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DIKELUARKAN DWIBULANAN
ISSUED BIMONTHLY

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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CATATAN GEOLOGI
Geological Notes

Dating the Kenny Hill Formation: spores to the fore

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Abstract: Several species of Carboniferous or Permian spores were discovered in clastic rocks of the Kenny Hill Formation exposed at Pantai Dalam, Kuala Lumpur. The stratigraphy of the Formation which is poorly fossiliferous in macrofossils may well be better understood by the study of spores which appear to be abundant in the rocks.

The Kenny Hill Formation covering large parts of Kuala Lumpur and adjacent areas is an important clastic unit overlying the Lower Palaeozoic Kuala Lumpur Limestone which has yielded confirmatory macrofossils such as Silurian tabulate corals and brachiopods (Gobbett, 1965) even though marmorized and metamorphosed. Furthermore, carbonate lenses in black schists in Tanjong Malim similar to the Hawthornden Schists underlying the Kuala Lumpur Limestone contain Ordovician cephalopods and gastropods (Kobayashi *et al.*, 1979). The Kenny Hill Formation is, however, poorly fossiliferous. The only fossil found which has been expertly identified and described is *Agathiceras* indicating Lower Permian (Abdullah Sani, 1985). Elsewhere trace fossils and unidentifiable plant remains have been found in Puchong (Stauffer, 1973) which do not give any age indication. On account of its stratigraphic position and lack of metamorphism it is popularly believed that the Kenny Hill Formation is unconformable on the Kuala Lumpur Limestone and is Upper Palaeozoic (e.g. Gobbett, 1965 and later commentators). The contact between the two units is, however, nowhere exposed.

The lack of fossil evidence in the Kenny Hill Formation has, unfortunately, resulted in the blooming of speculations as regards the geological evolution of the area. It is as yet uncertain as to whether the whole of the Upper Palaeozoic, from Devonian to Permian, is represented in the Kenny Hill Formation. Does the Formation also include elements of the succeeding Triassic?. Has the whole Formation been deposited entirely in the early Permian? There is also a belief that the lack of fossils in the Formation is real (and not a result of lack of exposures or efforts to find them) and the paucity may well have palaeoclimatic

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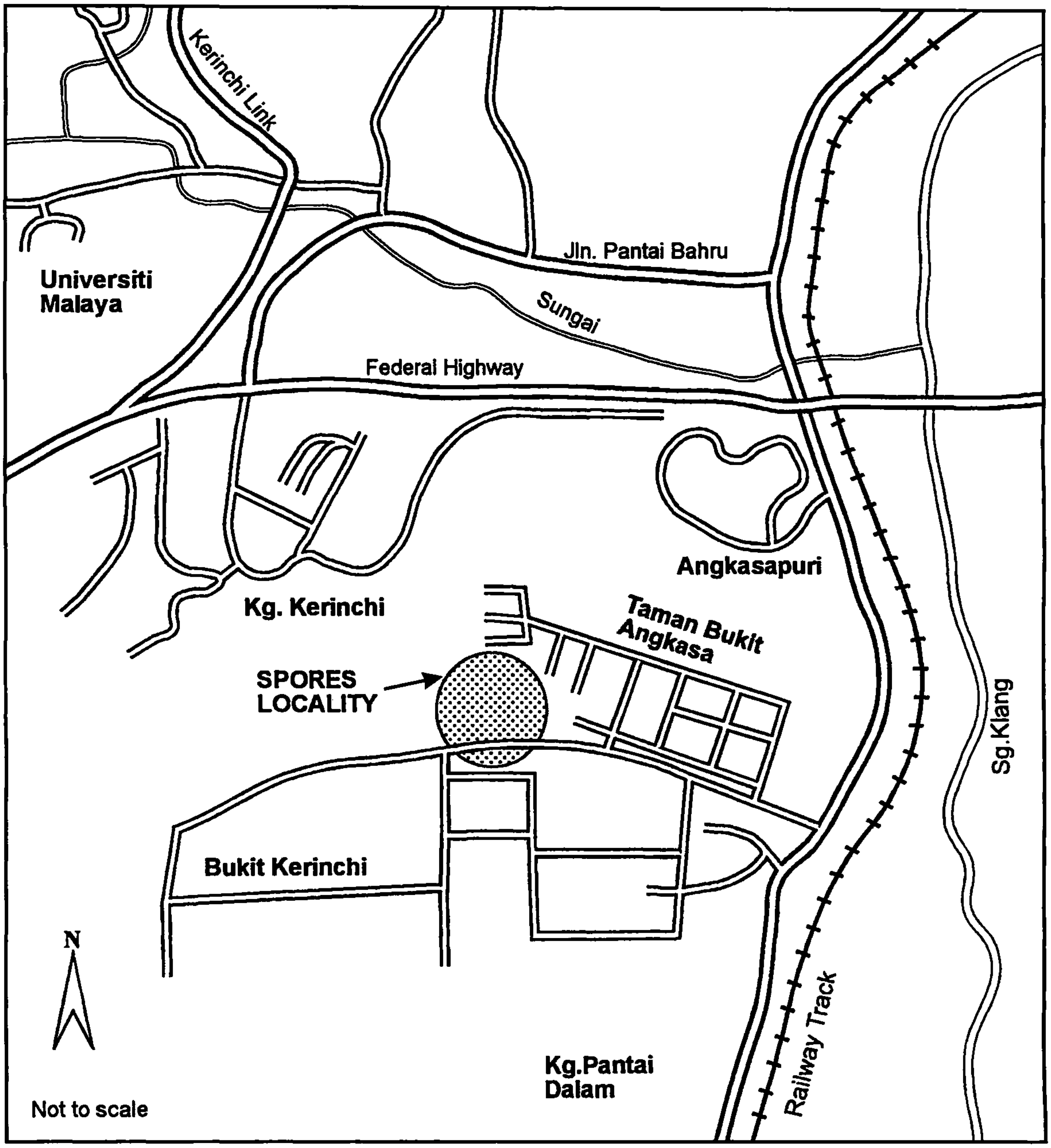

Figure 1. Location where specimens of the Kenny Hill Formation were collected for study of the spores.

connotation. To these and other titillating questions obviously more quality fossil evidence will help to resolve the raging problems.

The supposed poor fossil record in the Kenny Hill Formation is, however, only true relating to macrofossils. Microfossils have not been seriously looked for in the clastic rocks of the Formation. On 29 August 1993, specimens of clastics from the Kenny Hill Formation were collected from a site at Pantai Dalam (Fig. 1) for possible spores occurrence. The specimens were studied in the laboratories of the Institute of Geology, Chinese Academy of Geological Sciences in Beijing. By a stroke of good luck or rather, prescience, several species of spores were found to be present and their identification is listed below.

- *Leiotriletes* sp
- *Punctatisporites* sp
- *Dictyotriletes* sp
- *Verrucosisporites microtuberculatus* (Loose) Smith and Butterworth
- ? *Lycospora* spp
- *Acanthotriletes* sp

These species are probably either Carboniferous or Permian. Better preserved spores will enable a more definite determination of the age of the rocks.

We believe the discovery of the hitherto hidden floral remains, namely spores, in the rocks of the Kenny Hill Formation will open up a new and more fruitful direction in the research for age of the Kenny Hill Formation and perhaps also the palaeoclimate of the time of its deposition.

ACKNOWLEDGEMENTS

This work is a result of cooperative research under IGCP Project 321. Mr Xie Guanglian of the Chinese Academy of Geological Sciences, Beijing is thanked for translation and other assistance.

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CATATAN GEOLOGI
Geological Notes

Hydrocarbon-bearing fissure in the limestone of the Togopi Formation, Dent Peninsula, Sabah

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Abstract: This study is a follow-up to the oil staining study reported in the previous issue of *Warta Geologi* (Vol. 28 No. 4, 2002). A dark stained fissure occurs in the limestone of the Togopi Formation within the study area striking almost perpendicular to the oil-stained band reported previously. A brief organic geochemical characteristic of this limestone fissure is presented here and compared to the previously reported sample. A comparison is also made to a non-stained limestone collected within the same area. The present data supports the previous assumption that the oil staining is not indigenous to the limestone and may indeed be residual migrated hydrocarbon as previously suggested.

INTRODUCTION

The Togopi Formation has been studied by a number of workers (e.g. Woo, 1994; Ismail Che Mat Zin, 1994; Noad, 1998), however, no occurrence of the distinctive black bands have been reported prior to Wan Hasiah (2002) who suggested that the black stained layer contains migrated hydrocarbons. As a follow-up to the previous study, a second visit was made to the study area where a dark stained fissure was encountered. The staining within the fissure is in the form of a black powdery infill. The fissure is near vertical, trending 095/85NE and cuts the layers beneath the oil-stained limestone horizon (Fig. 1).

In this study, a limestone sample of the dark stained fissure was subjected to Soxhlet extraction, followed by liquid chromatography analysis. A limestone from the same area that contains no such staining was also extracted. The aliphatic fractions of these samples were subsequently analysed by gas chromatography-mass spectrometry (GC-MS).

RESULTS AND DISCUSSION

Figure 2 shows the total ion current (TIC) chromatogram of the aliphatic fraction of the limestone fissure analysed. As was observed in the previously published TIC (Fig. 3 of Wan Hasiah, 2002) a bimodal distribution was displayed. However, in contrast to the previous trace, this limestone fissure fingerprint shows a strong even to odd predominance particularly in the nC_{20} to nC_{28} range. The even to odd predominance is a typical feature for carbonate rocks (e.g. Palacas *et al.*, 1984), and in this case it seems to have overwhelmed the migrated hydrocarbon distribution.

Figure 3 shows the total ion current of the aliphatic fraction of a clean (non-stained) limestone of the Togopi Formation. The peak eluting between nC_{29} and nC_{30} is (presently) an unknown compound. Note the unimodal distribution of this fingerprint, which does not appear to contain migrated hydrocarbons (represented by predominantly higher molecular weight n-alkanes) as observed in the fissure limestone and the limestone previously reported (Wan Hasiah, 2002). Also note that this clean limestone sample displays a typical distribution for extracts of carbonate rocks showing an even to odd predominance n-alkane and with nC_{20} as the n-alkane maxima. The n-alkane maxima for the fissure limestone is nC_{26}. The difference in the n-alkane maxima and the overall distribution of these two limestone samples are due to the variation in the organic facies; in this case, it is attributed to the different type of organic matter assemblage as can be envisage from the variation in the fossil assemblage of the two limestone samples analysed. The clean, non-stained sample is a coral limestone, while the limestone fissure is a micritic limestone containing high abundance of algae remains.

Based on the comparison made between the three samples, there is a clear indication that the hydrocarbon fingerprints are associated with the black stains present in the fissure and in the limestone previously analysed. The origin of this staining, however, cannot be presently ascertained and will be a subject of further study.

CONCLUDING REMARKS

This study supports the previously reported oil-staining in the Togopi Formation limestone is not indigenous of the host limestone and that this staining may well be migrated hydrocarbons. The limestone fissure bearing the black stains analysed in this study shows a fairly similar n-alkane distribution, with the exception of the even to odd predominance, which is attributed to the organic facies variation among the limestone samples analysed.

Although the origin of the black stains occurring within the fissure and the limestone band previously described has not be determined at this stage, the presence of hydrocarbons associated with the staining is intriguing and

Figure 1. Near vertical dark stained fissure oriented almost perpendicular to the oil-stained limestone band above it. The length of the exposed fissure is about 4 m.

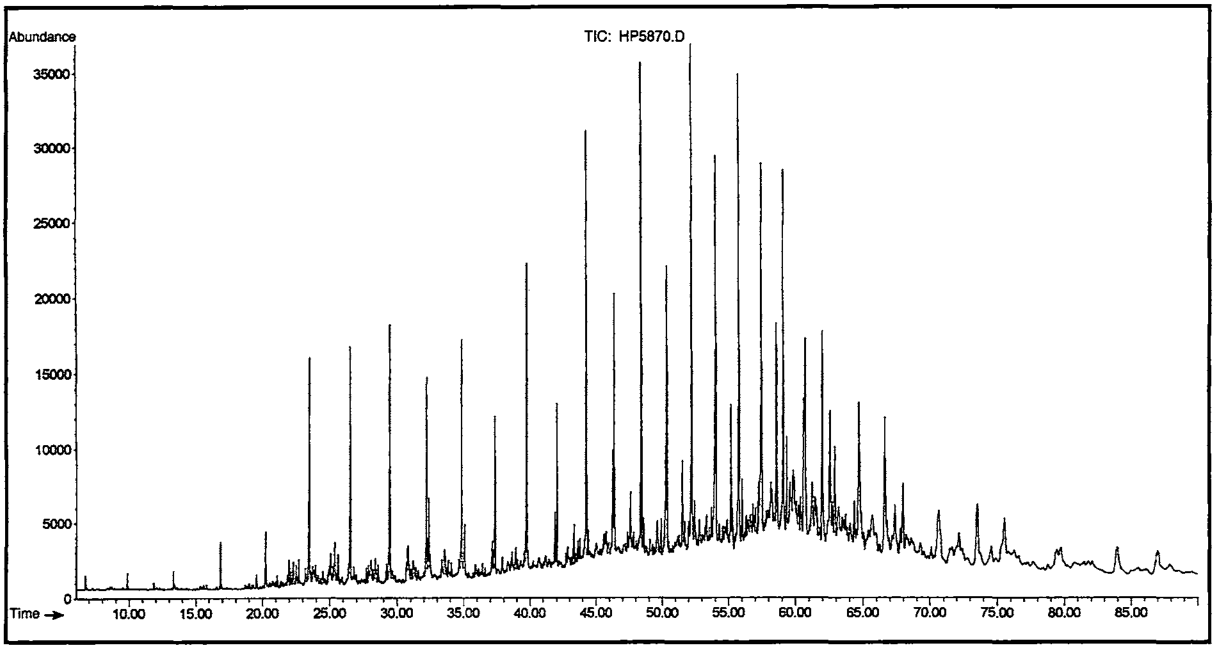

Figure 2. Total ion current (TIC) of the aliphatic fraction of the stained limestone fissure, Togopi Formation.

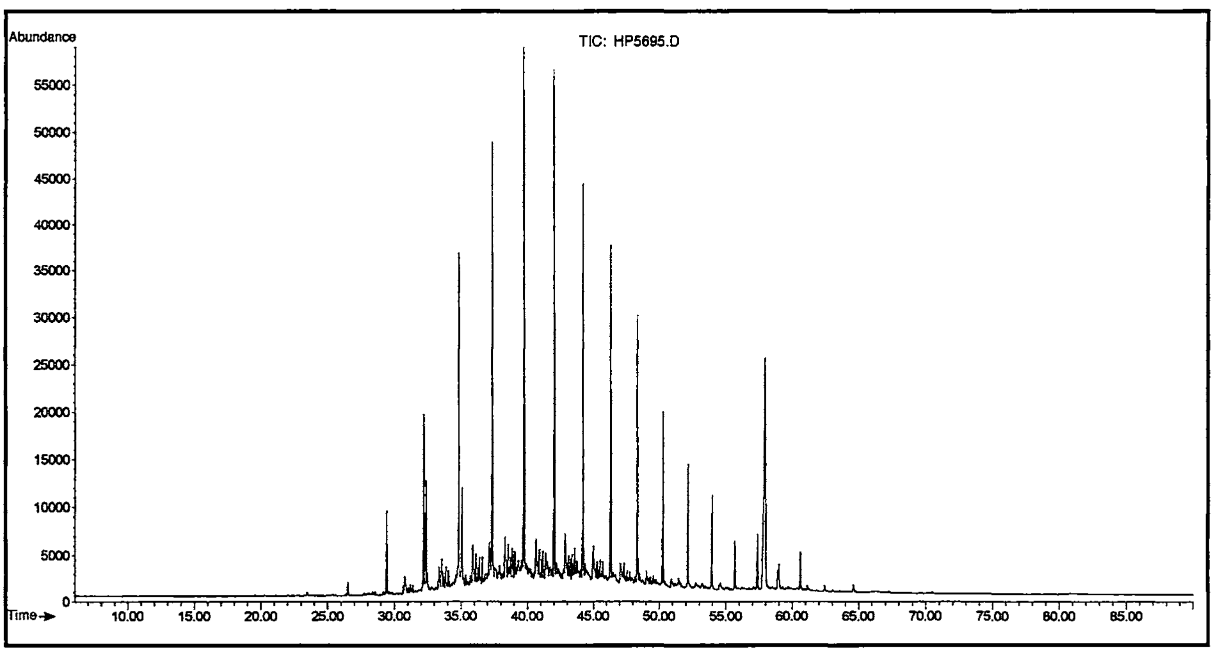

Figure 3. Total ion current (TIC) of the aliphatic fraction of the non-stained limestone, Togopi Formation.

ought to be studied further considering the study area is situated adjacent to the offshore petroleum province of the NE Sabah Basin, East Malaysia.

ACKNOWLEDGEMENTS

Fruitful discussion with Dr. Nuraiteng Tee is much appreciated. This study is supported by the University of Malaya PJP 2002 F0728 & F0729/2002A research grants.

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Manuscript received 2 September 2002

PERTEMUAN PERSATUAN
Meetings of the Society

EXTRAORDINARY GENERAL MEETING on 28th October, 2002 — Report

The EGM held on 28th October 2002 at 5.30 pm at the Geology Department, University of Malaya, chaired by the President, Abdul Ghani Rafek, was attended by 23 "members" when the meeting was called to order.

The EGM was in response to a letter dated 10th September 2002 by Chin Lik Suan undersigned by 12 "Corporate Members" proposing the following agenda for the EGM:

1. To direct the Council to suspend the current Editor of the Society from his post for failure to perform his duties to the members' satisfaction and disregard of members' directives and criticisms brought to his attention at the 2002 Annual General Meeting and past Annual General Meetings and, to appoint another Corporate Member to act in this post for the remaining term of office concerned.
2. To amend Article V. Section 1, of the Constitution to read as:

   Officers of the Society shall be a President, a Vice-President, an Immediate Past President, a Secretary, a Treasurer, an Assistant Secretary, an Editor (Bulletin) and an Editor (*Warta*). These together with eight (8) Councillors shall constitute the Council of the Society. The term of office of officers shall be one year, and for Councillors, two years, with half the Councillors being elected each year.
3. To amend subsequent articles of the Constitution whereby mention is made of the Editor so as to incorporate Editor (Bulletin) and Editor (*Warta*) throughout the whole Constitution of the Society.
4. To direct the Council to immediately implement these resolutions once this Extraordinary General Meeting be carried and to report this to the Registrar of Societies Malaysia.

The 12 signatories for the EGM include: Chin Lik Suan, Jimmy Khoo (JMG), Saim Suratman (JMG), Azman A. Ghani (UM), Mohamad Ali Hasan (UM), Mustaffa Kamal Shuib (UM), John Kuna Raj (UM), Wan Hasiah Abdullah (UM), Abdul Rashid Ahmad (UM), Che Noorliza Lat (UM), Samsudin Hj. Taib (UM), Mat Ruzlin Maulud (UM).

Pertaining to items 2 and 3, T.T. Khoo, a Former President of the Society had pointed out (by e-mail from Australia) that the EGM cannot amend the constitution.

In calling the meeting to order, the President proceeded to question Paramananthan for the request (signed by 3 members) that original letters calling the EGM be produced at the meeting. Param answered saying that there were irregularities. Loganathan then asked the President whether the Council really discussed the call for the EGM properly as the EGM is a very serious matter. The President answered that the members have the right to call for an EGM.

Boon Kong remarked at the lightning speed the Secretary took to send out the notice for the EGM.

Extraordinary General Meeting
on 28th October, 2002

Param then asked whether the EGM was legal? The President replied that it was called for by 12 members. A look around at that time showed that only 4 of the 12 who called for the EGM were present. Boon Kong then said that only 8 were mentioned when the subject was brought up at the Council Meeting in August 2002 and G.H. Teh concurred.

The Editor then informed the meeting that at the last Council Meeting on 21 October 2002 (where the President, Vice President, Secretary and Assistant Secretary were significantly absent), the Council was informed that the Secretary Ahmad Tajuddin was in fact the one who orchestrated the call for EGM by going around soliciting for signatures from staff of the Geology Department, University of Malaya under the pretext of just amending sections the Society's constitution. The Council found the action unethical and has requested an explanation. The President and the Secretary, however, maintained that no one was forced into signing.

Param then informed the President that in his haste and urgency to call the EGM, the Secretary probably did not know that one of the signatories calling for the EGM, namely, Mat Ruzlin, was not a member of the Society. He further added that two of the signatories had not paid their subscriptions for 2002 at the time they signed the call for EGM. Thus at the material time they were not members of benefit.

Abd. Rasid Jaapar reminded the gathering to get back to the issue to verify whether the EGM is legal or not.

The President and Secretary then suggested that the EGM can still go on since there are still 9 other signatories. Irked by such ignorance of procedures, J. Pereira then took the President and Secretary to task for not knowing the Society's Constitution. To that the President mentioned that he expected the Secretary and Council Members to advise him!

The Treasurer, C.P. Lee, was then asked by the Chairman to verify the membership of the signatories with Anna.

While waiting, Param then asked the Chairman the quorum for such a meeting. The Secretary answered saying it was 8. Param then asked the Secretary what happened to the amendments to the Constitution at the AGM 1995 where the quorum was raised to 30 to supposedly reflect the membership of the Society as required by the Registrar of Societies. The President said that he was not the President at that time. The Secretary, who was also Secretary at that time, then replied saying that nothing has been done as the Registrar of Societies did not reply to his letter!

Loganathan, annoyed by such irresponsible remarks from the President and Secretary, advised the Secretary to be prepared with some answers as it will definitely be brought up at the next AGM.

In the meantime, C.P. Lee came back and reported that Abdul Rashid Ahmad and Mustaffa Kamal Shuib paid their dues on 12 October 2002 (which means that they were not members when signing the call for the EGM) and Mat Ruzlin is not a member of the GSM. C.S. Hutchison then remarked, "Why do we have non-members getting involved in affairs of the Society? This has never happened before as we used to check the participants to verify their membership." Then Param advised the President to call off the EGM as it was ultra vires the Constitution.

The President then had no choice but to call off the EGM.

Abdul Rasid Jaapar then invited the Editor to update the gathering on the publications (off the record). The Editor mentioned that all can be found in the "Editor's Note" (appearing in *Warta Geologi* Vol. 28, No. 4) which the Editor has made available to all present at the EGM. Jimmy Khoo commented the note should have been brought out earlier. As the Editor proceeded to explain, H.D. Tjia rudely interrupted him, saying that the meeting was over. The Editor decided to leave it at that and requested members to read the 'Note'.

G.H. Teh

Ceramah Teknik (Technical Talk)

Chairman's Lecture I

Wednesday, 11 September 2002
Dept. of Geology
University of Malaya

Geology and tunnelling

TAN BOON KONG

Laporan (Report)

This series of technical talks called the "Chairman's Lecture", was initiated by Tan Boon Kong, to give the chairmen of the various Working Groups of the Society the opportunity to talk on any topic of their choice.

And to set a good example, Tan Boon Kong, Chairman of the Working Group on Engineering Geology and Hydrogeology, took the cue to start off the Series with his talk entitled "Geology and Tunnelling" at 5.30 pm on the 11th September 2002 at the Geology Department, University of Malaya. It is hoped the other Chairmen will follow the example set by Boon Kong.

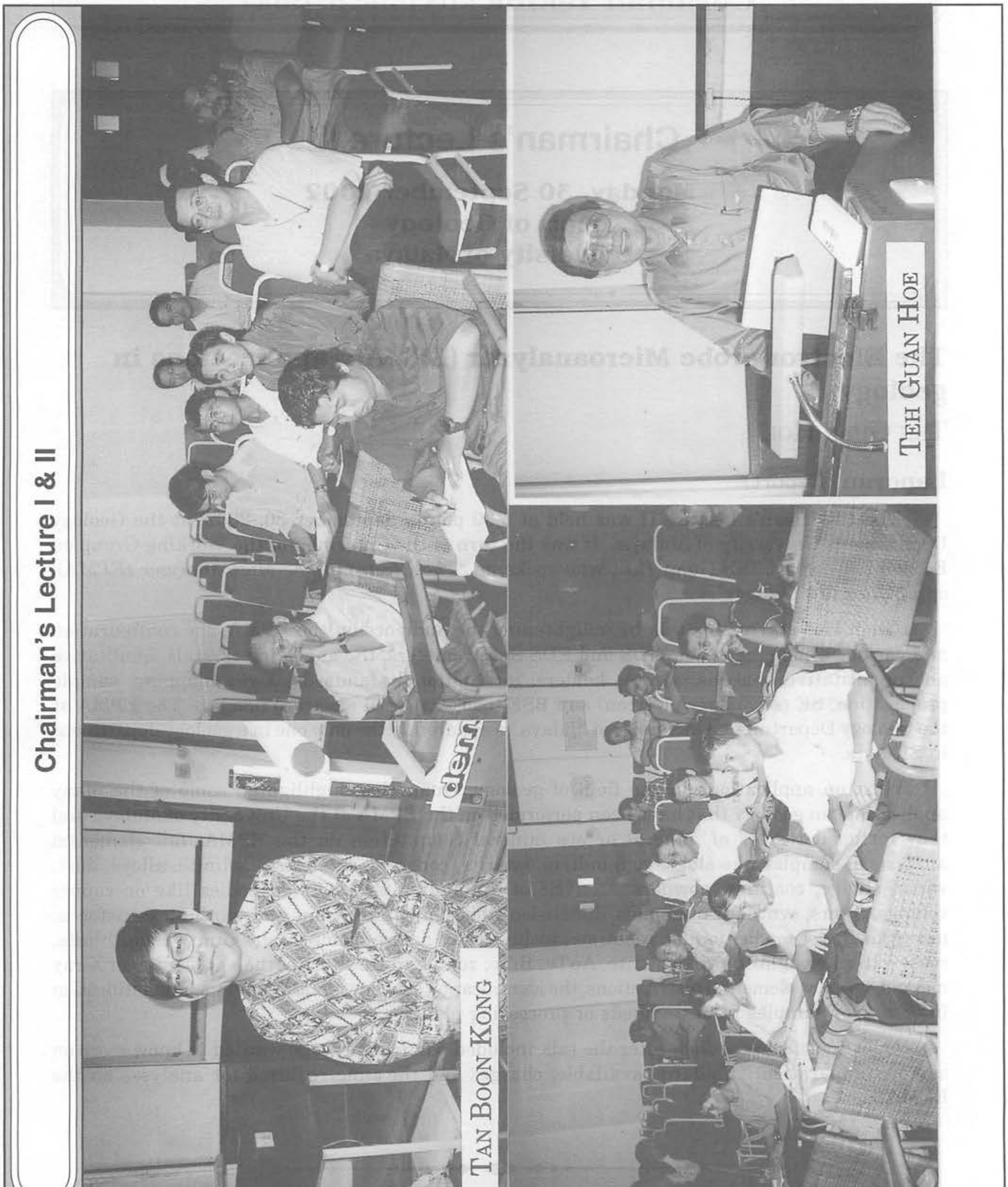
In his presentation, Boon Kong has chosen to discuss the topics under 2 main headings, namely geology input during site investigations and geological input during tunnelling.

Under geological input during site investigations, Boon Kong dealt with the following topics namely desk studies, topographic maps, geological maps, surface geological mapping, borehole data (sub-surface geology), lithology, structure, weathering, aerial photographs (lineaments/faults, etc.) and some good case histories were shown.

Next on geological input during tunnelling, the following topics were discussed namely, tunnel face mapping, rock mass classification (The Q-System), tunnel supports, seepage, overbreak, collapse, squeezing/swelling ground, rock burst, ground stresses, etc. and further case histories were shown and discussed.

There was a good round of questions and discussions at the end of the talk and it was heartening to see the younger participants taking an active role.

G.H. Teh


Chairman's Lecture I & II
TAN BOON KONG
TEH GUAN HOE

Ceramah Teknik (Technical Talk)

Chairman's Lecture II

Monday, 30 September 2002
Dept. of Geology
University of Malaya

The Electronprobe Microanalyzer (EPMA): applications in geology

TEH GUAN HOE

Laporan (Report)

The Chairman's Lecture II was held at 5.30 pm on September 30, 2002, at the Geology Department, University of Malaya. It was the turn of the Chairman of the Working Group on Economic Geology, Teh Guan Hoe, who spoke on *"The Electronprobe Microanalyzer (EPMA): applications in Geology"*.

Guan Hoe started his talk by enlightening the audience on the EPMA, the configuration and various components, the WDS and EDS Spectrometers, the analysing crystals, qualitative and quantitative analysis, sample holders, international standards, X-ray mapping, sample preparation, SE (secondary electron) and BSE (backscattered electron) images. The EPMA at the Geology Department, University of Malaya, is apparently the only one in a geology department in SE Asia.

Next on applications in the field of geology, Guan Hoe, highlighted some of the many applications in geology that have been performed on the EPMA at the University of Malaya and they included results of mineral or ore mineral composition on the EPMA; full elemental analysis of samples like slags, gold bullion, laterite, concrete, ceramics, kaolinite, alloys, dust, wires, sludge, coatings, powders; analysis of contaminants or foreign bodies like on copper tubings, filters, synthetic diamonds, dimension stones, ilmenite grains and synthetic gemstones; intergrowths of monazite and xenotime; inclusions of native bismuth, uranium, bismuthinite, rooseveltite, wodginite, wittichenite, AuTe, BiTe; zoning in cassiterite; the application of X-ray mapping to show elemental distributions, the identification of heavy minerals and their quantification in *amang* or samples from tin sheds or processing plants.

Questions from the floor after the talk included participants who wanted to know more on sample preparation, standards available, charges and the time required for analyses on the EPMA.

Seminar sehari

Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

7 September 2002
USM, Pulau Pinang

anjuran bersama

Kumpulan Geofizik Persatuan Geologi Malaysia
Pusat Pengajian Geofizik, USM
Program Geologi, PPSSSA, FST, UKM

Laporan

Kumpulan Geofizik Persatuan Geologi Malaysia dengan kerjasama Program Geofizik, Pusat Pengajian Sains Fizik, USM dan Program Geologi, Pusat Pengajian Sains Sekitaran & Sumber Alam, Fakulti Sains & Teknologi, UKM telah berjaya menganjurkan seminar sehari yang bertajuk "Sumbangan Geofizik dalam Kajian sekitaran dan Pemuliharaan". Seminar ini telah diadakan pada hari Sabtu bersamaan 7hb September 2002 di Dewan Kuliah A, Universiti Sains Malaysia, Pulau Pinang telah mendapat sambutan hangat dengan jumlah peserta seramai 130 orang. Peserta–peserta tersebut terdiri daripada ahli geofizik, ahli geologi, ahli akademik, Pelajar Geofizik USM, Pelajar geologi UKM dan UM, pengarah syarikat, pegawai penyelidik dan ahli perniagaan.

Empat belas kertas kerja yang mencakupi pelbagai aspek penyelidikan dalam bidang geofizik gunaan telah dibentangkan. Semua peserta mendapat satu kompilasi abstrak keras kerja beserta prosiding berbentuk CD yang mengandungi kertas kerja penuh yang telah dibentangkan. Tema utama seminar ini adalah penggunaan georadar (GPR) dalam kajian bawah permukaan bumi dan sesi demonstrasi telah di jalankan oleh kumpulan penyelidik geofizik USM yang diketuai oleh Dr. Zuhar Zahir Tuan Harith.

Kertas kerja yang dibentangkan pada kali ini mengandungi aspek geofizik di angkasa, hinggalah ke dalam bumi termasuk dibawah permukaan samudera. Senarai tajuk dan pembentang kertas kerja adalah seperti berikut:

1. Engineering and environmental geophysics: an overview
   Lee C.Y. (USM, cylee@usm.my)
2. Solar flare and telluric current
   Abdul Halim Abdul Aziz, Zuhar & Nawawi (USM, abdul@usm.my)
3. Correlation between Magnetic Intensity and Pipe-to-Soil Potential in PGU III Pipeline System (Joint PGB-PRSS-HCESB-USM paper)
   Jamalee Ahmad (Pgas, jamalee@petronas.com.my)
4. Changes of Penang coastal area from 1980 to 2000: view from the sky
   Khiruddin Abdullah & Zuhar (USM, khirudd@usm.my)
5. National offshore sand resources study — in the Straits of Malacca: geophysical and sampling survey techniques
   Devendran (Hydrosis (M) Sdn. Bhd., hydrosis@tm.net.my)
6. The application of geophysics and geology for the design and installation of a submarine pipeline
   Jeremy Tung (TL Geohydrographics Sdn. Bhd., jetung@pc.jaring.my)

Pengerusi Seminar semasa Perasmian.

Peserta seminar.

Demonstrasi GPR di USM.

7. Reservoir induced earthquakes — a case study from Kenyir, Terengganu
   Norliza Lat (UM, noorliza@um.edu.my)
8. Shallow seismic refraction data and wash boring data a comparison, its usefulness and the importance
   Samsudin Hj Taib (UM, samsudin@um.edu.my)
9. Pecirian turapan asfalt berdasarkan Analisis Spektrum Gelombang Permukaan (ASGP) di Putrajaya
   Khairul Anuar Mohd Nayan (khairul@vlsi.eng.ukm.my)
10. Pengukuran radon dan progeni radon terhadap beberapa sampel batu-batan dan bahan binaan
    Mohd Suhaimi Jaafar et al. (USM, msj@usm.my)
11. The detection and mapping of underground services using electromagnetic technique
    Rubiah Abdul Rahim (EM-Detection Sdn. Bhd., roob_ar@hotmail.com)
12. Mengesan rongga akibat dari paip bocor menggunakan kaedah Resistiviti pengimejan 2D
    Abdul Kahar Embi et al. (JMG, kahar@galian.gov.my)
13. Pemetaan air masin dalam akuifer pantai di Pekan–Nenasi, Pahang
    Umar Hamzah et al. (UKM)
14. Mapping of salt water intrusion in West Kedah-North Perlis area
    W.M.S. Wijesinghe, M.H. Loke & M.N.M. Nawawi (USM, wmswijesinghe@yahoo.com)

Beberapa poster hasil kajian geofizik dan pameran peralatan dan kepakaran beberapa syarikat yang menjalankan survei Geofizik di juga di adakan di luar dewan seminar. Syarikat yang terlibat ialah Winpower (M) Sdn Bhd.dan Equarater (Peneng) Sdn. Bhd. (EPSB). Seminar sehari ini tamat Jam 6.00 petang dan ditutup oleh Prof. Madya Dr. Mohd Nawawi Mohd Nordin, Ketua Program Geofizik, Pusat Pengajian Sains Fizik, USM.

Abdul Rahim Samsudin

Seminar sehari

Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

Kata Aluan Pengerusi Seminar

Seminar sehari " sumbangan geofizik dalam kajian sekitaran dan pemuliharaan" adalah seminar ketiga yang dianjurkan oleh Kumpulan kerja Geofizik, Persatuan Geologi Malaysia dengan kerjasama Pusat Pengajian Sains Geofizik, USM dan Program Geologi, Pusat Pengajian Sains Sekitaran dan Sumber Alam , UKM. Seminar ini diadakan adalah bertujuan untuk memberi peluang kepada semua ahli-ahli geofizik, jurutera, pentadbir, penyelidik, pelajar serta mereka yang berminat untuk mendapatkan maklumat terkini tentang kaedah geofizik dan saling mempelajari pengalaman masing-masing penyelidik..

Sebanyak lima belas kertas kerja akan dibentangkan termasuk satu kertas ucap utama bertajuk "Engineering & Environmental Geophysics: An Overview". Kertas kerja lain yang akan dibincangkan pada seminar kali ini mencakupi beberapa aspek kajian yang menggunakan pelbagai kaedah geofizik dalam mendapatkan maklumat dalaman bumi yang seterusnya boleh diguna pakai untuk menangani masalah sekitaran dan pemuliharaan.

Seminar kali ini memberi penumpuan khas kepada kepelbagaian penggunaan kaedah geofizik untuk mendapatkan maklumat bawah permukaan bumi, khususnya penggunaan peralatan geofizik yang dikenali sebagai Radar Tembus Bumi (GPR). Keupayaan alat GPR ini dalam memberi maklumat bawah permukaan dengan lebih pantas serta efisien di lapangan, menjadikannya lebih kos efektif dalam menangani masalah geoteknik dan sekitaran.

Bagi pihak jawatankuasa penganjur, saya mengucapkan berbanyak terima kasih kepada Y. Bhg. Prof. Dato' Dzulkifli Abdul Razak, Naib Canselor Universiti Sains Malaysia yang merasmikan seminar ini dan semua pembentang kertas kerja, peserta-peserta seminar dan semua ahli jawatankuasa penganjur yang terlibat dalam menjayakan seminar sehari ini. Saya juga mengucapkan terima kasih kepada pihak USM yang membenarkan seminar kali ini di adakan di USM dan kepada semua penyumbang kewangan terutama pihak WinPower Corporation (M) Sdn Bhd yang menaja jamuan makan dan minuman.

Prof. Dr. Abdul Rahim Samsudin/Dr.Zuhar Tuan Harith
Pengerusi /Pengerusi Bersama
Kumpulan Kerja Geofizik
Persatuan Geologi Malaysia

Seminar sehari

Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

Kata Aluan Presiden Persatuan Geologi Malaysia

Penganjuran aktiviti ilmiah sudah menjadi satu tradisi Persatuan Geologi Malaysia sejak ditubuhkan pada tahun 1967. Seminar sehari "Sumbangan Geofizik dalam Kajian Sekitaran dan Pemuliharaan" yang dianjurkan bersama dengan Program Geologi, PPSSSA, Fakulti Sains dan Teknologi, UKM dan Program Geofizik, Universiti Sains Malaysia, berupa seminar ketiga dalam siri seminar geofizik yang dimulakan pada tahun 2000. Selepas penganjuran seminar di Jabatan Mineral dan Geosains, Ipoh, dan Universiti Kebangsaan Malaysia di Bangi, Kampus Universiti Sains Malaysia di Pulau Pinang menjadi tuan rumah untuk seminar ini. Sebanyak 15 kertas kerja dijadualkan untuk pembentangan lisan dan beberapa poster berkaitan dengan geofizik juga dipamerkan. Satu demonstrasi penggunaan *"Ground Penetrating Radar"*, GPR, juga dijadualkan.

Penggunaan berkesan kaedah geofizik dapat membantu dalam kajian dan penyiastan sekitaran seperti pencemaran air bawah tanah dan pencemaran tanih, intrusi air masin serta penilaian keadaan sekitaran dan memperluaskan maklumat data penggerudian. Perkongsian maklumat dan pengalaman dalam seminar ini akan memberi peluang pada semua pengkaji dan penyelidik dalam bidang ini untuk memperkembangkan dan memajukan kaedah-kaedah geofizik. Seminar ini juga memberi peluang kepada para pelajar yang turut serta untuk melihat penggunaan praktikal kaedah geofizik yang dipelajari dalam dewan kuliah.

Bagi pihak Persatuan Geologi Malaysia, saya ingin merakamkan penghargaan dan mengucapkan berbanyak terima kasih terutamanya kepada pihak Naib Canselor, Universiti Sains Malaysia, yang sudi merasmikan seminar ini, dan juga menjadi tuan rumah seminar kali ini, Program Geofizik, USM, Program Geologi, UKM, pembentang dan penyumbang kertas kerja, syarikat WinPower Corporation (M) Sdn. Bhd. atas penajaan jamuan, peserta-peserta seminar dan jawatankuasa penganjur yang dipengerusi oleh Prof. Dr. Abdul Rahim Samsudin (UKM) dan Dr. Zuhar Tuan Harith (USM) (Pengerusi Bersama).

Dr. Abdul Ghani Rafek
Presiden
Persatuan Geologi Malaysia

Seminar sehari

Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

Ucapan Perasmian
Naib Canselor Universiti Sains Malaysia

Bismillahirrahmanirrahim

Assalamualaikum warahmatullahi wabarakatuh dan salam Sejahtera

Saudara/i Pengerusi Majlis,

Yang berbahagia Profesor Ahyaudin Ali
Timbalan Naib Canselor Penyelidikan dan Pembangunan, USM,

Yang berbahagia Profesor Ahmad Shukri Mustapa Kamal
Deputy Dean for Academic and Student Affairs, Pusat Pengajian Sains Fizik, USM,

Yang berbahagia Prof.Madya Dr.Abdul Ghani Rafek
Presiden Persatuan Geologi Malaysia,

Yang berusaha Dr. Zuhar Tuan Harith
Pengerusi Jawatankuasa Penganjur Seminar Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan Alam Sekitar,

Yang berusaha Prof. Dr. Abdul Rahim Samsudin
Pengerusi bersama Jawatankuasa Penganjur Seminar dan Pengerusi Kumpulan Geofizik Persatuan Geologi Malaysia,

Yang berbahagia Dr. Mohd. Nawawi Mohd. Nordin
Ketua Program Geofizik, Pusat Pengajian Fizik, USM,

Ahli-ahli Jawatankuasa Penganjur Seminar,

Para penaja, Pembentang dan peserta seminar serta hadirin dan hadirat yang dihormati sekalian,

1. Bersyukur kita ke hadrat Allah SWT dengan limpah kurniaNya dapat kita bersam-sama berkumpul pada Majlis perasmian Seminar sehari ***SUMBANGAN GEOFIZIK DALAM KAJIAN PERSEKITARAN DAN PEMULIHARAAN 2002*** ini.

2. Saya mengucapkan tahniah kepada Jawatankuasa Penganjur Seminar Sehari Geofizik 2002 kerana telah berjaya menganjurkan seminar ini dengan kerjasama **Kumpulan Geofizik Persatuan Geologi Malaysia, Program Geofizik, Universiti Sains Malaysia** dan **Program Geologi, Pusat Pengajian Sains Sekitaran dan Sumber Alam Universiti Kebangsaan Malaysia**. Seminar ini berjaya menemukan para Jurutera, perunding, usahawan, penyelidik, pelajar dan para akademik dari pelbagai Universiti dan institusi penyelidikan untuk berbincang dan mencari kata sepakat untuk memajukan lagi bidang sains geofizik di negara kita ini.

3. Menyentuh mengenai disiplin geofizik, tidak dapat dinafikan bahawa geofizik merupakan satu kaedah yang penting dan amat berguna untuk mendapatkan maklumat lithologi bawah permukaan *(subsurface lithology)*. Hal ini diakui sendiri oleh para jurutera yang terlibat dalam penyiasatan tapak. Dalam satu sesi dialog antara Institut Jurutera Malaysia (IEM), Persatuan Geologi Malaysia (GSM) dan Institut Geologi Malaysia (IGM) yang

diadakan pada Mac 1999 yang lalu, para jurutera mengakui bahawa antara masalah utama yang dihadapi ialah kewujudan lohong *(cavity)* dalam batu kapur. Kaedah yang selalu digunakan ialah penggerudian rapat *(closely spaced drilling)* yang diketahui umum memerlukan kos yang tinggi untuk dilaksanakan.

Semasa sesi dialog tersebut, para jurutera telah mencadangkan supaya diadakan projek penyelidikan bersama dengan ahli-ahli geofizik/geologi untuk mengenalpasti satu kaedah geofizik yang berkesan untuk mengenalpasti kewujudan lohong-lohong tersebut. Pada masa yang sama, kaedah tersebut diharapkan mampu mengenalpasti *pinnacles* dan *troughs* dalam batu kapur. Walaupun penyelidikan penggunaan kaedah geofizik bagi mengesan lohong dalam batu kapur pernah dilaksanakan oleh JMG dan institusi-institusi lain, mungkin ianya belum boleh lagi meyakinkan para jurutera untuk menggunakannya secara rutin.

4. Pihak USM sememangnya sentiasa menggalakkan penganjuran program seperti ini terutama yang membabitkan kepentingan Sains dan teknologi ke arah kesejahteraan dan pemuliharaan persekitaran negara kita. Justeru itu, Universiti akan terus meningkatkan usaha-usaha dalam penyelidikan dan pembangunan terutama dalam bidang sains Geofizik seperti geofizik sekitaran, geofizik kejuruteraan dan kegunaan teknologi geofizik dalam pemantauan persekitaran.

5. Kita harus sedar keupayaan untuk mewujudkan teknologi dan ciptaan baru adalah amat penting untuk negara kita menjadi negara maju menjelang tahun 2020. Penyelidikan teknologi tinggi yang dijalankan oleh penyelidik-penyelidik tempatan perlulah setanding dan diiktirafkan oleh masyarakat antarabangsa. Manakala keupayaan mencipta teknologi baru dalam bidang sains geofizik perlu dipergiatkan dengan usaha yang bersungguh-sungguh.

Hadirin dan hadirat sekalian,

6. Seminar sehari ini diharap dapat menggalakkan interaksi antara penyelidik dan usahawan untuk meningkatkan pengkomersialan produk dan teknologi geofizik serta menggalakkan penglibatan syarikat dan usahawan dalam mempromosi teknologi geofizik yang dibangunkan oleh penyelidik tempatan. Saya yakin bahawa seminar ini akan menjadi satu penggalak dalam usaha antara pihak penyelidik dan usahawan serta pihak swasta untuk memesatkan lagi teknologi inovatif tempatan dan terutamanya dalam bidang geofizik kejuruteraan dan sekitaran.

7. Akhir kata, saya berharap para peserta simposium perlulah mengambil peluang ini untuk berkongsi pengetahuan dan pengalaman dalam bidang Geofizik Kejuruteraan dan sekitaran. Perkongsian dan ide-ide baru yang dicetuskan melalui seminar ini diharap dapat memberi manfaat kepada semua. Saya juga berharap seminar seperti ini akan diteruskan lagi di masa-masa akan datang dan sekali gus berjaya menghasilkan satu rumusan yang boleh dibanggakan demi kemajuan negara.

8. Sebelum saya akhiri ucapan pada pagi ini, ingin saya mengucapkan setinggi-tinggi penghargaan kepada Jawatankuasa Penganjur yang diketuai oleh Profesor Dr. Abd. Rahim Samsudin dan Dr. Zuhar Tuan Harith serta semua ahli jawatankuasa beliau yang telah berusaha bagi memastikan seminar ini dikendalikan dengan sempurna. Saya juga mengucapkan terima kasih kepada semua pembentang kertas kerja yang telah menyiapkan kertas kerja mereka dan seterusnya membentangkannya dalam seminar ini. Kepada para peserta, diharapkan seminar ini dapat memberikan manafaat sepertimana yang diharapkan.

   Dengan ini, saya dengan sukacitanya merasmikan Seminar Setengah Hari SUMBANGAN GEOFIZIK DALAM KAJIAN PERSEKITARAN DAN PEMULIHARAN

9. Sekian Wabillahitaufik walhidayah, wassalamualaikum warahmatullahi wabarakatuh.

Seminar sehari

Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

Atucara Majlis

Dewan Kuliah A, USM

Masa		Atucara Majlis
7.30 – 8.00	:	Pendaftaran Peserta
8.05 – 8.15	:	Ucapan Aluan Pengerusi Seminar
8.15 – 8.30	:	Ucapan Dekan/wakil Dekan PPSF
8.35 – 9.00	:	Ucapan Perasmian oleh Naib Canselor USM
9.00 – 9.30	:	Minum pagi
9.30 – 10.10	:	***Ucap utama:*** Engineering & environmental geophysics: an overview Lee C.Y. (USM) (cylee@usm.my)
10.10 – 10.30	:	***Kertas teknik 1:*** Solar flare and telluric current Abdul Halim Abdul Aziz (USM), Zuhar & Nawawi (abdul@usm.my)
10.30 – 10.50	:	***Kertas teknik 2:*** Correlation between magnetic intensity and pipe-to-soil potential in PGU III Pipeline System Jamalee Ahmad (Pgas) (jamalee@petronas.com.my)
10.50 – 11.10	:	***Kertas teknik 3:*** Changes of Penang coastal area from 1980 to 2000: view from the sky Khiruddin Abdullah (USM) & Zuhar (khirudd@usm.my)
11.10 – 11.30	:	***Kertas teknik 4:*** National offshore sand resources study in the Straits of Malacca: geophysical and sampling survey techniques Devendran (Hydrosis (M) Sdn. Bhd.) (hydrosis@tm.net.my)
11.30 – 11.50	:	***Kertas teknik 5:*** The application of geophysics and geology for the design and installation of a submarine pipeline Jeremy Tung (TL Geohydrographics Sdn. Bhd.) (jetung@pc.jaring.my)
11.50 – 12.10	:	***Kertas teknik 6:*** The ecology of hydroelectric dam Kamarulazizi Ibrahim (USM) (kamarul@usm.my)
12.10 – 12.30	:	***Kertas teknik 7:*** Reservoir induced earthquakes — a case study from Kenyir, Terengganu Norliza Lat (UM) (noorliza@um.edu.my)
12.30 – 12.50	:	***Kertas teknik 8:*** Shallow seismic refraction data and wash boring data, a comparison, its usefulness and the importance Samsudin Hj Taib (UM) (samsudin@um.edu.my)
12.50 – 14.00	:	Makan tengah hari/Sembahyang Zohor

14.00 – 14.20	:	***Kertas teknik 9:*** Pecirian turapan asfalt berdasarkan Analisis Spektrum Gelombang Permukaan (ASGP) di Putrajaya Khairul Anuar Mohd Nayan (khairul@vlsi.eng.ukm.my)
14.20 – 14.40	:	***Kertas teknik 10:*** Pengukuran radon dan progeni radon terhadap beberapa sampel batu-batan dan bahan binaan Mohd Suhaimi Jaafar *et al.* (USM) (msj@usm.my)
14.40 – 15.00	:	***Kertas teknik 11:*** The detection and mapping of underground services using electromagnetic technique Rubiah Abdul Rahim (EM-Detection Sdn Bhd) (roob_ar@hotmail.com)
15.00 – 15.20	:	***Kertas teknik 12:*** Mengesan rongga akibat dari paip bocor menggunakan kaedah resistiviti pengimejan 2D Abdul Kahar Embi(JMG) *et al.* (kahar@galian.gov.my)
15.20 – 15.40	:	***Kertas teknik 13:*** Pemetaan air masin dalam akuifer pantai di Pekan-Nenasi, Pahang Umar Hamzah *et al.* (UKM)
15.40 – 16.00	:	***Kertas teknik 14:*** Mapping of salt water intrusion in West Kedah-North Perlis area WMS Wijesinghe, M.H. Loke & MNM Nawawi (USM) (wmswijesinghe@yahoo.com)
16.00 – 16.30	:	Minum petang/Poster
16.30 – 17.00	:	Demonstrasi GPR (Kumpulan Geofizik USM)
17.00 – 17.30	:	Penutup
17.30	:	Minum petang dan bersurai

Seminar sehari
Sumbangan Geofizik Dalam Kajian Sekitaran dan Pemuliharaan

Abstrak-abstrak Kertas Teknik

Engineering and environmental geophysics: an overview

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The application of geophysical techniques to engineering and environmental problems has become increasingly important and widespread over the last two decades. This can be attributed to heightened environmental awareness and parallels the rather rapid developments in data processing techniques, computer technology and new geophysical survey equipment and methods. The geophysical techniques commonly utilized in such surveys include seismic reflection and refraction, gravity, magnetics, electrical, electromagnetics, radioactivity, borehole and the relatively new georadar. Engineering applications include geotechnical site investigations (involving bedrock mapping, fault delineation, detection of sinkholes and other subsurface voids, mapping of core boulders and geotechnical investigations to determine the mechanical parameters of rocks and soils); surveys for submarine cable and pipeline routes; studies for bridge, tunnel and highway alignments; investigations of dam sites; and marine surveys for land reclamation, marine salvage operations, coastal engineering and the construction of offshore structures. Environmental geophysics involves hydrogeological investigations (inclusive of the mapping of saline water intrusion); environmental monitoring (including mapping of contaminant/leachate plumes, investigations of buried wastes, detection of radon gas and similar sources of environmental radioactivity) and monitoring of geohazards (such as volcanic activity, earthquakes, tsunamis, landslides, land subsidence and gas blowouts). Geophysics has also been employed increasingly in archeological studies. It is thus evident that geophysics is a very powerful yet cost-effective tool with an increasingly wide range of applications.

Solar flare activities and its effects on the earth

ABDUL HALIM ABDUL AZIZ, MOHD NAWAWI MOHD NORDIN & ZUHAR TUAN HARITH
Pusat Pengajian Sains Fizik
USM

Geomagnetic disturbances are commonly known as magnetic storms if global in scale, or magnetic substorms if localized in scale can induced a major hazard. These geomagnetic hazards have impact on technologies such as electric power utilities, pipeline operations, radio communications, navigation, satellite operations, geophysical exploration and GPS (global positioning system). This paper attempts to describe solar flare activities and its effects on the earth. A large solar flare is an incredibly complex phenomenon on the surface and atmosphere of the Sun. Its effects on the earth's surface and its atmosphere is well known. The nature and theory of solar flares are discussed and some of its effects, including the generation of telluric current, will be described briefly. A preliminary result of probable telluric effect measurements will be presented.

Correlation between magnetic intensity and pipe-to-soil potential of PGU III Pipeline System

JAMALEE AHMAD[1], SHAHARIN RAJAB[2], ZUHAR ZAHIR TUAN HARITH[3] & MOHD NAWAWI MOHD NORDIN*

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The variations in pipe-to-soil potential readings of the main pipeline system of Sector 3, Peninsular Gas Utilisation III have been suspected, for quite some time, due to local telluric currents interference. A survey to confirm the correlation between the geomagnetic induced currents and potentials was carried out by means of 24 h data logging of field magnetic intensity and the pipe-to-soil potentials (PSP). Linear regression of field data at 16 monitoring stations resulted into 5 stations having *good* correlation (correlation coefficient, R2 from 0.5092 to 0.6236), 7 stations having *acceptable to poor* correlation (R2 from 0.2703 to 0.4832), and 4 stations having *no* correlation between the PSP pairs (R2 = 0). Diurnal variations caused such PSP fluctuations with stations being determined as very quiet, fairly quiet and fairly hectic based on their normalized delta plots. The resultant effect from combined currents (telluric, AC and DC) was suspected to yield low to zero correlation coefficients.

Changes of Penang coastal areas from 1980 to 2000: view from the sky

KHIRUDDIN ABDULLAH & ZUHAR ZAHIR TUAN HARITH

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11800 Pulau Pinang

Land reclamation and coastal development are two major factors contributing to coastal changes in Penang. To map such changes over a large area using conventional surveying technique is time consuming and expensive. With the advent of remote sensing technology, synoptic view of the area can be mapped in a relatively very short time from airborne and space-borne platforms. Spatial details can be obtained depending on the type of sensors used and the height of the observations. In this study, coastal changes of Penang coastlines from 1981 to 2000 were mapped using remote sensing images. The data from aerial photographs (taken in 1981), SPOT panchromatic image (captured in 1996) and SPOT Multispectral image (acquired in 2000) were used to see such changes. The photographs were scanned to convert the data to digital images. SPOT 1996 was used as the reference image due to its large coverage and fine pixel resolution. The 1981 and 2000 images were registered to the corresponding 1996 SPOT image based on selected control points. The images were then resampled using the nearest neighbor technique. In order to see the changes, the time series images were overlapped and the coastlines were traced. The land areas covered by those changes were estimated. This technique is found to be simple and cost effective for such environmental studies.

National offshore sand resources study in the Straits of Malacca: geophysical and sampling survey techniques

DEVENDRAN, A.

Hydrosis (M) Sdn. Bhd.

Geophysical and Sampling techniques are commonly used in marine exploration to study the large number of seabed and sub seabed present. This paper discusses the geophysical and sampling techniques used to map the sand resources in a marine environment. The geophysical survey encompasses three (3) different techniques, namely echo sounding, side scan sonar survey and sub bottom profiling. Using these techniques the bathymetry, seabed features and the sub seabed features were studied. Sandy deposits are usually associated with seabed features such as ripples, mega ripples, sand waves and sand dunes usually clearly identified on sonograms. These features are also seen on echograms. Sub seabed sand deposits are associated with various types of seismic signatures on seismograms. By combining the results from the various techniques, maps of sand deposits along with their deposition features can be charted.

Almost every geophysical survey has to be supplemented with a sediment sampling survey to validate the geophysical findings as well as to determine the grain size of the sandy deposits. Three (3) sediment-sampling techniques were used i.e., grab sampling for seabed sediments, piston coring for unconsolidated sediments and vibro coring for consolidated sediments. An average of five (5) meters samples were obtained with the coring techniques. The sediment samples were analysed for particle size, carbonate, organic and quartz contents.

The results of the geophysical and sampling surveys were used to identify and compute the sand deposit volumes. The findings also formed the basis for the environmental impact assessment studies.

The application of geophysics and geology for the design and installation of a submarine pipeline

JEREMY TUNG

TL Geohydrographics Sdn. Bhd.

A submarine pipeline route survey was carried out in mid 2000 to investigate the feasibility of installing a submarine pipeline connecting gas field facilities in Papua New Guinea (PNG) to mainland Australia.

TEKNIK LENGKAP SDN BHD, (TLSB), through its marine survey division TL Geohydrographics, was engaged to perform the marine investigation to determine the feasibility of this route using geophysical methods that included the acquisition of the following types of data:

1. Bathymetry or water depth along the proposed route
2. Sonar imagery of sea floor and its conditions
3. Sub-bottom geological information, including soil properties
4. Current measurements

The survey was carried out using one offshore vessel and two near shore or shallow draft vessels, equipped with various state-of-the-art electronic sensors and systems.

The ecology of hydroelectric dam

KAMARULAZIZI IBRAHIM

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The damming of the river has profound change to watersheds. The creation of storage and head allows dams to generate electricity. Nothing alters a river as totally as a dam. A reservoir is the antithesis of a river, the essence of a river is that it flows, the essence of a reservoir that it is still. Every dam site has unique geological characteristics. Gaining a thorough understanding of these characteristics is expensive and time consuming. The builders just hope that they will not find any unstable formations which will fail to support their foundations or cause the roofs of their tunnels to come crashing down. Similarly with the hydrological data, a dam traps sediments and nutrient, alters the river's temperature and chemistry, and upsets the geological processes of erosian and deposition throught which the river sculpts the surrounding land.

It is well established that large dams can trigger earthquakes. Today there is evidence linking earth tremors and reservoir operation for more than 70 dams. Reservoir-induced seismicity (RIS) has been observed for dams over 100 meters high. Dam can both increase the frequency of the earthquakes in areas of already high seismic activity and cause earthquakes to happen in areas previously though to be seismically inactive.

Dam and reservoir operation is not dictated by optimization rules but by the struggles of interest groups. The inflexibility of hydropower in terms of its siting is paralleled by the inflexibility to cope with changes in the rate of growth of energy demand over the many years it takes to plan and construct large dams. Energy demand forecasts consistently overestimate future needs of electricity in the name of sustainable economic growth.

Reservoir induced seismicity (RIS) — a case study from Kenyir, Terengganu

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Reservoir Induced Seismicity (RIS) is associated with earthquakes caused by the impoundment of water. The general "rule of thumb" used is that dams with height of more than 100 metres and capacity of more than 1 cubic kilometre may be prone to RIS. With a lot of large dams exceeding this criteria being built for water and energy supply around the world, the need for RIS assessments is crucial to ensure that people, property and the environment are safe during and after the construction of each dam. Even though, statistically, less than 20% of large dams experienced RIS, reservoir induced tremors, such as the magnitude 7.0 in Koyna, India, has been known to destroy the dam and cause casualties and damages to villages downstream. Most RIS occurred near the dam, originating from shallow depths. RIS has been known to occur as early as during dam construction to as late as 18 years after completion.

RIS could be caused by several factors including the additional stress put on the crust by the dam structure and water reservoir, the change in pore pressure, and the failure of nearby faults or other plane of weaknesses. Before the construction of a large dam, an RIS assessment should be done using integrated data, including dam statistics, geology and pre-construction seismicity, to evaluate the risk involved. Continuous monitoring is also necessary to see how the seismicity changes with the changing of water levels and time.

In Malaysia, RIS was made "popular" by the occurrence of tremors after the Kenyir Dam was built in Terengganu. Kenyir Dam is 150 metres high with a storage capacity of 13.6 cubic kilometres. The dam, built in a previously aseismic area, was responsible for several earthquakes from 1984 to 1987. The Seismology Department of the Malaysian Meteorological Services recorded a total of 28 earthquakes with magnitudes ranging from 2.5 to 4.6. The tremors were felt at a distance of more than 50 km. The area now is again aseismic; a suggestion that the region may have achieved a new, stable stress regime.

Shallow seismic refraction data and wash boring data, a comparison, its usefulness and the importance

SAMSUDIN HJ TAIB

Jabatan geologi
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Kuala Lumpur

The geophysical techniques have been used in many site investigations. In small scale site investigations the technique has often been neglected due to a number of reasons. Among the main reason cited are: cost constrain, lack of knowledge on geophysics by the personals involved in planning of the site survey and lack of confidence in the technique. The later is partly related to the to the difficulty at times to correlate the results to the borehole data in as much as the lack of understanding of the limitation of each of the geophysical techniques either in its field procedure or the interpretations.

In a proposal by the Institute of Engineers, Malaysia for the planning of hill-site development, the subsurface investigation is included as a major part of the planning exercise prior to the platform layout and analysis and design of slope. In the subsurface investigation boring is the main procedure for investigation and geophysics is stated as only sometimes included or used. In slope studies a non destructive and mobile technique such as geophysical method could be more efficient in obtaining the needed information. Therefore, it is imperative that the geophysical data be comparable to the borehole data so that the geophysical techniques are easily acceptable. One of the geophysical techniques often used in the shallow and small-scale site investigation is the seismic refraction technique. This paper describes some comparison between the seismic refraction interpretations to the information obtained with the wash boring procedure.

Pecirian turapan asfalt berdasarkan Analisis Spektrum Gelombang Permukaan (SASW) di Putrajaya

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Kaedah Analisis Spektrum Gelombang Permukaan (SASW) merupakan suatu teknik uji kaji seismos tanpa musnah di lapangan yang dapat digunakan untuk penilaian kekukuhan dan kedalaman struktur turapan jalan dengan cepat dan menjimatkan. Kaedah ini mampu mengukur modulus dinamik elastik pada tingkat terikan bahan turapan di bawah 0.001 peratus yang mana modulus dinamik bahan adalah malar dan tidak dipengaruhi oleh terikan. Oleh itu parameter ini boleh dijadikan faktor penting dalam penilaian kualiti jalan. Kaedah SASW dibina berasaskan

teori perambatan gelombang permukaan *Rayleigh* pada media yang elastik. Punca hentaman dengan julat frekuensi yang berubah digunakan untuk mejana tenaga yang bergerak melalui zarah-zarah bahan sepanjang permukaan lapisan turapan. Sepasang meter pecutan menegak, diletakkan selari dengan punca hentaman untuk menerima isyarat gelombang yang selanjutnya diproses menggunakan penganalisis isyarat dinamik. Dengan menganalisis perbezaan fasa spektrum gelombang yang diperolehi, lengkung eksperimen serakan halaju gelombang Rayleigh terhadap panjang gelombang dapat diplot. Seterusnya, proses songsangan dilakukan untuk menyesuaikan model teori terhadap lengkung eksperimen yang dihasilkan. Modulus elastik dinamik bahan turapan jalan ditentukan dengan hubungan halaju gelombang ricih, ketumpatan bahan dan nisbah Poisson. Dari kajian yang dilaksanakan pada struktur turapan di projek pembinaan jalan di Putrajaya satu set pengalas bola dan tukul didapati sesuai untuk penjanaan spektrum frekuensi tinggi dan rendah yang diperlukan. Perbandingan hasil profil turapan melalui kaedah SASW ini dilakukan terhadap profil turapan asfalt yang telah direkabentuk untuk menilai ketepatannya.

Measurements of radon 220 emanation from main building materials

MOHAMAD SUHAIMI JAAFAR, ZUHAR ZAHIR TUAN HARITH, SITI NOORSERIWANI ADRIS & MOHD RIDHWAN MOHD SHARIFF

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Rn is a naturally occurring radioactive inert gas and comes from the radioactive decay of uranium. The two isotopes of the element Rn that are important in health protection are ^{222}Rn and ^{220}Rn which are part of the decay series originating from ^{238}U and ^{232}Th, respectively. ^{222}Rn is the first decay product of the naturally occurring element ^{226}Ra. Materials containing ^{226}Ra create an a-radiation hazard for the human respiratory system because of the airborne progeny of its daughter ^{222}Rn. When building materials with a high radium concentration are being used, the radon progeny in ordinary buildings may increase the radiation exposure of the public to unacceptable levels. In this study, the exhalation rate of radon from various commonly used building materials was determined by placing the materials in a closed container and measuring the current and average Rn levels. The preliminary data obtained was useful in identifying the building materials at risk and having elevated ^{222}Rn concentrations.

The detection and mapping of underground services using electromagnetic technique

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The objective of this exercise is to detect as accurately as possible, all existing underground utilities and to produce accurate coordinated maps of these utilities. This information also can be incorporated into a **Geographical Information System** or be used to facilitate efficient construction design, costing of utility diversion and to maintenance and avoid damage to existing utilities during construction.

This aim is not only to pin point the location of these utility lines but also to determine attributes such as depth, type, size, material, etc.

A suitable technique has to be used to obtain the information from underground and a number of techniques are available:

1. **Sonic surveying**
   Injection of sound or ultra-sonic waves into the ground or along a line is a technique for tracing plastic water pipes but is not suitable for locating other buried services.

2. **Dowsing**
Certainly the oldest technique. Although the hazel twig and all its variants continue to be used with varying effects by practitioners of this obscure but interesting art, ease of handling is the only one of its features which can be claimed with any certainty.
3. **Ground Penetrating Radar**
Much research and development is being applied to this technique, because it is the theoretically capable of 'seeing' non-metallic as well as metallic pipes. Unfortunately the size, cost and complexity of the equipment needed to interpret the results puts this technique currently outside the range of usefulness for everyday work
4. **Electromagnetic location**
This method of locating buried pipes, cables and sewers has become almost universal. Its main shortcoming is that it will not locate non-metallic lines such as plastic pipes.
However, utility companies taking the small amount of trouble to lay tracer wires with non-metallic pipes are not affected by this shortcoming.
The technology has a large number of advantages and this leads to prevalent development and utilization.

Mengesan rongga akibat dari paip bocor menggunakan kaedah resistiviti pengimejan 2D

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Kedah

Paip air bawah tanah yang bocor yang tidak dikesan bukan sahaja menyebabkan kerugian malah jika berlaku kebocoran ia juga boleh menyebabkan pengwujudan rongga yang boleh membahayakan. Tanda-tanda fizikal seperti pancutan air kadangkala tidak kelihatan kerana lapisan tanah telap serta arah kebocoran berada di bawah paip. Teknik pengesanan kaedah resistiviti pengimejan 2D telah digunakan untuk mengesan kedudukan paip bocor. Imej resistiviti 2D jelas menunjukan kedudukan aliran air daripada paip bocor ke lokasi air keluar. Rongga berair yang terbentuk juga jelas kelihatan dari imej yang dihasilkan.

Pemetaan air masin dalam akuifer pantai di sekitar Pekan-Nenasi, Pahang

UMAR HAMZAH, ABDUL RAHIM SAMSUDIN, ISMAIL C. MOHAMAD, NORHAFIZI KHALID & SHAHIMI SALI

Program Geologi, Pusat Pengajian Sekitaran & Sumber Alam
Fakulti Sains & Teknologi, UKM

Masalah kejatuhan paras air bawah tanah dan peningkatan jumlah kemasinan dalam air tawar yang terdapat dalam akuifer aluvium di sekitar Pekan-Nenasi, Pahang telah dikesan melalui kerja-kerja pemantauan air bawah tanah. Sebahagian daripada input pemantauan termasuk data survei geofizik yang digunakan serentak dengan data hidrogeologi kawasan kajian. Survei geofizik yang digunakan dalam kajian pemantauan ini ialah teknik geoelektrik termasuk duga dalam dan pengimejan khususnya untuk menganggarkan sempadan zon-zon air tawar-payau-masin dan perlapisan akuifer dalam enapan aluvium. Hasil survei yang dilakukan menunjukkan zon-zon konduktif yang mewakili kawasan pengaruh air masin-payau lebih tertumpu berhampiran dengan muara-muara

sungai dan tepi pantai di sekitar 4–5 kilometer. Keputusan awal menunjukkan pencapaian yang diperolehi dari survei geoelektrik hanya terbatas pada kedalaman tidak melebehi 20–30 meter. Oleh itu akuifer yang terdapat di bahagian yang lebih dalam tidak dapat diselidiki dengan survei geoelektrik.

Mapping of the saltwater intrusion in west Kedah and north Perai area, Malaysia

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The two-dimensional electrical imaging technique was employed in the coastal plain area of South-West Kedah and Northern Perai area in West Malaysia to map the saltwater and freshwater boundary. The survey was carried out using the Wenner electrode arrangement. The electrical method was used, as it is very sensitive to changes in ground water salinity. At most of the places under investigation, the saltwater intrusion was found to be delineated in a depth range of 5 m to 25 m. The resistivity of the saltwater area is in the range of 2–10 Wm and the interface was found to be approximately 6km far from the coastline. The resistivity models obtained from the inversion of the field surveys data in the investigation area was found to be in good agreement with the available geophysical and borehole information. The two dimensional electrical imaging method using the Wenner array configuration was found to be highly suitable for mapping saltwater intrusion in coastal areas.

Petroleum Geology Conference & Exhibition 2002

15–16 October 2002
Istana Hotel, Kuala Lumpur, Malaysia

Report

The Petroleum Geology Conference & Exhibition 2002 was held on the 15–16 October 2002 at the Istana Hotel, Kuala Lumpur.

The Conference this year was declared open by Yang Berbahagia Tuan Hj. Akbar Tajudin Abdul Wahab, Senior general Manager of Petroleum Management Unit, PETRONAS. In his opening speech, Tuan Haji Akbar noted that the challenges facing the oil industry have become more global in nature with oil prices being the main driving factor in determining the level of exploration and production activities.

He is glad that the country continues to be successful in attracting oil companies to explore in our basins, an indication that our basins are still prolific and the opportunity to discover oil and gas is still there.

He noted that oil and gas exploration has come a long way in Malaysia and currently Malaysia produces 600,000 barrels crude oil per day, 90,000 barrels of condensate per day and 5.6 billion std cu ft gas per day from 44 oil fields and 11 gas fields. He announced Malaysian first deepwater oil discovery by Murphy Oil, thus opening up a new frontier for Malaysia's petroleum industry.

He is confident that hydrocarbon resources in our basins trapped in more challenging conditions can be comprehensively explored and exploited using innovative ideas and latest state-of-the-art technology.

He paid tribute to the geoscientists in PETRONAS who have helped to shape the views of oil companies regarding our basins and it is indeed the geoscientist's knowledge, understanding and interpretation, using all the available tools, is the key success factor in the discovery of oil and gas.

There were 23 technical papers presented over 4 sessions. The keynote paper was on "PCSB's strategy for growth in the E&P Business — the challenges and opportunity" by En. Mohamad Johari Dasri, Chief Executive Officer of PETRONAS Carigali Sdn. Bhd. In addition there were 20 posters on display. There were also 33 Exhibition Booths which were well decorated, displaying current and latest technologies available in the market.

This 24th Petroleum Geology Conference & Exhibition once again turned out to be a very successful gathering of over 450 participants. The Organising Chairman En. Ali Md Shariff and his Organising Committee should be congratulated for a job well done.

G.H. Teh

Petroleum Geology Conference & Exhibition 2002

15–16 October 2002

Istana Hotel, Kuala Lumpur, Malaysia

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

Yang dihormati Tuan Pengerusi Majlis,

Yang berbahagia Tuan Haji Akbar Tajuddin Abdul Wahab
Senior General Manager, Petroleum Management Unit, PETRONAS,

Yang Berbahagia En. Mohamad Johari Dasri
Keynote Speaker PETRONAS Carigali,

Yang Berusaha, En. Ali Mohd Shariff
Pengerusi Jawatankuasa Penganjur Persidangan Geologi Petroleum 2002,
Para Jemputan,

Ahli-Ahli yang dihormati,
Rakan-rakan Geosaintis,

Tuan-tuan dan Puan-puan para hadirin yang dihormati sekalian,
Assalamualaikum dan Salam Sejahtera,

Saya bersyukur kepada Allah SWT, kerana dengan umpah kurniaNya dapat kita berkumpul dalam dewan yang endah ini pada pagi ini. Dengan mengambilkira penyertaan antarabangsa pada pagi ini, izinkan saya meneruskan ucapan saya dalam Bahasa Inggeris.

Distinguished guests,
Fellow Geoscientists,
Ladies and gentlemen,

On this pleasant morning and in this beautiful hall, please allow me to extend a very warm welcome to all of you on behalf of the Geological Society of Malaysia with "Selamat Datang". The start of today's Petroleum Geology Conference and Exhibition is the 24th time that petroleum geoscientist and experts of the oil and gas industry have gathered here in Kuala Lumpur. I would like to thank Tuan Haji Akbar Tajuddin, for taking time from his busy schedule to be with us today morning and to officiate this mornings Conference.

Ladies and gentlemen,

I understand from the organising committee that the response to this year's Petroleum Conference was really overwhelming, with over 40 requests for oral presentation. After painstaking consideration, 24 papers have been chosen for oral presentation with an almost equal number of 20 to be presented as posters. This response reflects the intense research and development, as well as exploration, that is currently ongoing in the oil and gas sector. Perhaps for the coming years, the possibility of conducting parallel sessions needs to be considered. I would like to thank the paper presenters for their support and their willingness to share their findings with us. Our gathering here is taking a truly international nature, with papers on the petroleum geology of Morocco and Pakistan.

Ladies and gentlemen,

About one year ago, at last year's Petroleum Geology Conference, I mentioned briefly the developments regarding the "Registration of Geologists' Bill". For this Conference, I understand that a representative of the Institute of Geology Malaysia is present at the Geological Society's exhibition booth to provide us with the latest information on the progress of this bill.

Ladies and gentlemen,

Much energy and effort from various individuals and parties goes into making any conference a success. Therefore, please allow me this opportunity to thank:

- Yang Berbahagia Tuan Haji Akbar Tajuddin
- the organisations and companies that have sponsored and contributed to this Conference
- the organisations that have taken up the exhibition booths
- the contributors and presenters of the technical papers and posters
- En. Ali Mohd. Shariff and his committee
- and all the participants at this Conference.

Finally, please accept my most humble apologies for any shortcomings at this Conference. And especially for those amongst you who are here for the first time or back after some years, do also take time to enjoy what Malaysia has to offer.

Thank you very much.

Wabillautaufik Walhidayah
Wassalamulaikum w.b.t.

Petroleum Geology Conference & Exhibition 2002

15–16 October 2002

Istana Hotel, Kuala Lumpur, Malaysia

Opening Address by Tuan Haji Akbar Tajudin Abdul Wahab, Senior General Manager, Petroleum Management Unit, PETRONAS

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

Yang Berusaha, En. Ali B Mohd Shariff
Organising Chairman of the Petroleum Geology Conference & Exhibition 2002,

Distinguished Guests,

Participants,

Ladies and Gentlemen,

Assalumualaikum and a very good morning.

First of all, I would like to send the apology of Ybhg. Dato' Mohamad Idris Mansor, Advisor to E&P Business, PETRONAS for not being able to be here for the forum. Let me take the opportunity to welcome all of you and especially to those who have travelled from abroad, I wish you "Selamat Datang ke 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 experts of the oil and gas industry and to deliver the opening address at the Petroleum Geology Conference 2002 organised by the Geology Society of Malaysia.

The work put in by the Geological Society of Malaysia to organise this annual petroleum geology to promote new exploration ideas and geological concepts and even to just share the experiences within the petroleum fraternity is commendable indeed. I hope this conference will enhance the technical knowledge and transform our geoscientists into an astute oil finder. It is noteworthy that more than 300 participants including students from the local universities are attending this year's conference where 24 technical papers will be presented. The response for papers presentation was overwhelming. The Committee had received more than 45 papers requested for oral presentation but due to time constraints, only 24 papers were chosen for oral presentation whereas 20 papers will be presented as posters. Again, I wish to commend the geoscience community in this region for the support to this event and your contributions would certainly promote better understanding on the subsurface geology of our basins. I am sure participants will also get the opportunity to listen to the latest state-of-the-art technology being used in the search for hydrocarbons which is now extremely necessary in view of the diminishing size of our prospects to be explored in Malaysia.

Distinguished Guests,
Ladies and Gentlemen,

As oil and gas business is becoming competitive, the challenges facing oil industry have become more global in nature. Oil prices continue to be the main driving factor in determining the level of E&P activities undertaken by the industry. Oil is a commodity that is important worldwide and use as a source of energy. Historically, it is difficult to predict oil prices as it fluctuates in accordance with the world political scenario and environment. Global competition for exploration and production become more challenging as basins become more mature. Besides these challenges, there is also an increased demand for environmental requirement by the public where E&P companies have to take into consideration and integrate it into its operations. Since the discovery of Miri-1 in 1910, oil and gas exploration in Malaysia has come a long way. Over the last 25 years, the level of E&P activities in Malaysia has heightened with some RM8 billion spent on exploration activities and RM49 billion spent on development and production activities in our quest to add new resources and develop and produce the discovered resources. As of 1 January 2002, we have acquired a total of about 1.3 million line-km of 3D and 600,000 line-km of 2D seismic data. We have also drilled more than 950 wells resulting in the discovery of 134 oil fields and 173 gas fields. 18 of these 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 successful. To-date we have discovered more than 8.0 billion bbls of oil and 100 TSCF of gas reserves, of which 4.8 billion and 13 TCF have been produced. As at 1 January 2002, our country total remaining reserves (crude oil plus condensate) stands at **4.2** billion Standard Tank Barrel (STB) of oil and **87.5** trillion Standard Cubic Feet (SCF) of gas.

Over the last one year, we have discovered ten (10) new oil fields and four (4) gas fields from thirty-one (31) exploration wells drilled with a total additional new reserves of 300 million STB oil and 1.7 trillion SCF gas. In 2002, a total of 47 wells will be drilled by our PS Contractors. Currently, we are producing around 600,000 barrels crude oil per day, 90,000 barrels of condensate per day and 5.6 billion std cu.ft gas per day from **44** oil fields and **11** gas fields. Nippon will be producing gas from Helang gas field in year 2003. The latest oil field that will come on stream will be by Murphy Oil in April 2003 from West Patricia Field. Murphy shall be our fifth oil producer after Exxon Mobil, Shell, PETRONAS Carigali and Talisman (Lundin). I am also pleased to announce and congratulate Murphy Oil of their recent significant deepwater oil discovery in Block K, offshore Sabah. I wish to put this on record as Malaysia's first major oil discovery in the deepest water depth of more than 1,300 meters. This discovery has opened up a new frontier for Malaysia's petroleum industry. We hope to see more oil developments and its development coming on stream. This will certainly enable Malaysia to sustain its 600 KSTB/D oil production as long as possible by way of new field reserves addition and new hydrocarbon discoveries in near future.

Ladies and Gentlemen,

On the commercial side we have accomplished success in attracting oil companies to invest in our basins. We want to ensure that our investors are successful in the efforts on exploration and achieve the commercial value and fair return on their investment. With the introduction of the more liberal Revenue over Cost (R/C) PS terms in 1997 into our PSCs for the continental shelf areas, we have attracted a total of 19 PSCs with eight (8) oil companies based on the new terms, four (4) of which are new players in this region. That is an indication that our basins are still prolific and the opportunity to discover oil and gas is still there, as viewed by new players.

Although the discovery may not be the big elephants but they are substantial enough to make it commercial since our areas have platforms/pipelines that can be utilised to tie and develop them.

Ladies and Gentlemen,

As mentioned, our basins are getting into a mature stage for exploring for new reserves, but we know there are still substantial amount of hydrocarbons from smaller fields to be found. These are trapped in more challenging conditions such as subtle stratigraphic plays, in deeper sections below overpressure zones or in frontier onshore and deepwater areas. I am confident that the hydrocarbon resources in our basins can be comprehensively explored and exploited using innovative ideas and latest state-of-the-art technology to uncover the remaining resources. In this context, service companies play a more important role in providing the required technologies that are available in the market. It is therefore crucial that we all work together i.e. PETRONAS/ PS Contractors/Service Companies to realise the benefits.

I am proud to say that the geoscientists in PETRONAS have also helped to shape the views of oil companies regarding our basins. We have drilled in the Malay Basin to prove that indeed there is deep reservoir potential below the overpressure zones. New play of the carbonate bank or stratigraphic trap carbonates have proven to trap hydrocarbon in the Central Luconia Province. Exploration in the West Baram Delta below the overpressure zones have successfully discovered new oil and gas fields. In the frontier area, where major oil discoveries in turbidite play fan were made in a water depth below 500 meter, many prospects are becoming mature and upgraded as drilling candidates. More than 20 exploration wells are planned in the deepwater areas over the next 2-year. In Central Luconia Province, our geoscientists have also discovered a gas field in pinnacle carbonates thereby upgrading the prospectivity in this area. I know that there are several technical papers lined up for presentation by distinguished speakers who will be sharing some of their findings on the work that they have done. Many people in the oil and gas industry sometimes tend to forget the importance of Geoscientists. Without the Geoscientists, hydrocarbon cannot be found and discovered.

It is the Geoscientist that determine where the hydrocarbon kitchen exists, or source rock, the possible migration path and the possible hydrocarbon traps and play types where the hydrocarbon could be accumulated. Without the geoscientist analysis of the subsurface and the mapping of the potential hydrocarbon prospects, the oil companies would not gamble and drill wildcats which are expensive. It is indeed the Geoscientist's knowledge, understanding and interpretation using all the tools available is the key success factor to the discovery of oil and gas. As such, data acquisition such as seismic and well data are indeed important for us to acquire, analyse, interpret and make good predictions of the subsurface potentials.

Distinguished Guests,
Ladies and Gentlemen,

Since 1974, we have acquired plenty of 3D seismic data and in the near future we are acquiring more 3D seismic not only for development but exploration as well. The question that is posed to the oil companies is: can we add value to our huge volume of 3D seismic data? I am glad to note that new 3D seismic data specialise reprocessing techniques have emerged that include coherency technique, fault seal analysis, 3D visualization technique, 3D AVO technique and illumination modelling have enhanced the interpretations. Some of these will be presented here by the service providers and specialist companies. I understand that there are more than 30 booths on display outside by these companies that have proven commendable record of providing excellent technologies to our success. I hope that with such collaboration between the oil companies and the services providers we would ensure a continued increase in exploration success.

I hope more exploration success shall prevail in the near future with good technological alliance amongst all parties. With the continued technological advances 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.

I would like to conclude by reminding my 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 service 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.

With that note, it is with great pleasure that I declare the Petroleum Geology Conference & Exhibition 2002 open.

Thank you.

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2002

Petroleum Geology Conference & Exhibition 2002

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Petroleum Geology Conference & Exhibition 2002

15–16 October 2002
Istana Hotel, Kuala Lumpur, Malaysia

PROGRAMME

Tuesday, 15 October 2002

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 Tuan Haji Akbar Tajudin Abdul Wahab, Senior General Manager, Petroleum Management Unit, PETRONAS***

09:30 : ***Keynote Address:*** PCSB's strategy for growth in the E&P Business — the challenges and opportunity.
Mohamad Johari Dasri (PETRONAS Carigali Sdn. Bhd.)

10:00 : ***Coffee Break*** *(sponsored by Geoeast)*

Session 1 : Morning Session

Session Co-Chairmen:
Kurujit Nakornthap *(CEO, Malaysia-Thailand Joint Authority)*
Hoh Swee Chee *(GM, CS Mutiara Petroleum Sdn. Bhd.)*

10:30 : ***Paper 1:*** Depositional history and origin of porosity in a small carbonate platform of Central Luconia, offshore Sarawak
Valentina Zampetti, Wolfgang Schlager (Vrije Universiteit/Earth & Life Sciences), Arnout-Jan-Everts & Jan-Henk van Konijnenburg (Sarawak Shell Bhd.)

11:00 : ***Paper 2:*** Predicting reservoir quality from seismic data — lessons from the Cakerawala Field development, Malaysia-Thailand Joint Development Area (MTJDA), Block A18
Cathal Daly (Carigali Triton Operating Co) & Vichai Assavarittiprom (Malaysia-Thailand Joint Authority)

11:30 : ***Paper 3:*** Sumandak: discovery in a forgotten play
Azli Abu Bakar & M Khair Abd Kadir (PETRONAS Carigali Sdn. Bhd.)

12:00 : ***Paper 4:*** Spectral decomposition: extending the limits of sismic resolution for reservoir delineation
Dylan Mair (Landmark Graphics)

12:30 : ***Lunch*** *(sponsored by Landmark)*

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PROGRAMME

Tuesday, 15 October 2002

Session 2 : Afternoon Session

Session Co-Chairmen

Martin Stauble *(XM, Sarawak Shell Bhd / Sabah Shell Petroleum Co. Ltd.)*

M Izham Ismail *(XM, ExxonMobil Exploration & Production Malaysia Inc)*

14:00 : ***Paper 5:*** Facies organisation and depositional environments of coal-bearing sucessions within the Nyalau Formation (Oligocene-Late Miocene) in the Bintulu area (Tinjar Province), Sarawak.
Ismail Elforjani Shushan (University of Malaya), Abdul Hadi Abdul Rahman (University of Science Malaysia) & Wan Hasiah Abdullah (University of Malaya)

14:30 : ***Paper 6:*** Characterising productive sands in the Shallow Clastic field: integration of Under Balanced Drilling (UBD) and core analysis results
J-H van Konijnenburg, Mah Kok-Gin & J. MacArthur (Sarawak Shell Berhad)

15:00 : ***Paper 7:*** Sequence stratigraphic study of Pab sandstone Mehar Block, Middle Indus Basin, Pakistan
Othman Ali Mahmud (PETRONAS) & Sahalan Abd Aziz (PCSB Pakistan)

15:30 : ***Paper 8:*** Guntong — key challenges and issues in the management of a large complex oil field
Wan-Nawawi Wan-Mohamad, Petrick L. Coyne, Paul V. Hinton, Janani Karthirmagoo & Razmahwata M. Razali (Esso Production Malaysia Inc.)

16:00 : ***Coffee Break*** *(sponsored by Geoeast)*

16:30 : ***Paper 9:*** Sequence stratigraphical analysis of the NW Borneo sedimentary basins
Kim Morrison & Wong Chung-Lee (Sarawak Shell Bhd)

17:00 : ***Paper 10:*** Structural geology of the Neogene Maliau Basin, Sabah
Felix Tongkol (University Malaysia Sabah)

17:30 : ***Paper 11:*** Reservoir characterization in deepwater Malaysia
Phil Beale (Jason Geosystem) — Not presented.

18:30 : ***Icebreaker*** *(sponsored by Baker Atlas)*

Petroleum Geology Conference & Exhibition 2002

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Istana Hotel, Kuala Lumpur, Malaysia

PROGRAMME

Wednesday, 16 October 2002

Session 3 : Morning Session

Session Co-Chairmen

Jack L. Kerfoot *(SXM, Murphy Sarawak Oil Co. Ltd / Murphy Sabah Oil Co. Ltd)*
Bjorn Martinsen *(XM, Amerada Hess)*

07:45	:	Second day convenes
08:15	:	***Paper 12:*** Fault seal analysis: a case study of the Temana Field, offshore Sarawak, Malaysia *Shutaro Hasegawa (Japan National Oil Corp), Naofumi Sakuyama (Idemitsu Oil & Gas Co), Syoji Iwanaga (Geoscience Research Laboratory) & Othman Ali Mahmud (PETRONAS)*
08:45	:	***Paper 13:*** Did the Nortwest Borneo Trough terminate at the West Baram Line — what do the Miocene adakite/diorites indicate? *Charles S. Hutchison*
09:15	:	***Paper 14:*** Unraveling sediment distribution in ancient shelf-slope-basin settings, Block SB302, offshore Sabah. *Lai Soo Khuan & Tan Bee Hoon (Amerada Hess)*
09:45	:	***Paper 15:*** Real time wellbore stability using drilling data and logging while drilling data *Frank Wijnands (Schlumberger)*
10:15	:	***Coffee Break*** *(sponsored by Jason Geosystems)*
10:45	:	***Paper 16:*** The evidence of carbonate turbidites in Central Luconia *Francis Ho, Guenter Jaeger & Piet Lambregts (Sarawak Shell Bhd)*
11:15	:	***Paper 17:*** The integration of the reservoir characterization and seismic study of West Patricia field, Balingian Province, offshore Sarawak *Raja Azlan Raja Ismail (Murphy Sarawak Oil Co. Ltd)*
11:45	:	***Paper 18:*** Tertiary stratigraphy, structure and tectonic evolution of Southern Sabah: implication to the tectono-stratigrahic evolution of Sabah, Malaysia *Allagu Balaguru (Jabatan Mineral & Geosains Malaysia), Gary Nichols & Robert Hall (Royal Holloway University of Londan)*
12:15	:	***Paper 19:*** 3D seismic acquisition planning, deepwater Sarawak Block F: challenges, methodology and solutions *D. Goulding, P. Desegaulx (Amerada Hess), A. Chaouch (TotalFinaElf), S. Fairhead (Amerada Hess) & T.Brice (WesternGeco)*
12:45	:	***Lunch*** *(sponsored by PGS)*

Petroleum Geology Conference & Exhibition 2002

15–16 October 2002
Istana Hotel, Kuala Lumpur, Malaysia

PROGRAMME

Wednesday, 16 October 2002

Session 4 : Afternoon Session

Session Co-Chairmen

Abu Samad Nordin *(GM, PETRONAS Carigali Sdn. Bhd)*
Andrew Wright *(XM,YPF Repsol)*

14:00 : ***Paper 20:*** Vitrinite reflectance analysis: minimizing the errors
Wan Hasiah Abdullah (University of Malaya) & Peter Abolin (PETRONAS Research & Scientific Services Sdn. Bhd)

14:30 : ***Paper 21:*** The influence of shallow marine depositional systems on deep water sand distribution in Brunei and the adjacent areas of Malaysia
Joseph J. Lambiase (University of Brunei Darussalam)

15:00 : ***Paper 22:*** Geology and petroleum system of the Eastern Moseta and Middle Atlas Domains of Morocco
Fatima Charrat, Mohamad El Alji (ONAREP, Morocco), Mohd Hamidi M Nor, Ng Tong San, Supian Suntek & H.D. Tjia (PETRONAS Carigali Sdn. Bhd)

15:30 : ***Paper 23:*** AVO, rock properties and pitfall
Deva P. Ghosh & Liau Min Hoe (PETRONAS Carigali Sdn. Bhd)

16:00 : ***Paper 24:*** The pink fan: a classic deepmarine canyon-fill complex, Block G, NW Sabah
Colin Grant (Sabah Shell Petroleum Co. Ltd)

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

17:00 : ***Coffee and Adjourn*** *(sponsored by Jason Geosystems)*

Petroleum Geology Conference & Exhibition 2002

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POSTER SESSION

1. Facies organization and depositional environments of some selected outcrops of Sandakan Formation (Upper Miocene), Sandakan, Sabah
T.A. Hodairi (University of Malaya), A.R. Abdul Hadi (Universiti Sains Malaysia) & W.H. Abdullah (University of Malaya)
2. Reservoir and fault delineation using Spectral Decomposition in West Patricia Field, offshore Sarawak
Mohd Khalid Jamiran (Murphy Sarawak Oil)
3. Extreme simulation: successful application of parallel VIP in complex reservoir environment
Abdul Hadi Yahya Luddin (Landmark Graphics)
4. Seismically constrained reservoir modeling: the E8 gas field, offshore Sarawak
Updesh Singh, Peter Duindam, Charlie Ash, Mah Kok Gin (Sarawak Shell Berhad)
5. Fluid inclusion screening of Central Luconia carbonates — follow up 2002
Piet Lambregts (Sarawak Shell Berhad)
6. Play inventory in Straits of Melaka based on Blocks PM320 and PM322 evaluation
Andrew Chan (SEPM BV (Shell))
7. Exploration opportunities in Malaysia
Salahudin Saleh Karimi, Abd Rahman Eusoff, Othman Ali Mahmud & Hamdan Mohamad (PRAD, PETRONAS)
8. Facies analysis and paleogeographic implication of the Jelai Formation (Middle-Upper Triassic), Central basin of Peninsular Malaysia
Charles Makoundi (University of Malaya)
9. Structural style, Tertiary stratigraphy and basin evolution of southern Sabah: implication to the tectonic evolution and sedimentation of Sabah, Malaysia
Allagu Balaguru (Jabatan Mineral & Geosains Malaysia), Gary Nichols & Robert Hall (Royal Holloway University of London)
10. Geologic modeling of shally-sand reservoirs in J-Group, Tapis Field, Malaysia
G.S. Kompanik & J.W. Erickson (ExxonMobil Exploration and Production Malaysia)

Petroleum Geology Conference & Exhibition 2002

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POSTER SESSION

11. Successful development of a thin oil column using horizontal drilling in the Palas field, Malay Basin
Ang Dwen Woel & Mike D. Crumley (Esso Production Malaysia Inc)

12. Real Time Wellbore Stability using Drilling Data and Logging While Drilling Data
Frank Wijnands (Schlumberger)

13. Towards a geodynamic model for Peninsular Malaysia: evidence from high Ba-Sr rock from the Central Belt of Peninsular Malaysia
Azman A. Ghani & Mustafa Kamal Shuib (University of Malaya)

14. A tide- and wave-influenced, barrier island-lagoonal complex within the upper section of the Nyalau Formation (Oligocene-Late Miocene) at Kampong Sungai Plan, north Bintulu, Sarawak
Abdul Hadi Abd. Rahman (University of Science Malaysia)

15. Sedimentology and reservoir properties of shoreface sandstones in the Sandakan Formation, Sabah
Suraya Tulot & Joseph J. Lambiase (University of Brunei Darussalam)

16. Geology of Kinabalu field and its water injection scheme
Boniface b. Bait (Sabah Shell Petroleum Co. Ltd.)

17. Structural bends of northwest Sabah: causes and implications for exploration
H.D. Tjia (PETRONAS Carigali Sdn. Bhd.)

18. Sea-bed imaging through high resolution short offset re-processing in the Malay Basin
Sriyanee DeSilva, Wee Eng Swee (Amerada Hess) & Julian Sherrif (Robertson Research)

19. DecisionSpace: an intergrated asset optimization system providing multi-scenario decision support for the entire team
Abdul Hadi Yahya Luddin (Landmark Graphics)

20. 3D generalised inversion as direct input into static model in Kamunsu East Field — a case study
Timothy E. Johnson, John W.K. Voon, Boon-Teck Yong, (SSB), Huw Davies, Satvayan B. Reymond & Noel Lucas (Schlumberger)

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2002

15–16 October 2002
Istana Hotel, Kuala Lumpur, Malaysia

ABSTRACTS OF PAPERS

Keynote Address

PCSB's strategy for growth in the E&P Business — the challenges and opportunities

MOHAMAD JOHARI DASRI

PETRONAS Carigali Sdn. Bhd.

INTRODUCTION

Some brief background of PCSB.

FORGING AHEAD

Continuing PCSB' journey into the future of the E & P environment and the need to grow to stay relevant in the industry.

ELEMENTS FOR GROWTH IN E & P

Discussion on what does it take to grow in the future E & P environment.

GEOLOGY IN THE GROWTH STRATEGY

Discussion on technical challenges, economic & geo-political and people challenge.

OPPORTUNITIES

Paper 1

Depositional history and origin of porosity in a small carbonate platform of Central Luconia, offshore Sarawak

VALENTINA ZAMPETTI[1], WOLFGANG SCHLAGER[1], ARNOUT-JAN EVERTS[2] AND JAN-HENK VAN KONIJNENBURG[2]

[1]Vrije Universiteit/Earth & Life Sciences
1081 HV Amsterdam, The Netherlands
[2]Sarawak Shell Berhad, Malaysia

Recently acquired 3D seismics, wireline logs and selected core samples were used for a detailed reconstruction of the growth history of the platform as well as the sequence of diagenetic events and the origin of porosity. Platform growth started in the Late Oligocene/Early Miocene probably by coalescence of isolated patch reefs. Growth history includes phases of progradation, backstepping and occasional collapse of the platform

flanks. The most pronounced seismic reflectors in the platform are produced by the change from clean carbonate to overlying argillaceous carbonate during flooding events (transgressive systems tracts). Some of these flooding events are preceded by lowstands and exposure of the platform top. Platform growth was terminated by gradual submergence (drowning) indicated by smooth, concentric seismic reflectors forming a convex mound. During the growth cycle of the platform, the flanks increased in height from less than 50 m to over 250 m. The broad western and eastern flanks were controlled by bundles of low-offset faults that were active during platform growth. The narrow northern and southern flanks occupy the space between two fault zones. During the late stage of platform growth large landslides occurred along the fault zones. The slide masses can be traced seismically about 1.5 km into the basin; associated layers of carbonate sand and rubble are indicated by high-amplitude basinal reflectors and can be trace out into the basin. Modern day analogue data suggest that these deposits could extend all the way across the basin to the base of slope of the neighbouring platform.

Three different processes have significantly contributed to porosity in the carbonate rocks: selective leaching during exposure, dolomitization and leaching during deep burial, probably by warm fluids rising from depth. Quantitatively, the last group is by far the most important. As most of the carbonate porosity formed by carbonate dissolution under deep burial, the slide masses and related turbidites may contain highly porous rocks in the basins between the platforms. These bodies may contain hydrocarbon reservoirs that are separated from the charged platforms where their upslope ends are enveloped in clay-rich hemipelagic sediment. In other places, the porous slides and turbidites may establish connections between neighbouring platforms.

Paper 2

Predicting reservoir quality from seismic data — lessons from the Cakerawala Field development, Malaysia-Thailand Joint Development Area (MTJDA), Block A18

Cathal Daly[1] and Vichai Assavarittiprom[2]

[1]Carigali-Triton Operating Company (CTOC)
[2]Malaysia-Thailand Joint Authority (MTJA)

The use of acoustic impedance for predicting reservoir quality is well established in the oil and gas industry. Variations in the rock velocity and density can be related to variations in porosity and pore fluid content. These relationships together with estimates of acoustic impedance derived from seismic data can be used to make pre-drill predictions of net pay sand. Two key uncertainties need to addressed when using seismically derived acoustic impedance in this manner. First, due to limitations in the resolution of typical seismic data, the fine detail of the reservoir cannot be uniquely determined. Second, the relationship between acoustic impedance and porosity is statistical in nature and is better described as a probability function rather a simple regression. In this paper we show how these uncertainties have been approached in predrill reservoir prediction in the Cakerawala Field. In addition to describing the methodology we provide a detailed comparison of the pre- versus post-drill net pay estimates and a discussion of where the approach has been both successful and unsuccessful.

The Cakerawala Field is located in the Malaysia-Thailand Joint Development Area (MTJDA), Block A18 approximately 150 km off the east coast of Narathiwat in Southern Thailand and Kota Bharu in Northern Peninsular Malaysia. As with most shallow reservoirs in the Malay Basin seismic amplitude anomalies provide a very effective means of finding hydrocarbons in Block A18. Typically, the reservoir rocks are of relatively high porosity and presence of gas produces prominent bright spots and flat spots in seismic data. While direct hydrocarbon indicators are quite useful in the exploration phase a more quantitative approach is called for to guide well targeting for field development. Specifically the goal is to provide predrill estimates of net pay to optimize development well locations and also to refine reserves estimates. The approach used in Cakerawala Field was the stochastic inversion technique developed by Jason Geosystems. Using existing well control, probability density functions were defined to characterize the range of variation expected in the fine detail of the reservoir and the uncertainty in the relationship between impedance and both lithology and porosity. These PDF's were then used to guide a series of inversions or different realizations of the reservoir. Although multiple reservoir realizations can be used in various ways (including running each realization through reservoir simulation) the approach taken here was to average the net pay from all realizations to yield a "most likely" net pay map over two relatively thick reservoir sequences. These maps were then used to target all development wells and generate the pre-drill net pay predictions.

When comparing predicted versus actual pay in we found a very good relationship in Sequence II where reservoirs are relatively thick and laterally continuous. The predictions were significantly better than could be achieved by using existing well control only, and provide a very reliable method for future well targeting.

In Sequence I however several factors combined to generate errors. Although there is a reasonably good linear relationship between predicted and actual pay there are some significant outliers. Analysis of the outliers showed one case of significant over-prediction of pay (i.e. predicted greater than actual) when the well penetrated a high quality sand channel. Since none of the calibration wells encountered such a channel this error could possibly be controlled by rerunning the stochastic inversion with better calibration. The second, set of outliers indicated a tendency to under-predict pay in areas where the seismic data were obscured by the presence of shallow gas. This error is difficult to address directly within the inversion methodology but can be approximately corrected by applying scalars based on shallow gas maps. Both under-prediction and over-prediction errors are more likely in Sequence I because, compared with Sequence II, the individual subsequences are thinner and spatially more variable due to differences in the depositional environment. Although both sequences were deposited in a tidally influenced estuary/marine to delta front setting, the gas bearing Sequence II reservoirs are generally mouth bar sediments while Sequence I reservoirs are more estuarine.

In conclusion, estimates of acoustic impedance based on seismic data have been found to be very useful for predrill prediction of net pay in the Cakerawala field. Several sources of error remain, with error due to the presence of shallow gas being the most significant. A scaling approach based on shallow gas mapping has been developed to correct this error. Ongoing work is focused on integrating net pay prediction maps with reserves estimation methodology.

Paper 3

Sumandak: discovery in a forgotten play

AZLI ABU BAKAR AND MOHD KHAIR ABD KADIR
Petronas Carigali Sdn. Bhd.

For years it was thought that the Stage IVC sediments along the footwall of Moris fault in NW Sabah were either not prolific or gas proned. Wells drilled in this area did not produce encouraging results. The mainly stratigraphic plays ranging from basin floor fans to eroded shelf were soon forgotten.

The latest 2D seismic data acquired with a longer cable identified series of this forgotten play trending N-S. The processed data revealed evidences of possible petroleum accumulation such as structurally conformable anomalies.

Sequence stratigraphic approach was applied in constructing the depositional model. Three major sequence boundaries marked by unconformities were identified in the Stage IVC, with the depositional environment ranged from deep water to coastal setting.

The basin modelling study showed that petroleum was generated and migrated into this area from the adjacent basin in the east and trapped in this stratigraphic play.

The AVO modelling could not conclusively confirmed the presence of petroleum due to the lack of shear wave data. However, the presence of structurally conformable positive AVO together with amplitude shut-offs and flat events in the stacked data provided some confidence in the existence of petroleum accumulation in the traps.

As the result of the studies, PCSB has decided to test this forgotten play by drilling the Sumandak-1 well in 2001. The result has confirmed the presence of substantial petroleum accumulation in Stage IVC.

This discovery is significant towards understanding the petroleum system in the area and opening new ideas for further exploration in NW Sabah basin.

Paper 4

Spectral decomposition: extending the limits of seismic resolution for reservoir delineation

DYLAN MAIR
Landmark Graphics (Malaysia) Sdn. Bhd.

Spectral decomposition is a seismic processing technique that has only recently been adapted for use directly in 3-D seismic data interpretation and reservoir imaging workflows. This technique has the potential to generate greater resolution of reservoir boundaries, heterogeneities and bed thickness than traditional broadband seismic displays and attribute extractions.

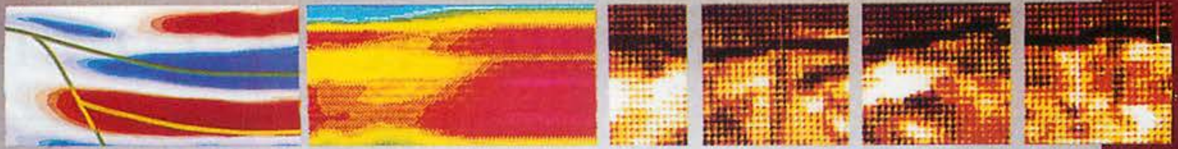
Spectral decomposition is used to identify thin beds through analysis of the frequency spectrum in a short window around the time of the bed. A thin bed spectral interference pattern is imposed by the distribution of acoustic properties within the short analysis window. In this example, a simple homogeneous thin bed introduces a predictable and periodic sequence of notches into the amplitude spectrum of the composite reflection.

Spectral decomposition can be used qualitatively, to reveal stratigraphic, structural edges and bodies, and relative thickening or thinning; and quantitatively, to give an accurate prediction of reservoir thickness or intra-reservoir travel time.

Interpretive processing using spectral decomposition has been applied to: delineation of facies/stratigraphic settings (such as flood plane boundaries, reef boundaries, channel sands, incised valley-fill sands, and other thin beds); resolving the order of deposition and migration routes; mapping detailed structural settings involving complex fault systems (such as reservoir compartmentalization); mapping near-surface environmental hazards (such as expulsion features and other near surface instabilities); and assisting reservoir modeling (mapping fluid changes, pressure changes and changes in 4D surveys).

The spectral decomposition interpretive processing workflows were developed at Amoco and first described by Partyka *et al.* (1999). There the authors describe two key processing and interpretation workflows: the "tuning cube", and "discrete frequency energy cubes" (also called "volume reconnaissance"). Additional enhancements to these workflows have since been devised, in both the seismic processing and the subsequent interpretation. Apache also has several patented and patent-pending enhancements for spectral decomposition processing.

Spectral decomposition is applied to conventional post-stack 3-D seismic data. It is generally preferable (as for most attribute analysis work) to have the seismic data processed for true amplitude recovery. Ideally, no band pass filtering, surface-consistent, migrated and output is either in 16-bit or 32-bit format. The sample rate should also be kept to a minimum. However, any moderately clean 3-D dataset can be used to investigate the potential of spectral decomposition and evaluate whether reprocessing of the seismic data is necessary. Ray trace modeling may be used in more complex terrains to determine whether any information might be found in the data.



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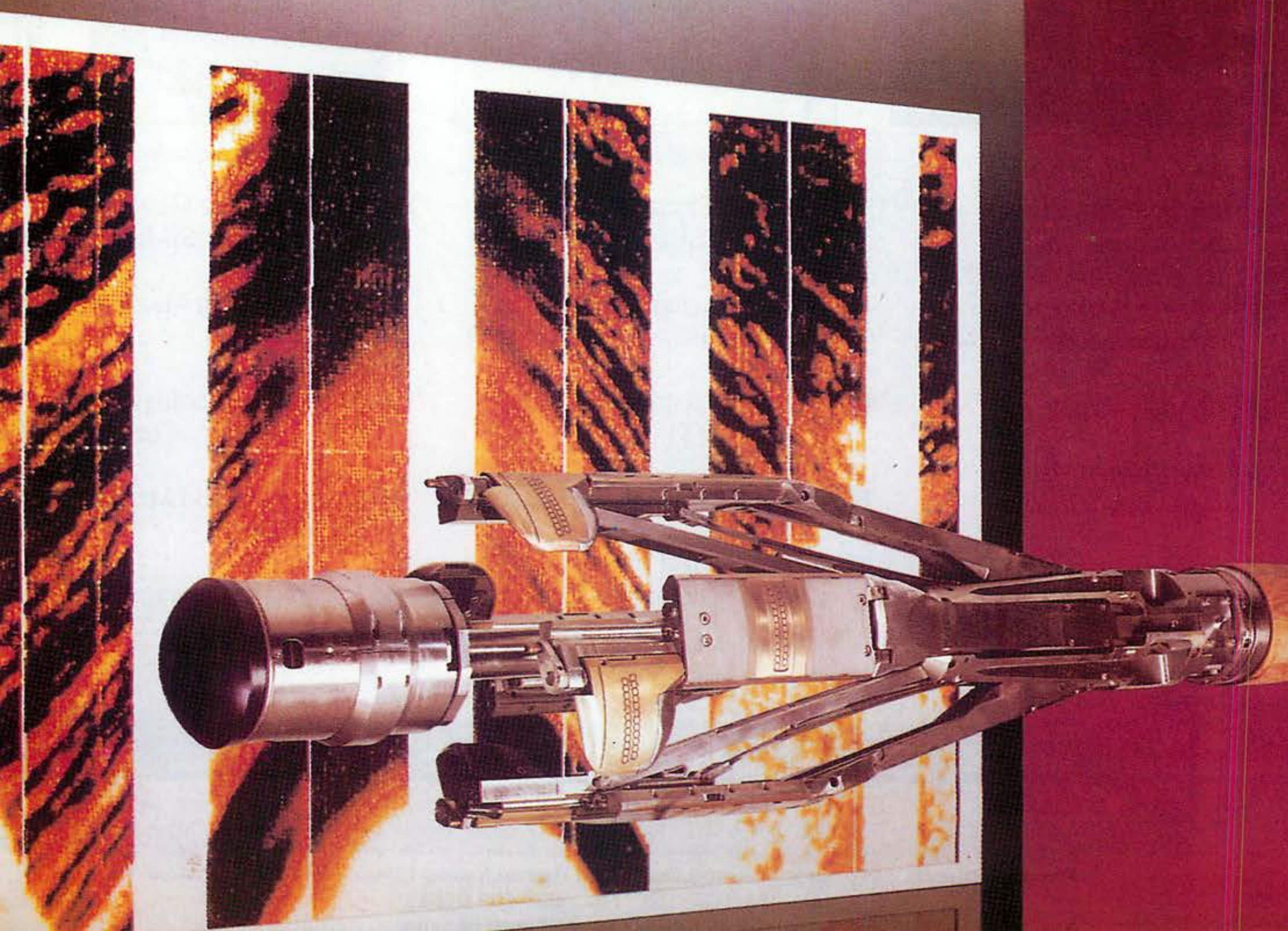

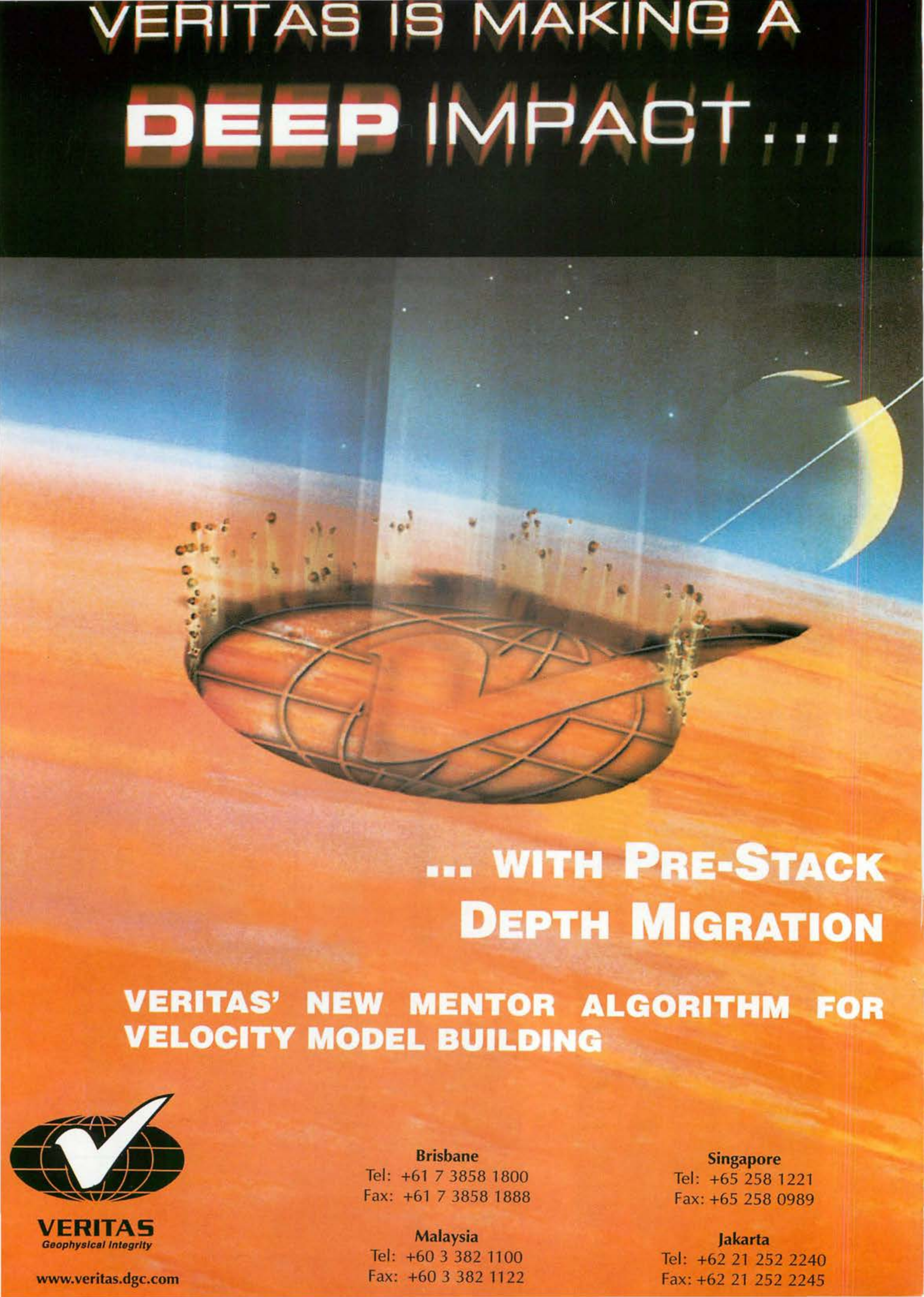
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Paper 5

Facies organisation and depositional environments of coal-bearing successions within the Nyalau Formation (Oligocene-Late Miocene) in Bintulu area (Tinjar Province), Sarawak

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The Nyalau Formation (Oligocene-Late Miocene) which outcrops around the Bintulu town in Sarawak is the onshore extension of the oil-bearing successions of the Balingian Province in offshore Sarawak. This formation represents an important analogue to the petroleum systems that occur in the offshore, oil-prone province. This paper describes the sedimentology and facies organisation of several coal-bearing outcrops of the Nyalau Formation in south Bintulu, and offers possible interpretation of their depositional environments.

Along the Bintulu-Tatau road south of Bintulu town, a road-cut at Sungai Mas exposes nearly 15 metres of coal-bearing, sand-shale-clay succession. This upward-fining succession is made up of at least five different lithologies, reflecting the interaction of different depositional processes.

At the base, about six meters of cross-bedded, wavy-bedded and laminated/draped sandstone is exposed. This unit, which is interpreted as a sandy, inter-tidal deposit, is overlain by about 2.1 m of distinct light-gray, clayey seat earth. Clay-XRD analysis of this rootlets-bearing, fossil soil layer shows that it is highly enriched in kaolinite minerals. A thin (~ 3–5 cm) coal layer lies immediately on top of the clayey unit. On top of the coal layer, about 10 cm of thin, silt-coal interbedding occur. A two meter thick of dark, carbonaceous and silty shale overlies the coal facies association. The whole section is capped by more than five meters thick of dark gray, carbagillitic shale. The seat earth, coal and related, coalified units are interpreted as swamp-to-coastal floodplain deposits. The overall facies organisation at the Sungai Mas outcrop, which is a shallowing-upward succession, reflects deposition within a distributary system in a tide-influenced, coastal plain environment.

At the Bintulu New Airport site, a small hill-cut exposes more than a hundred metres of coal-bearing, sand-shale-clay succession. This thick succession can be separated into five different fining-upward, shallowing-upward cycles. The lowermost fining-upward cycle is a 20 metre, mud-dominated cycle with a 1.5 metre basal sandstone capped by more than 18 metres of laminated mudstone.

The basal sandstone unit show draped, wavy- and flaser-bedded structures while the laminated mudstone is marked by the presence of thin sand-silt lenses. Several distinct and laterally continuous layers of iron-oxide are found interbedded within the mudstone unit. This cycle is interpreted as a tide-influenced, flood-plain environments. The iron-oxide layers probably represent iron-pan deposits formed during intermittent periods of emergence.

The second cycle is also a mud-dominated succession. At the base, two amalgamated beds of trough (~6 m), cross-bedded and bioturbated (Ophiomorpha) sandstone with well-developed mud-drapes occur. This is overlain by more than 22 meters of laminated-to-lenticular bedded mudstone, with a few well-developed, isolated rippled-sandstone lenses. This cycle is characteristic of a tidal-flat setting, with the basal sand unit representing a small tidal-channel fill.

The third cycle exposed at the new airport site is a heterolithic succession. The cycle is made up of about 20 meters of inter-succession of wavy- and rippled-bedded sandy intervals and mud-dominated lenticular-bedded intervals. The inter-succession of the sandy and the muddy heterolithic units reflects the dynamics of the depositional processes, alternating between a lower inter-tidal sand-flat zone to an upper inter-tidal, mud-flat environment. This cycle is interpreted to represent part of the intertidal margin of a tide-dominated estuary or a broad river bank.

The fourth cycle is the coal-bearing fining-upward succession. The basal 8.0 meters of sandstone show flat-to-low angle cross-bedded structures, with fairly well-developed drapes and laminations. Bioturbation is common but not pervasive here. This is overlain by about 2 meters of generally sandy, sand-shale alternation. The thickness of each sand and shale layers are between 2 to 5 cm. Most of the sand layers display well-developed mud- and carbonaceous-drapes. A 1.5 metres thick muddy siltstone unit, with interbedded thin sandstone layers (bearing distinct carbonaceous/plant debris laminae), overlies the sand-shale alternation bed. This unit is succeeded by a dark gray, laminated-to-lenticular bedded mudstone. Overlying this mudstone is 2.0 meters of dull gray, clayey mudstone similar to the one found at Sungai Mas outcrop (seat earth). A thin (about 20 cm) layer of dark brown silty clay overlies the seat earth, which is then overlain by about 15 cm of coal seam. This cycle is capped by about 4 metres of light gray, clayey mudstone.

Only the basal part of the topmost cycle is exposed at the outcrop. This is represented by a thick (about 9 m), medium-to-coarse grained, trough cross-bedded sandstone. This yellowish-coloured sandstone unit display medium- to large-scale trough cross-bedding. Each of the trough cross-bedded sets are internally laminated and in places shows well-developed, carbonaceous/plant debris drapes and laminations. The unit is sparsely bioturbated.

The upper two cycles (Cycle 4 and 5) is interpreted to represent part of a well-vegetated, distributary network of a tide-dominated coastal plain. The facies and stratal organisation of the Nyalau Formation rocks in south Bintulu describes a channelised, tide-influenced, well-vegetated, coastal plain environment. This setting is probably similar to the present day micro-tidal coastal plain of Sarawak.

Paper 6

Characterising productive sands in the Shallow Clastics field: integration of Under Balanced Drilling (UBD) and core analysis results

J-H van Konijnenburg, Mah Kok-Gin and J. MacArthur

Sarawak Shell Berhad
Miri, Sarawak, Malaysia

The Shallow Clastics field, located in the Central Luconia province off-shore Bintulu, is a large 2.5–3 Tscf field awaiting development. The Shallow Clastics reservoirs, which cover an area of ca. 210 km^2, consists of alternating sand shale sequence. It is a low-relief structure consisting of two *en-echelon* anticlines with NE-SW fold axes. Dips are extremely gentle (2 degrees or less) even out on the flanks. The gas bearing intervals occur in three main sand-shale sequences, the F-, H- and L-sands, each subdivided into higher order sequences. Of these the H1 and H2 combined contain around 80% of the total reserves and the L1/2 combined another 10%.

The depositional environment is interpreted as mid- to inner-shelf for the shales and shoreface for the sands; all based on log signature (repeated cleaning-upward successions), observations from core and sidewall samples/cuttings (sedimentary structures, fossil assemblages), as well as seismic expression (repeated progradation patterns).

The key reservoir facies are:

- Upper Shoreface: consists of relatively clean, fine to medium sandstones, typically with a cleaning-up signature and commonly a gradational base.
- Lower Shoreface: consists of relatively shaly, very fine to fine sandstones, typically with a serrated log signature and cleaning-upward.
- Transition zone: this category includes transition lithologies i.e. shaly sand or sandy shale.
- Channel – Observed as sharp based blocky sand signature on GR-logs, not observed in core.
- Shale: (non reservoir).

One core is available, taken in 1997, recovering 90 ft of H1 and 40 ft of L1/2 sands. Average net sand porosities are between 24–28%, with related permeabilities between 20–300 mD. However, capillary pressure measurements revealed that even for samples with porosities of up to 28% (and corresponding high permeability), residual water saturations (S_{rw}) were 35 to 40%. Furthermore, transition zones are up to 300 ft for above-mentioned porosities. These observations are in apparent contradiction: How do high porosities and permeabilities relate to high S_{rw} and long transition zones? Moreover, how do the observed rock properties influence the productivity of the sand intervals?

Early 2002, the first UBD well in Malaysia was drilled by Shell in to the L-sands of the Shallow Clastics field. Apart from the productivity benefits of under balanced drilling, UBD provided a "live" in-flow log while drilling. With this information in combination with well test data over the L-sand interval, productive intervals could be identified, revealing that certain sand intervals did not contribute to flow despite their predicted reservoir properties. This is not possible with conventional methods. Based on log characteristics, these intervals were identified as lower shore-face and transition zone facies with predicted permeabilities of < 20 mD. This raised the question why apparent 20 mD gas filled sands do not produce under given well test conditions?

Petrographic analysis of the available core material combined with X-Ray Diffraction (XRD) measurements and facies description showed that the reservoir rock is extremely fine grained with 50% of rock made up of fine sand and in the lower shore face and transition zone facies ~ 25% in silt/clay fraction. The fine grained nature of the rock can explain the observed long transition zones at higher porosities (capillary effect).

With XRD measurements and thin section description the amount and type of dispersed clay present in the matrix could be quantified. In the lower shore face and transition zone facies dispersed clays are an important matrix constituent which can make up to 25% of total reservoir rock. The dominant clay types are illite (30–50%), mixed layer illite/smectite (25–50%), minor chlorite and kaolinite. All of these clay minerals are hydrophilic and will bind water to their mineral structure. This will influence the capillary behaviour of the rock. The presence and quantity of these dispersed clays can therefore explain the high S_{rw} values observed.

Moreover smectite swells in the presence of (formation) water, thereby obstructing pore space and thus permeability. Laboratory core measurements are typically done on cleaned and dried core plugs. Therefore, plug permeability for the clay prone lower shore-face and transition zone facies is likely to over estimate the actual *"in-situ"* permeability.

The results of the UBD well allowed us to quantify this effect and use it in a predictive sense in the reservoir modelling part of the Field Development Planning process. Permeability is the dominant driver for well deliverability and constraining permeability uncertainty by integrating core analysis and UBD results have helped to optimise the number of development wells.

Paper 7

Sequence stratigrapic study of Pab sandstone, Mehar Block, Middle Indus Basin, Pakistan

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The Mehar Block is located along the eastern front of the Kirthar Foldbelt, in the lower part of the Middle Indus Basin, onshore Pakistan. It covers an area of about 5,030 sq. km. PETRONAS Carigali (Pakistan) Limited (PCPL) is the operator for this block with a working interest of 75%. The other partners are Orient Petroleum Inc. (20%) and Pakistan Government Holding (5%).

The primary exploration objectives in Mehar Block and the surrounding areas are the Late Cretaceous age Pab sandstone and Eocene age Sui Main limestone. Mazarani-1 wildcat well drilled in Mehar Block encountered gas in the Sui Main while to the south of Mehar Block exploration wells Zamzama-1 and Bhit-2 encountered significant gas columns within the fluvio deltaic Pab.

Despite numerous wells drilled and many discoveries made from the two main reservoir targets, the depositional setting and facies distribution of these reservoirs, especially the Pab sandstone, are not clearly understood and is more often a geological issue to operators in the area. Previous interpreters in this region introduced different models for the Pab. One of the more popular depositional models is that Pab sandstone is located within two main depositional lobes; i) a Western Lobe; which represents a deepwater setting and ii) an Eastern lobe which is interpreted as within fluvio-deltaic setting. High variability in thickness of Pab sandstone encountered in one location to another within a short distance complicate the interpretation when presumed under a simple static siliciclastic depositional model.

In an effort to further understand and define the reservoir distribution of Pab sandstone as well as the Sui Main limestone in Mehar Block, PCPL conducted a sequence stratigraphic study for the area. The study aims to produce the best fit and workable stratigraphic framework for the said region, and subsequently to identify the best reservoir fairway to locate Mehar-1 exploration drilling candidate. It would also allow for the identification of potential play-types available in the area. The study was performed in March-April 2002 by a team comprising one PCPL personnel and a Geoscientist from PETRONAS' KL office.

This paper discusses the finding of the study. The team concludes that the Mehar Block is situated in a depositional flow shadow zone west of Jacobabad paleo-high that may result in some starvation of deltaic sedimentation causing variable distribution of sands at Pab stratigraphy in the area. Hence, it would be more appropriate and accurate to describe the Pab in relation to its depositional processes e.g. fluvial channel, shoreface, slope fan, basin floor fan within the sequence framework etc. instead of a singular Pab sandstone terminology as traditionally used.

Paper 8

Guntong — key challenges and issues in the management of a large complex oil field

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Guntong field, located offshore Peninsular Malaysia, is a large anticline covering an area of 50 square km. It consists of 15 vertically stacked, highly heterogeneous reservoirs with two major N-S faults dividing it into three fault blocks; East, Central, and West. Recent geological, 3D seismic, and geophysical studies revealed more complexities in this field.

This paper describes some of the significant reservoir management challenges and the evolution of depletion plans due to the geological, development, and facility complexities.

The East and Central fault blocks were developed in 1985 with a central processing platform, two satellite platforms, and 94 wells. A combination of 5-spot and peripheral waterflood depletion plan was selected and the reservoirs were commingled into two groups. While this was a cost-effective scheme, it added significant challenges in reservoir management and surveillance to optimize waterflood pattern balancing and vertical flow profiles. The interpretation of reservoir wettability has also changed based on special core analysis data and simulation history matching, which resulted in a change of operating pressure strategy.

Production is compressor limited, but many changes have been made to maximize the capacity of the existing equipment. Water injection meters have had a high failure rate. While a long-term solution is being sought, portable clamp-on meters have provided the necessary surveillance data.

The West fault block was developed in 1995 with 44 wells and gas injection scheme. Reservoir compartmentalization presents significant challenges in maximizing gas injection effectiveness.

Various studies are underway to further increase production and reserves, including workovers, infill drilling, and facilities optimization.

Paper 9

Sequence stratigraphical analysis of the NW Borneo sedimentary basins

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The Cenozoic sedimentary sequence of NW Borneo is a record of the complex interplay between fluctuations in sea level, tectonically driven upheavals of the Borneo Landmass and also the localised structural movements related to shale diapirism. In this paper we show how analysis of selected key wells in the main geological provinces of Sarawak and Sabah helps unravel the superimposition of these processes and assess their importance in terms of the genesis, character and the distribution of the basin fills at various times in the last 25 Ma.

The cyclic depositional character of the Neogene and Quaternary sedimentary packages in the on- and offshore basins of Sarawak and Sabah was first recognised in the Baram Delta and described by almost every author since the late 1960's. The depositional "Cycles" (in Sarawak) or "Stages" (in Sabah) were recognised at basin scale, used for intra-basin correlations, and applied at a much smaller scale for well-to-well correlations of single sedimentary packages (reservoirs/seals). The recognition of the local "Stages" and "Cycles" passing diachronously across basinal boundaries was believed to be difficult or impractical.

The introduction of sequence stratigraphical analysis techniques has provided the basis for integrating "cycle" and "stage" boundaries with "classical" sequence components. It is now possible to base a regional correlation on the assignation of the earlier "cycles" to Haq TB sequences (3rd order cycles). The regional correlation of these TB sequences is based on the iterative integration of detailed biostratigraphy from well sections with seismic data. The significance of the major tectonic events and resultant unconformities is not disputed, however, the recognition of the main TB sequences is important because it allows the reconstruction of the sedimentary history at basin scale, assists in timing of the tectonic events and forms the basis for correlation across basin and political boundaries.

The application of a consistent stratigraphic framework for NW Borneo enhances our ability to predict lithology and source rock development, understand how the key tectonic episodes are manifested across the region and link the prospective exploration fairways.

Paper 10

Structural geology of the Neogene Maliau Basin, Sabah

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The Maliau Basin is one of a series of saucer-shaped basins found in Central and Southeast Sabah. These basins are depositional sites of ancient sedimentary rocks. The Maliau Basin is made up of about 7,500 metres thick sandstone and mudstone layers deposited in a deltaic-coastal environment, assigned the Kapilit Formation. The layer at the base of the basin consists mainly of mudstones reaching up to 2,000 metres thick. Near the rim of the basin, thick sandstone interbedded with thin mudstone and coal seam occur. Towards the centre of the basin a series of sandstone-dominated and mudstone-dominated sequences of various thicknesses occur. The deposition took place during the Middle Miocene epoch (10–15 million years ago). The basin sits on older sedimentary rocks (Tanjong Formation), also comprising of thick layers of sandstone and mudstone, with slight unconformity.

The orientation of bedding generally follows the semi-circular shape of the basin. The dip of bedding varies from 5 degrees to 40 degrees. The dip becomes gentler towards the rim of the basin. Based on the convergence of dip direction, the geological centre of the Maliau Basin has been located near the Camel Trophy Field Station. Sub-vertical to vertical fractures of various scales, which usually occur perpendicular and parallel to the strike of bedding, show various orientations. Four fracture orientations predominate, NW-SE (extensional fractures), NE-SW (tensional fractures), NNW-SSE (left shear fractures) and WNW-ESE (right shear fractures). Fault occurrence is quite rare inside the basin. Outside the basin, minor normal faults trending E-W and NE-SW have been recorded. The presence of a sheared zone at the southeastern part of the Maliau Basin possibly indicates field evidence for the major Lonod Fault.

The gentle dip and the lack of faulting and folding within bedding suggests that the Maliau Basin sediments have undergone a relatively mild deformation compared to other rock units, such as the Labang Formation in the surrounding area. The concentric bedding strike pattern suggests that at least two main compression directions occurred here. Based on the orientation of major faults, such as the Lonod Fault, the fracture pattern and the slight tilt of the basin towards the Southeast, a NW-SE and NE-SW compression direction is interpreted. The NW-SE compression appears to be related to the closure of the Sulu Sea Basin whereas the NE-SW compression appears to be related to sinistral horizontal faults.

Paper 11

Reservoir characterization in deepwater Malaysia

PHIL BEALE

Jason Geosystem

Paper not presented.

Paper 12

Fault seal analysis: a case study of the Temana Field, offshore Sarawak, Malaysia

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The Technology Research Center of Japan National Oil Corporation (JNOC-TRC) and the Petroliam Nasional Berhad (PETRONAS) conducted a case study of fault seal analysis for the Temana Field, offshore Sarawak, Malaysia, using the software FAULTAP, designed by JNOC-TRC. The objectives of the study were (i) to establish whether the selected faults in the Temana Field were likely to be hydrocarbon seal and how this behaviour varied at different stratigraphic levels on the fault surface, and (ii) to apply to and test FAULTAP on an actual field for further development of the software.

FAULTAP is a PC-based software written in C++ language. It aims to provide a practical assessment of fault sealing on the trap scale. The input data include (1) fault traces and seismic horizons from the interpreted seismic data imported from seismic interpretation software in the form of an ASCII file, (2) log data for characterizing the lithology, thickness and subsurface fluid saturation and (3) subsurface pressure data (e.g., RFT data).

TEMANA FIELD

The Temana Central was selected for the case study considering the simple fault-related structural style, excellent data availability and quality, and excess of hydrocarbon charge. The Temana field is located 22 km

WNW of Bintulu, offshore Sarawak, Malaysia. The Temana field is a westerly plunging fold structure, which is bounded by two thrust faults in north and southeast. The two thrust faults merge into one major fault to northeast of Temana field. The field consists of smoothly curved structures with NE-SW trending normal faults that provide fault traps for hydrocarbon. A major unconformity is observed at the base of Cycle VI, undeformed Pliocene sediments.

The main reservoirs are Cycles I, II and III sands deposited in the fluvial, lower coastal plain and nearshore marine environments. The main source rocks are coals and coaly shales in Cycle I and II. The kitchen area of the Temana field is the southwest sub-basin of the structure. The faults and intraformational shales are seals for each reservoir sands, and the clayey sediments at base cycle VI transgression provide a regional top seal for the structure. Fault O and Fault S were selected for the fault seal case study.

FAULT O

Fault O is a NE-SW trending normal fault down to SE between fault block 52 and block 54. Temana-37 is a deviated well drilled through the footwall block 52 along Fault O. No well has been drilled through the hangingwall block 54 of Fault O. Temana-37 penetrates several hydrocarbon-bearing sandstones, H-series at the top and K-series at the TD of the well. Many RFT pressure data are available for use from both hydrocarbon-bearing sandstones and water sands of Temana-37.

The well correlation was conducted by seismic-well tie using Temana-37. Fault interpretation of the Temana Central 3D-seismic data was conducted intensively to construct fault surface accurately. Then, depth-converted horizons and faults sticks data were imported to FAULTAP for fault seal analysis.

One of the shale smear algorithms for predicting across-fault sealing is Clay Content Ratio (CCR) of FAULTAP, which is the same equation as Shale Gouge Ratio of Yielding *et al.* (1997) as follows:

$$CCR = (\text{Layer thickness} \times \text{Layer clay fraction})/\text{Fault throw} \times 100$$

CCR is the percentage of clay that may be contributed from the various faulted layers into the fault rock. The higher values of CCR indicate more efficient fault seal. The published literature says that CCR values of < 20% suggests that the points on the fault surfaces are non-sealing, while the CCR values of > 20% are generally seal (Gibson, 1994; Bouvier *et al.*, 1989; Yielding *et al.*, 1997).

I-series sands display high CCR values in a range of 60-80%, on the other hand J-series sands display moderate CCR values in a range of 30-60%. It is interpreted that all the interval of footwall reservoirs are likely to be sealed by Fault O, especially in the reservoir interval of I-series sands, however, the J sands may have very low sealing potential zones on fault surface. The cross plots shows that the CCR values for the hydrocarbon bearing sands are greater than 33%, and we can draw a seal failure envelope as a seal capacity line. The seal capacity line for CCR can be useful to predicting fault seal for undrilled fault trap in the Temana area. Because this calibration study was conducted only for Fault O and for limited reservoir interval, the additional calibration will be needed for more accurate prediction for fault-sealing evaluation.

FAULT S

Fault S is a series of normal faults down to the west between TEJT-C and TEJT-W platforms in the Temana Central. The faults are left stepping en-echelon faults across the oil pool trapped by NE-SW trending Fault H at the eastern boundary of the Field. The main production reservoir is I-60 sand in this area. The amplitude map of I-60 sand indicates the distribution of I-60 sand, and in-fill well locations were proposed on this map.

A question came out whether Fault S is a sealing fault or not. The oil water contact is not confirmed in this pool. If Fault S is a sealing fault, it may affect the accumulation of oil in the production area in the western part of Fault S. To evaluate the sealing potential of Fault S, we selected Fault S-north, northern segment of Fault S, for FAULTAP analysis. Because the throw of the en-echelon faults of Fault S across confirmed oil pool is small, it is difficult to create structural framework at the crest of the structure for analysis.

The interesting area to be interpreted for sealing or non-sealing fault is a fault tip area in the southern end of the structural high. The horizon of I-60 sand is just below IL04PSSB seismic picking horizon. The display shows that the CCR values on the fault surface contacting I-60 sand is lower than 20% at the tip of the fault. FAULTAP analysis suggests that Fault S-north is non-sealing for I60 sand. The result suggests that the trap system of the I-60 sands of the Temana Central is fault sealing trap to the east by Fault H and stratigraphic lateral seal to the south. The northern limit of the trap is dependent on structural dip, or may be the limit of the distribution of I-60 channel sands.

Paper 13

Did the Northwest Borneo Trough terminate at the West Baram Line — what do the Miocene adakites/diorites indicate?

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It is widely accepted that the Northwest Borneo Trough represents a now extinct plate margin and that it was an active trench during spreading of the South China Sea marginal basin, from anomaly 11 (31 Ma, Oligocene) to anomaly 5c (16 Ma, Middle Miocene). The Mount Kinabalu pluton cooled through the temperature range 500° to 300°C during the interval 13.7 to 10.0 Ma and, as a result of uplift tectonics, is related to activity at the Northwest Borneo Trough. Its actual emplacement age (> 13.7, Middle Miocene) cannot be determined because it was a slow-cooling pluton. In no way does it represent a volcanic arc, which lies farther to the southeast–the Cagayan Ridge through Sandakan (Hutchison *et al.*, 2000). All tectonic models show the Trough terminating at the West Baram Line, with total silence about what might have happened westwards of this Line.

The models of Sarawak have ignored the existence of the Miocene Sintang Suite sub-volcanic arc, which extends through Kuching and Bau south-south-easterly along the length of the Ketungau Basin in Kalimantan. This arc indicates that the Northwest Borneo active trench continued westward and did not terminate at the West Baram Line. The Cretaceous to Palaeocene igneous rocks can be paired with an equivalent age accretionary prism to form an appropriate arc-trench system, as shown in tectonic cartoons by Moss (1998). The Sintang Suite volcanic-plutonic arc has no outcropping similar age accretionary prism material. The latter, therefore must lie beneath the South China Sea.

What then is the West Baram Line? If it had been a transform fault, it could have displaced the active trench left-laterally. There are several major faults of similar orientation cutting Mount Kinabalu and the Crocker Range, which can be attributed to spreading in the South China Sea Basin. The offset trench to the west of the West Baram Line has neither been identified nor discussed.

In general, the subducting oceanic lithosphere slab does not melt, but dehydrates, contributing fluids into and enhancing melting conditions in the overlying mantle wedge. The Lower Miocene diorites of the Sintang Suite are typical of subduction-related arc magmatism derived from melting of the mantle wedge. They have yielded whole-rock Lower Miocene K:Ar dates within the range 21.9 to 23.7 Ma (Prouteau *et al.*, 2001).

Melting of the subducting slab, of Mid Ocean Ridge Basalt composition (MORB), has been shown to result in trondhjemite-tonalite-dacite (TTD), produced by high pressure under a high geothermal gradient. Such magmas are characteristic of the Archaean greenstone belts, when the Earth was hotter. They have become rare since then. Cenozoic TTD rocks do occur and are known as ADAKITE. The adakitic dacites and microtonalites of the Sintang Suite have yielded whole-rock K:Ar Upper Miocene dates within the range 6.4 to 14.6 Ma (Prouteau *et al.*, 2001).

Oceanic crust (MORB) younger than 25 Ma has a heat flow in the range 2.8–8.0 HFU, whereas older crust has a relatively constant 1.0–2.5 HFU. The popular concept is that in orogenic terrains, where young, hot oceanic crust subducts, the slab itself has the ability to melt, producing Cenozoic adakite magma under garnet amphibolite to eclogite metamorphic conditions (Drummond *et al.*, 1996). Experimental study of adakites from the 1991 Mount Pinatubo dacite have led Prouteau *et al.* (2001) to a modified theory that Sintang Suite adakites originated from partial melting of MORB basalts from a fragment of oceanic lithosphere that continued to reside within the upper mantle following some previous subduction event (the diorite-producing Lower Miocene subduction).

The different hypotheses have no effect on the general conclusion that Lower to Middle Miocene subduction resulted in the Sintang Suite. Sintang Suite rocks form stocks and dykes and have hypabyssal to volcanic petrography. They caused metamorphism of the Eocene coals of the Silantek Formation. No volcanic morphology has been discovered, so it must be concluded that the sub-volcanic intrusions had their overlying volcanic edifices eroded. Archaean TTD granitoids of greenstone belts have an extremely strong genetic relationship to gold mineralization. Likewise the Middle Miocene adakites are responsible for the gold (with antimony and mercury) deposits of Bau.

The location of the trench of the arc-trench system has been neglected by geologists seeking to understand the tectonic evolution of Sarawak and Borneo. Several obvious arcuate lineaments, extending seawards from known on land geology, may be discerned on SEASAT images, but no obvious trench-like feature can be seen.

Where, then, could the cryptic suture reside? With the same trend as the Northwest Borneo Trough, it could continue southwestwards within the Balingian Province, between South Acis and Temana, landward of which position many anticlines have up thrust the basement and Cycles I through V are generally absent. The cryptic suture would have been uplifted within a collision zone as the Central Luconia micro continent converged on mainland Borneo.

The trend of the possible suture swings from the Balingian Sub-Basin to a NNW direction, and is lost in the complexity of the major West Balingian Line. The fundamental geology of Southwest Luconia has not been sufficiently documented to enable a discussion of where the cryptic suture could reside but it is not in the half-graben province of what Petronas and Shell (wrongly) named the offshore Tatau Province.

Paper 14

Unraveling sediment distribution in ancient shelf-slope-basin settings, Block SB302, offshore Sabah

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The study area lies within the south western portion of the Block SB302, about 80 kilometres offshore Northwest Sabah, East Malaysia. Geologically, the block straddles the inboard and outboard transition zone of the Northwest Sabah Basin. The basin was initiated by southeast ward subduction beneath NW Borneo, which led to the development of the Rajang-Crocker accretionary prism. The Middle Miocene Deep Regional Unconformity marks the end of subduction, and was succeeded by a series of unconformity bound, northwesterly prograding shelf systems (Stages IVA to G).

The aim of this study is to investigate the Pli-Pleistocene Stage IV F and IV G, which are extremely well imaged on 3D seismic data. A thorough understanding of these shallower shelf-slope-basin systems is essential in order to understand the deeper, more structurally complex intervals.

Major horizons that correspond to the top and bottom sets of the shelf progradational complexes were mapped based on internal seismic characters. Subsequently, strata slices and associated seismic amplitudes have been extracted from the 3D seismic data. The results reveal clear images of the paleo-drainage patterns, thought to have formed over the routes allowing sediment to be redistributed from the former shelf to deep marine settings. The key features identified in the area are shallow marine shelf top complex, shelf break, slope, slope channels and mini basins.

Mapping the depositional systems of the shallow section has revealed the changing relationship between relative sea level, paleo-environment and sediment transportation route. Recognising that "the present is the key to the past", allows the results of the study to be applied to deeper, more structurally complex shelf-slope-basin systems.

Paper 15

Real Time Wellbore Stability using Drilling Data and Logging While Drilling Data

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Logging While Drilling (LWD) has been around for a number of years, developing from early, basic measurements to the present suite of LWD tools that give quality comparable to wireline data, and in certain cases, exceed what is possible with wireline–measurements before invasion takes place for instance or certain azimuthal measurements. Further advances in technology make it possible to transmit increasing amounts of data in real-time, including since 2001, azimuthal images from density or resistivity measurements.

Real-time LWD data have proven their value in applications such as real-time geological and petrophysical interpretations, geosteering and geostopping. Apart from LWD measurements, a large array of MWD measurements have been developed for use by drillers. Such MWD measurements include Downhole Weight On Bit (DWOB), Torque (DTOR), vibrations, drilling shocks measurements and Annular Pressure While Drilling (APWD). Exceedingly, it is becoming clear that LWD measurements have enormous potential for Real-Time drilling optimization and wellbore stability applications, especially when combined with aforementioned MWD tools. Such LWD/MWD drilling applications form the subject of this presentation.

Paper 16

The evidence of carbonate turbidites in Central Luconia

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Central Luconia has long been recognized as a prolific carbonate province with great oil and gas potential. Carbonate reefs were mainly growing on structural highs formed during the Late Oligocene rifting. Main phase of Carbonate growth occurred during the mid to late Miocene. Some of these carbonate build-ups are aerially very extensive and cover several hundred km^2. Eustatic sea level changes during the Miocene influence the growth rate of and facies distribution within carbonate build-ups.

It is well described in literature and observed in outcrops that during sea level highstands when the entire carbonate platform were flooded, the so called "highstand shedding" occurred. It has been long recognized in Central Luconia that carbonate talus and debris accumulated at the flanks of major build-ups. However, its distance of transportation is short and hence limited in distribution aerially. Recently, with the advent of high-resolution 2D seismic data, a different type of sedimentation mechanism has been studied and mapped in Central Luconia: "carbonate turbidites" which were transported a considerable distance into adjacent basins.

These widely distributed stacked turbidites have been identified based on anomalous seismic amplitudes. These seismic anomalies can be traced back to lows and canyons on the carbonate platform, which indicates that these are indeed the seismic response of carbonate sediments sourced and shed-off from the build-ups.

During sea level highstands, high carbonate growth rate caused the steep platform margins to prograde. Significant amount of carbonate grains and "sands" accumulated on the platforms and their fringes. Occasional storm events would then transport these carbonate "sands" further into the basinal area in the form of turbidites, which have a spectacular transportation distance of more than 50 km from the source. These turbidites are generally ponded in the lows between major build-ups. Sedimentation of individual fans and units seems to be controlled by syn-sedimentary faulting within the basins.

Carbonate turbidites have been found and described in many different geologic provinces of the world. Examples stretch from the modern analogues around the Great Bahama Bank to ancient deposits in the Permian Basin of West Texas.

Paper 17

The integration of reservoir characterization and seismic study of the West Patricia field, Balingian Province, offshore Sarawak

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West Patricia field is located about 48 km NNW of Bintulu in about 40 m of water. The oil in West Patricia field was discovered by drilling West Patricia-2 well in 2000 by Murphy Sarawak Oil based on 3D seismic data. The well tested oil in B7 sand and gas in B9 sand of Cycle III interval and gas, condensate and water in C-sand of Cycle II interval. The field was further appraised by drilling West Patricia-4 and 5RD in 2001 and 2002, respectively. To date, a total of four oil reservoirs (B5.5, B7, B8.5 and B8.9 sands) and six gas reservoirs (B4, B4.2, B4.8, B5, B8 and B9 sands) were discovered in Group B interval alone within a total depth of less than 1200 m TVDSS. Murphy will proceed with the development of West Patricia in 4Q 2002 with the first oil production targeting for April, 2003.

The integrated studies in West Patricia field were conducted following the availability of more information such as conventional core data (the core was cut in B7 sand of West Patricia-4 well), hydrocarbon characterization using FMI logs calibrated to core and the seismic studies such as Spectral Decomposition Frequency and Phase Analysis. The regional geochemistry study for SK-309 and 311 which was conducted in 2000 and also geochemistry studies conducted for each well are also available but they are not part of this paper.

Core and Facies Interpretation, Log-Core calibration of B7 core, log analysis of all West Patricia wells and Geochemistry studies were all conducted by PRSS while the characterization of hydrocarbon reservoirs using FMI logs and FMI to core calibration were done by Schlumberger Data and Consulting Services. Porosity and permeability data of Routine Core Analysis and capillary pressure data of SCAL were conducted by Core Laboratory.

Paper 18

Tertiary stratigraphy, structure and tectonic evolution of Southern Sabah: implications to the tectono-stratigraphic evolution of Sabah, Malaysia

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Integrated surface mapping, dating and radar image interpretation of strata in southern Sabah, Malaysia has made it possible to revise the lithostratigraphy, chronostratigraphy, structure and tectonic evolution of the area. The recognition in the field of an Early Miocene regional unconformity, which may be equivalent to the Deep Regional Unconformity recognised offshore, has allowed the development of a stratigraphic framework of groups and formations which correspond to stages in the sedimentary basin development of the area. Below the Early Miocene unconformity the succession can be resolved into deposits of an accretionary complex of Eocene age overlying an ophiolitic basement, and late Palaeogene deep water succession which formed in a forearc basin.

The late Palaeogene deposits underwent syn-depositional deformation, including the development of extensive melanges, all of which can be demonstrated to lie below the unconformity in this area. Some localised limestone deposition occurred during the period of uplift and erosion in the Early Miocene, following which there was an influx of clastic sediments deposited in delta and pro-deltaic environments in the Middle Miocene. These deltaic to shallow marine deposits are now recognised as forming two coarsening-upward successions, mapped as the Tanjong and Kapilit Formations. Their map distribution have been revised. The total thickness of these two formations in the southern Sabah Basin amounts to 6,000 m, only half of the previous estimates.

The Tanjong and Kapilit Formations are deformed into broad NW-SE-trending synclines separated by narrow anticlines. The anticlines are sub-parallel to major faults and associated with high angle reverse faults, and positive flower structures. Secondary fold-faults formed oblique to the major faults. The structural style suggests that the NW-SE trending faults acted as major left-lateral transpressional zones. The faults may in part be reactivated basement structures. The Early Miocene unconformity is interpreted to be the result of deformation and uplift following underthrusting of continental crust of the South China Sea which terminated Paleogene subduction beneath North Borneo. Renewed subsidence is related here to rifting in the Sulu Sea which led to the development of a major Miocene depocentre above the older forearc accretionary complex. The major transpressional deformation probably occurred during the Late Pliocene, and is possibly related to propagation of deformation from Sulawesi towards NW Sabah. This strike-slip deformation which uplifted the area is termed here the Meliau Orogeny. Renewed extension during the Quaternary has caused some sequence repetition. The 'circular basins' of the Meliau, Malibau and Tidung areas, are interpreted as remnants of a single large basin, deformed in the NW-SE trending transpressional fault zones.

Paper 19

3D seismic acquisition planning, deepwater Sarawak Block F: challenges, methodology and solutions

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Following interpretation of 5,300 line km 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. Block F lies in the distal deepwater toe-thrust setting of the Upper Miocene – Pliocene Bunguran delta system and is characterised by NW-SE trending thrust-faulted anticlines associated with thin-skinned gravity tectonics. The existing 2D seismic data highlighted problems of poor sub-surface imaging associated with shallow gas, steep dips, significant out-of-plane energy on strike oriented lines and possible shale diapirism. Additionally, the data were found to be very sensitive to minor changes in stacking velocity, the trends for which were difficult to reconcile between dip and strike derived velocity analyses. Within a limited budget environment, the challenge was to design a cost-effective 3D seismic survey that could address the key uncertainties within the 2D interpretation and cover the main area of fold belt prospectivity (c. 2,000 km^2) without compromising data quality.

The acquisition planning was undertaken with input from Geophysical Operations groups in London (Amerada Hess Limited) and Paris (TotalFinaElf) along with a number of geophysical contractors. Many of the standard acquisition parameters such as source and streamer depth, source volume, cable length, record length, acquisition fold and migration aperture were designed utilising existing multi-vintage 2D data within the block. Parameters such as number of streamers and optimum weather window were based upon historical data and operating experience.

The 3D survey area design was based upon a ranking of the prospective structures identified on the 2D data. This produced a desired survey outline elongate in the NW-SE (strike) orientation. In order to acquire a survey of this nature in the most cost-effective manner it is necessary to maintain the longest average line length possible, in this case to shoot in the strike direction. To determine whether this was technically acceptable, a comparative study of dip vs. strike acquisition was undertaken along with an investigation into the characteristic ocean current behaviour in the area. The dip vs. strike acquisition study was undertaken by WesternGeco utilising 2D horizon and velocity data as the basis for the input earth model. The acquisition parameters as determined from the earlier 2D based modelling were used to simulate 3D acquisition over an area of c.1,500 km^2 within the Block F fold belt. The simulation was run for both dip and strike acquisition where fold of coverage at two main target horizons was modelled for both acquisition orientations. The illumination modelling results were then used in conjunction with the comparative costs (dip acquisition being significantly more expensive than strike due to shorter average line length) and available metocean data to determine the optimum acquisition orientation.

An additional element of pre-survey modelling was undertaken in an effort to minimise the amount of infill required during acquisition. Proprietary TotalFinaElf methodology and software were utilised to simulate 3D acquisition with varying degrees of differential feather and generate synthetic data sets containing variable fold of coverage. 3D pre-stack interpolation algorithms were tested prior to DMO/pre-stm to determine whether acquisition "holes" of varying sizes for discrete offsets could be healed via processing, instead of via the traditional method of infill during acquisition. The resulting "must infill" specifications were somewhat more relaxed than existing contract criteria, thus providing an additional cost saving opportunity without risk to the data.

Paper 20

Vitrinite reflectance analysis: minimising the errors

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Vitrinite reflectance is an optical method for assessing the thermal maturity of a rock. The technique was developed by coal petrographers in the 1930's to assess the rank of coal. The method was widely adopted during the 1970's by organic petrologists and organic geochemists as a method for determining the thermal maturity of petroleum source rocks. An accurate determination of thermal maturity is of fundamental importance in basin evaluation as it can be used to bracket episodes of hydrocarbon generation during the burial history of a source bed: revealing whether a rock is in the oil window, gas window, immature or post-mature for hydrocarbon generation. In many geological situations, vitrinite reflectance can be relied upon to make this assessment reasonably accurately. However, there are many examples in the literature where vitrinite reflectance analysis has produced misleading maturity data (Hutton and Cook, 1980; Price and Barker, 1985; Goodarzi *et al.*, 1987). The causes of these misleading data are many. The main purpose of this paper is to discuss the origin of error in vitrinite reflectance analysis, particularly with reference to SE Asian basins, and to suggest ways to minimise the errors.

Vitrinite reflectance analysis is a semi-subjective optical method for determining thermal maturity. It is measured using a high powered reflecting microscope similar to those used in ore microscopy although oil immersion objectives, rather than air, are used. The microscope is fitted with a photometer that is used to measure the amount of light reflected from the surface of a highly polished rock sample. The amount of light reflected is compared to that reflected from the surface of a standard (often sapphire) from which the reflectance of the sample can be calculated.

Vitrinite reflectance analysis is referred to as semi-subjective because although the measurement and calculation are made automatically by the photometer system, the specific part of the sample upon which to make the measurement is selected by the operator.

Vitrinite was selected by organic petrologists as an indicator of thermal maturity because it is the most abundant maceral in coals, generally has an homogenous surface, and shows a uniform, progressive change in physical and chemical properties during its maturation history all the way from peat to meta-anthracite. This progressive change during increasing maturation manifests itself as a continuous increase in reflectance of vitrinite.

Vitinite reflectance has now become so well ingrained in oil and gas exploration that the progress of hydrocarbon generation from a source rock is defined by its vitrinite reflectance. A rock is commonly described as being in the oil window if it has a vitrinite reflectance of between 0.50% and 1.30%. If the vitrinite reflectance is less than 0.50% the source rock is classified as being immature for oil generation. If the reflectance is between 1.30% and 2.00% it is considered to be in the gas window. It is therefore clear that if there are significant errors in vitrinite reflectance data then the relative state of oil and gas generation from a prospective source rock can be seriously misinterpreted. Examples of such occurrences are common in the literature, with the most common phenomena being that of vitrinite reflectance suppression. In such cases, measured reflectance values are anomalously low suggesting the rock is of much lower maturity than it truly is. If such occurrences of suppression are not recognised, poor exploration decisions could result.

The main causes of erroneous vitrinite reflectance data include one or more of the following:

- Preparation procedures.
- Varying vitrinite types and hydrogen enrichment of vitrinite.
- Interference effects of other macerals, sometimes sub-microscopic.
- Impregnation of bitumen or oil.
- Caving and additives.

Clearly, some of these causes are avoidable, bearing in mind the semi-subjective nature of vitrinite reflectance analysis. Of those not avoidable, some are recognisable and the data can be tagged as possibly suppressed. Examples of these causes, and suggestions for their avoidance, are discussed in this paper.

An example of the influence of bitumen impregnation in which a clearly suppressed vitrinite reflectance profile is demonstrated, as well as what is thought to be a representative vitrinite reflectance profile. Let's assume that this well was drilled in a high risk frontier area, and the suppressed data set was unrecognised as suppressed and thought to be valid. The next step in the exercise would likely be regional maturity modelling. In all likelihood, the modelling exercise would be calibrated on available well data as control points. In this example, this would lead not only to erroneous maturity assessments in the kitchen areas but also to erroneous estimation of timing of hydrocarbon generation relative to structure formation.

Paper 21

The influence of shallow marine depositional systems on deep water sand distribution in Brunei and the adjacent areas of Malaysia

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The distribution and reservoir potential of deep water sandstones is strongly dependent upon the sediment supply systems that deliver sand to the shelf edge. Efficient delivery occurs on numerous margins where deltas prograde to the shelf edge during sea level lowstands. Middle Miocene to Recent sedimentation on the Brunei margin has been characterised as the product of two relatively large deltaic systems, the middle Miocene – Pliocene Champion Delta of northeastern Brunei and the Pliocene – Recent Baram Delta of southwestern Brunei and Sarawak (Sandal, 1996), and progradation of both deltas to the shelf edge during sea level lowstands has been invoked as a mechanism for supplying sand to the deep sea. A recent seismic study of the Pleistocene – Recent succession of the Baram Delta in southwestern Brunei confirms that the delta progrades to the shelf during sea level lowstands (Hiscott, 2001), suggesting that sand was indeed available for delivery to the deep sea at those times both in Brunei and Sarawak; this process almost certainly occurred during the Pliocene as well.

Although only 150 km away, northeastern Brunei is very different from the Baram Delta. Whilst the Baram River drainage basin consists of a single, relatively large river that empties directly into the South China Sea on an exposed coastline, several smaller rivers with a cumulative drainage area that is significantly less than that of the Baram River debouch into the protected waters of Brunei Bay. Depositional systems within the Brunei Bay drainage basin are varied and generally are segregated into wave-dominant shorelines and tide-dominant embayments by the coastal geometry that is a product of structurally generated topography. The geographic separation of wave- and tide-dominant areas is distinctly different from the mixed wave and tide system of the modern Baram Delta as described by Lambiase *et al.* (2002).

The Brunei Bay drainage basin now occupies the same part of the margin as the former Champion Delta and several lines of evidence indicate that the Champion system was not a simple delta. The Brunei Bay drainage basin is much smaller than the Baram River drainage basin and appears incapable of depositing a delta anywhere near as large as that interpreted for the Champion system. Similarly, there is no evidence that a large river ever existed within the Brunei Bay drainage basin; all the middle Miocene and younger fluvial outcrops are the deposits of several relatively small rivers. Also, integrated outcrop and subsurface studies indicate that the Champion system was a complex depocentre comprising the same wide variety of depositional environments, with the same wave-dominant and tide-dominant facies associations, as the modern Brunei Bay drainage basin and that, as in the modern system, structurally generated topography controlled facies distribution.

One aspect of the structural control on topography, and hence facies, is that the number of rivers reaching the shoreline, and their locations, changed frequently

because subsiding synclines, episodically active shale-cored ridges and growth faults created an evolving topography. This process is well illustrated by the Pliocene – Recent history of the Brunei Bay drainage basin. The distribution of fluvial outcrops within the drainage basin suggests that prior to the mid-Pliocene(?), two of the major rivers that now flow into Brunei Bay followed much different pathways. The Limbang River apparently flowed northward along the axis of the Berakas Syncline and, after depositing the fluvial sandstones that crop out along the Brunei coast, turned sharply to the east because it was captured by the onset of the latest, ongoing episode of subsidence in Brunei Bay. Similarly, the Padas River formerly flowed to the northwest across what is now the Klias Ridge and was deflected southward into Brunei Bay by a combination of renewed subsidence in the bay and uplift on the Klias Ridge.

The shifting sediment supply routes resulted in a highly variable sand supply to the shelf edge during sea level lowstands. At times when all the rivers in the drainage area coalesced before reaching the shore of the South China Sea, a delta smaller than the modern Baram Delta supplied moderate amounts of sand to one location on the shelf edge. At other times, multiple, but even smaller, deltas distributed an equivalent volume of sand over a wider area. During some lowstands, very little, if any, sand reached the deep sea because most was trapped in rapidly subsiding depocentres on the shelf. The present-day Brunei Bay is an example of this last scenario. If sea level were to fall, no sand could reach the shelf edge until the bay first filled with sediment. This appears unlikely because the bay is subsiding rapidly enough to maintain water depths in excessive of 50 m deep despite a relatively high sediment influx from several rivers. Consequently, all sand would be deposited within Brunei Bay, as apparently happened during the last Pleistocene sea level lowstand (Abdul Razak Damit, 2001). Consequently, the deep water sand accumulations sourced from the Champion system are expected to be smaller and more scattered, both spatially and temporally, than those deposited by a large shelf edge delta. Successful prospecting will require careful analysis of the supply system on the shelf.

In conclusion, the distribution and character of potential reservoir sands in the deep water areas of Brunei and immediately adjacent Malaysia is strongly controlled by sedimentary processes on the shelf. It is expected that progradation of the Baram Delta to the shelf edge sourced larger, more abundant accumulations of sand than the smaller, more complex supply systems of the Brunei Bay drainage basin and that this will be reflected in the relative reservoir potential of the two areas.

Paper 22

Geology and petroleum systems of the Eastern Meseta and Atlas Domains of Morocco

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Morocco (Maghreb), located in Northwest Africa, has three main structural domains: The (a) Rif Domain, the (b) Atlas Domain comprising two different structural regions, the relatively stable eastern and western Meseta, (characterized by mildly deformed Mesozoic strata) and the active Middle–High Atlas Belts, where the Meso-Cenozoic section was highly folded during the Alpine orogeny; and finally, the (c) Sahara-Anti Atlas Domain at the south, marks the stable margin of the West African Craton. The eastern Meseta, with the Middle and the High Atlas chains (Atlas Domain *ss.*) is the objective of our study; it extends eastward through Algeria. The Middle Atlas and the High Atlas tectonic belts frame the Meseta.

The Cambrian marine transgression over the northwestern African continental platform allowed deposition of shales, silts and sands over a faulted land surface. Folding at the Late Cambrian generated an irregular angular unconformity with the Ordovician sequence. This sequence, dominantly argillaceous at the beginning, ended with a regressive phase of glacio-marine sedimentation that developed coarse sandstones and micro-conglomerate. Volcanic eruptions caused localised metamorphism. The Ordovician ended with regression due to the emergence of the area (Taconic phase). Glacio-eustatism followed, leading to the widespread Silurian deposits of graptolite-bearing black clays in shallow marine, confined (euxinic) troughs. During the Lower and the Middle Devonian, basins developed with flysch deposits. Black shales of Lower Devonian are exposed only in the northeast of the Middle Atlas. The Upper Devonian experienced the transpression and shutting down of the basins. A generalized decollement of the Devonian series seem to have occurred during the Bretonian and the Sudetian folding phases. Nappes of these series are well exposed in the southwest of the Middle Atlas. In the High Atlas, Devonian reef limestones crop out as a carbonate platform.

At Early Carboniferous, the area underwent extension and basin formation along N70° faults. The deposits were mainly marine, giving way to thick, non-marine, conglomeratic and locally coal-bearing intramontane basins in the Late Carboniferous. In the Tendrara Basin, four wells reached the Visean and Namurian, which are composed of black shales, marls with calcareous intervals and volcanic intrusives. In Missour Basin, one well penetrated the Westphalian, represented by alternating beds of conglomerates, micro-conglomerates, silty–sandy shale with thin coal horizons, and the Namurian, represented by shales, silty shales and sandstones. At the end of the Carboniferous, folding and uplifting of the terranes led to erosion and hence, angular unconformity over the whole Morocco. The Upper Triassic sediments begin with a fining upward sequence of basal conglomerates, sandstones, siltstones and shales of fluvial to shallow water environments, submitted to periodic emergences. Missour basin to the West shows more than 636 m of basal sequence in TT-1 well, compared to Tendrara basin to the East with 272 m in TE-1 well. This westward thickening of the basal Triassic sequence could be due to the proximity of Missour area to the source of the continentally derived clastics. In the Late Triassic to Early Jurassic, thick salt with interbedded shales and silts show that the area was more or less closed off from the open sea that periodically supplied with salt water. Regionally widespread and continuous basalt flows lie within the evaporite sequence reflecting the onset of rifting within the Atlas Domain, contemporaneous to the opening of the Atlantic Ocean.

During Early Lias, a marine transgression abruptly changed deposition of lagoonal-clastic sediments to marine carbonates, while some isles remained emerged surrounded with deposits of red clays and anhydrite. During the Middle Lias, the carbonate platform broke down and variable environments with facies deposits changes came into existence: bituminous deep marine limestones alternating with marls suggest that sedimentation took place under more or less euxinic conditions (Issouka Area). Slope deposits, with reef complexes formed along the edges of the Atlas troughs edges. At Late Lias tectonic movement leading to uplift of the western Middle Atlas and the Meseta, while at the same time subsidence occurred in the Atlas troughs. This tectonic instability continued through the Middle Jurassic (Aalenian-Bajocian) with more subsidence of the troughs (Boulemane marls) and development of carbonate platform in the Meseta. The end of Middle Jurassic time (Bathonian) is marked by a tectonic uplift and regression of the Tethys towards the north. Continental deposition in the south, deltaic and turbiditic in the north, were interrupted, during the Upper Jurassic, by the emplacement of a carbonate platform.

At Cenomanian the sea invaded the area developing bituminous shales in sub basins, as well as carbonates and sandstones, which were unconformably deposited over the Jurassic sequence. Slow subsidence rate, resulted in thin sedimentary sequences at the close of the Mesozoic Era. Alpine tectonic activity in the mobile atlas belts began to play an increasingly important role in shaping future sedimentary environments.

During the Tertiary, erosion of newly formed relief fed the Neogene basins and the tabular areas depositing conglomerates, siltstones, marls and limestones.

The area was affected by three main orogenic phases:

- Hercynian Orogeny: from Upper Devonian to Carboniferous. The regional compression is related to Gondwana and Laurasia collision. NE-SW and E-W are the main fault trends in the area. Thrust, nappes, granite intrusives, and volcanic extrusives, are the main structural events during this orogeny. In some basins, sedimentation was contemporaneous with folding, creating a series of piggy-back basins.
- During Triassic-Early Jurassic time, Northwest-Southeast extension, related to the formation of the North and Central Atlantic, gave rise to the intra-continental High and Middle Atlas rift trends that appear to be superimposed on Hercynian structural discontinuities. This extensional stress regime also created listric normal faults facillitating long-term subsidence along the margins of the Meseta. Its effect within the interior of the Meseta manifested as macro-tensional gashes (Jebel Missour graben) and minor normal faults. The Middle and High Atlas developed as regional grabens (aulacogens). The Middle Atlas was a mega-tensional gash in the transfer region between two easterly striking sinistral transform faults in Northwestern Africa.
- Late Jurassic to Early Cretaceous time marked the final infilling of the Atlas rift systems. Mild transtensional stresses (associated with oblique left-lateral collision of Northwest Africa and the Iberia Peninsula) may have been the mechanism that initiated movement of the salt. The main phase of post-salt folding and faulting took place, however, during later times when the Atlas domain was experiencing true structural inversion.
- From Early Cretaceous through Tertiary and Quaternary time, the relative motion between Northwest Africa and the Iberia Peninsula changed from oblique left-lateral transtensional to oblique right-lateral transpressional to compressional.

Structural inversion of the Atlas troughs commenced during the Late Cretaceous and continued throughout the Tertiary and Quaternary. The Meseta and the west of the Middle Atlas behaved as stable blocks and were thus only slightly affected.

Reactivation of normal faults and decollement within the salt and salt movements were the main responses.

Two petroleum systems were defined in the Atlas Domain *sensu stricto*:

- The Palaeozoic-Triassic Petroleum System, where the source rock could be of Silurian, and/or Carboniferous age. The Silurian source rock, as encountered in the Tadla basin, is represented by type II–III but dominantly type II hot shales (known by their high Gamma Ray Response) which range from immature to overmature states. The Namurian shales in the Meseta (Missour and Tendrara basins) are marginally mature to overmature. The Westphalian source rock, encountered in the Missour basin has TOCs between 1% in the shales and 79% in the coals. The S2 is higher than 5 mg/g and the maturation rate is within oil window. The different stages of maturation registered in both the Carboniferous and Silurian are due to the complexity of structuration (thrusting, underthrusting), hot spots, granite intrusion and difference of subsidence rates half grabens compared to those in the ponded basins, and other factors.

The main reservoirs are the basal Triassic and Carboniferous clastics sealed respectively by salt and shales. Traps are mainly structural for the Carboniferous and structural and stratigraphic for the Triassic.

- The Jurassic Petroleum System is characterized by Lower Jurassic (Domerian) rich, marine type II source rock. Lower Lias carbonates and Dogger sandstones and carbonates represent the reservoirs. Traps are structural, formed contemporaneously with the Atlas Tectonic Inversion, and stratigraphic (reefs). They could be attractive in the area because, wherever adequately explored in Morocco, oil and gas was produced from these reservoirs. Even though the Jurassic is outcropping, production of oil and gas occurred in various compartmentalized Jurassic intervals, ranging from Domerian to Toarcian and Dogger, in the pre-Rif ridges of the Rif Domain.

Paper 23

AVO, rock properties and pitfalls

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In recent years, Angle Dependent Reflection Coefficient or in short "AVO" has had considerable success in locating hydrocarbons, particularly gas. However, there has also been some glaring failures which has turned some explorers to have a somewhat skeptical approach towards the application of AVO for prospect evaluation. We believe that some of the pitfalls in interpreting AVO responses are not well understood or at the best not anticipated.

Traditionally the approach in industry towards AVO has been more of one from a seismic data processing standpoint only. The important connection with Rock Properties has been somewhat missing. This paper reviews this missing link and provides a workflow for AVO analysis and develops some guidelines.

The interpretational aspects of AVO is stressed. Modelling plays a keyrole in understanding the AVO behaviour and DSI shear log information is a must. Trend curves, for the important basins we are exploring in, helps a long way in decoding the elusive AVO response and relates it to lithological or porefill changes.

Finally, it is stressed that AVO should be seen more as one of the many variables that has to be considered in drilling a prospect. It is definitely a risk reducer that can enhance our overall chances of exploration success.

Paper 24

The pink fan: a classic deepmarine canyon-fill complex, Block G, NW Sabah

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The key risks for exploration in deepwater basins are reservoir, hydrocarbon charge and trap retention. Over the last two years SSPC's deepwater asset team has made a concerted effort to de-risk the NW Sabah deepwater prospect portfolio through large-scale 3D seismic acquisition, integrated basin analysis studies, green-field exploration and deepwater field appraisal. This evaluation is allowing the main deepwater turbidite fan systems to be slowly unraveled and will in the future turn NW Sabah a classic area for the study of passive margin deepwater sedimentation.

The NW Sabah basin has a surprisingly rich sand fairway, with at least four fan depositional cycles being recognised within the Upper Miocene stratigraphy between 10.6 and 6.7 Tertiary boundaries, TB3.1–3.3, all coincident with uplift and erosion of the main Sabah Massif. The thickest and best known fans are those of the Kebabangan, Kinarut and Kamunsu, all named after the wells which discovered them.

The pink fan is the last of the major sand-prone Upper Miocene fans deposited in the Kamunsu basin and was deposited the furthest outboard, partly in response to the relentless progradation of the shelf edge across the passive Sabah margin and partly due to local tectonics which strongly influenced the contemporaneous seafloor profile. The older fan units within this tectonically active basin are all disconnected from their slope feeders by faulting and erosion. In the past, this hindered reservoir prediction and the generation of viable palaeogeographical reconstructions. The pink fan is still connected to its feeder canyon and, best of all, has been drilled twice in recent years. This well data in combination with detailed seismic evaluation has enabled the unraveling of this confined fan unit to a degree not yet achievable within the other major fans.

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ABSTRACTS OF POSTERS

Poster 1

Facies organization and depositional environments of some selected outcrops of Sandakan Formation (Upper Miocene), Sandakan, Sabah

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This paper discusses sedimentological aspects of fieldwork carried out at several localities in central Sabah Sub-basin, the onshore extension of the offshore Sandakan Sub-basin, which contains several hydrocarbon-bearing reservoirs. The sedimentology and facies organization of several well-exposed successions of the Sandakan Formation and the interpretations of their depositional environments are described.

The study area is situated within the NE Sabah basin, which is located along the east coast of Sabah. This basin has been divided into the Central Sabah Sub-basin and the Sandakan Sub-basin (Leong and Azlina Anuar, 1999). The sedimentary succession within the basin has been dated to be of Miocene to Pliocene in age, and can be found exposed in the Sandakan Peninsula and the Dent Peninsula, which lie between Labuk Bay and Darvel Bay.

In the low-lying areas south of Sandakan town, roadcuts along a new bypass road from Jalan Ulu Batu Sapi to Kampong Bahagia expose several thick, well-preserved outcrops of mud-dominated, sand-shale successions. The background shale is dark gray to black in color; the sandstones are irregularly thin-bedded, characteristically channelised layers. The sandstone Layers are interpreted as load cast or gutter cast formed by wave scour on shelf mudstone bed.

Near the hilltop army barracks along Jalan Thunyne, Taman Samudera, thick hummocky cross-stratified sandstones are found interbedded with thin shale. These fine to very fine-grained sandstones have been interpreted as storm deposits, and they represent part of a prograding storm-dominated shorefaces. Two large and very thick, coarsening-upward sandstone-shale successions occur at the hilltop areas near the IOI Oil Mill–Kampong Bahagia site and along Cecily Road. Both hill-cut outcrops display similar facies organization. At the Cecily Road outcrop, more than 100 meters of upward — coarsening, upward-sanding coal-shale-sandstone successions are exposed.

The succession can be separated into three units:

i) Lower Unit- this is a coal-bearing, mud-dominated sequence. The base comprises of laminated to lenticular-bedded, brownish gray mudstone with large, cobble-sized coalified wood fragments, capped by two, thin layers of coal. The upper part of the unit is marked by the presence of thicker, wavy- to flaser-bedded sandstones and rippled sandstone lenses, encased in flaky, carbonaceous mudstone. Plants debris are found scattered within the unit. This unit probably represents a lagoonal-estuarine deposit with a well-developed swamp.

ii) Middle Unit- this unit is a thick, sandstone-shale succession punctuated with several thick, trough cross-bedded sandstone. The interbedded sandstones are wavy- to flaser-beded, with well-developed mud-drapes while the mudstones are laminated to lenticular bedded. They both represent deposition in a broad tidal flat environment. The thick, trough cross-bedded sandstones are sub-tidal, channelised deposits.

iii) Top Unit- this uppermost unit is dominated by thick (50-200 cm) clean, cross-bedded sandstones, frequently displaying rippled top. These sandstones possibly represent a broad sandy tidal flat environment, most likely with some fluvial influence.

The geographic locations of the outcrops and the structural geology of Sandakan Formation imply a simple organization for the different outcrops. The thick mudstone unit with ubiquitous presence of gutter cast sandstone lenses represents the lower part of the investigated Sandakan Formation. This unit may be succeeded in places by thick, hummocky sandstones. The tide-dominated, lagoonal-estuarine and tidal flat deposits of Cecily Road and IOI-Kg Bahagia represent the uppermost part of the succession. The organization of the different sedimentary facies of the Sandakan Formation suggest a gradual, upward-shallowing of the environment and a marked change in the depositional regime: a change from a lower shoreface to shoreface, wave- and storm-dominated environment to a tide-dominated, lagoonal-estuarine to tidal flat environment with appreciable fluvial influence.

Poster 2

Reservoir and fault delineations using Spectral Decomposition in West Patricia Field, offshore Sarawak

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The West Patricia Field is located approximately 40 km north of Bintulu, in the Balingian Province, Offshore Sarawak. The major reservoirs in the field comprise of Early to Middle Miocene Cycle III sandstones. These reservoirs are interpreted to be deposited by fluvial/deltaic distributary channels in a lower coastal plain environment. The resultant channel sands are generally thin (~ 10 m thick) and laterally variable, reflecting the rapid changes associated with meandering channels. Structurally, West Patricia field has undergone at least three major tectonic phases, and this is reflected by the complex fault patterns that dissect the field today. Following early rifting (major normal faults), the structure underwent transpression and inversion that resulted in a series of reverse and normal faults. This was subsequently followed by a phase of structural relaxation that produced intensed normal faultings.

To image the complex stratigraphy and faulting, 3D seismic data was acquired in West Patricia in mid-2000. However, the presence of intense faulting, shallow reefs and gas clouds resulted in poorer than expected data quality especially at the crest. Efforts are currently underway to improve the data quality through seismic reprocessing. In parallel, new ways of interpretation are being adopted. One of these is the use of frequency and phase domain interpretation using Spectral Decomposition (SpecDecomp™) technology. SpecDecomp™ works by transforming the seismic data via a Discrete Fourier Transform (DFT) into the frequency domain. The transformed (phase independent) amplitude spectra is utilized to delineate temporal bed thickness variability, while the phase spectra is used to indicate lateral geologic discontinuities. The theory behind this analysis is that a reflection from a thin bed has a characteristic expression in the frequency domain. This characteristic is indicative of the temporal bed thickness and can be resolved below one fourth of a wavelength.

This poster would describe and discuss the results observed from the application of spectral decomposition technology in West Patricia.

Poster 3

Extreme simulation: successful application of parallel VIP in complex reservoir environment

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Production & Business Management Systems
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From the beginning of reservoir simulation the goal has been to rigorously simulate all relevant physics and geology such as results from the models would accurately predict the future. Unfortunately, this has often not been the case. Compromises were required due to limitations of computer hardware, field data and simulator rigor. The introduction of inexpensive commodity parallel computer hardware has significantly increased the power of the tools available to the engineer so that he is now able to address the extreme challenges of simulation: field-wide simulation at the geological model scale and tight coupling of the surface network with the reservoir simulator.

Examples of the successful application of Parallel VIP will be represented: a field-wide simulation of a retrograde condensate field at the scale of the geological model and a multi-reservoir compositional study including the effect of regional surface facilities on production.

Poster 4

Seismically constrained reservoir modeling: the E8 gas field, offshore Sarawak, Malaysia

UPDESH SINGH, PETER DUINDAM, CHARLIE ASH AND MAH KOK GIN
Sarawak Shell Berhad

The E8 gas field, located in the Central Luconia province, offshore Sarawak, Malaysia, is currently at field development planning stage, with first gas planned for 2006. It comprises two carbonate reefal buildups of Middle Miocene age, a southern steep-sided pinnacle type and a northern lower relief platform type separated by a saddle area. The E8 field has expectation GIIP of some 2.5 Tscf with only 3 well penetrations but a good 3D seismic coverage. Some of the key subsurface uncertainties in the E8 field which impact field development are GIIP, reservoir permeability and aquifer strength. Multiple subsurface realizations were generated in GEOCAP to capture the range in these uncertainties. This was achieved by the integration of well and seismic data including the use of sparse spike and stochastic seismic inversion techniques.

The volumetric assessment of the various GEOCAP realisations showed that the uncertainties in reservoir properties have a relatively minor impact on GIIP, with the main uncertainty being the structural geometry. This is contributed by uncertainty in top carbonate definition at the flanks with stringer development and the saddle area. An important control on reservoir permeability is the presence and distribution of dolomite within the reservoir. The dolomite appears to be related to 4^{th} and 5^{th} order sequence boundaries. Various models were generated to capture the uncertainty in dolomite distribution; well-based models with dolomite layers modelled as correlatable units or as more restricted well bodies, and models based on stochastic inversion of the seismic data.

The reservoir permeability impacts the number of wells required, with the extensive high permeability scenario resulting in a reduction in well numbers to meet capacity. Although available well data suggest an absence of extensive fractures in E8, the presence of potential fractures within the tight aquifer section was modeled to study impact on production behaviour. Dynamic simulation results based on the multiple realisations suggest that the E8 field essentially behaves as a depletion drive reservoir with little water production during production life.

Poster 5

Fluid inclusion screening of Central Luconia carbonates — follow up 2002

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A pilot study had been carried out using 8 wells as a calibration set in 2001, results were presented at the 2001 GSM conference. Clear indications for top seal failure, lateral seal failure and the liquid content of the gas had been observed and reasons for failure of dry wells were established. Given these encouraging findings a follow up study was initiated. Results of this work will be presented and discussed.

Fluid inclusion screening 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. This 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 quite a number of structures were dry and nearby structures, in a similar geological setting, were gas-bearing. For the ongoing carbonate evaluation it is important to know if structures are dry due to "lack of charge" or due to "retention failure". This technique can provide a quick and cheap way to resolve some of these questions.

Poster 6

Play inventory in Straits of Melaka based on Blocks PM320 and PM322 evaluation

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Straits of Melaka has long been overshadowed by its hydrocarbon-rich sister fields in the Northern and Central areas, located barely 150 km away. Previous conceptual plays rely predominantly on fundamental hydrocarbon play concepts of 4-way dip closures with interpretations based on paper sections. With the advent of newer seismic lines, crispier processing techniques, interpretations of digitized lines in a workstation environment, and more importantly, fresh conceptual hydrocarbon play concepts, hydrocarbon prospectivity in the Straits of Malacca might yet to see the light of day.

Block PM320 is situated on the northwestern flank of Straits of Melaka and constitutes a shelfal extension of the North Sumatra Basin (NSB). 4 wells drilled in the 80s' pursued the Basement High Plays, which focused primarily on topographical highs with pinnacle reefal carbonates. With the exception of Singa Besar-1 which discovered 3.7 mmscfMMSCF of gas with 38% CO_2 content, all other wells have been dry. New play generation requires identifying the pinch-out onlapping trap of the TB2.2/2.3 onto Pre-Tertiary dolomitic basement, which is time equivalent to the prolific Baong Formation and is the primary reservoir for the gas fields in the NSB. The TB2.2/2.3 pinch-out trap focuses on the stratigraphic element, which was never previously pursued. Current evaluations have yielded the Temenggung lead, which has a potential sizeable closure of 77 km^2 with an estimated 50 bscf GIIP.

Block PM322 is located on the eastern margin of the Central Sumatra Basin (CSB). In an otherwise featureless province dominated by shallow basement, PM322 is highlighted by 5 grabens (Sabak, Angsa, Port Klang, Johor and Kukup), each of which is generally characterised by steep-dipped flanks and gently-sloped flanks. As such, each graben necessitates its own self-sustaining petroleum system in order to establish its own hydrocarbon potential, and Angsa Graben holds the highest potential for hydrocarbon prospectivity due to its depth and size. New play concepts revolves around the identification of stratigraphic alluvial fan play, and onlap trap of Sequence 3 onto basement and fault intersection trap configuration. Alluvial fan is a synsedimentary deposit via gravity transport during the conception of the graben in the Eocene, and this play relies on onlap traps with lateral sealing provided by lacustrine shales. Potential trapping configuration for Sequence 3, a lacustrine fluvial-deltaic sands, relies for the sequence to onlap against Pre-Tertiary recrystallized limestone. Another potential trap is the fault dependent closures that segments the objective sequence.

Recent seismic acquisition has provided better seismic resolution that has revealed in greater detail of the complex geological structuration due to transtensional tectonical regime which was not apparent on the older 2D paper sections. Limited by 2D coverage in a sparse grid, new identified plays are exciting but remain conceptual. 3D is the way forward in firming up the conceptual hydrocarbon plays.

Poster 7

Exploration opportunities in Malaysia

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EXPLORATION AND DEVELOPMENT HISTORY

Prior to 1976, oil companies in Malaysia operated under a concession system. PETRONAS was formed as a result of the Petroleum Development Act (PDA) in 1974, and took over as the sole custodian of all petroleum resources in Malaysia. Production Sharing Contract (PSC) terms were introduced in 1976. In 1985, new PSC Terms were introduced primarily to attract more foreign investments to explore for oil and gas resources. The 1985 PSC terms offered a better profit split for the contractor. With the push towards deepwater exploration, PETRONAS introduced a Deepwater PSC in 1992 specifically designed to accelerate exploration in deeper waters (beyond 200 m). In 1997, a more liberal petroleum arrangement was introduced. The 1997 R/C PSC is a self-adjusting formula of cumulative revenue/cumulative cost designed to provide incentives to develop smaller oil and gas discoveries. As of 1.1.2002 about 1.3 million line-km of 3D seismic and 642,000 line-km of 2D seismic has been acquired in Malaysia. A total of 956 exploration wells have been drilled from 1962 to 2001. Since the inception of the latest R/C PSC arrangement in 1997, there is a marked increase in exploration drilling and seismic activities. In 2002 we are planning to drill 47 exploration wildcat and appraisal wells and shoot a total of 187,000 line km of both 2D and 3D seismic. There are currently 44 producing oil fields and 11 producing gas fields and several others are under development. These oil and gas fields produce about 600,000 barrels of oil per day and 5.5 billion cubic feet of gas per day respectively. The nation's oil and gas reserves stood at 3.4 billion barrels and 82.5 trillion cubic feet respectively as of 1 January 2001.

PETROLEUM GEOLOGY OVERVIEW

Peninsular Malaysia Region

There are four basins in the Peninsular Malaysia region. The Malay Basin and the Penyu Basin are located offshore to the east of the peninsular. The other two basins, namely the Central Sumatra Basin and the North Sumatra Basin lie to the west of the peninsular and are mostly offshore with a small portion lying onshore. The Malay Basin contains about 12-km thick Neogene sediments that were deposited within the non-marine to shallow marine environment. Reservoirs consist of channel bodies, stack bar sands and braided stream deposits. Significant oil and gas discoveries have been made from all three reservoir types. Deep geo-pressure play in the northern region promises to be the trend of the future. In the Penyu Basin, oil has been discovered on horst blocks of Oligocene synrift play consisting of fluvial sandstones reservoirs. Other objective targets are of Miocene post-rift play. Oligocene synrift play also form the main play for the Straits of Melaka Basins

Sabah Region

There are three major basins in Sabah. The Sabah Basin, which is located in the NW Sabah, is mainly offshore while the other two basins cover some areas in the N.E. and S.E. of onshore Sabah. The Sabah Basin contains 12-km thick Neogene sediments that were deposited within the deep marine and progradational shelf slope environment. Reservoirs consist of channel bodies, shallow marine clastics and deepwater turbidite. Significant oil and gas discoveries have been made from deepwater channel and fans and promise to be the trend in the future. Although exploration activities have been sparse in the Northeast Sabah Basin, minor oil and gas discoveries have been found in the deltaic sandstones. Other objective targets are deepwater fans and possibly carbonate build-ups. The Southeast Sabah Basin objectives intervals are of the fluviatile and estuarine sandstones.

Sarawak Region

The Sarawak Basin covers a wide area both onshore and offshore the State of Sarawak that has been divided into geological provinces, namely the West Baram Delta, Balingian, Central Luconia, Tinjar, Tatau, West Luconia and SW Luconia and SW Sarawak Provinces. Exploration activities have been more intensive in the West Baram Delta, Central Luconia and Balingian Provinces, although the other provinces have been explored to some extent and have fair share of seismic acquisition and exploration drilling. Hydrocarbon has been found in all provinces. The main drilling objectives in Sarawak Basin, among others, range from the Oligocene-Miocene coastal to nearshore sandstone in structural traps in Balingian Province, Miocene reefal carbonate in Central Luconia Province to Miocene Deltaic sandstones Baram Delta Province. The sedimentary succession on the Sarawak Basin shelf is in excess of 12 km thick. Recently, renewed interest in the prospectivity of the West Luconia Province and the north portion of the Central Luconia Province (including deepwater area) has seen a rise in exploration activities. Except for the northern part, the onshore Tinjar Province has seen relatively sparse exploration activities. However, in view of the recent gravity/magnetics survey and also the interpretation of SAR data in the area, exploration works are set to increase.

OFFERED ACREAGES

There are currently several open blocks available for data review for all interested oil companies in all the three regions. These open blocks offer wide-ranging exploration opportunities. The mature shallow water blocks emphasis on exploration of new subtle and higher risk playtypes. In the deepwater blocks Sarawak open area, PETRONAS is actively seeking new investment and is currently planning two multiclient 3D surveys. There are also exploration opportunities in the "virgin" onshore blocks in Sarawak and Sabah where tremendous exploration opportunities still exist as evident from newly acquired and existing data.

PETRONAS maintains an open file system for all exploration data in Malaysia. Data of all open exploration acreage is available for review by interested oil companies without charge all year round. Upon completion of the data review, the companies are required to submit a written report on the assessment of the review blocks or area. Interested companies may propose for any of the open area with suitable minimum work and financial commitment for PETRONAS considerations.

Poster 8

Facies analysis and paleogeographic implication of the Jelai Formation (Middle-Upper Triassic), Central basin of Peninsular Malaysia

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The axial Malayan province comprises four major formations that include: the Jelai formation, Jurong formation, Kerdau formation, Gunong Rabong formation and the Semanggol formation.

Over the years, a detailed sedimentologic study of the Jelai formation is still missing except for some work on paleontology and superficial lithologic description previously provided.

The present sedimentological study of the Jelai formation in the central basin of Peninsular Malaysia indicated that deposition took place in shallow water conditions. A non-marine environment represented by the Benta conglomerate indicates a distinct alluvial environment not belonging to the Jelai formation. Paleontologic data revealed the presence of Costatoria sp (myophoria facies) which is a bivalve of shallow water marine zone. Trace fossils such as cruziana has been found in mudstones in the following areas: Kuala Lipis, Temerloh and Segamat. In addition, plant fossils have been found in tuffaceous sandstone and mudstone both in the Temerloh area. As a result, cruziana and plant fossils are both clues of shallow water environment. Scanning electron microscopy of clay samples indicated that quartz (SiO_2), orthoclase ($KAlSi_3O_8$) and zircon ($ZrSiO_4$) are major components associated with the clay minerals. Fluorine, titanium, carbon are accessory chemical elements. Iron oxides are also present.

X-ray diffraction (XRD) revealed the following main clay minerals: illite, montmorillonite and kaolinite whereas gypsum, pyrite are also present. High proportion of quartz in clay samples has been noticed both by grain size analysis and XRD. This indicates a shoreline proximity of the Jelai formation. Petrographic study of arenite (sandstone) showed six distinct facies:

1. Medium to coarse-grained sandstone, ferruginous, poorly sorted with abundant rock fragments, containing quartz, trace of mica, plagioclase grains which are mostly altered, and trace of orthoclase. Grain size varying from 0.25 to 1 mm.
2. Fine to medium-grained sandstone, argillaceous, moderately to well sorted, containing quartz, muscovite, trace of orthoclase, little amount of plagioclase and biotite, iron oxides, and rock fragments. Grain size varying from 0.12 to 0.5 mm.
3. Coarse-grained sandstone, argillaceous, strongly bioturbated, containing quartz grains and convolute lamination.
4. Medium-grained sandstone, tuffaceous, moderately to poorly sorted. This facies contains quartz grains, feldspar and fragments of quartzite and glass.
5. Fine-grained sandstone, poorly to moderately sorted, containing quartz grains, feldspar, muscovite, clay minerals and coal fragments.
6. Quartzite, containing quartz, feldspar and trace of iron oxides.

Petrographic study of rudite (conglomerate and breccia) indicated five distinct facies:

1. Sheared sedimentary breccia (olistostrome), containing fragments cemented by iron oxides. Mineralogy showed the presence of quartz, feldspar, altered mica, and abundant rock fragments.
2. Conglomerate, containing quartz, altered muscovite, rock fragments cemented by iron oxides.
3. Conglomerate, containing quartz clasts, abundant rock fragments, roots, wood fragments and sand lenses.
4. Vein breccia, containing quartz and fragments of quartzite embedded in an iron groundmass.
5. Breccia, containing subangular quartz grains, quartzite fragments and volcanic pieces of rock.

Petrographic study of lutite led to four distinct facies:

1. Pebbly mudstone
2. Laminated claystone
3. Black shale
4. Massive to bedded mudstone

The volcanic facies in the Jelai formation is mostly represented by tuffs found in Benta and Temerloh.

Facies distribution shows that sandstone facies occurs in the central and northeastern part of Kuala Lipis. This facies becomes bioturbated and tuffaceous in Temerloh. Quartzite appears in Segamat only.

Conglomerate appears in the northeastern part whereas olistostrome is seen in the southwestern part of Kuala Lipis. Pebbly mudstone is found in Kuala Lipis town and the northern side. Black shale outcrops in Kuala Lipis and Temerloh. Breccia is seen in Segamat whereas tuffs occur in Benta and Temerloh. The tectonic behaviour of the study area showed proof of landslides producing olistostrome. Flexure folding, microfaulting, thrust faulting and compressional stresses have been noticed. Shearing mechanism is obvious in Segamat, Kuala Lipis and Malacca and their suroundings. Volcanic activity has affected the Triassic sediments (Jelai formation).

Poster 9

Structural style, Tertiary stratigraphy and basin evolution of southern Sabah: implications to the tectonic evolution and sedimentation of Sabah, Malaysia

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The Southern Sabah Basin is located in the south-central part of Sabah, Malaysia, and includes the enigmatic 'circular basins' of Sabah. The Oligocene-Neogene sedimentary rocks in this basin were studied by surface mapping and SAR image interpretation. A new geological map covers an area of approximately 10,000 km^2 of the region has been produced, with a new Neogene stratigraphy and structural interpretation. A new Cenozoic tectono-stratigraphic evolutionary model for this region is proposed as a result of the study.

Mesozoic ophiolitic basement rocks are unconformably overlain by Upper Cretaceous to Middle Eocene deep marine turbidites of the Sapulut Formation. These are succeeded by the Labang and Kuamut Formations (Kinabatangan Group) which are deep water turbidites deposited between the Late Eocene to Early Miocene. The Labang Formation shows evidence of several deformation events. There are abundant syn-depositional and syn-diagenetic extensional faults, but also evidence of several phases of folding. The Kuamut Formation includes deep-water sedimentary rocks which are chaotically deformed mud-rich blocky melanges and mudstone-dominated brittle faulted rocks. The two formations are interpreted to include subduction-related tectonic melanges, olistostromes and mud-rich diapirs representing different structural positions in an accretionary wedge. Much of the deformation of the Labang and Kuamut Formations is interpreted to have occurred in a forearc region.

There is an important unconformity between the Labang/Kuamut Formations and younger rocks which represents a period of deformation, major uplift and erosion, followed by subsidence and sedimentation of the Serudong Group. The deformation event corresponds to the Sabah Orogeny of Hutchison (1996) and is Early Miocene (NN2-NN3). The unconformity is well dated by nannofossils and foraminifera and is older than previously suggested; it is interpreted to correlate with the deep regional unconformity (DRU) of offshore NW Sabah.

The Serudong Group includes local Burdigalian marine carbonates, and the Tanjong, Kalabakan, Kapilit and Simengaris Formations which were deposited in a large fluvio-deltaic system prograding towards the ENE. The Tanjong and Kalabakan Formations were deposited in the Late Early to Middle Miocene and are succeeded by the Middle to Upper Miocene Kapilit Formation. The Tanjong and Kapilit Formations each contain two upwardly coarsening megasequences, which comprise a lower mudstone and siltstone dominated sequence (Unit I), overlain by a sandstone and mudstone dominated sequence with some coal beds (Unit II). The Kalabakan Formation is dominated by shallow marine to shelf mudstones and is the distal equivalent of the Tanjong Formation. The Kapilit Formation was deposited above the Tanjong Formation after a major transgressive event; an important deeply incised erosional surface marks the boundary between them. This is correlated with the Intermediate Regional Unconformity (IRU) of offshore Sabah. The Simengaris Formation is unconformable upon the older formations and was deposited during the latest Miocene to early Pliocene, and this unconformity is correlated with the Shallow Regional Unconformity (SRU) of offshore Sabah.

Syndepositional structures in the Miocene sediments indicate subsidence and regional extension in a NW-SE direction. The Tanjong and Kapilit Formations are deformed by broad NW-SE-trending synclines separated by narrow anticlines. The anticlines are sub-parallel to major faults and associated with high angle reverse faults, and positive flower structures. Secondary fold-faults formed oblique to the major faults. The structural style suggests that the NW-SE trending faults acted as major left-lateral transpressional zones. The faults may in part be reactivated basement structures.

The Early Miocene unconformity is interpreted to be the result of deformation and uplift following underthrusting of continental crust of the South China Sea which terminated Paleogene subduction beneath North

Borneo. Renewed subsidence is related here to rifting in the Sulu Sea which led to the development of a major Miocene depocentre above the older forearc accretionary complex. The major transpressional deformation, probably occurred during the Late Pliocene, and is possibly related to propagation of deformation from Sulawesi towards NW Sabah. This strike-slip deformation which uplifted the area is termed here the Meliau Orogeny. Renewed extension during the Quaternary has caused some sequence repetition. The 'circular basins' of the Meliau, Malibau and Tidung areas, are interpreted as remnants of a single large basin, deformed in the NW-SE trending transpressional fault zones.

Poster 10

Geologic modeling of shaly-sand reservoirs in J-Group, Tapis Field, Malaysia

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The need for a comprehensive study leading to the building of a geologic model for full field reservoir simulation to evaluate remaining opportunities, including EOR, and infill drilling with the potential to add reserves was the incentive for this project. Tapis Field is located in the offshore Malay Basin approximately 300 kilometers east of the Malaysia peninsula. The structure is an east-west trending asymmetrical, compressional anticline covering about 85 km^2. The Field was discovered in 1969, and first oil production commenced in 1978. Presently the field is being produced from five platforms that have resulted in a well database of 133 well bores. The largest oil and gas volumes are in the Group J sands, where the maximum hydrocarbon column is 650 meters. The field is in a mature state of development, and overall, the J reservoirs are over 80% depleted. Historically, original oil in-place, and original gas in-place volumes have been difficult to assess in the Group J because of the high volume of shaly-sand reservoirs, and relatively fresh water aquifers. This study indicates about 44% of the J oil is contained in shaly sands.

In 2001, a comprehensive, integrated field study was approved to characterize the I, J and K reservoirs A fine-scale geologic model was built for the Group J reservoirs: J10, J15, J18, J20, J24, J25, and J30. The geologic model was completed in June 2002, and will serve as the basis for additional reservoir simulation studies.

GEOLOGIC MODEL DESCRIPTION

A three-dimensional geologic model was built using ExxonMobil proprietary geologic modeling package, RESMAP. The geologic models consist of reservoir facies, porosity, permeability, net pay, and water-saturation. The reservoir facies model was constructed from petrophysical facies predicted in each well data string based on a discriminant function analysis approach. Sequential indicator geostatistical algorithms, with conditioning from facies probability grids, were used to build the reservoir facies model. The porosity model was built using sequential Gaussian simulation. The permeability model was constructed using a facies-specific sequential Gaussian, bivariate cloud transform simulation. A capillary-pressure based 3-D water saturation model, using saturation functions defined by Formation Evaluation (FE), was built to calculate in-place hydrocarbon volumes. Geologic modeling process worked closely with Formation Analysis, and the work process proved iterative.

The model incorporates 21 stratigraphic horizons that extend over a model area of interest of 10 km. by 22 km. The mean model thickness is 172 meters. Geologic model cells are 100 by 100 meters, and have a vertical resolution on average of 0.3 meters and include 971 layers and 8.46 million cells. Cell geometry is onlap and truncation.

LITHOFACIES MODEL

A lithofacies model was based on the 3-D distribution of "petrofacies" within the stratigraphic framework. Petrofacies were predicted for each depth along the well-log data strings. Six petrofacies were modeled: S1 (lithofacies 1), S2 (lithofacies 2), S41 (lithofacies 3), S42 (lithofacies 4), S43 (lithofacies 5), and M1 (shale lithofacies 6). All petrofacies are represented in the Lower J reservoirs, however S1 and S41 are not present in Upper J reservoirs. Lithofacies 1 through 4 constitute reservoir facies, and contain in-place, saturated hydrocarbons, but S43 and M1 shale represent non-hydrocarbon saturated rock volumes, and are treated as non-net rock volumes in the geologic modeling process. The petrofacies were then modeled in 3-D space using geostatistical algorithm called *Sequential Indicator Simulation (SIS)*. The lithofacies model was also highly conditioned by facies probability maps to control the spatial position of the lithology within each sequence. This process is called conditioning by "local-varying mean" or LVM. The LVM can be two-dimensional if based on a grid, or three dimensional if the lithofacies probability is set as an attribute in the 3-D model that varies in *x*, *y*, and *z* space. Horizontal and/or vertical conditioning was used in most model sequences.

Horizontal variograms indicate sand continuity around one kilometer along the major axis, and less than 1,000 meters along the minor axis. Azimuth trends are near 110-115 degrees, and are based on isopach trends. This trend is thought to be caused by repeated stacking of shore-parallel sandbar forms, shaped by current and wave action. These middle shoreface sandbars ultimately became expressed as linear features in isopach maps. These trends are also consistent with trends observed in nearby fields. Abundant well control, and good facies descriptions tend to yield well-defined vertical variogram range and sill information.

POROSITY MODEL:

A geostatistical-based porosity model was built using a standard algorithm, *Sequential Gaussian Simulation* (SGS). Histograms of total porosity were made from the well-log data and were used as the porosity source in the modeling process. Porosity data was initially reviewed by lithofacies—by sequence. Certain members of these porosity groups were subsequently combined on the basis of similar mean porosity. Porosity data also indicate a deterioration of with depth as indicated by cross-plotting porosity and depth data. We did not attempt to rigorously quantify this relationship, but we did attempt to capture the relationship as best as possible within the scope of this study. The petrofacies approach did indeed capture this relationship in part, because lithofacies, predicted off-structure, tended to be downgraded.

PERMEABILITY AND WATER SATURATION MODEL:

The permeability model was built for the Upper and Lower J Reservoirs, dependent on lithofacies and porosity. The source of permeability data was calculated permeability from Formation Analysis, tied to core plug measurements. A 3-D water saturation model was built based on capillary pressure, using the original, pre-production contacts. Capillary pressure is a key component of water saturation modeling. Capillary pressure is calculated as a function of elevation above fluid contacts and density differences. Water saturation is a function of capillary pressure and permeability. The water saturation model used the same saturation equations as Formation Evaluation, or at least as close as possible. Water saturation was calculated for all permeability greater than 0.1 md. The following saturation equation was used:

$$SW = (a/(Pc-Pct)) + Swirr$$

where: a = degree of curvature, defined as a function of permeability
Pct = threshold entry pressure, defined as a function of permeability
Swirr = irreducible water saturation, defined as a function of permeability

KEY LEARNINGS

- Historically original in-place oil volumes have been difficult to assess in Tapis. Nearly 50% of the Upper and Lower J OOIP is in shaly sandstone reservoirs (possible large volume uncertainty).
- Geologic models of shaly-samd reservoirs require robust lithofacies descriptions.
- Capillary-pressure saturation model is critical for in-place resource volumes.
- Porosity and permeability data from Formation Evaluation sources must be carefully calibrated to core plug measurements.
- Petrofacies prediction by discriminant function analysis requires significant cross-validation to assure quality (log analyst-modeler-stratigrapher).
- Seismic attribute analysis indicates amplitudes do not predict oil-bearing sands.

Poster 11

Successful development of a thin oil column using horizontal drilling in the Palas field, Malay Basin

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The Palas field is located in the 1995 PSC area and is approximately 215 km east of Kerteh, Terengganu. The Palas field was discovered in 1977 and six exploration wells were drilled to delineate the field over a period of 16 years. The initial development program began in 1985 after installation of the Palas A platform. The platform is a 32-conductor, unmanned satellite connected to the Guntong A platform, 12km to the west. The initial eighteen well development program primarily targeted the I-100/102 sands with minor completions in other I series sands (I-50, I-55, I-60, I-62, I-68, I-70, I-75, I-80, I-90 and I-95).

The last exploration well, Palas-6, was drilled in 1993 to delineate the undeveloped Group J sands. From the well's positive results, and supported by recent 3D seismic data, reservoir modeling and simulation work; an additional development drilling program was initiated in 2001. Thirteen horizontal wells and one conventional well are planned to develop reserves from a thin oil column within the J-20/21 and J-30/40 reservoirs. Twelve of the horizontal wells have been drilled thus far.

Early in the 2001 development program, two wells were drilled using pilot holes to determine the hydrocarbon contacts in the J-20/21 and J-18/19 reservoirs. The Palas A-20 well successfully delineated the J-20/21 G/O and O/W contacts, using a pipe conveyed formation test tool (MDT) in the high angle pilot hole. After plugging back, the information was used to optimally position the horizontal wellbore in the thin oil column within the J-20/21 reservoir. The Palas A-23 was successfully geosteered to stay within the thin, dipping J-18/19 reservoir, while penetrating both the G/O and O/W contacts. While the J-18/19 was deemed uneconomic to develop, the well was plugged back and drilled horizontally to the J-20/21 reservoir.

Subsequent horizontal wells have targeted the J-20/21 and J-30/40 reservoirs. Because of the thin oil column, these horizontal wells are geometrically steered at a specific depth, optimally positioned between the G/O and O/W contact. To reduce directional survey uncertainty below what can be obtained from MWD, gyro surveys are run at appropriate depths during the drilling operations. Additionally, recent wells have utilized rotary steerable drilling assemblies, making it possible to drill long horizontal sections that could not be drilled using conventional mud motor drilling assemblies. The rotary steerable assemblies also provide near bit inclination measurements, which reduce the survey to bit projection uncertainty. This in turn reduces the wellbore undulation, permitting the wellbore to remain optimally positioned between the contacts in the thin oil columns.

The Palas A-27 well was the eighth horizontal well drilled to develop the J-20/21 and J-30/40 reservoirs. Because of the well's position on the structural nose of the southeast flank and the low bed dip (1-2°), a long horizontal section was required to penetrate the complete reservoir section. Total measured depth of the Palas A-27 well is 5,817 m and the horizontal length set a new Malay Basin record of 2627m MD (45% of the total measured depth). The well path was optimized using seismic, to penetrate positive AVO responses, which correlate to sand development. Using a rotary steerable drilling system (RSS) with a near bit inclination sensor (~1.2 m from the bit), the well bore was maintained within a +/-1.4 m vertical window throughout the entire 2627m horizontal section. The wellbore intersected 970 m MD of net sand and was completed as a dual oil well, producing at a record rate of 12 kb/d, with no water and with gas volumes near the solution GOR.

Poster 12

Real Time Wellbore Stability using Drilling Data and Logging While Drilling Data

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This is a poster version of Paper 15.

Poster 13

Towards a geodynamic model for Peninsular Malaysia: evidence from high Ba-Sr rocks from the Central Belt of Peninsular Malaysia

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Peninsular Malaysia has been divided into three belts, namely the Western, Central and Eastern Belt. The boundary between the Western and Central belts has been drawn by joining occurrences of serpentinite bodies into a line called the Bentong-Raub Line (Hutchison, 1975, 1977). Recently, Metcalfe (2000) proposed this line to represent a suture zone which forms a boundary between the Gondwana derived Sibumasu and Indochina terrane. New trace elements data from the gabbro, syenite and monzonite of the Central Belt of Peninsular Malaysia showed that they have very high LIL elements i.e. Ba (2401–10,744 ppm; mean: 4,590 ppm) and Sr (578–2,340 ppm; mean: 1,000 ppm). The elements are nearly 1,000 times rock/mantle. Further north, Cobbing *et al.* (1992) recorded a sample from the Boundary Range batholith (near Kuala Krai area) has 9,836 ppm Ba and 344 ppm Sr, (Sr content, however much less than the Raub rocks). Occurrence of high Ba and Sr rocks from the Raub area may indicate the influence of mantle plume. The high Ba and Sr values probably result from the penetration of the lower lithosphere by a small volume of the mantle material that is enriched in those elements (cf. Green and Wallace, 1988; Ionov *et al.*, 1993; Rudnick, 1993). Evidence of the interactions with mantle material is provided by the occurrence of mafic enclaves and mafic synplutonic dykes everywhere in this area.

The data is consistent with melting of cooler, thickened, metasomatised mantle lithosphere when a hot plume-like asthenospheric linear diapir impinged against a mafic lower crust. Some of these mantle magma stalled and crystallized at the base of the crust and subsequently partial melting formed the granitic magma as the asthenospheric upwelling increased. Any tectonic model of Peninsular Malaysia must be refined to take into account the mantle underplating beneath the Central Belt.

Subduction-Collision models (Mitchell, 1977) must be refined to include the rise of hot asthenosphere. One likely explanation is a 'slab breakoff' model which is a natural consequence of ocean closure which is plausible from strength and buoyancy consideration. This would account for the long linear belt of high-K, calc-alkaline magma some with high characteristic trace elements signatures such as high Ba and Sr. However other characteristics of 'slab breakoff' such as the presence of picrites, komatiite and exhumation of high P continental slices have yet to be demonstrated for Peninsular Malaysia.

'Aborted rift' (Tan, 1976; Khoo & Tan, 1983) and 'Mantle plume' models can explained the rise of the hot asthenosphere due to a mantle plume. The crust underwent crustal thinning leading to the formation of the graben structures. However this model need to invoke a subsequent continental subduction that engulfed a small or narrow ocean of limited extent to account for the absence of mantle derived magma and the emplacement of a large volume of peraluminous type magma in the Western Belt. Other features such as the presence of picrite and komatites have yet to be demonstrated. Magmatic provinces associated with mantle plumes have equant shapes and sizes which fit the Central Belt granite but the long linear arrangement is more difficult to explain.

Poster 14

A tide- and wave-influenced, barrier island-lagoonal complex within the upper section of the Nyalau Formation (Oligocene-Late Miocene) at Kampong Sungai Plan, north Bintulu, Sarawak

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The Nyalau Formation (Oligocene-Late Miocene) is the onshore extension of Cycles I and II of the Balingian Province of offshore Sarawak, which contain important source and reservoir rocks for oil and gas (Du Bois, 1985). The low-lying, hilly countryside and coastal areas surrounding the Bintulu town in Sarawak form part of the extensive Oligocene to Early Miocene sedimentary succession. Good rock exposures can be found along the Bintulu-Tatau road south of Bintulu town, right up to the north of Bintulu town around the rocky coasts and hill-cuts at Tg. Kidurong, and along the Bintulu-Miri road.

The Nyalau Formation consists of a succession of hard, fine to medium-grained sandstones interbedded with shales. Some coals are present in restricted parts of the formation. Leichti *et al.* (1960) estimated a thickness of 17,000–18,000 feet for this predominantly siliciclastic succession. The Nyalau Formation lies conformably on the Buan Formation but with a sharp transition. Locally, it overlies unconformably the Tatau and Belaga Formations. Since no internal discontinuity has been discovered so far, it is generally thought that the deposition of the Nyalau Formation is continuous during the Oligocene to Miocene time. This clastic unit interfingers with the Setap Shale Formation in the northeast. The top boundary of the formation forms an erosional surface. The formation is moderately folded. The formation is thought to represents a progradational sequence, which comprise a basal shallow marine sandy unit (Biban Sandstone Member), followed by the main Nyalau succession which reflect deposition in the lower coastal plain to marginal marine environments (Leichti *et al.*, 1960; Haile, 1963; Wolfenden, 1960; Kho, 1968; Mohd Idrus & Redzuan, 1999).

A hill-cut at the rear section of Kampong Sungai Plan in north Bintulu near Tanjong Kidurong exposes more than a hundred metres of rock succession belonging to the upper part of the Nyalau Formation. Detailed sedimentological logging of the lower part of the succession reveal facies and stratal organization that can be related to a barrier bar-lagoonal complex strongly affected by tidal and wave processes, with a marked impression of a relative, sea level rise.

Five facies association were recognized in the field. These are informally referred to as SP-1, SP-2, SP-3, SP-4 and SP-5.

Facies association SP-1 is a sandstone unit characterized by rippled, flaser-bedded and cross-bedded structures, with associated carbonaceous/mud laminations and drapes. The trace fossil *Ophiomorpha* can be found scattered throughout the unit. Small, rounded mud chips commonly occur at the lower part of the facies. This medium- to fine-grained sandstone unit is generally flat bedded, with thickness ranging from 200 cm to more than 1500 cm thick for amalgamated, composite units (commonly amalgamated with and overlain by SP-3). Thin units of SP-1 display sharp and flat basal contact with the underlying unit; however, two thick composite unit exhibit distinct, scoured erosive base.

SP-1 is interpreted as a sandy tidal flat deposit, which sometimes overlie and is amalgamated with basal, cross-bedded and erosive-based tidal channel unit. The overall organization of the facies suggests that these cross- and flaser-bedded sandstone layers, and the channelised basal part, were deposited on sandy tidal-flats and sub-tidal channels, located within the back-barrier/lagoon margins of a barrier bar-lagoon complex.

Facies association SP-2 is an interbedded unit of thin, rippled and flasered sandstone layers and lenticular-bedded mudstone. This unit, when present, overlie SP-1 or SP-3, and together they form an upward fining succession.

Flaser bedding, which is characterized by the presence of remnant mud layers in the ripple troughs, indicates a condition in which the deposition and preservation of sand are more favourable than for the mud (Reineck and Singh, 1986). Lenticular bedding requires conditions of low current or waves action depositing minimum sand, and dominant slack water conditions for mud deposition. Terwindt (1971) suggested that the thin sand layers may represent isolated small-scale ripples that have travelled over a clay bed and which have been covered by clay subsequently. The interpreted environment of deposition for SP-2 is the intertidal, muddy tidal-flat within the back barrier zones.

Facies association SP-3 is characterized by cm to metre thick, flat-bedded and horizontally laminated sandstone. These sandstone beds always overlie the flaser bedded units of SP-1. Except for the very distinctly flat, low angle bedding, these layers display no other structures.

These sub-horizontal stratified sandstones are washover deposits, which are formed when wind-induced storm surges spill over barriers, and form sheet-like deposits of sand into the lagoon behind the barrier bar. Each of the cm to metre thick bed is thought to represent one single overwash event (Reinson, 1992; Schwartz, 1982).

Facies association SP-4 is a well laminated, dull gray, silty mudstone with conspicuous, thin, silt and sand layers. The association of SP-4 with SP-2, SP-3 and SP-5 suggests that SP-4 is probably a proximal, lagoonal deposit. The presence of silt and silt-sand layer in SP-4 may have been due to the dispersal of washover detritus into the back lagoon. In a way, it can be regarded as a wave-influenced lagoonal deposit.

Facies association SP-5 is a fairly homogeneous unit of black, carbonaceous and laminated mudstone. This unit is interpreted to be the subaqueous, lagoonal suspension deposit.

Detailed field logging of the outcrop shows that the different facies associations described above are arranged into three different types of shallowing-upward successions. These are:

I. ***SP-1/SP-2 type***, is a simple shallowing-upward succession, indicating the shallowing-up of the environment from a sub-tidal to an inter-tidal level occurring within the tide-dominated back-barrier areas.

II. ***SP-1/SP-3/SP-2 type***, shallowing-upward succession. Most of the shallowing-upward successions recorded at Kampong Sungai Plan are of this type. The vertical facies organization here indicates the increasing influence of wind-generated wave and storm surges as a depositional mechanism. However, the capping of the succession by SP-2 shows that tidal processes still prevail within the back-barrier/lagoonal environment.

III. ***SP-5/SP-4/SP-1/SP-3 type***, shallowing-upward succession. This succession suggests a marked change in the environment, from a subaqueous lagoon setting to a back-barrier sand flat level. This form of stratal organization is also an indication of the landward migration of the barrier island, which is one of the main processes that occur during a transgression (Reinson, 1992).

The overall stratification of facies at the outcrop in Kampong Sungai Plan, Bintulu, represent a trangressive episode in the depositional history of the Nyalau formation, within a wave-dominated, microtidal barrier island and related lagoon environments.

Poster 15

Sedimentology and reservoir properties of shoreface sandstones in the Sandakan Formation, Sabah

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Shoreface sandstones are recognized worldwide as excellent and important petroleum reservoirs as well as in Brunei and Malaysia. However, few studies relate sedimentological data and stratigraphic successions to porosity, sand body geometry and permeability trends. This is especially true for low latitude settings on semi-enclosed seas where depositional environments, and hence stratigraphic successions, are markedly different from the temperate, open ocean coasts where most of the commonly-used facies models were derived. Wave energy generally is low in semi-enclosed seas and shoreface sands often form sand bodies that are thinner, narrower, finer-grained and muddier than their open-ocean counterparts. The shoreface reservoir sands of Brunei and adjacent Malaysia that were deposited under the low wave energy regime of the South China Sea are an excellent example (Sandal, 1996; Petronas, 1999). However, the rate at which those sedimentary parameters vary with changing wave energy remains poorly understood, especially for low energy systems.

The middle Miocene Sandakan Formation of Sabah is comprised of sandstones and mudstones from several shallow marine depositional environments, including shoreface sandstones (Noad, 1998). Facies associations within the Sandakan Formation are much different than those on the northwest Borneo margin and suggest a significantly higher energy depositional environment. The sandstones are well-exposed in several prominent ridges that allow estimation of lateral continuity as well as detailed facies and stratigraphic analysis.

Four facies are represented in the major sandstone outcrops. Upper shoreface sandstones have excellent reservoir properties. They are fine to medium grained, moderate to well sorted and occur as 10–30 m thick units that coarsen upward and are laterally continuous for at least 1 km. The units consist of amalgamated 0.3–1.0 m thick beds with erosional bases that are locally separated by thin (< 0.01 m), laterally discontinuous mud layers. Generally, the sands appear massive with little bioturbation but trough cross-bedding, low-angle cross-bedding and parallel lamination are relatively common and most of the bed surfaces are wave-rippled. The sandstone units have a net to gross of 90 and porosities that range from 20 to 32% and average 27%.

Beds of very fine to fine grained lower shoreface sandstones separated by very thin, highly carbonaceous mudstones are stacked into 8–10 m thick units. The moderately bioturbated sands are parallel laminated and wave-rippled with mud rip-up clasts; hummocky cross-stratification and trough cross-bedding indicative of storm events occur locally. Porosity averages 18% but reservoir potential is only moderate because carbonaceous mud laminations and drapes form abundant permeability barriers. The medium grained, moderate to well sorted, clean sandstones within the offshore transition facies are storm beds that are 0.7–1.5 m thick with erosional bases and wave-rippled tops; hummocky cross-stratification, parallel lamination and planar and trough cross-bedding are common. Despite an average porosity of 20%, reservoir potential is moderate because the sands are separated by 0.3–0.5 m mudstones that constitute significant permeability barriers. The fourth facies is thick mudstones that Noad (1998) has interpreted as tidal flat and mangrove swamp deposits based on faunal evidence.

Outcrop successions consist of progradational parasequences. Offshore transition storm sands and interbedded mudstones pass upward into lower shoreface sandstones followed by upper shoreface sandstones in some outcrops and directly into upper shoreface sandstones in others. There is an abrupt, but transitional, boundary between the shoreface sands and the tidal mudstones that cap each parasequence. The facies associations suggest that the depositional environment was a relatively high energy, wave-dominant coastline immediately shoreward of an extensive mangrove swamp, whilst the stratigraphic succession indicates progradation in response to relatively small changes in sea level. The offshore mudstones that occur in nearby outcrops (Noad, 1998) probably record larger sea level falls.

An apparent modern analogue for the depositional environment of the Sandakan Formation is the north coastline of the Dent Peninsula in Sabah. There, large tracts of mangrove swamp lie shoreward of a ~100 m wide, vegetated barrier beach of fine sand that extends for approximately 50 km along the coast. The beach is broken at 4–6 km intervals by tidal estuaries that have spits growing to the northwest, suggesting longshore transport in that direction. Sediment plumes extend seaward from the estuaries during the ebbing tide and presumably transport fine sediment offshore. Progradation of the Dent Peninsula shoreline would deposit the same sedimentary structures, facies and stratigraphic succession, as in the Sandakan Formation outcrops, with mangrove swamp muds overlying shoreface sands that succeed offshore transition storm sands and interbedded muds. Sediment plumes associated with estuaries may supply a large amount of carbonaceous mud to the lower shoreface.

Hindcasting from wind records indicates that the coastline of the Dent Peninsula is not an exceptionally high energy environment. The strongest winds blow from the east-northeast approximately 10% of the time; the 500 km fetch suggests that wave heights rarely exceed 1.5–2.0 m waves, which is small compared to open ocean coasts but larger than in northwest Borneo where they rarely exceed 1 m (Sandal, 1996). However, the waves approaching the Dent Peninsula are large enough to overwhelm the effects of the small spring tidal range of 1.2 m, to develop the clearly wave-dominant shoreline and, by analogy, to have deposited the shoreface sands of the Sandakan Formation with their excellent reservoir properties.

Poster 16

Geology of Kinabalu field and its water injection scheme

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This paper will discuss the geology and development of the L reservoir unit in the Kinabalu field, Sabah and includes the discussion on the innovative water injection scheme being implemented for pressure maintenance to sustain oil production.

Kinabalu field, situated 55 km west-north-west of Labuan Island was discovered in 1989 by KN-1 well with a total pay counts of 1,043 ft NOS, 113 ft NGS and 310 ft NHS. The field contains 519 MMstb oil-in-place, developed in 1997 and to date some 45 million barrels had been produced. The gas and oil are transported by pipelines through Samarang facilities and then onwards to Labuan Crude Oil Terminal for storage and export. The major producing reservoirs in the Kinabalu field are K and L units trapping hydrocarbons against the Kinabalu growth fault.

The intercalated sands and shales of L reservoirs were deposited in a shallow marine environment during Middle Miocene time. Production performance and a very fast pressure drop in these reservoirs suggested very limited to no water-drive. Several options were investigated to provide pressure support to this major oil reservoir, including injecting sea-water scheme and dumping of shallower formation water. In the Kinabalu field, water is produced from the shallower sand bodies (B & C-Sands) and injected into the L reservoir unit through two horizontal wells. To date a natural dumping rates up to 1,200 barrels per day are experienced in these wells and electric submersible pumps (ESP) will be installed soon to increase the injection rate up to 20,000 barrels per day. Some 16 million barrels oil will be realized from this pressure maintenance scheme thus adding some 2,000 to 4,000 barrels oil per day to the Kinabalu field production.

Poster 17

Structural bends of northwest Sabah: causes and implications for exploration

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From Sarawak in the southwest to Sabah in the northeast, the Cenozoic structures trend in broad waves roughly parallel to the shoreline with three notable deviations: northerly in the Limbang- Brunei area, easterly in two localities in Sabah, that is, one at approximately Tuaran and an other at the latitude of Mantanani Island. The easterly structural strikes in northern Sabah persist across land as far as the Sulu Sea. In the subsurface offshore of NW Sabah, the two changes in structural trends from NE to E are also seen as far as the Northwest Sabah Trough. The structural bend in the offshore of Sabah is especially evident in a zone containing the Bunbury-St. Joseph syncline, Mantanani south-verging thrust, South Furious-Barton fields, Tiga Papan upthrusted horst, and the Bonanza Fault. North of the Bonanza Fault, the structures resume their NNE direction to eventually assume a northerly strike in Philippine waters. Conventional field mapping complemented by interpretation of aerial photographs and radar images indicate the presence major, most probably fault, lineaments striking almost normal to the coastline.

Near Kota Kinabalu, the NW tectonic transport direction of the Palaeogene West Crocker strata is represented by asymmetric folds and thin-skinned, low-angle thrusting. At Mengaris quarry within the zone of easterly trends, the West Crocker beds are thrusted toward northeast which is distinctly at right angle to the tectonic vergence of structures of western Sabah. An analogue of such structural pattern is shown by the Pine Mountain Thrust system in the Appalachian at the Kentucky-Tennessee boundary of the United States. Thrusting in directions at right angles to the thrust front are shown by the Jacksboro and Russell Fork faults. Some of the folds are also perpendicular to the WNW thrust. It is now postulated that the Sabah right-angle structural bends are part of a major overthrust system that verges northwest and is flanked by major wrench faults: the West Baram Line in the southwest and the Bonanza and Balabac faults in the northeast. The Lower Tertiary thrust sheet mapped offshore in the northern Outboard Belt most probably belongs to this system This major structural event is believed to correspond with the Deep Regional Unconformity (DRU; earliest Middle Miocene or Stage IVA). The youngest known onshore beds involved are of Stage III (22.3 - 15 m.a; Kudat Formation) The Sabah structural bends suggest that the main tectonic transport of the overthrust was northwest, where inadequate accommodating space has forced the overthrust flanks to "spill over" sideways. The spillover direction has been perpendicular to and was facillitated by major flanking faults bounding the relatively faster advancing thrust slab.

In terms of hydrocarbon prospectivity, the overthrusting event disturbs maturation and expulsion of new HC, affects remigration and probably trapping/sealing integrity, and may change reservoir volumes of pre-Stage IVA petroleum systems.

Poster 18

Sea-bed imaging through high resolution short offset re-processing in the Malay Basin

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Amerada Hess (Malaysia) recently re-processed 149 km^2 of 3D seismic data over the Cendor-Desaru structure to further enhance the seismic imaging at shallow depths as well as below a shallow-gas affected zone. High resolution, short offset 3D seismic processing was developed primarily to reduce costs involved in site survey exercises by utilising pre-existing 3D seismic data rather than acquiring dedicated 2D site survey seismic data for shallow hazard analysis. The Robertson Research's method of high resolution, short offset approach differs from conventional 3D processing in a number of important ways:-

- The data are processed at a sample interval of 2 ms (as opposed to 4 ms in conventional processing) allowing for the inclusion of un-aliased frequencies of up to 250 Hz to be processed. This potentially doubles the vertical resolving power of the data over conventionally processed 3D.
- The data are limited to near offset ranges only, typically 3–6 fold depending on signal/noise ratios. This excludes the requirement for far offset corrections as applied in conventional processing (e.g. accurate NMO, DMO) prior to zero offset migration. Restricting processing to near offsets also reduces ray-path & stacking complications in areas of non-hyperbolic move-out (e.g. areas affected by shallow gas concentrations) and leads to improved imaging in such areas.
- Data positioning 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 migrated data positioning and hence improves lateral resolution. Data regularisation is achieved via a 2-pass 3D-migration approach, inline followed by crossline.

The results of the re-processing have resulted in excellent imaging of the sea–bed and shallow intervals.

Poster 19

DecisionSpace: an integrated asset optimization system providing multi-scenario decision support for the entire team

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Optimizing asset value is a complex endeavor due to the wide range of uncertainties that span many disciplines. The new Landmark DecisionSpace system is used to rapidly analyze multiple scenarios to drive optimized asset decisions across the E&P value chain, that is from subsurface identification and characterization, well planning, scheduling, production profile prediction, and economics. Landmark's DecisionSpace is a collaborative environment for the entire asset team, enabling members to work together to comprehend multiple scenarios and incorporate the uncertainties that drive project risk. Integrated and automated workflows, supported by business metrics, enable asset teams to both dramatically increase productivity and focus on high-impact tasks. Landmark's DecisionSpace leads to optimized asset management by enabling teams to streamline decision-making processes, reduce cycle time and to "right-size" field development.

Poster 20

3D generalised inversion as direct input into static model in Kamunsu East Field — a case study

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A reservoir characterization project was carried out on the Kamunsu East gas field in offshore North West Borneo, Malaysia. The aims were to produce a notional field development plan as quickly as possible while increasing understanding of the 3D sand body geometry and lithofacies. An innovative workflow was developed using a variety of software and techniques to best achieve the project aims. The field consists of complex deep-water canyon turbidites of Miocene age in a thrust-footwall setting. Detailed structural mapping was enhanced and updated against the results of a sparse spike inversion based on a single well and 3D seismic. Body checking of seismic and acoustic impedance volumes helped to delineate 3D sand bodies, connectivity and preliminary volumes. Core, image log and dip-meter analysis was integrated with the structural interpretation and body-checking of acoustic impedance. This together with fan-scale 'stratigraphic' slicing of the turbidite fan system aided understanding of the evolution of the fan and allowed meaningful zonation of the reservoir. In addition, neural network-based classification of well logs allowed the drilled reservoir sands to be sub-divided into 4 lithofacies. 3D geostatistical and neural network classification of AVO, acoustic impedance and dip-azimuth volumes then allowed the well-based lithofacies classification to be extended throughout the reservoir within two fluid types. The updated fault and horizon mapping was used to build the initial static model. The models were populated with sand and fluid distributions from the calibrated inversion results and reserves were computed. Subsequently an AVO inversion was carried out and derived lithology and porosity volumes were used to update and improve the static modelling. The study demonstrates that an integrated approach using a variety of techniques in a multidisciplinary team allows rapid and cost-effective 3D reservoir description leading to accelerated field development planning.

IEM-GSM Forum

Engineering Geology & Geotechnics in Coastal Development

23 October 2002

Bangunan Ingenieur
Petaling Jaya

Report

The Forum is the 11th in the series organised by GSM/IEM since 1992. This Forum focused on coastal development. 13 papers were presented, and the topics ranged from Engineering Geology input, groundwater, soil stabilizations, soft soil problems, etc. The case histories presented include those from Peninsular Malaysia, Singapore, Thailand and Indonesia.

Response was overwhelming, with about 100 participants.

Tan Boon Kong
Chairman
Working Group on Engineering Geology & Hydrogeology
26th October 2002

Programme

8.00–8.45 am	Registration
8.45–9.00 am	Opening Remarks by Organising Chairman, Assoc. Prof. Tan Boon Kong
9.00–9.30 am	Engineering investigation in coastal development works *Lee Eng Choy*
9.30–10.00 am	Coastal changes and engineering structures *J.K. Raj*
10.00–10.30	A case study on the use of vacuum consolidation for improving soft clay for coastal development *Kenny Yee*
10.30–11.00 am	Tea Break
11.00–11.30 am	Ground improvement for soft soil stabilisation in coastal areas *V.R. Raju*
11.30–12.00 noon	Application of value engineering to geotechnical design for a factory structures on soft alluvial flood plain in Indonesia *Liew S.S.*

12.00–12.30 pm	Geological input in coastal development — some case studies in Peninsular Malaysia and Singapore *Tan Boon Kong*
12.30–1.30 pm	Lunch
1.30–2.00 pm	Problems of road construction on soft coastal alluvium *Neoh Cheng Aik*
2.00–2.30 pm	Geology and groundwater resources of the Langat Basin *Chow Weng Sum*
2.30–3.00 pm	Dynamic pile testing interpretation for piles founded in coastal soft soils *Mun Kwai Peng*
3.00–3.30 pm	Tea Break
3.30–4.00 pm	Geotechnical considerations in constructions in sensitive coastal sedimentation zones *Lee Eng Choy*
4.00–4.30 pm	Ground improvement of thick deposit of soft clay for Sepang Power Plant *Kem Yah*
4.30–5.00 pm	Laying a single piece geotextile over slurry lagoon at Changi, Singapore *Simon Kam*
5.00–5.30 pm	A case history of a coastal land reclamation project *Chen Chean Sin & S.M. Tan*
5.30–5.45 pm	Closing Remarks by Organising Co-Chairman, Ir. Mun Kwai Peng

Abstracts of Papers

Engineering investigations in coastal development works

LEE ENG CHOY

DPI Konsult Sdn. Bhd.

Natural forces and processes predominating in a coastal environment significantly influence development works within a coastal regime. In order to ensure the safety and stability of structures built in this zone, it becomes necessary for the engineer to understand these coastal processes in order to be able to estimate the forces acting on the structure.

In a coastal zone, the ground condition is closely related to the coastal processes and hydrodynamic forces influencing the sediment transport, deposition and erosion. A thorough understanding of the origin of our shorelines is essential to the proper execution of development works within the coastal zones. It is thus necessary for the engineer to understand the depositional history of the ground he intends to build on in order to assess the safety and stability of the structures. This knowledge is commonly obtained from executing a desk study followed by an effective investigation programme in the appropriate areas.

The primary objective of the desk study and the investigation programme is to gather information concerning the site conditions within the construction zone and in the surrounding areas with the aim of obtaining sufficient information to characterise the ground and understand the engineering behaviour of constructions on it. The information to be gathered shall be relevant to the needs of the project in relation to the development of the design and successful implementation of the construction works.

Coastal changes and engineering structures

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Breakwaters, jetties and other structures constructed at coastlines where there is an oblique approach of wavefronts have a direct impact on the along-shore transport of beach sediments by littoral drift; there occurring accretion of sediments up-drift of the structures, but erosion down-drift of them. An example of this impact is provided by the breakwaters at Kuala Sg. Pengkalan Datu (Kuala Sg. Besar) in Kelantan Darul Naim where the southeast-northwest trending coastline consist of sandy beaches, whose continuity is interrupted by large river mouths at Kuala Sg. Pengkalan Datu and Kuala Besar, and smaller ones at Kuala Pak Amat and Kuala Semut Api. Aerial photographs flown in 1948, 1949, 1957, 1963, 1966 and 1974 show that, although over the years, there have been variable sites of erosion and accretion of beach sediments, there has occurred an overall recession of the coastline. This overall recession is due to a northwestward directed littoral (or beach) drift which results from the oblique approach of wavefronts throughout the year, especially during the Northeast Monsoon. Breakwaters constructed on both sides of Kuala Sg. Pengkalan Datu between 1986 and 1987 have accentuated the effects of this littoral drift with accretion of sediments up-drift of the southern breakwater, but erosion and shoreline retreat down-drift of the northern one. Construction of breakwaters and other structures in coastal areas needs to take into consideration their impact on prevailing processes.

A case study on the use of vacuum consolidation for improving soft clay for coastal development

KENNY YEE

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Malaysia

A 350 MW combined cycle power plant is to be constructed on soft clay situated close to the Gulf of Thailand. Include in the construction, an access road is to be built over very soft Bangkok clay. Ground improvement using Menara Vacuum Consolidation technique was introduced in this project for the first time in Thailand. The vacuum consolidation technique was employed to provide the required stability and consolidation.

The site is located in Samut Prakam province of Thailand, south of Bangkok. The geological formation belongs to the Chao Phraya River plain with the upper 20–25 m of soft clay deposited under marine conditions. The water content varied from 90–135% with undrained shear strength of less than 10 kN/m^2 in the upper 10 m. Fill of up to 4.3 m was placed in order to build a 1.33 m embankment above ground elevation.

The design criteria include residual settlement not exceeding 40 cm over 25 years; differential settlement not exceeding 1:750 and a factor of safety not less than 1.3 against shear failure. Vacuum pumping was kept for 7 months. The average degree of consolidation achieved ranged from 87–93% and an average increase of 22 kN/m^2 in the undrained shear strength. The main concern was to maintain stability of the 4.3 m fill during construction.

The ground improvement work was carried out based on a turnkey design-and-built contract including a performance guarantee. The philosophy behind the selection of the vacuum consolidation treatment and the results after treatment are presented in this paper.

Ground improvement for soft soil stabilisation in coastal areas

V.R. RAJU

Keller (M) Sdn. Bhd.

The presence of soft marine clay deposits along the western coast of Malaysia necessitates the use of ground improvement techniques when coastal facilities such as flood protection embankments and ports/marinas are to be built. Ground improvement is required to ensure adequate slope stability of soft marine soils because of their low shear strength. In this paper two ground improvement techniques, namely Dry Deep Soil Mixing and Vibro Replacement, are presented as treatment techniques to meet the requirements with regards to settlements and slope stability.

Application of value engineering to geotechnical design for a factory structures on soft alluvial flood plain in Indonesia

SHAW-SHONG LIEW

Gue & Partners Sdn. Bhd.

This paper aims at giving a framework on how value engineering can be applied to geotechnical design to improve the value of the project. Case history of such application on an alternative design to a palm oil mill over very soft alluvial flood plain in east coast of Sumatra of Indonesia is presented to demonstrate how a safe and cost effective geotechnical solution for the foundation treatment is developed. Innovative short floating pile design, piled raft foundation and inverted "T" arrangement retaining wall design have resulted in a cost saving of 30% and significant time saving. With the systematic approach and thoughtful brainstorming on design process, the final design turns up to be a successful showcase of value engineering in geotechnical design.

Geological input in coastal development — some case studies in Peninsular Malaysia and Singapore

TAN BOON KONG

Geology Programme
Faculty of Science & Technology
Universiti Kebangsaan Malaysia
Bangi, Selangor

Geological input is necessary in various engineering construction projects. In coastal development projects, this statement is also true and applicable. This paper presents several engineering construction projects sited in coastal areas of Peninsular Malaysia and Singapore whereby geological input or information form part and parcel of the project requirements. The projects cited include the construction of breakwaters, extension of an airport, harbour, an aqua-culture project, condominium, bridge, marina, hotel and commercial development. The type of geologic input of course varies from project to project, as is the site geology, both surface and sub-surface geology which are site-specific. The example case studies presented illustrate the need for geologic input as part and parcel of project implementation.

Problems of road construction on soft coastal alluvium

NEOH CHENG AIK
E-Geo Consultant Sdn. Bhd.

This paper briefly discusses various problems of road construction on soft coastal alluvium. Practical and cost effective techniques of ground treatment that have been commonly adopted in Malaysia to solve the problems especially the stability and settlement problems are deliberated with case histories. Performance and effectiveness of some of the completed ground treatment techniques such as sand replacement, EPS embankment, stone columns, prefabricated vertical band drain with surcharge, woven geotextile reinforcement and piled embankment are also briefly discussed. Factors and design considerations affecting the choice of suitable or cost effective ground treatment techniques are explained. Suggested scope of monitoring to assess performance and acceptance criteria of ground treatment works is also included.

The discussion in this paper is intended to shed some lights and guidance for engineers involved in design and construction of road on soft coastal alluvial soil or marine clay.

Geology and groundwater resources of the Langat Basin

CHOW WENG SUM
Minerals and Geoscience Department

The Langat Basin is one of the most rapidly developing areas in Malaysia and water supply to the Basin is almost reaching its maximum capacity.

Studies conducted by the Minerals and Geoscience Department jointly with the Japan International Cooperation Agency showed that the Basin has substantial areas of alluvium with an aquifer reaching up to 120 m thick and there is potential for tapping the groundwater.

The groundwater in the Basin is a useful supplementary source in times of drought.

Dynamic pile testing interpretation for piles founded in coastal soft soils

MUN KWAI PENG
Tesonic (M) Sdn. Bhd.

This paper presented at the IEM-GSM Forum on "Engineering Geology & Geotechnics in Coastal Development" organised by the Geological Society of Malaysia and the Geotechnical Engineering Technical Division of the Institution of Engineers Malaysia, on the 23rd October 2002 at the Bangunan Ingenier, Institution of Engineers Malaysia is to discuss some interpretation of dynamic pile testing results for piles founded in coastal soft soil. The author as a pile testing professional using the technique of Stresswave Measurement has more than 15 years of experiences in testing all type of piles. The interpretation principle will be discussed.

Geotechnical considerations in constructions in sensitive coastal sedimentation zones

LEE ENG CHOY

DPI Konsult Sdn. Bhd.

The physical environment of our coastlines is complex and dynamic. The seabed, shoreline and water characteristics respond continuously to the ever-changing effects of tides, waves, ocean (and river) currents and winds. These changes occur on time scales varying from only a few seconds (wave by wave), to a few months (seasonally), to several years (long term erosion or accretion/siltation).

When engineering works are undertaken in the coastal zone, changes may be forced on to the natural processes. Such changes are not always beneficial and may degrade the economic, social and environmental value of the coastline as a result of erosion, siltation and deteriorating water quality. In addition, significant engineering challenges may be encountered when attempting the implementation of engineering works within such dynamic regimes.

A case study is described to illustrate the phenomena of siltation in the coastal regime, the rate of which is considerably accelerated by piled structures. The review also illustrates the sensitivity of the environment, its potential impact on the behaviours of structures constructed within its influence zone, and the construction techniques utilised to overcome or reduce the potential impacts on the new constructions and existing adjacent structures.

Ground improvement of thick deposit of soft clay for Sepang Power Plant

KEM YAH

The proposed Sepang Power Plant site is located in the district of Sepang, 50 km south of Kuala Lumpur, and is approximately 15 km from the coastal sea front. Site preparation work including site clearance, installation of vertical drains and filling commenced in October 2000. Platform construction and preliminary trial piling was completed in July 2001.

Soil investigation and site selection were carried out in September/November 2000. The existing ground level (previously an oil palm plantation) is at approximately +3 mRL with ground water level fluctuate at approximately 0.6 m to 1.2 m below existing ground level. The nearby Langat River platform and is subjected to tidal variations.

The predominant soil conditions encountered is a thick layer of very soft marine clay with intermediate loose to medium sand layers overlying by stiff to hard clayey silt.

Examination of the undrained shear strength (C_u) tests indicates that the soil materials is essentially that of normally consolidated (N_c) recent alluvium marine clay. Values of C_u is also estimated from correlation made by Bjerrum and Simons (1970) between PI and C_u/P_p' where P_o is the vertical effective stresses.

The existing ground level is approximately at +3.0 mRL, the design specification is to provide adequate protection against a 1:100 year flood level of +7.8 mRL (the tidal River Langat is situated at approximately 500 m from the site). The final design solution seeks to optimise the required earthwork fill quantities, construction duration and proposed widening/improvement of River Langat (which aim to reduce the 1:100 year flood level).

The final design platform is at +6 mRL to be protected by a perimeter bund with a design, crest height of 8.8 mRL.

Laying a single piece geotextile over slurry lagoon at Changi, Singapore

SIMON KAM

Forest Point Sdn. Bhd.
Malaysia

The technique to launch a very large sheet of woven polyester geotextile measuring 900 m x 720 m over a silt pond is described in this paper. Challenges including, the choice of the polyester geotextile with a density higher than water, launching wrench system, the effect of the catenary tension in the introduction of the floats and the installation and handling of the 360 m/ton textile are discussed.

A case history of a coastal land reclamation project

C.S. CHEN & S.M. TAN

SSP Geotechnics Sdn. Bhd.
Malaysia

Rapid industrial and commercial expansion in recent years have created the need for more land. One of the options to create more land is to reclaim coastal land. This paper presents a case history of a coastal land reclamation project where the site was partly on landfill and partly of soft tidal land. The landfill consists of variety of materials inclusive of domestic refuse, construction debris, organic substance etc. Subsoil at the site mainly composed of very soft clay layer overlying firm silty clay or medium dense silty sand layers. Hard or very dense soil layer was encountered at 40 to 50 m below the seabed. Potential problem of long term consolidation settlement of the soft compressible soil was expected. Biodegradation of the landfill resulting unexpected ground settlement was also a concern. Ground treatments were carried out. Surcharge method with and without vertical drains were used to treat the soft clay layer depending on time available for treatment. Dynamic compaction method was adopted to treat the landfill. Geotechnical instruments were installed to monitor the subsoil behaviour. Settlement monitoring results are presented in this paper.

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PERSATUAN GEOLOGI MALAYSIA

GEOLOGICAL SOCIETY OF MALAYSIA

ANNUAL GEOLOGICAL CONFERENCE 2002

Renaissance Hotel,
Kota Bharu, Kelantan
26 – 27 May 2002

Editors: G.H. Teh, Ismail Yusoff, Azman Abdul Ghani & T.F. Ng

Collaborators:
- Minerals and Geoscience Department Malaysia
- Universiti Kebangsaan Malaysia
- University of Malaya
- Universiti Sains Malaysia
- Institute of Geology Malaysia

Bulletin of the Geological Society of Malaysia

MAY 2002 *Conference Issue* No. 45

BERITA-BERITA PERSATUAN
News of the Society

KEAHLIAN (Membership)

The following applications for membership were approved:

Student Members

1. Nik Ahmed Azran Anizam
Jabatan Geologi, Universiti Malaya, 50603
Kuala Lumpur.

2. Mustaza Musa
Jabatan Geologi, Universiti Malaya, 50603
Kuala Lumpur.

3. Tam Chie Fatt
Jabatan Geologi, Universiti Malaya, 50603
Kuala Lumpur.

4. Mohd Badrol Jusoh
Jabatan Geologi, Universiti Malaya, 50603
Kuala Lumpur.

5. Aruha binti Azmi
Jabatan Geologi, Universiti Malaya, 50603
Kuala Lumpur.

PETUKARAN ALAMAT (Change of Address)

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

1. Chiong Siong Khai
Teca (B) Sdn. Bhd., Gadong B.S.B. 3108,
P.O. Box 835, Negara Brunei Darussalam.

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

1. Ivan James Sta Maria
   7 Puteri 4, Taman Segamat Jaya, 85000
   Segamat, Johor.

PERTAMBAHAN BAHARU PERPUSTAKAAN (New Library Additions)

The Society has received the following publications:

1. Palaeontological Abstracts, vol. 16, no. 4, 2001 & vol. 17, nos. 1 & 2, 2002.
2. Episodes, vol. 25, no. 3, 2002.
3. Monthly statistics on mining industry in Malaysia, March-June 2002.
4. Journal of Geosciences, Osaka City University, vol. 45, 2002.
5. Bulletin of the American Museum of Natural History no. 267 (2001).
6. American Museum Novitates, 2001: no. 3354; 2002: nos. 3359, 3360, 3361, 3362, 3363, 3364.
7. AAPG Explorer, September 2002.
8. Oklahoma Geology Notes, vol. 62, nos. 1 & 2, 2002.
9. AAPG Bulletin, vol. 86, no. 6, 2002.
10. Tin International, vol. 75, no. 8, 2002.
11. Acta Palaeontologica Sinica, vol. 41, no. 2, 2002.
12. Acta Micropalaeontologica Sinica, vol. 19, nos. 1 & 2, 2002.
13. USGS Professional Paper: 2002: 1634 (CD), 1644, 1657, 1663, 1660, 1667. 2001: 1625-C (CD), 1648. 2000: 1623 (CD).
14. USGS Circular: 2002: no. 1220.

BERITA-BERITA LAIN
Other News

KALENDAR (CALENDAR)

2002

November 20–23
ROLE OF NATURAL RESOURCES AND ENVIRONMENT FOR SUSTAINABLE DEVELOPMENT IN SOUTH AND SOUTHEAST ASIA, Dhaka, Bangladesh. (Contact: Ms. Afia Akhtar, Convenor, NESDA & Vice President, AGID, Director, Geological Survey of Bangladesh, 153 Pioneer Road, Segunbagicha, Dhaka 1000, Bangladesh. Tel: 880-2-418545 (O), 9337559, 9350412 (H); E-mail: afia@agni.com or mnhasan@agni.com; or Mr. Nehal Uddin, Member Secretary, NESDA, Deputy Director, Geological Survey of Bangladesh, 153 Pioneer Road, Segunbagicha, Dhaka 1000, Bangladesh. Tel: 880-2-9348318; E-mail: nehalu@bttb.net.bd)

2003

SIXTH INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL GEOCHEMISTRY, Edinburgh, Scotland. (Contact: John Farmer, Dept. of Chemistry, The University of Edinburgh, Joseph Black Building, Kings Buildings, West Mains Road, Edinburgh EHP 3JJ Scotland. Tel: 0131-650-1000; Fax: 0131-650-4757; E-mail: J.G.farmer@ed.ac.uk)

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

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

June 15–17
7TH ICOBTE — INTERNATIONAL CONFERENCE ON BIOGEOCHEMISTRY OF TRACE ELEMENTS, Uppsala, Sweden. (Contact: George R. Gobran. Fax: 46 (18) 67 34 30; E-mail: George.Gobran@eom.slu.se or ICOBTE7@slu.se; Website: http://www.eom.slu.se)

June 16–18
5TH INTERNATIONAL CONFERENCE ON THE ANALYSIS OF GEOLOGICAL AND ENVIRONMENTAL MATERIALS, Rovaniemi, Finland. (Contact: Website: http://www.gsf.fi/geoanalysis2003)

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

September 15–18
INDUSTRIAL MINERALS AND BUILDING STONES — IMBS 2003, Istanbul, Turkey. (Contact: Erdogan Yüzer, Maden fakültesi, Ayazaga KampÜsÜ, 80626 Maslak/Istanbul,

Turkey. Tel/Fax: 90 212 285 61 46; E-mail: yuzer@itu.edu.tr)

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

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

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

2004

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)

August
32ND INTERNATIONAL GEOLOGICAL CONGRESS, Florence, Italy. Congress theme: *"The Renaissance of Geology: From the Mediterranean area toward a global Geological Renaissance-Geology, Natural Hazards, and Cultural Heritage"* (Contact: E-mail: 32igc@32igc.org; Website: http://www.32igc.org/)

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)

GEOLOGICAL SOCIETY OF MALAYSIA PUBLICATIONS

Bulletin 1 (Feb 1968). 79 p. Studies in Malaysian Geology. Edited by P.H. Stauffer. A collection of papers presented at a meeting of the Geological Society on 31st January 1967. **Out of Stock.**

Bulletin 2 (Dec 1968). 152 p. Bibliography and Index of the Geology of West Malaysia and Singapore by D.J. Gobbett. Price: RM5.00.

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Bulletin 5 (Feb 1973). 70 p. The Search for Tungsten Deposits by K.F.G. Hosking. Price: RM5.00.

Bulletin 6 (Jul 1973). 334 p. Proceedings, Regional Conference on the Geology of Southeast Asia. A collection of papers, Kuala Lumpur, March, 1972. Edited by B.K. Tan. Price: RM5.00.

Bulletin 7 (Jun 1974). 138 p. A collection of papers on geology. Edited by B.K. Tan. Price: RM5.00.

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Bulletin 17 (Dec 1984). 371 p. A collection of papers on geology. Edited by G.H. Teh. Price: RM10.00.

Bulletin 18 (Nov 1985). 209 p. Special Issue on Petroleum Geology. Edited by G.H. Teh & S. Paramananthan. Price: RM15.00.

Bulletins 19 (Apr 1986) **& 20** (Aug 1986). GEOSEA V Proceedings Vols. I & II, Fifth Regional Congress on Geology, Mineral and Energy Resources of SE Asia, Kuala Lumpur, 9-13 April 1984. Edited by G.H. Teh & S. Paramananthan. Price for both Bulletins 19 & 20: Members: RM30.00; Non-Members: RM60.00.

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Bulletin 23 (Aug 1989). 215 p. A collection of papers on the geology of Malaysia, Thailand and Burma. Edited by G.H. Teh. Price: RM10.00.

Bulletin 24 (Oct 1989). 199 p. A collection of papers presented at GSM Annual Geological Conference 1987 and 1988. Edited by G.H. Teh. Price: RM10.00.

Bulletin 25 (Dec 1989). 161 p. Special Issue on Petroleum Geology Vol. IV. Edited by G.H. Teh. Price: RM20.00.

Bulletin 26 (Apr 1990). 223 p. A collection of papers presented at GSM Annual Geological Conference 1989 and others. Edited by G.H. Teh. Price: RM10.00.

Bulletin 27 (Nov 1990). 292 p. Special Issue on Petroleum Geology Vol. V. Edited by G.H. Teh. Price: RM20.00.

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Bulletin 33 (Nov 1993). 419 p. Proceedings Symposium on Tectonic Framework and Energy Resources of the Western Margin of the Pacific Basin. Edited by G.H. Teh. Price: RM40.00.

Bulletin 34 (Dec 1993). 181 p. Bibliography and Index — Publications of the Geological Society of Malaysia 1967-1993. Compiled by T.F. Ng. Edited by G.H. Teh. Price: RM20.00.

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Bulletin 36 (Dec 1994). 186 p. Special issue on Petroleum Geology Vol. VIII. Edited by G.H. Teh. Price: RM50.00.

Bulletin 37 (Jul 1995). 506 p. Proceedings AAPG-GSM International Conference 1994. Southeast Asian Basins: Oil and Gas for the 21st Century. Edited by G.H. Teh. Price: RM60.00.

Bulletin 41 (Dec 1997). 165 p. Papers from Petroleum Geology Conference 1996 and others. Edited by G.H. Teh. Price: RM50.00.

Bulletin 43 (Dec 1999). 698 p. Papers from GEOSEA '98 (Ninth Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia). Edited by G.H. Teh. Price: RM70.00.

Bulletin 45 (Jun 2002). 375 p. Annual Geological Conference 2002 Conference Issue. Edited by G.H. Teh, Ismail Yusoff, Azman Abdul Ghani & T.F. Ng. Price: RM50.00.

Field Guide 1 (1973). 40 p. A 7-day one thousand mile, geological excursion in Central and South Malaya. By C.S. Hutchison. **Out of stock.**

Abstracts of papers (1972). Regional Conference on the Geology of Southeast Asia, Kuala Lumpur, 1972. 64 p. 8 figs, 3 tables, many extended abstracts. Edited by N.S. Haile. Price: RM2.00.

Proceedings of the Workshop on Stratigraphic Correlation of Thailand and Malaysia Vol. 1. (1983). 383 p. Technical Papers. Price: Member: RM5.00; Non-member: RM15.00.

WARTA GEOLOGI (Newsletter of the Geological Society of Malaysia). Price: RM5.00 per bimonthly issue from July 1966.

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Proceedings Annual Geological Conference 2000. 435 p. Edited by G.H. Teh, Joy J. Pereira and T.F. Ng. Price: RM60.00.

Proceedings Annual Geological Conference 2001. 320 p. Edited by G.H. Teh, Mohd. Shafeea Leman and T.F. Ng. Price: RM50.00.

CD-Rom — Geology of Borneo Island (2001). Compiled by Robert B. Tate. Price: RM60.00.

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Script Requirements

Scripts must be written in Bahasa Malaysia (Malay) or English.

Two copies of the text and illustrations must be submitted. The scripts must be typewritten double-spaced on paper not exceeding 210 x 297 mm (or 8.27 x 11.69 inches, A4 size). One side of the page must only be typed on.

Figure captions must be typed on a separate sheet of paper. The captions must not be drafted on the figures. The figure number should be marked in pencil on the margin or reverse side.

Original maps and illustrations or as glossy prints should ideally be submitted with sufficiently bold and large lettering to permit reduction to 18 x 25 cm: fold-outs and large maps will be considered only under special circumstances.

Photographs should be of good quality, sharp and with contrast. For each photograph, submit two glossy prints, at least 8 x 12.5 cm and preferably larger. Use of metric system of measurements (SI) is strongly urged wherever possible.

An abstract in English which is concise and informative is required for each paper.

References cited in the text should be listed at the end of the paper and arranged in alphabetical order and typed double-spaced. The name of the book or journal must be in *italics*. The references should be quoted in the following manner:

HAMILTON, W., 1979. Tectonics of the Indonesian region. *U.S. Geological Survey Professional Paper 1078*, 345p.

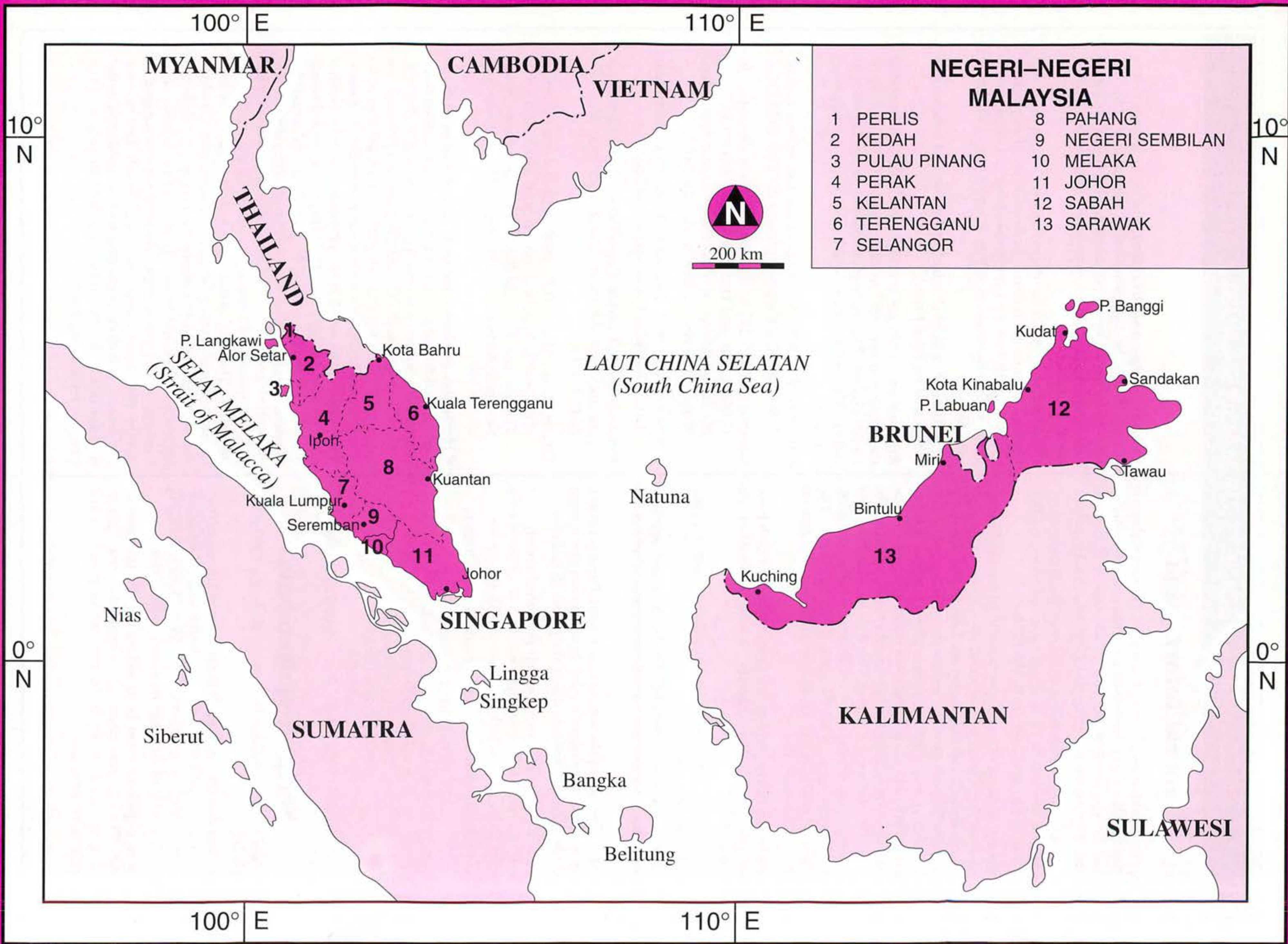
HOSKING, K.F.G., 1973. Primary mineral deposits. *In* Gobbett, D.J. and Hutchison, C.S. (Eds.), *Geology of the Malay Peninsula (West Malaysia and Singapore).* Wiley-Interscience. New York, 335-390.

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

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

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

Submission of electronic text. In order to publish the paper as quickly as possible after acceptance, authors are requested to submit the final text also on a 3.5" diskette. Both Macintosh and PC (DOS/Windows) platforms are supported. Main text, tables and illustrations should be stored in separate files with clearly identifiable names. Text made with most word processors can be readily processed but authors are advised to provide an additional copy of the text file in ASCII format. Preferred format for illustration is Encapsulated PostScript (EPS) but authors may submit graphic files in their native form. It is essential that the name and version of softwares used is clearly indicated. The final manuscript may contain parts (e.g. formulae, complex tables) or last-minute corrections which are not included in the electronic text on the diskette; however, this should be clearly marked in an additional hardcopy of the manuscript. Authors are encouraged to ensure that apart from any such small last-minute corrections, **the disk version and the hardcopy must be identical**. Discrepancies can lead to proofs of the wrong version being made.


NEGERI–NEGERI MALAYSIA
1 PERLIS
2 KEDAH
3 PULAU PINANG
4 PERAK
5 KELANTAN
6 TERENGGANU
7 SELANGOR
8 PAHANG
9 NEGERI SEMBILAN
10 MELAKA
11 JOHOR
12 SABAH
13 SARAWAK
100° E
110° E
10° N
0° N
MYANMAR
CAMBODIA
VIETNAM
THAILAND
N
200 km
P. Langkawi
Alor Setar
Kota Bahru
Kuala Terengganu
Ipoh
Kuantan
Kuala Lumpur
Seremban
Johor
SELAT MELAKA
(Strait of Malacca)
LAUT CHINA SELATAN
(South China Sea)
Natuna
SINGAPORE
P. Banggi
Kudat
Kota Kinabalu
Sandakan
P. Labuan
BRUNEI
Miri
Tawau
Bintulu
Kuching
Nias
Lingga
Singkep
Siberut
SUMATRA
KALIMANTAN
Bangka
Belitung
SULAWESI