# E&P industry performance improvements require process and technology changes

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The E&P industry faces a number of performance challenges that it must address in order to compete in the global market place. Investment has been historically drawn to this industry despite the high levels of risk by the promise of long-lived profitable returns that oil and gas assets can provide. Typically, returns on investments are generally less than 7% although to sanction most projects, the expectation is a return much higher and in the order of 18%. Various analysts suggest this discrepancy is attributed to an underestimation of project risk coupled with an overestimation of predicted production. This leads to us ponder whether this is a technology problem or a people problem? What is required are means to improve overall performance of the industry. Certainly improvements in both process and technology will have a significant contribution to achieving better results.

A number of papers recently published suggest the need for better decision analysis processes coupled with well defined cross- discipline assessment of technical uncertainties. These processes are complex and technology is just now coming forth that will allow teams to reduce the pain of uncertainty analysis and facilitate exploring multiple scenarios and associated risk in order to better predict the project performance. Additional technologies are coming forth designed to reduce process pain points. These process pain points have been identified by Landmark through collaboration with over 20 companies to map common processes in the upstream E&P sector with the intent to create solid next generation technology for asset teams.

Technology improvements to date have primarily focused on improving intra- discipline workflows especially around reducing repetitive task, integration and visualisation. Today, organisations are looking for ways to reduce decision making time while improving their understanding of uncertainties that impact project economics. Continued development and deployment of vital technologies will help correct the underperformance of our industry.

*Paper 39*

# Reservoir Connectivity Analysis: understanding of fluid distribution within productive intervals in Tabu and Tapis fields, Malay Basin

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Reservoir Connectivity Analysis (RCA) is a work-process that synthesizes and integrates sound geologic interpretation derived from multiple sources of data. The techniques build a model for field plumbing and fill history consistent with fluid elevations and pressure observations. The primary goals of the analysis are to:

1. Establish original fluid contact elevations
2. Identify the position of connections between reservoir compartments
3. Investigate possible reservoir connectivity reasons behind some anomalous production
4. Identify potential by-passed oil opportunities for future in-fill drilling

RCA was conducted at Tabu and Tapis as part of the on-going field study effort (2002–2003). Productive reservoir intervals in both fields are highly compartmentalized mainly due to the complex interplay between stratigraphy and post depositional structural movement.

Fluid contact controls include not only spill points (through saddles or around fault tips) but also breakover elevations separating oil or water legs across flanks, capillary gas and oil leak through internal seals. Isolated stratigraphic traps can control contacts in certain fill history scenarios. Examples interpreted at Tabu and Tapis include perched oil in gas caps and down-dip movement of oil legs isolated by late gas displacement.

A model for fill history is coupled with the plumbing geometry to build a complete and internally consistent description of the pathways for displacement of oil and free gas.

The RCA results in better understanding of the fluid distribution and reservoir compartmentalization in Tabu and Tapis fields. It is a necessary process to properly understand how petroleum fluids are distributed and connected in a field, especially in a faulted and dominantly channelized reservoir field. It is ideally suited for development and production applications where data density limits the number of subsurface scenarios.

***Paper 40***

## Oil discovery in the Sepat Field

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Sepat Field is located about 200 km off Kuala Terengganu, offshore Peninsular Malaysia. The field was discovered in 1970 via Sepat-1 well. The crestally located well penetrated some 1,800 m of sediments and recorded gas with high level of $CO_2$ contamination (60-65%) in the B100, D34 and D36 Reservoirs. Subsequently, the field was appraised in 1998 via Sepat-2 well, located some 100–200 m downdip of Sepat-1. Sepat-2 reached a TD of 1,781 m and affirmed the gas extension of the shallower reservoirs but recorded water for the deeper sands (D60 and below). Both wells were TD'ed just at the onset of high overpressures.

PMU are currently undertaking drilling into HPHT (High Pressure, High Temperature) zones in the Malay Basin to open up new plays. Analysis of the hydrocarbon distribution in the nearby Inas Field, 20 km to the south indicated the presence of oil rims in D60 and E30 Reservoirs. In view of this and the Sepat-2 results, the exploration/ appraisal Sepat Deep-1 well was positioned accordingly to test for the oil potential in the appraisal mode, and simultaneously meeting its exploration objectives in the HPHT zones.

Sepat Deep-1 was spudded on 11th September, 2003. It confirmed the gas deposits of reservoirs B100, D34 and D36. Reservoir B100 was production tested and the $CO_2$ contamination was recorded at 65%. Similarly, the deeper reservoirs encountered gas, but from Reservoir E6 onwards the $CO_2$ content from MDT samples remains at below 5%. Oil was intercepted in Reservoirs D60, D65 and possibly E30. The oil in D60 is waxy and has an API of 37 deg. This reservoir was production tested and flowed 2,300 bpd. However, D65 yielded non-waxy 40 deg. API oil. Sepat Deep-1 was TD'ed at 2,480 m in Lower F reservoirs, still in HPHT conditions.

The current drilling results indicated the presence of significant oil reserves in a 'contaminated gas' field in the Malay Basin and the $CO_2$ content becomes significantly low with depth. The excess $CO_2$ may aid in enhanced oil recovery in the same field and the clean gas may further enhance the production of the contaminated gas through blending. These findings may open new exploration concepts in the Central Malay Basin with respect for deep seated reservoir and low $CO_2$ gas contamination.

*Paper 41*

# Carbonate Build-Ups in Central Luconia: new Insights from 3D

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Shell's exploration effort in the Central Luconia province offshore Sarawak has concentrated on Middle to Upper Miocene carbonate build-ups, this has up-to-now resulted in the discovery of some 38 Tcf of gas reserves. An analysis of the exploration history shows that the critical success factors in exploring this carbonate play are related to hydrocarbon retention and hydrocarbon migration / charge focus. One aspect of the former is the existence of potential thief-beds within the overlying clastic sequences, the latter being dominated by the underlying basin structure as well as the timing of trap formation.

The result of the Basin Framework Study covering the whole of NW Borneo provides a better understanding of the basin-wide tectonic and stratigraphic history of Central Luconia. This stratigraphic framework was used in the interpretation of the recent semi-regional 3D seismic datasets. The high-quality data allows a sequence-stratigraphic interpretation of the intra-carbonate architecture and of the surrounding inter-build-up lows. The effects of eustatic fluctuations can be recognised within the build-ups and matched to the time-equivalent characteristics in the non-build-up areas in the basinal lows. This allows correlation of well-defined bio-stratigraphic markers and sequence boundaries into the less age-constrained build-ups.

Examples of this sequence-stratigraphic interpretation will be shown:

- Faulting and its impact on the start of carbonate build-ups
- Identification and significance of sequence boundaries within the carbonate build-ups (Karst, Annealing)
- Identification and significance of sequence boundaries between the carbonate build-ups (High-stand carbonate shedding, thief zones)
- Stages of drowning of build-ups

The advancements in establishing an absolute time frame for the growth and cessation of the build-ups leads to an improved understanding of the risks in exploring these build-ups. It is expected that this approach, with 3D seismic being the enabler, will impact the overall carbonate portfolio and lead to further success within this mature gas province.

In existing fields the recent identification of multi-level karst systems using multi-attribute volume interpretation techniques and subsequent modelling of the karst properties lead to significant insights into the field production behaviour with immediate consequence on infill drilling operations and longer term reservoir management strategy.

*Paper 42*

# An integrated approach to pore pressure prediction in an exploration setting, Deepwater Sarawak Block F

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Block F lies in the distal deepwater toe-thrust setting of the Late Miocene–Pliocene Bunguran delta system and is characterised by NW-SE trending thrust-faulted anticlines associated with thin-skinned gravity tectonics. The overall lithology is likely to be quite shaly in such a deepwater domain. Calibration from the Mulu-1 well shows that rates of sedimentation are very fast with 1 to 2 km of Pleistocene overburden. These are typical conditions favourable to the development of undercompaction and overpressures within the sediments. A multidisciplinary approach has been developed to address these phenomena.

## SEISMIC VELOCITY FIELD

Following interpretation of 2D seismic data acquired in 2001, the Sarawak Block F partnership decided to acquire a dedicated 3D seismic survey in order to reduce exploration risk within the block.

It was first noted on the 2D seismic data that the velocity trend in block F was controlled by compaction but was unusually slow. The presence of this slow trend was confirmed by the 3D data, however below a certain depth the velocity trend was seen to deviate from a simple compaction function. Specifically, interval velocities became nearly constant or a velocity reversal was observed. Picking the velocities this way resulted in a dramatic improvement of the seismic data quality and was also in agreement with the under compaction model described above. It was also noted that the velocities were lower in the core of the anticlines (10% less than in adjacent synclines. The WesternGeco contractor 3D high density velocity field was validated by different approaches (including "deltastack" picked velocity field), and illustrate this lateral velocity variation.

## PRESSURE PREDICTION FROM SEISMIC

Pressure prediction calculations were then performed on these data using an Eaton-type methodology. In order to properly calibrate the "normal compaction profile" necessary for this algorithm, pressure prediction was performed and calibrated at the Mulu-1 well and subsequently undertaken on the 2D line joining this well to the 3D survey data. Results of these pressure prediction studies show overpressures gradually increasing with depth to a value of 1.5 g/cc eMw predicted around 3,200 ms TWT.

## BASIN MODELLING

An alternate approach to pore pressure prediction was also taken involving a Temis2D basin modeling carried out by PRSS/BEICIP on the same 3D crossline. Shale permeability values were considered dependent on the silt content of the sediments, the latter depending on the distance to the palaeo-shelf. The Temis2D density section was converted to seismic velocity using Gardner equation parameters calibrated on the Mulu logs, and the result shows a good reproduction of the observed seismic velocity field anomaly. The Temis2D section was then fine-tuned to match the prediction from seismic in the syncline location, allowing extrapolation towards the anticline where the prediction from seismic may be less reliable.

## GRAVITY MODELLING

Anomalies in the gravity field were also noted on the data acquired over Block F, with unexplained high frequency gravity lows detected above some of the anticlinal structures. Presence of shale diapirism was initially considered, and later discarded thanks to the quality of 3D seismic imaging. 2D Gravity modelling conducted on the density section obtained by Temis2D showed a remarkably good fit with the gravity signal bringing independent confirmation of the validity of the modelled phenomena.

## HYPOTHESIS FOR THE ORIGIN OF OBSERVED ANOMALIES IN ANTICLINES

The observed low densities and slow seismic velocities are believed to result from a high porosity of the sediments, mainly shales, attributed to undercompaction. Lateral pressure transfer from syncline to anticline is believed to increase the overpressure in the sediments located at anticlinal locations. The effect of high fluid pressure is to lower the effective stress applied to the sediment grains during compaction, hence their relatively slower compaction rate. The high clay content of deepwater sediments, very fast sedimentation rates and structural relief of the Block F ramp anticlines are conditions favourable to the development of undercompaction, overpressure and its lateral transfer towards the structural culminations.

This multi-disciplinary approach has explained in an internally consistent manner some observations previously unexplained within Block F. It has led to a better understanding of the petroleum system of this block, and will contribute towards the design of a successful operational programme.

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# ABSTRACTS OF POSTERS

***Poster 1***

## A sequence stratigraphic perspective of the Dent Group, Eastern Sabah

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This paper presents parts of the results of geological study conducted by PETRONAS Research and Scientific Services Sdn. Bhd. and Petroleum Management Unit of PETRONAS, in the Dent Peninsula area, eastern Sabah. The purpose of the study is to understand the geology, stratigraphy and the hydrocarbon potential of the area

The Middle Miocene to Pleistocene Dent Group of Sandakan Sub-basin is part of the Northeast Sabah Basin as defined by Leong and Azlina (1999). It overlies the Segama Group of the Central Sabah Sub-basin. Located in the southern portion of the Sulu sea, with a small part of it lying on the onshore Dent Peninsula, Eastern Sabah. The Dent Group consists of post-rift sedimentary packages, overlying the older syn-rift Tanjong and/or the volcaniclastic of the Segama Group. It consists of fluviodeltaic to marine sediments characterised by strong southeastward progradation. The Dent group has been divided into three lithological units namely, the Sebahat, Ganduman and Togopi formations. A number of stratigraphic schemes have been proposed for subdividing the lithological units in the sub-basin. According to Leong and Azlina (1999), the difficulty remains in assigning lithological units to this scheme due to lateral facies variation and poor biochronostratigraphic control, except for the youngest unit.

The stratigraphy of Eastern Sabah was first documented by Fitch (1955), who had identified two sets of sedimentary packages from the area, described as Lower Miocene and Upper Miocene sets. The Lower Miocene consists of sandstone, shale, limestone and tuffite, and the Upper Miocene of shale, limestone and sandstone with coally films and well preserved plant remains. These two units are separated by an unconformity. It was Haile and Wong (1965) who assigned these units to formal formational units: the Segama and Dent groups respectively.

Ismail Che Mat Zin (1994), extended the study of the Dent Group into offshore Eastern Sabah using the data from exploration wells and seismic sections. He also identified the "Older Sebahat" unit of the Dent Group, occurring as subcrops in the offshore area. A detailed sequence stratigraphic study of offshore Eastern Sabah, was carried out by Wong (1993) using wells and seismic data.

The oldest unit in the Dent Group is the Sebahat Formation, which ranges from late Middle Miocene to Late Miocene (Walker, 1993). Ismail Che Mat Zin (1994) assigned a Pliocene age for the Sebahat Formation equivalent in offshore areas. Palynological and nannofossil analyses of Sebahat mudstone samples, collected at Silasuka Quarry (locality 27) indicate Late Miocene age. While the Sebahat shale sample at Sahabat 7 Block (locality 26) indicates Middle Miocene age, and so the age range suggested by Walker (1993) is likely correct. The overlying Ganduman Formation ranges from late Middle Miocene to Late Miocene (Walker, 1993). Wong (1993), however, extends the Ganduman Formation from Late Miocene to Late Pliocene based on sequence stratigraphic studies.

Ismail Che Mat Zin (1994) assigned a Pliocene age for the Ganduman Formation equivalent in the offshore area. Palynological and foraminiferal analyses of shale samples from localities 34, 35, 36, 38, and 42 suggest the age ranges from Middle Miocene to Pliocene. The age of the Togopi Formation ranges from Pliocene to Pleistocene (Walker, 1993).

From field study, it is believed that there is an unconformity separating the Togopi from the underlying Ganduman Formation. The presence of a conglomeritic unit which is believed to be in the same sequence as the Togopi Formation in Tungku area is interpreted as unconformably overlying the Ganduman Formation. This therefore divides the Dent Group into two separate sequences. The lower sequence consists of the Sebahat Formation, Ganduman Formation and their equivalent and the upper sequence comprises of the Togopi Formation and its equivalent. Hence, the older, lower sequence is referred to here as Sequence 1 and the younger upper sequence as Sequence 2.

In the offshore Dent Peninsula, the lowstand fans that are equivalent to the Sebahat Formation have been interpreted by Wong (1993) as basin floor fans, slope fans and turbidites. These sedimentary packages are believed to be part of a lowstand systems tract of Sequence 1. This unit is also believed to be the lateral equivalent to some of the onshore conglomeritc units that have been described as part of the Tabanak and Tungku formations. At several outcrops of Tabanak and Tungku formations, this conglomeritic unit unconformably overlies well-bedded shoreface strata, interbedded marine tuffaceous sandstone and mudstone with an angular erosional unconformity. The abrupt facies change across the angular erosional surface indicates an unconformity. This unconformity is believed to be a sequence boundary that occurred following major relative sea level fall during early Late Miocene time. The conglomerate unit is thought to have been deposited as alluvial plain within an incised valley.

The shaly Sebahat formation is believed to represent the transgressive systems tract of Sequence 1. It overlies the lowstand conglomeritic unit. The contact between the two sequences has been described by Ismail Che Mat Zain (1994), and it is likely that, the surface represents a major transgressive event prior to deposition of the thick Sebahat Formation. The upper boundary of this formation is transitional, as observed in outcrops. The interbedded sandstone and mudstone of Ganduman Formation, which is interpreted as a lower shoreface deposit, overlie thick dark shelf mudstone of the Sebahat Formation. The contact is believed to be a marine-flooding surface, and is characterised by thin hard calcareous band separating the lower shoreface deposit of the Ganduman Formation above, and the thick shelf mudstone of the Sebahat Formation below.

The highstand systems tract of Sequence 1 are the prograding fluviodeltaic to nearshore packages of the Ganduman Formation. The variation in facies is observed from west to east, indicates the change from a deltaic to a shoreface setting. Further east, the sandy shoreface facies pintches out into shelf mudstone. A marine-flooding surface, as observed at Locality 30, separates the prograding unit of the Ganduman Formation above, from the thick transgressive shelf-mudstone of the Sebahat Formation below.

Sequence 2 consists of sedimentary packages that have been described as the Togopi Formation and its equivalent. The conglomeritic unit as observed at Kg. Tungku, is believed to be part of the lowstand systems tract of the sequence. It consists of a stacked multi-storey braided channel deposit interpreted as a remnant of an incised valley-fill fluvial system. This unit is believed to have been deposited following the late Pliocene tectonic event.

The transgressive to highstand sedimentary packages of Sequence 2 consist of marl, calcareous sandstone and allotochnous carbonate of the Togopi Formation. These packages are interpreted as shallow marine deposits. The limestone is matrix-supported with skeletal fragments and minor quartz grains. The skeletal components are mainly of benthonic foraminifera, red algae, mollusk fragments, echinoderms, coral fragments and bryozoans, indicative of a shoal limestone.

*Poster 2*

# Facies and sedimentary cycles within the D and E Group in the north-eastern sector of the Malay Basin, Malaysia

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Core analysis of the Middle Miocene (E and D Group) succession in the north-eastern sector of the Malay Basin identified fifteen (15) lithofacies, differentiated on the basis of lithology, sedimentary structures, fossil content (& trace fossils) and diagenetic features. The lithofacies are:

- *Lithofacies S-1: Draped-to-massive-to-laminated sandstone,*
- *Lithofacies S-2: Ripple-to-wavy bedded sandstone/siltstone interbedding, with minor shale,*
- *Lithofacies H-1: Heterolithic, wavy-bedded and laminated sand/silt/shale interbedded facies,*
- *Lithofacies H–2: Heterolithic, sand/shale wavy-bedded and laminated,*
- *Lithofacies M-1: Laminated mudstone, with thin stripes of siltstone layers and lenses,*
- *Lithofacies M-2: Maroon-colored, bioturbated and silty mudstone,*
- *Lithofacies M-3: Dark gray, well laminated mudstone with large plant fragments,*
- *Lithofacies M-4: Maroon, silty, bioturbated, Diplocraterion-bearing,*
- *Lithofacies M-5: Gray, clayey and laminated mudstone, with Fe-cemented bands,*
- *Lithofacies M-6: Gray, laminated mudstone, with Diplocraterion and/or Teichicnus,*
- *Lithofacies M-7: Dark gray, blocky mudstone,*
- *Lithofacies M-8: Black carbonaceous mudstone with coal lenses,*
- *Lithofacies M-9: Dull gray silty mudstone, well bioturbated, Lithofacies C – Black coal,* and
- *Lithofacies PS: Bleached, yellowish-brown soil-like unit (Paleosol).*

These lithofacies can be grouped into three broad lithofacies associations. These are:

a) *Proximal overbank facies association* —
fine-grained sand and silt deposits of levee, crevasse-channel and crevasse-splay, formed as a result of overbank flow of channel bed load;

b) *Lacustrine-floodplain lithofacies association* —
laminated silt, shale and heterolithics deposited in low energy environments (lakes) on the floodplain;

c) *Backswamp lithofacies association* —
coal and paleosols formed by organic activity and pedogenesis.

These facies associations reflect deposition within a coastal-estuarine or coastal-deltaic floodplain environment. The presence of the trace fossils *Diplocraterion* and *Teichicnus* within the floodplain facies, in the upper section of the E Group, and the basal part of the D Group indicate brackish-water conditions, and signify marine incursions into the coastal floodplain environment. This may be related to a major transgressive phase.

*Poster 3*

# Application of Shell volume interpretation software in fast-track 3D seismic interpretation

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Sarawak Shell Berhad/ Sabah Petroleum Company exploration is operated under the Production Sharing Contract environment. The agreements call for certain seismic, drilling and financial commitments to be fulfilled within the 7 years of exploration period. The early discovery and fast-track development of the fields will enhance the economics of the investment. Hence, Shell is always in search of the fast-track technologies, not only to shorten the cycle time but also to reduce the risks associated with exploration. In view of the increasing usage of the 3D seismic data in hydrocarbon exploration, Shell has developed a suite of software to reduce the turnaround time for the 3D volume seismic interpretation. The package will provide not only the understanding of the regional structural framework and the seismic facies distribution, but also the detection of the potential presence of hydrocarbons.

In SSB/SSPC, a workflow for the semi-automated 3D seismic volume interpretation utilizing the above-mentioned Shell developed volume seismic interpretation package has been established recently. The key features of the workflow are as follows:

1. Noise reduction: Filters applied following the direction of seismic reflections themselves rather than the grids of seismic data to improve the horizon continuity and fault interpretability.
2. Seismic fault detection: Fault highlighting based on seismic discontinuities/ fault zones and structural trends (dip, azimuth and combined dip/ azimuth seismic volumes)
3. Regional horizon tracking: Fast interactive tracker of 'phantom horizon' based on a single click on the seismic section.
4. Seismic facies identification: Seismic facies classification based on neural network and multi-attribute volume.
5. Seismic based hydrocarbon detection: (1) Large footprint median filter in horizontal direction for flat spot detection, (2) Tracking of subtle amplitude variations along structure, and (3) Pore-fill prediction based on AVO response of near and far offset seismic cubes.

The poster will show the overall workflow, each step of which will be illustrated with seismic examples. The workflow, however, will be continuously updated to capture the latest release of the ongoing development of the technology. It is anticipated that the workflow will not only speed up the seismic interpretation to compensate for the long lead time required for the high resolution seismic acquisition and sophisticated seismic processing, but also to minimize the exploration uncertainties and to improve the profitability of the company.

*Poster 4*

# The application of quantitative interpretation technology to offshore Sarawak and Sabah, Malaysia

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Quantitative Interpretation (QI) of seismic data is a vital activity to improve the characterization of reservoirs and to predict their hydrocarbon potential in all stages of exploration, appraisal and development. It should be an integrated activity done by a team of Geophysicists, Petrophysicists, Geologists, and increasingly, Reservoir Engineers. QI technologies are multi-disciplinary in nature and difficult to master.

The business impact of applying today's QI technology is very significant. Over the past few years, computer workstations have added tremendous interpretative abilities and there has been a revolutionary change in Quantitative Interpretation of seismic data: Sophisticated seismic modelling and seismic inversion have augmented and to a large extent replaced the traditional attribute analysis (Amplitude/AVO). A correspondingly sharp increase in QI activities around the world has resulted from the significant improvement of QI technology.

Rock properties, AVO modelling and Seismic-well match are the important foundations to start an Amplitude evaluation project. In addition to the traditional AVO attributes crossplotting, we have the technology to examine the impedances. Moreover, probabilistic inversion enables us to verify the proposed reservoir model or even determine a distribution of models that all fit the seismic data.

Some of the most effective QI techniques we have currently applied to offshore Sarawak and Sabah are shown in this paper. All the tools we used for these QI projects shown in this paper weren't available 10 years ago. With rapidly changing technologies, geoscientists have an increasing need to acquire expert geophysical knowledge. Workstation skills are essential to utilizing today's technology; technical knowledge is equally important to plan and execute QI projects properly and to achieve an unbiased pay prediction.

*Poster 5*

# 4D seismic forward modeling in offshore Sarawak fields

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4D seismic forward modeling is applied to oil and gas fields of offshore Sarawak, Malaysia. Three examples from clastic and carbonate fields are presented to show 4D feasibility for oil and gas reservoirs with different drive mechanisms.

- Clastic reservoir with depletion drive. Fast pressure declines result in excess gas production. The reservoir is complex in its geometry and compartments. 4D forward modeling shows clear seismic response changes as production progress. The 4D seismic survey is seen as a critical reservoir management tool.
- Carbonate build up with strong aquifer drive. Production results in high residual gas saturation, leaving behind a substantial amount of reserve. 4D forward modeling and 4D seismic survey provide monitoring of water movements and is therefore a critical tool in reservoir management.
- Platform carbonate build up gas reservoir with weak aquifer support. The reservoir has low porosity. 4D forward modeling provides the asset team with feasibility of future 4D seismic survey.

*Poster 6*

# Application of probabilistic inversion in Sarawak gas fields

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Probabilistic inversion provides multiple subsurface models consistent with geological, petrophysical, and geophysical knowledge of reservoir. Constrained by seismic data, the multiple realisations of subsurface derived from probabilistic inversion quantifies the uncertainty of reservoir properties. The probabilistic inversion results are used in construction of static reservoir models and uncertainty management for field development of Sarawak gas fields.

*Poster 7*

# Fluid inclusion screening of 16 Carbonate wells from Central Luconia, offshore Sarawak — final results

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Fluid inclusion screening (FIS) is a fast and cost effective technique, which has been used routinely in the oil industry for several years now. With this technique cutting samples are dried and crushed, fluid inclusion volatiles are released and then analysed in a mass spectrometer. This provides a log of palaeofluids and/or present day geochemistry throughout the stratigraphy and reveals information on hydrocarbon composition, migration, seals and proximity-to-pay zones.

Historically in Central Luconia the Miocene carbonate build-ups have been the main exploration objective. The key risks associated with this play are the charge and retention risks as a number of structures were dry whereas nearby structures, in a similar geological setting, were found gas-bearing. For the ongoing evaluation of the remaining prospectivity of the carbonate build-ups in the Luconia province it is important to know if structures are dry due to "lack of charge or lack of migration focus" or due to "retention failure". This technique can provide a quick and cost effective way to resolve some of these questions.

A successful pilot study was carried out in 2001 using eight recent carbonate wells as a calibration set. This study is a follow-up, in which 16 wells were analysed. These wells are mostly dry, with a few gas-bearing calibration wells and deep (pre-Carbonate) penetrations.

The results of this fluid inclusion analysis had a good fit to the well and seismic data, but not as good as in the pilot study. Indications for top seal failure, lateral seal failure and the liquid content of the gas have been observed and reasons for failure for most of the dry wells were established.

The results of the FIS of all wells, 24 in total, have been used to update the charge chance polygons of Central Luconia.

As stated in the pilot study this technique can clearly help us to better understand the hydrocarbon habitat of the Central Luconia carbonate play and it is recommended to analyse more (dry) wells in the future, in order to constrain basin modelling and charge risking further.

This study is part of Shell's continuous effort to use new technology to unravel the basin and charge history to facilitate exploring in a creamed basin.

*Poster 8*

# Challenges of developing a stacked clastic gas field

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The Laila gas condensate field, offshore Sarawak, comprises a thick (~2,000 ft) Upper Miocene succession of shallow marine sediments associated with major growth fault systems and deposited as part of the paleo-Baram delta. It is a marginal gas field (<300 Bscf UR) awaiting development to supply gas to MLNG-DUA. The structure is a NE-SW 3 way dip closure roll-over associated with a gravity induced tectonic regime and a later compressional phase (Upper Miocene). Laila is bounded to the east by a long NE-SW bounding fault and is dissected by a NW-SE splay fault in the middle of the structure; thus dividing the field into 2 major fault blocks: Main Block (footwall) and Block 1 (hanging wall in relation to Main Block). Minor fault splays are also observed in various intervals, but these faults were considered not to have a big impact on reservoir fluid dynamics.

The gas bearing intervals occur in 15 separate sands in the P, Q, R and S zones, which are then subdivided to parasequences. No core is available. Sidewall samples from the shallowest sand interval (P1) display fine–very fine grained sand with a silty matrix. Cleaning-upward signature on gamma ray, as well as prograding stacking patterns observed on seismic suggest that the bulk of the sequences correspond to a stack of prograding shoreface and/or deltaic sands. The field has high CGR, low permeabilities (3–7 mD from R1 DST) and is overpressured from R1 downwards. 3D seismic (pre-stack time) was recently acquired and AVO analysis was conducted along with this study.

In early 2003, a field study was initiated to characterize the stacked reservoirs of the Laila field for volumes (GIIP & UR), uncertainty identification for appraisal well drilling optimization and for flow unit definition. An appraisal well is planned for 2004.

For the purpose of this study only the Q5 sands of Block 1 and the R1 sands (which represent 50% of the GIIP) were modeled. The interval of interest is approximately 550 ft thick with 5 flooding surfaces: Q5A, Q5C, Q5D, Q5E and R1. Individual sands of the Q sequence are 20–70 ft thick, whereas the R1 sand, which represents the thickest sand, is 120–150 ft thick.

A 15 x 1.5 km 3D static model was built using Petrel v2003 using the PSC boundary as AOI limits. The model incorporates 2 mapped seismic horizons that were used to constrain zonal intervals. Zones were made conformable with high vertical resolution layering (mean = 1.15 ft). Listric faults were made linear for simplicity in the pillar gridding process, which uses a 300 x 150 grid increment.

Key uncertainties (i.e. sand continuity, porosity) that might have an impact on field development and GIIP were tested. The volumetric assessment of the various static models showed that the structural trapping mechanism uncertainty in Block 1 has the biggest impact on GIIP. Amplitudes, Vp/Vs and seismic facies maps suggest a drastic change to the NE of Laila-2. Reflectors in this area are chaotic and dim, suggesting either lateral shale-out, sub-seismic faulting, or slump scars. Lateral shale-out is assumed to be the most likely case, but the possibility of pay in this area cannot be ruled out. Seismic facies mapping in various intervals indicate a large lobate body terminating to the east. Severe dip shale-outs are considered unlikely given the size of the accumulation (edge of model is 1.5 km downdip of main bounding fault), nevertheless drastic dip shale-out realizations were modeled for sensitivity analysis. The downside impact of dip shale-outs is the order of 25–35 percent, which is significant given the small size of the field.

Since no clear GWC's were encountered, the high side potential of deeper contacts is another big uncertainty to GIIP. Contacts were postulated based on spillpoints, AVO, logs and pressure plots. Porosity distribution (i.e. kriging vs Gaussian simulation) does not have a big impact on volumes. The base case porosity model was co-kriged using S-impedance as a secondary control to well logs. No clear reduction of porosity with depth is seen A decrease in reservoir quality is seen north-eastwards towards Laila-2.

An XRD study conducted on Laila-2 cuttings showed total clay content of approximately 7–16%. However, a significantly high proportion of that is illite (36–58%) and mixed layer illite-smectite (19–28%). Pore bridging illite may very well be the culprit of the low permeabilities seen in the well tests, however, only a proper study on future core will give us a clue to the low flow potential of these rocks. Cuttings are not considered to be reliable and will always be questioned.

*Poster 9*

# Volume interpretation in the Malay Basin: how to leverage the value of 3D data by using state of the art technologies to better understand stratigraphical plays

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Increasingly, exploration and subsequent development is focusing on subtle stratigraphical plays which have hitherto proved difficult and complex to model. This poster demonstrates how, by integrating conventional seismic interpretation techniques with state-of-the-art multi-attribute volume interpretation tools an exhaustive inventory can be made of stratigraphical features (bodies) and a classification of their acoustic response. In turn, this allows a full inventory of leads and discrimination of the most attractive prospects.

It must be stressed that these tools are not meant to be strictly stand-alone and that best results are achieved when this valuable information is carefully integrated with all structural, stratigraphical, sedimentological, lithological, petrophysical and geophysical elements derived from well data, regional studies and other investigations.

This approach is valid both for exploration prospect screening and for production development, in particular with regards to the ability of certain techniques, such as spectral decomposition, to improve on conventional seismic resolution and highlight previously sub-seismic geometrical features.

*Poster 10*

# Reservoir heterogeneities of lower coastal plain estuarine sands, West Patricia Field, offshore Sarawak

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West Patricia Field is located 48 km NNW of Bintulu in 40 m of water. West Patricia-2 discovered oil at West Patricia Field in 2000, and three appraisal wells were subsequently drilled between 2001 and 2002. Four major oil reservoirs were discovered, the B5.5M, B5.5L, B7M and B8.5 sands (Cycle III interval). Four main fault blocks are recognized in the field, namely Central Fault Block East (CFBE), Central Fault Block West (CFBW), S1 and S2. Phase I development drilling was designed to produce oil from the eastern part of the field and consisted of six producers and seven appraisal sidetracks drilled in late 2002. The Post Phase I reserves assessment assigns the field reserves as follows: B7M (~75%), B5.5M&L (~22%) and B8.5 (~3%). Currently West Patricia total production is maintained at a flat rate of 15,300 BOPD combined from these four reservoirs.

## RESERVOIR CHARACTERIZATION

Core from the B5.5M and B7M and image logs (FMI & OBMI) from the exploration/appraisal and Phase I development wells underpin the reservoir characterization study. The results suggest that in general the B5.5M, B5.5L, B7M and B8.5 sands were deposited as stacked estuarine river mouth bars and as cut and fill channels. Observations from cores that support this depositional model are as follows:

- Both the B5.5M and the B7M are characterized by the presence of shale drapes within the sand indicating that they are low energy deposits. Fluvial channels are higher energy deposits would not preserve such drapes as well.
- Both the B5.5M and the B7M core are characterized by a sharp sand — shale boundary at the top which is uncharacteristic of fluvial channel deposits.
- The lack of bioturbation in shales suggests a restricted depositional environment.
- There are no rootlets in the shales suggesting they were not deposited in a flood plain environment.
- The sediments from the cores are non-calcareous, which suggest absence of marine influence.

The FMI/OBMI image shows alternating fining and coarsening up-wards parasequences. The fining upwards pattern is interpreted as the cut and fill channel sands whilst the coarsening upwards pattern is interpreted as the estuarine river mouth bar sands. This alternating pattern suggests sediment supply switching during deposition, which can produce laterally extensive river mouth bars.

No coal layers are observed in the West Patricia reservoir interval. This, together with the non-calcareous nature of the sediments suggests a distal environment — probably an estuarine lagoon. Coals are observed in the B7M reservoir interval at Congkak-1 and at Sepang-1 on the western side of the field. The predominantly fining upward pattern and the OBMI/FMI images suggest that the B7M in Congkak-1 and Sepang-1 is a fluvial channel deposit. This fluvial system is thought to be the sediment source for both the estuarine river mouth bars and the cut & fill channels further to the east at W. Patricia.

A stratigraphic correlation suggests that sands and shales are correlatable up to ~1,500 meters implying potentially good lateral connectivity. However the shale drapes observed in cores and estuarine shales interpreted from logs and OBMI/FMI images may act as baffles to fluid movement during production. It is inferred from the stratigraphic correlation that the estuarine river mouth bar sands prograded into the distal part of the estuarine lagoon through time. At the B7M level, the sand thickness decreases from the western side of the field (WP-5RD) to the eastern side of the field (WPPA wells and WP-1). The B7M sand also displays a thickening upward succession characteristic of a progradational sequence set (Van Wagoner, 1998). The B5.5L reservoir in Congkak-1 is interpreted as a flood plain deposit whilst the equivalents in WP-5RD and wells to the east are interpreted as estuarine river mouth bar sands. At the B5.5M level the interpreted flood plain sediments extend further to the east i.e. from Congkak-1, through WP-5RD and WPA-5. They change into the river mouth bar sands at WPA-4.

## ROCK PROPERTIES

The measured porosities and permeabilities of the river mouth bars and cut and fill channels are virtually indistinguishable. The field average porosity of the river mouth bars is 26.6% and the permeability 2,900 mD. The corresponding values for cut and fill channel are 25.9% and 2,480 mD. The fluvial channel has average porosity and permeability of 27% and 4,100 mD respectively. The main porosity type of these reservoirs is intergranular.

The B7M sand is very fine to lower medium, sub angular to rounded with moderate to good sorting. The framework grains are predominantly quartz (83%–96%), followed by feldspar (1.5%–3.2%), clay (2%–10%), siderite (0.2%–0.5%) and pyrite (0.2%–2.4%). Clay fraction XRD results show that kaolinite (33.5%–57.2%) is the main clay type followed by illite (21.9%–35.3%), mixed layer illite/smectite (19.6%–24.7%) and chlorite (0%–7.8%). Cements are trace to minor (0.8%–2.8%) and consist of siderite, quartz overgrowths, pyrite and ferroan dolomite. The diagenesis is thought to be at an early stage due to the occurrence of common point to point grain contact and the paucity of quartz overgrowths.

## 3D GEOLOGICAL MODEL DESCRIPTION

As the observed porosities and permeabilities of the river mouth bar and cut & fill deposits are so similar, for 3D modeling purpose these two facies were merged into one facies referred to as the River Mouth Bar Sand. The 3D model consists of 5 different facies as observed from cores and image logs. These are the River Mouth Bar Sand, the Fluvial Channel Sand, Estuarine Shale, Flood Plain Shale and Abandoned Channel Shale. The 3D geological grid size is 75 m x 75 m x 0.5 m to adequately capture the rock heterogeneity, with total grid cells of 2,412,696.

The reservoir geometry was modeled on stratigraphic correlation distances and progradation pattern. For the River Mouth Bar Sand this resulted in a model that shows good connectivity and the potential presence of sand to the east of the Central Fault Block, and on the southern flank of the field and also along the modeled shoreline that separates fluvial from estuarine deposits.

In general, the modeled rock properties show better quality reservoir distributed in a N-S trend conforming to the modeled shoreline. The quality of the reservoir deteriorates towards the distal part of the estuarine facies.

*Poster 11*

# Technology integration for reservoir characterisation and optimized well planning at Larut Field — offshore Malay Basin

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The Larut oil and gas field, consisting of the Main, East, North and West fault blocks, is located offshore approximately 270 km north-northeast of Kerteh, on the east coast of Malaysia. The Larut 1 exploration well, drilled in the Main fault block, discovered the field in 1990. Subsequently, eight other wells were drilled to delineate the adjacent fault blocks. The initial 27 well development drilling programme started drilling in December 2001 with first oil production in February 2002. To date EMEPMI has completed a total of 19 wells.

This poster illustrates how seismically derived reservoir characterization studies have been used to provide valuable input into opportunity identification, well design and well optimization. The use of neutral networks and integrated well planning will be illustrated.

A 325 square kilometer 3-D seismic survey was acquired over the field in 1991. The original processing through 3-D post-stack migration yielded a data set that was moderate to good quality. This was used in the appraisal drilling and pre-development planning. In order to improve imaging, well optimization and risk mitigation, the original 3-D data set was reprocessed in 2002 through pre-stack time migration (Pre-STM). The full fold Pre-STM stack and the AVO volumes (near and far angle stacks are the data sets currently being used to support the development drilling programme.

Hydrocarbons occur in the late Oligocene to mid Miocene Group F, H, I and K shallow water sandstones. The main reservoirs occur within the Group I fluvial sandstones, comprised of stacked and individual channel sands. In some instances, such as the I40, these channels may be mapped directly from 3D seismic. Horizon keyed multivariate linear regression has been used to help characterize some of the major reservoirs. However, many reservoirs are unable to be mapped using conventional seismic techniques as the thickness of these reservoirs is below seismic resolution.

In order to extract more information from the 3-D seismic data, neural networks in Hampson-Russell's Emerge software are being used to aid the reservoir characterization of some of the more challenging intervals. Emerge is a software application that analyzes well log (e.g. porosity) and seismic data, finds linear/non-linear relationships between the well log and seismic data at the well, and subsequently uses these relationships to estimate a 3-D volume of the log values at all seismic trace locations. The seismic data may be conventional amplitude data or derived attribute volumes (e.g. P-Impedance or Instantaneous Frequency). Emerge can also use discriminant analysis, a mathematical clustering technique, to determine relationships in the seismic data that can be exploited to classify the seismic into discrete bins that share similar characteristics.

The first Emerge model was built using discriminant analysis to perform a lithology classification. A relative porosity volume was subsequently estimated, and both are being used in VoxelGeo for Geobody visualization and seed detection. The volumes may also be loaded.

*Poster 12*

# Improved reservoir characterisation from inversion of high resolution 3D seismic data

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A comparison of the acoustic impedance data is made between standard processing and ***short offset*** (high resolution) processing carries out by Robertson Research for a 3D seismic data set acquired in the Malay Basin. Fugro-Jason's inversion technique removes the wavelets from the seismic data (thereby further increasing resolution) and therefore allows a more meaningful comparison of the two datasets in terms of rock properties, not influenced by effects of tuning, phase difference and other boundary effects. The short offset re-processing was aimed at increasing the fidelity of seismic data for shallow hazard assessment and to improve the deeper data for reservoir characterisation. It was hoped that the higher quality of the seismic data could lead to significant differences in interpretation of thin reservoirs in terms of reservoir extent, distribution of reservoir quality and connectivity. The original 3D seismic data was acquired using a dual source, six cable configuration, the streamer length being 4,800 m with 100 m separation. The data was originally processed using a standard processing flow that included flexi-binning and was migrated post-stack.

The main differences between the short offset processing and standard processing are:

1. There is no resampling of the data in either space or time. This means that frequencies of up to 250 Hz can remain in the data with no aliasing effects. The lack of any spatial resampling (trace sum, trace drop) avoids 'smearing' of the data and increases spatial sampling for the input to the migration operator.
2. The data is limited to the near offset ranges only, typically 3–6 fold depending on signal/noise ratios and hence excludes the requirement for far offset corrections prior to zero offset migration. Restricting processing to near offsets also reduces ray-path and stacking complications in areas of non-hyperbolic move-out (e.g. areas affected by shallow gas concentrations) which leads to improved imaging.
3. Data imaging is exactly honoured in short offset processing i.e. the data are not binned prior to migration. This reduces spatial averaging and results in more accurate migration data positioning and hence improves lateral resolution. Data regularisation is achieved via either a 1 pass or a 2 pass Kirchhoff migration approach.

The high-resolution data was then inverted using Fugro-Jason's global constrained sparse spike inversion algorithm and compared with a similar inversion carried out on the original 3D seismic data. The inversion focussed on a known hydrocarbon interval where the reservoirs were deposited in a tidal flat setting. Sandstones, siltstones and mudstones are interbedded in metre to decametre-scale with occasional tidal and, more rarely, fluvial channel sand bodies which are in the tens of metre scale. Sand development within background tidal flat deposits shows a km-scale lateral variability similar to modern day analogues.

The short offset processing produces a seismic volume with higher frequency content (80 Hz compared with 60 Hz on the original processing). The increased bandwidth obviously produces higher resolution data. Both seismic volumes provide a good match to the well data within their respective bandwidths. After inversion of both seismic volumes to acoustic impedance, a comparison was made for a known gas sand that was 18 m thick at well penetration. The inversion of the short offset processed data showed the down dip extent of the gas to be increased, the location of the lowest impedances within the channel to be changed and the connectivity between different channels to be altered.

*Poster 13*

# Insights on prospectivity of disputed zones, South China Sea

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Disputed areas of the South China Sea (SCS) outboard of current oil and gas production can be explored easily and effectively using potential fields data in map views coupled with geological literature. Potential fields techniques are uniquely suited to such screening evaluations because the foundation data sets, particularly gravity, are seamless, cover huge areas at low cost, provide basin-scale sedimentation as well as structural information and can identify large targets. When integrated with published knowledge, gravity and magnetics data provide powerful exploration tools; in disputed zones, perhaps the only ones readily available.

Gravity and magnetics data provided by GETECH were used to revamp the tectonic interpretation of the SCS, redefine basins and identify new depocenters, structures, and sediment delivery systems from the deepwater margins of northern Borneo, Palawan, southern China and eastern Vietnam.

The basins rimming the SCS and their tectonic setting, with the "outboard" area of interest indicated, are shown on an isostatic gravity image. Extension preceding SCS spreading produced the graben/half-graben rift topography common to the Paleogene section in the outboard areas, whether the area remained on the north margin or was detached and carried its Paleogene sequence to the south margin. These restricted rift depocenters contain the primary source rocks and many of the sandstone reservoirs of both the explored and outboard areas. The Neogene post-rift section is an overall transgressive sequence that covered the rift topography as the margins of the new ocean subsided. In the outboard area, the relatively thin Neogene is expected to be primarily a regional seal and provide overburden necessary for hydrocarbon generation. Local carbonate reservoirs and source intervals are possible.

Structures seen over much of the area are large, given the approximately 6–8 km resolution of the gravity data used. Large targets are an economic necessity because water depths generally exceed 1,000 m. Deep water, remote locations and disputed political boundaries will delay seismic exploration and drilling of this frontier, but the authors' interpretation indicates areas worth further investigation.

*Poster 14*

# Technology changes supporting improved performance of E&P industry processes

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The E&P industry falls short of expected profit returns, despite promising the long-lived returns that an oil and gas asset can provide. This industry often has high levels of uncertainty and risk, which oil companies attempt to quantify before embarking on each individual E&P project. However, while the expected return has a typical hurdle rate of 18%, the actual return on investment is usually less than 7% (Brashear *et al.*, 2001). This discrepancy in predicting return has been attributed to systemic limitations in decision analysis processes and frequently used workflows (Brashear *et al.*, 2001), which result in repeated underestimation of risk and overestimation of the predicted production of the project.

Several papers published recently highlight the need for companies to follow well-designed decision analysis processes in association with clearly defined, multi-disciplinary analysis of technical uncertainties (Floris and Peersmann, 2000; Begg *et al.*, 2001). Integrating all of these processes without comprehensive supporting technology is not realistic given the performance and infrastructure limitations of conventional technology and applications. An enormous change is necessary.

Landmark consultants and developers have worked for five years, with more than 20 companies, to map the requirements of new technology that is required to improve uncertainty assessment and decision analysis. Pain points associated with common processes in upstream E&P were studied to provide a comprehensive review of the computing technology issues currently faced by oil companies (Lukats *et al.*, 2003). Landmark then embarked on a plan to create a new generation of technology that eases the pain points while providing for improved understanding of risk. This paper details a new asset-team focused technology system that Landmark has built to improve the value of E&P decision analysis processes.

*Poster 15*

# Prioritising exploration leads in the Sudan using magnetic alteration seepage signatures recognised in high resolution aeromagnetic data

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It has been known for many years that entrapped hydrocarbons frequently coincide with distinctive zones of micromagnetic anomalies. Field studies have shown that these sub nT amplitude anomalies can be explained by haloes of shallow/subsurface magnetite deposits which are the result of inorganic and (more importantly) microbial alteration of haematite to magnetite in the presence of hydrocarbon microseepage. These studies have consequently demonstrated that indeed *most* hydrocarbon traps leak vertically. In the absence of significant cultural magnetic interference or shallow volcanic magnetic signature, and with favourable ground conditions, a sufficiently detailed high-resolution aeromagnetic survey can very effectively locate seep-induced micromagnetic responses. One such survey has been recently performed over the Muglad Basin of Southern Sudan, flown with a relatively small line spacing (500 m) and low ground clearance (100 m) — a typical of "normal" hydrocarbon aeromagnetic survey specification. The analysis of these data shows how a high-resolution survey can be a valuable means of: (i) delineating exploration fairways, but more importantly, (ii) prioritising seismic structural leads and (iii) targeting unforeseen non-structural hydrocarbon traps.

Numerous researchers including: Jenny, Pirson, Donovan, Roberts, Foote, Machel, Land, Saunders, Schumacher and LeSchack, have studied this phenomenon over the past 70 years confirming its validity, and indeed many of whom recommending its use as a standard exploration method (See separate file for a fuller bibliography of relevant papers). Yet despite this, and acknowledging the similar documented achievement of the closely related surface geo/biochemistry approach (Wagner *et al.*, 2002), the oil industry is yet to fully embrace it as a standard exploration tool. The micromagnetic exploration approach is likely to remain empirical for some time to come due to the complex interplay of the geological, geochemical and biochemical factors involved. It is this empiricism that appears to deter some oil companies. The validation for this exploration approach, provided by the accompanying southern Sudan case history, contributes to the growing body of evidence that this is a valuable exploration tool that ought to be used with greater confidence in the field.

The micromagnetic exploration approach is empirical, and in common with *all* oil exploration methods, cannot always be expected to provide definitive answers. The approach nonetheless provides a valuable means of mapping closely coupled microseep responses when ground conditions are favourable. It is probably most successful when applied over land areas that have a sustained or annually recharged water table (like the Sudd region of Southern Sudan), and, *shallow* lakes and seas. Arid regions with intact *palaeo* shallow basal water table deposits may also be amenable to this approach.

Sophisticated data microlevelling plays a critical role in the proper conditioning of high resolution magnetic data for micromagnetic aureole recognition.

We believe that as smaller oil fields become more economic to exploit, the high resolution aeromagnetic technique should become especially useful insofar as the physical size of a leaky reservoir is not the main factor in determining the size, amplitude or area, of aureole response. Factors such as: timing of charge, overpressure, seep duration and seep rate are probably more significant.

***Poster 16***

# Measurement of sediment surface heat flow and its application in deepwater exploration

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A tremendous amount of heat is constantly transported from the earth's center to the surface by thermal convection and conduction. A portion of the heat conducted through the earth's crust is used to drive the chemical reactions that transform organic matter contained in sedimentary rocks into petroleum. Measuring this heat and understanding its transport mechanisms through the crustal rocks are essential to the science of deepwater petroleum exploration.

The thermal history of deepwater sedimentary basins is of great interest to petroleum geologists because the hydrocarbon maturation process is controlled primarily by the temperature the sedimentary source rock has experienced since its deposition. Researchers mathematically constrain the sedimentary thermal history by building a physical model that simulates the processes whereby sediments gradually become heated as they are deposited, buried, and compacted over time. The researcher must have detailed knowledge of the sedimentation history, the thermal properties of the sediments, and the regional geothermal heat flux in reconstructing the thermal history of the basin of interest.

To determine maturity of potential source-rock intervals, either 1-D or 2-D models are constructed and calibrated. To calibrate these models, corrected bottom-hole temperatures or sediment surface heat-flow measurements need to be used. Because most deepwater and ultra-deepwater wells only penetrate the upper 2,000–3,000 m of sediments, there is usually a lack of data regarding thermal conditions at depth. Heat flow through the seafloor is one of the few constraints to such models that can be measured directly. If the main characteristics of the model are correct, the measured heat flow should agree with the model results.

Seabed heat flow measurements can also identify areas of anomalous heat flow that may indicate localized fluid flow within the sediments or the conductive effects of salt diapirism. In addition, for the purpose of field development subsequent to a discovery, the measured temperatures determine how stable gas hydrates are in shallow sediments, which sometimes determines the stability of the ocean floor in deep waters.

On both local and regional scales, fluid flow along faults across formations can modify the conductive thermal regime, as can topographic highs. Fluid flows, when accompanied by gases at pressures above local hydrostatic, can percolate across formation boundaries and yield local geographic anomalies that can point directly to hydrocarbon generation at depth. Other heat flow variations are produced by differing amounts of stretching during basin formation and by varying sedimentation rates. Also, the enhanced thermal conductivity of salt structures refracts heat, and any enhanced radioactive heat generation, especially in black shales, produces additional heat that must be considered when formulating heat flow interpretations.

Case studies for the application to deepwater exploration of sediment surface heat flow measured by this method are presented. Data from basins around the world are presented and compared. Examples from 2D thermal model calibrations, the effects of salt diapirism, and the application gas hydrate boundary zone research are presented.

*Poster 17*

# Deformation styles in the Northwest Borneo and North Makassar Basins

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Neogene delta systems around Borneo contain numerous world-class hydrocarbon accumulations, with original in-place resources greater than 10 billion barrels of oil and 55 trillion cubic feet of gas.

Exploration over the past ten years has been extended into the deep-water domain with significant discoveries, particularly in distal parts of the Mahakam and Baram Deltas where several active petroleum systems have been recognised within geological settings where there is a complex interplay between tectonics and sedimentation.

In this paper we compare and contrast the structural development of the Mahakam Delta and West Sulawesi Fold Belt in the North Makassar Basin and the Baram delta system in the Northwest Borneo Basin.

In essence, structuring is similar in the Baram and Mahakam delta systems, albeit with a much stronger influence of older basement structures in the Baram system.

Structuring in the Baram system is primarily controlled gravitational and sedimentary loading with strong influence of older basement-related structures. Sand/shale ratios and the degree of undercompaction play a decisive role in the deformation style, together with the degree of decoupling from the underlying basement (Sandal, 1996).

In neither system is there any appreciable structuring directly related to tectonic events external to the delta system.

The West Sulawesi Fold Belt, however, is the direct result of transpression and collision, resulting from movements on the strike-slip fault system, which have (temporarily) created the island of Sulawesi.

*Poster 18*

# Comparison of source rock geochemistry of selected organic-rich rocks from the New Airport Site and Tg. Kidurong, Bintulu, Sarawak: implication for oil generation from Terrestrial-derived organic matter

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Organic-rich sediments and coals constitute much of the Oligocene-Miocene Nyalau Formation that outcrops in south and north Bintulu area, Sarawak, East Malaysia. The main aim of this study is to examine the organic-rich sediments at Bintulu new airport and Tanjong Kidurong sites. The examination involved several organic geochemical source-rock analyses including petrological studies on polished sections e.g. vitrinite reflectance (%Ro), Soxhlet-extraction, thin layer chromatography (TLC) and GC/MS analysis to obtain biomarker distributions. Such methods are used to characterise the organic matter types and their contribution to hydrocarbon generation, and to determine the thermal maturity, and condition of deposition.

The liptinite maceral group (mostly sporinite) was found to characterise the coal samples at Bintulu new airport site, although the vitrinite group (mostly vitrodetrinite and collotelinte) constitute the major part of the organic-rich sediments of both areas. Occurrence of sporinite and other liptinites are relatively low in sediments from Tg. Kidurong.

Petrographic features indicative of oil-generation include the occurrence of exsudatinite veins that are commonly thought to represent the very beginning of oil-generation in coals (e.g. Teichmuller, 1974; Wan Hasiah, 1997). Other oil generative features include cutinite and suberinite associated with oil-hazes.

Vitrinite reflectance (%Ro) was measured on collotelinite in coal and on dispersed vitrinite particles in other sediments. The data obtained is summarised in Table 1. Both areas were found to have Ro (mean) in the range of 0.49-0.64% indicating early oil window maturity. The sample possessing 0.49 %Ro was observed to be heavily stained with bitumen, thus lowering the reflectance value.

Biomarker parameters that support these maturity levels include the CPI values close to 1, the 22S/(22S+22R) ratios of 0.52-0.62 (for $C_{31}$), and 0.60-0.63 (for $C_{32}$).

The n-alkane distributions of the analyzed sample extracts at Bintulu new airport site (sbna9-2, sbna9-3, sbna7, sbna8), exhibit similar unimodal patterns that range from n-$C_{14}$ to n-$C_{37}$ and maximise at n-$C_{31}$ or n-$C_{29}$. They are marked by a strong contribution of higher-molecular weight n-alkanes generally from n-$C_{23}$ to n-$C_{33}$ which are indicative of terrestrial organic matter (Tissot and Welte, 1984).

The sample extracts at Tanjong Kidurong sites (mnlg4 and S8) generally show bimodal patterns ranging from n-$C_{14}$ to n-$C_{37}$ and maximizing at n-$C_{16}$ and at n-$C_{29}$. Consequently, they are characterized both by the predominance of the lower-molecular weight n-alkanes (mnlg4) and also by higher-molecular weight n-alkanes (S8). This suggests organic matter input from mixed marine and terrestrial environments (Tissot and Welte, 1984).

The sample extracts from Bintulu new airport site show higher values for the ratio n-$C_{31}$/n-$C_{15}$ that range from 3.5 to 25.5 (Table 1). The pristane / phytane ratios for both sites ranges from 2.8 to 4.5. These values are similar to those cited by Khorasani (1987) for coals deposited in dysaerobic conditions (i.e. intermediate between aerobic and anaerobic condition), thus suggesting similar condition of deposition for coals under current investigation.

The m/z 191 triterpane distributions show similar hopane distributions in both locations, which are dominated by 17a (H), 21b (H)-hopanes, the most abundant being $C_{30}$ (peak 6), with the $C_{31}$-$C_{35}$-homohopanes decreasing progressively. $T_m$ (17a (H) 22,29,30-trisnorhopane; peak 2) is overwhelmingly dominant over $T_s$ (18a (H) 22,29,30-trisnorneohopane; peak 1). Oleanane (peak 5) is present in all the analyzed extract samples and indicates a higher plant input (angiosperm) (Ekweozor *et al.*, 1979).

The available data in the present study confirms that the organic source matter in Bintulu new airport site is principally of a terrestrial type while in Tanjong Kidurong site it is principally of mixed marine and terrestrial types. No algal-derived organic matter was observed in the samples under current investigation.

***Poster 19***

# The Late Miocene Sandakan Formation, East Sabah: facies, depositional environments and relative sea level change

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This paper discusses sedimentary facies and lithofacies associations and their depositional environments with the relative sea level change.

The Sandakan Formation is situated within the Central Sabah sub-basin, which is located on the east coast of Sabah. Rock belonging to the Sandakan Formation can be found exposed in the Sandakan Peninsula and the Dent Peninsula, which lie between Labuk and Darvel Bays. The type area of the Sandakan Formation is the Sebuga area lying between the Batu Sapi Road on the south and the Labuk Road on the north.

Twelve sedimentary facies have been identified within the Sandakan Formation. These facies are: SDS1 (rippled tops sandstone), SDS2 (thick sandstone-shale interbedding), SDS3 (thin sandstone-shale interbedding), SDS4 (hummocky cross-stratified sandstone), SDS5 (channelized/gutter cast sandstone), SDS6 (thick clean, cross-bedded sandstone), SDS7 (sandstone lenses/layers), SDM1 (grey mudstone with carbonaceous materials, coal fragments), SDM2 (lenticular-bedded mudstone), SDM3 (laminated-mudstone), SDM4 (laminated-mudstones with interbedded laminated siltstone and sandstone), and SDC1 (coal layers).

These facies can be grouped into six different lithofacies associations, namely:

1) Lithofacies association A (thick laminated-mudstone with gutter cast)
2) Lithofacies association B (hummocky cross-stratified sandstone interbedded with facies SDM4)
3) Lithofacies association C (thick clean, cross-bedded sandstone)
4) Lithofacies association D (sandstone-shale succession)
5) Lithofacies association E (laminated-mudstone with coal clasts)
6) Lithofacies association F (laminated-mudstone with coal layers)

Lithofacies association A represents offshore, shelfal mudstone. Lithofacies association B interpreted as having been deposited within the lower shoreface zone. The upper shoreface environment is represented by lithofacies association C. Lithofacies association D represents tidal flat environment. The lagoonal-estuarine and -swamp environments are suggested by lithofacies associations E and F.

The proposed stratigraphic organization of the investigated Sandakan Formation, based on the geographic locations of the outcrops and the structural geology of the formation, shows that the thick laminated-mudstone with gutter casts sandstone of lithofacies association A represent the lowermost part of the investigated Sandakan Formation. This lithofacies association may be succeeded by thick hummocky cross-stratified sandstone of lithofacies association B. The tide-dominated, lagoonal-swamp and -estuarine of lithofacies associations F and E with tidal flat deposits of lithofacies association D in the Cecily Road and IOI-Kg Bahagia represent the middle parts of the succession. The uppermost part of the succession represented by the presence of upper shoreface of lithofacies association C.

The stratigraphic organization and lithofacies associations of the Sandakan Formation suggest three contrasting paleoenvironmental settings: open-marine, tidal flat and lagoonal-estuarine and -swamp. The organization of lithofacies associations A, B, F, and E of the Sandakan Formation suggests a gradual, overall, upward-shallowing of environment and a marked change in the depositional system: a change from an offshore to lower shoreface, to lagoonal-estuarine and -swamp environments with probably some fluvial influence. These are illustrated by the block diagrams A, B, and C. Lithofacies associations D and C suggest a transgressive phase: from tidal flat to upper shoreface.

The thick laminated mudstone with gutter cast sandstone which is slightly bioturbated and shows carbonaceous laminae (lithofacies association A) records depositions in a restricted, offshore, shelfal environment (open-marine) during the early phase of relative sea level rise.

Lithofacies association A may be succeeded in places by the lower shoreface deposits of lithofacies association B (hummocky cross-stratified sandstones), which records sedimentation in wave- and storm-dominated (open-marine) environment, as the relative sea level began to fall. The continual falling of relative sea level led to the deposition of hummocky cross-stratified sandstones (lithofacies association B) to be deposited within the lower shoreface environment.

Suraya and Lambiase (2002) have suggested that the hummocky cross-stratified sandstones of the Sandakan Formation as having been deposited in the lower shoreface zone while Noad (1998) interpreted this lithofacies as sub-tidal tempestites.

The upward transition into lagoonal-swamp and -estuarine deposits is suggested by the presence of lithofacies association F and E. Lithofacies association F suggests deposition in a lagoonal-estuarine with well developed swamp, suggested by the occurrence of coal layers. Lithofacies association E records deposition in lagoonal-estuarine, most probably in a marsh area.

Rahmani (1988) suggests that estuarine systems are characterized by a tripartite style of sand-to-mud-to-sand fill. Dalrymple (1992) propose that most estuaries comprise three zones: (i) an outer zone dominated by marine processes, (ii) a central zone where marine energy is dissipated by fluvial currents, and (iii) an inner, river-dominated zone. The distribution of total energy that produces the tripartite division is more pronounced in wave-dominated estuaries than in tide-dominated systems (Zaitlin and Shultz, 1990). In the case of Sandakan Formation, the occurrence of thick laminated-mudstone with carbonaceous detritus (Facies SDM1) may suggest the central zone of the estuary. The presence of Facies SDS3 and SDC1 associated with Facies SDM1 may be indicative of the inner, river-dominated zone.

Reading and Collinson (1996) suggested that in humid and temperate lagoons, the muds are often rich in organic matter, including plant debris washed in by rivers. The remains of such rich vegetation are typical of low-lying fresh water swampland or lagoonal deposits (Sellwood, 1978; Rangel *et al.*, 2002).

The units overlying lithofacies associations E and F represent the establishment of a tidal flat and an upper shoreface (lithofacies associations D and C). They reflect a rise in the relative sea level: from tidal flat to upper shoreface. The lithofacies association D records deposition in tidal flat. It is represented by a rhythmic alternation of sandstone beds (which are occasionally rippled tops) with lenticular mudstone. These deposits maybe locally cut by intertidal runoff channels, suggested by the occurrence of Facies SDS3 (thin cross-bedded sandstone-shale succession). Noad (1998) suggested a similar interpretation. He interpreted the sandstones of this lithofacies association as having deposited in sub-tidal channel-mouth shoals.

The transition upward into upper shoreface is suggested by the thick clean, cross-bedded sandstone of lithofacies association C. Within the upper shoreface environment storm processes transport sand-grade material whilst fair-weather wave action has a winnowing effect, removing clay- and silt-grade material, resulting in very clean sandstone. This suggestion agrees with the interpretation of Suraya and Lambiase (2002). Noad (1998) indicated that the upper shoreface in Sandakan Formation is absent.

During the time of lithofacies association C, the relative sea level began to rise up again forming progressive upper shoreface environment landward.

*Poster 20*

# Sedimentary facies development of breccia dominated sediments in Tanjung Sekakap-Tanjung Murau area, Mersing, Johor

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[2]Geological Engineering Department, Faculty of Engineering
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## THE MURAU CONGLOMERATE FORMATION

The mainly rudaceous rock unit exposed along the east coast of Johor between Pulau Batu Chawang and Tanjung Leman was described by Koopmans (1968) as the Conglomerate Member of the Tembeling Formation. Later, Ahmad Jantan *et al.* (1988) updated it to the Murau Conglomerate Formation. In the present study, the formation is divided into three different units, i.e. the Tanjung Murau, Tanjung Tenggaroh and Tanjung Leman units based on their different facies assemblages, hence different depositional environments and processes.

## THE TANJUNG MURAU RUDROCK UNIT

The Tanjung Murau rudaceous rock unit is the biggest unit of the Murau Conglomerate Formation forming several ridges between Tanjung Sekakap and Tanjung Murau with fresh coastal beach rocks and cliff outcrops. This unit is generally composed of polymict clasts range from schist, phyllite, slate, shale, sandstone, quartzite and mudstone, and apparently devoid of volcanic clasts. The clasts are generally angular to very angular, ranging from granule to boulder, poorly sorted, randomly oriented and poorly imbricated. This unit is unconformably overlain by the older metamorphic rock unit which is widespread in the eastern coast of Johor. At the base of the Tanjung Murau unit, a basal breccia is well developed. The lowermost succession of the breccia is usually dominated by clasts of metamorphic origin. The clasts gradually changed from cobble-boulder dominated in the lower succession to pebble-cobble dominated in the higher succession. Alternating sandstone and gravelstone only began to develop in the middle and upper parts of the succession, with clasts of metamorphic origin getting lesser and replaced by clasts of sedimentary origin. In the uppermost succession, red mudstone is developed.

## TANJUNG MURAU SEDIMENTARY FACIES

Eight sedimentary lithological logs were constructed based on studied outcrops from various parts of the sequence between Tanjung Sekakap and Tanjung Murau. Ten sedimentary facies can be recognised from these lithological logs based on sedimentary textures and structures (Table 1). Previous works including those by Chough *et al.* (1990), Hwang *et al.* (1995), Miall (1996) and Kim and Chough (2000) were used as the main references in establishing sedimentary facies within the Tanjung Murau rudaceous rock dominated sequence. The breccia dominated Tanjung Murau rudaceous rock unit of the Murau Conglomerate Formation can be divided into several sedimentary facies namely the disorganized cobble-boulder supported breccia (Bd); crudely stratified cobble-boulder-rich breccia (Bs); crudely stratified cobble-rich gravelstone (Gs-1); disorganized clast-supported gravelstone (Gd); crudely stratified pebble-rich gravelstone (Gs-2); normally-inversely graded gravelstone (Gn-i); cross bedded gravelstone (Gc); stratified sandstone (Ss); massive sandstone (Sm); and homogenous mudstone (Mh) (see Table 1). The Tanjung Murau rudaceous rock unit exhibits a general fining upward sequence. The lower part is dominated by coarse breccia, followed by gravelstone dominated facies in the middle and fine sandstone and mudstone facies in the upper part of the sequence.

## DEPOSITIONAL ENVIRONMENT

The breccia dominated Tanjung Murau unit as a whole can be interpreted as a composite fan-delta with both alluvial fan and Gilbert-type fan delta deposits dominated, based on depositional models suggested by Wescott and Etheridge (1980) and later work by Chough *et al.* (1990). The alluvial fan association is featured by discontinuous breccia and gravelstone, where debris flow dominant. Gravelstone within the facies Gs-1, Gd, Gs-2 and Gc as well as facies Ss with sheeted geometry represents the Gilbert-type facies association. The thick breccia and gravelstone without the presence of basinal plain, slope apron as well as prodelta associated facies shows that the rate of sedimentation is similar to that of subsidence. Rapid subsidence of the Murau sedimentary basin led to the basin filling on steep slope in a continental margin environment. This can be seen at the base of the unit exposed in Tanjung Murau and west of Tanjung Sekakap where alluvial fan deposits are dominant. Toward the top of the succession, the Gilbert-type fan delta deposit become dominant as the subsidence rate gradually reduced.

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# BERITA-BERITA PERSATUAN
# NEWS OF THE SOCIETY

## KEAHLIAN (Membership)

The following applications for membership were approved:

**Full Member**

1. Zaki bin Alias
   Jabatan Mineral & Geosains, Beg Berkunci 2042, 88999 Kota Kinabalu, Sabah.

**Student Member**

1. Sarmiza bt Mohamed Sapiai
   Program Geophysics, Universiti Sains Malaysia, 11800 USM, Penang.

## PERTAMBAHAN BAHARU PERPUSTAKAAN (New Library Additions)

The Society has received the following publications:

1. Monthly statistics on Mining Industry in Malaysia, July 2003.
2. Earth Science Frontiers, vol. 10 supplementary, 2003.
3. Earth Science Frontiers, vol. 10, nos. 1 & 2, 2003.
4. Geoscience, vol. 17, nos. 1 & 2, 2003.
5. Geosciences Journal, vol. 7, no. 3, 2003.
6. Journal of Shijiazhuang, University of Economic, vol. 26, nos. 1–3, 2003.
7. Acta Geoscientia Sinica, vol. 24, nos. 2–4, 2003.
8. AAPG Explorer, Oct, Nov & Dec 2002.
9. Acta Palaeontologica Sinica, vol. 42, nos. 2 & 3, 2003.
10. Acta Micropalaeontologica Sinica, vol. 20, nos. 1 & 2, 2003.
11. Palaeontological Abstracts, vol. 18, nos. 1–3, 2003.
12. SOPAC: Proceecings of the 32nd session, 2003.
13. AAPG Bulletin, vol. 87, nos. 11–12, 2003.
14. USGS Circular 2002: no. 1143, 1224; 2003: no. 1242, 1247.
15. USGS Professional Paper 2002: nos. 1661-A, 1670, 1631, 1627, 1530-B, 1669, 1530-C; 2003: no. 1668.

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# PROCEEDINGS

# GEOSEA '98

## Ninth Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia

*Earth Science in Support of Growing Southeast Asian Economies*

August 17 – 19, 1998
Kuala Lumpur, Malaysia

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# BERITA-BERITA LAIN
# OTHER NEWS

## KALENDAR (CALENDAR)

### 2004

**January 14–16**
*ASIAN MARINE GEOLOGY* (5th International Conference), Bangkok, Thailand. (Contact: Thanawat Jarupongsakul, Department of Geology, Faculty of Science, Chulalongkorn University, Bangkok 10330, Thailand. Fax: +(662) 2185464-5; E-mail: thanawat@sc.chula.ac.th)

**February 8–13**
*17TH AUSTRALIAN GEOLOGICAL CONVENTION*, Hobart, Tasmania, Australia. (Contact: Conference Design, P.O. Box 342 Sandy Bay Tas 7005. Tel: 61 3 6224 3773; Fax: 61 3 6224 3774; E-mail: mailto:17thagc@gsa.org.au; Website: http://wqww.17thagc.gsa.org.au/)

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

**March 29–31**
*EURADWASTE'04 — Radioactive Waste Management Community Policy and Research Initiatives*, Luxembourg. (Contact: Christophe Davies, European Commission Office: MO75 - 5/42, B-1049 Brussels, E-mail: christophe.davies@cec.eu.int; Fax: (32 2) 2954991 or Simon Webster, European Commission Office: DM24-07/091, B-1049 Brussels; E-mail: simon.webster@cec.eu.int; Fax: (32 2) 2950061).

**April 18–21**
*AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS AND SOCIETY FOR SEDIMENTARY GEOLOGY (SEPM)* (Joint Annual Meeting and Exhibition), Dallas, Texas, USA. (Contact: AAPG Conventions Dept., P.O. Box 979, Tulsa, OK 74119, USA. Tel: +1-918 560 2679; Fax: 1-918 560 2684; E-mail: convene@aapg.org; Website: www.aapg.org)

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

**June 7–11**
*10TH COAL GEOLOGY CONFERENCE*, Prague, Czech Republic. (Contact: Prof. Jiri Pesek, DSc., Faculty of Science, Charles University, Albertov 6, 128 43 Prague 2, Czech Republic. Fax: +420-2-21951450 or +420-2-24921736; E-mail: ir@natur.cuni.cz).

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

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

**August 20–28**

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

**August 27 – September 4**

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

**September 11–19**

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

**September 15–17**

*SEDIMENTOLOGY* (23rd Annual Meeting of the International Association of Sedimentology), Coimbra, Portugal. (Contact: Rui Pena dos Reis, uiversidade de Coimbra, Dpto. Ciências da Terra, Largo Marquês de Pombal, 3014 Coimbra, Portugal; E-mail: penareis@ci.uc.pt)

**October 10–15**

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

**November 7–10**

*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; Website: http://www.geosociety.org/meetings/index.htm)

**December 13–17**

*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 6900; Fax: +1 202 328 0566; E-mail: meetinginfo@agu.org; Website: http://www/agu.org/meetings).

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# WARTA GEOLOGI PERSATUAN GEOLOGI MALAYSIA

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*Cover photo: Honeycomb sandstone, Machinchang Formation, Pasir Tengkorak, Langkawi by Lee Chai Peng*

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