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PERSATUAN GEOLOGI MALAYSIA

WARTA GEOLOGI

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KANDUNGAN (Contents)

GEOLOGICAL SOCIETY OF MALAYSIA

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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The Sabah Complex — A lithodemic unit (a new name for the Chert-Spilite Formation and its ultramafic association)

BASIR JASIN
Jabatan Geologi, Universiti Kebangsaan Malaysia,
43600 Bangi, Selangor Darul Ehsan.

Abstrak: Formasi Rijang-Spilit telah lama digunakan sebagai unit litostratigrafi formal. Penamaan formasi ini sangatlah mengelirukan. Kajian geologi singkapan baru formasi tersebut telah menghasilkan banyak maklumat penting. Di sini dicadangkan Kompleks Sabah sebagai satu unit litodem menggantikan Formasi Rijang-Spilit. Kompleks Sabah ini bukan sahaja menggantikan nama formasi tersebut tetapi merangkumi batuan ultramafik yang berasosiasi dengannya. Kompleks Sabah terdiri daripada batuan peridotit, serpentinit, basalt, spilit, lava bantal dan jujukan rijang. Kewujudan radiolaria dalam rijang membolehkan penentuan usia batuan itu dengan lebih tepat. Usia jujukan rijang ialah Kapur Awal. Batuan volkano mafik-ultramafik dianggap berusia lebih tua daripada Kapur Awal kemungkinannya Jura Akhir.

Abstract: The Chert-Spilite Formation has been used as a formal lithostratigraphic unit for a long time. The naming of this formation has resulted in some confusion. Geological investigation of several new outcrops provides new information. Here, I would like to propose Sabah Complex as a lithodemic unit to replace the Chert-Spilite Formation. This complex is not only to replace the Chert-Spilite Formation but to include its ultramafic association. The Sabah Complex is composed of peridotite, serpentinite, basalt, spilite, pillow lava and chert sequence. The occurrence of radiolaria in the chert enable more precise age determination. The age of the chert is Early Cretaceous. The mafic-ultramafic volcanic rocks must be older than Early Cretaceous, most probably Late Jurassic.

INTRODUCTION

The Chert-Spilite Formation was introduced by Fitch (1955) for a sequence of rocks consisting of chert, shale, sandstone, calcareous siltstone, limestone, marl, porcelanite and conglomerate associated with basic volcanic rocks comprising pillow lava, basalt, spilite and diabase. Eversince then the term has been used as a formal lithostratigraphic unit. This formation has been reviewed by Wilson (1963) but he retained the term Chert-Spilite Formation.

The aims of this paper are to revise this formation and to propose a new appropriate name in accordance with the present stratigraphic code (North American Commission on Stratigraphic Nomenclature, 1983).

COMMENT ON THE TERMINOLOGY OF THE CHERT-SPILITE FORMATION

The term Chert-Spilite Formation has resulted in some confusion. A "Formation" is a formal lithostratigrahic unit which is usually applied to sedimentary, low-grade metamorphic and volcanic rocks which were deposited in accordance with the Law of Superposition. Since the Chert-Spilite Formation is composed of two genetically different classes of rocks viz. sediments and mafic igneous rocks, the word "Formation" is not applicable here. Therefore, this unit is not a lithostratigraphic unit.

The terminology of the Chert-Spilite Formation is incorrect. A formation name consists of a geographic name followed by a lithic designation or by the word "Formation". The word "Chert-Spilite" cannot be used as a name of a formation. In order to avoid further confusion the term Chert-Spilite Formation should be abandoned.

Sanudin Hj. Tahir and Tan (1986) have suggested that the Chert-Spilite Formation should be included in a stratigraphic unit called the Sabah Mélange. I disagree with this idea because not all the Chert-Spilite Formation occurred as olistholiths in chaotic deposits (mélange), but only some boulders or blocks of the formation might have been transported into younger formation viz. the Ayer Formation, the Garinono Formation and the Kuamut Formation. In other places such as in Kudat, Taritipan, Telupid, and Banggi Island the Chert-Spilite Formation is not associated with chaotic deposits. The term mélange is neither a lithostratigraphic nor a lithodemic unit. The age of the mélange is very much younger than the actual age of the Chert-Spilite Formation.

According to North American Commission on Stratigraphic Nomenclature (1983), two or more genetically different classes of rocks which are found together and cannot be differentiated should be grouped as a complex. A complex is a lithodemic unit consisting of a mixture or assemblage of rock belonging to two or more classes of rocks, that is igneous, sedimentary and metamorphic rocks. The term complex is more appropriate for naming this rock association. Here, I would like to propose the word "Sabah Complex". The Sabah Complex is not only to replace the Chert-Spilite Formation but to include its ultramafic association.

LITHOLOGY OF SABAH COMPLEX

The Sabah Complex is mainly composed of two classes of rocks, that is sedimentary rocks which consists of thinly bedded chert interbeds with siliceous shale and mafic-ultramafic igneous rocks, which comprises basalts, spilite, pillow lava, serpentinite, serpentinised peridotite and peridotite. This rock association is considered to represent a part of a dismembered ophiolite sequence. The other rock types such as sandstone, siltstone, limestone and conglomerate which were previously considered as a part of the formation (Fitch, 1955; Wilson, 1963) are of younger age and are therefore excluded from this complex.

The chert is thinly bedded and contains numerous skeletons of radiolaria of various shapes and sizes. The chert is made up of biogenic silica (radiolarite). The chert is interbedded with siliceous shale. The shale is highly weathered and soft. This rhythmic bedding is called ribbon chert. This chert sequence overlies comformably the mafic-ultramafic rocks. This type of chert is usually found in the deep water environment.

Mafic-ultramafic volcanic rocks consist of pillow lava, basalt, spilite, serpentinite, serpentinised peridotite, and peridotite. These rocks are slightly sheared. The boundaries of these rocks are not clear. Serpentinite and peridotite are usually found in the upper layer of the outer mantle (Nicolas, 1989). They probably crystallised during the early phase of seafloor rifting or spreading. Spilite, basalt, and pillow lava were formed from the cooling of molten liquid which escaped through fissures or fractures particularly in oceanic crust. This rock association represents the initial oceanic crust. This mafic-ultramafic rock association was actually a part of initial oceanic crust formed during the early period of rifting prior to the deposition of the chert sequence.

DISTRIBUTION OF THE SABAH COMPLEX

The distribution of the Sabah Complex is more or less similar to those of the Chert-Spilite Formation but it includes the ultramafic rocks. The Sabah Complex is mainly found in Banggi Island, Kudat, Taritipan, Telupid, Segama valley, and Pulau Timbun Mata (Fig. 1.). Smaller outcrops may be found in Ranau and Sandakan areas. Fragments of the Sabah Complex are found as olistoliths in the younger chaotic formations viz. Kuamut, Garinono, and Ayer formations.

AGE OF THE SABAH COMPLEX

The age of the Chert-Spilite Formation was dated to range from Late Cretaceous to

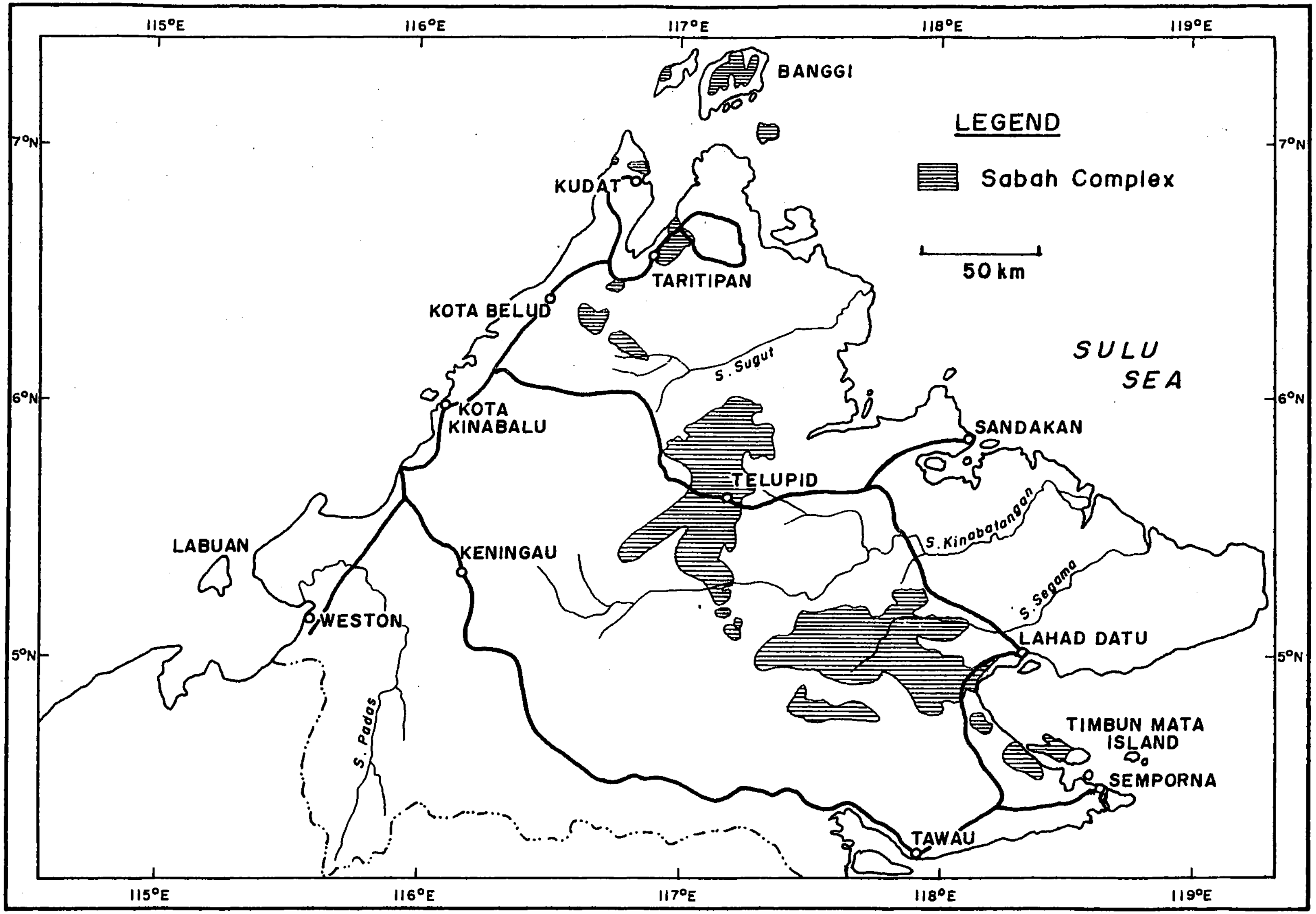

Figure 1: Distribution of the Sabah Complex.

Eocene (Fitch, 1955; Wilson, 1963). The age of the formation was revised by Leong (1977). He suggested the Early Cretaceous age (Valanginian to Barremian) based on the radiolarian assemblage from the Upper Segama area.

Recently, more radiolarian chert samples were collected from Kudat, Taritipan, and Telupid areas. Sixteen species of radiolaria were identified from several samples of Bukit Pengaraban, near Kudat Town. They are *Conosphaera tuberosa* Tan Sin Hok, *Archaeodictyomitra puga* Schaaf, *Archaeodictyomitra lacrimula* (Foreman), *Thanarla conica* (Aliev), *Thanarla pulchra* (Squinabol), *Parvicingula* sp., *Pseudodictyomitra carpatica* (Lozyniak), *Obesacapsula rotunda* (Hinde), *Sethocapsa orca* Foreman, *Paronaella* sp., *Orbiculiforma* sp., *Sethocapsa* cf. *uterculus* (Parona), *Stichocapsa pseudodecora* Tan Sin Hok, *Xitus spicularius* (Aliev), *Xitus vermiculatus* (Renz), and *Eucyrtis elido* Schaaf. This assemblage indicates that the age of the chert is Barremi an (Basir Jasin and Sanudin Hj. Tahir, 1988). The occurrence of *Obesacapsula rotunda* suggests that the age may range from Valanginian to Barremian.

The chert from the Taritipan area was dated by radiolarian assemblage which consists of *Conosphaera tuberosa* Tan Sin Hok, *Archaeodictyomitra lacrimula* Foreman, *Archaeodictyomitra puga* Schaaf, *Thanarla conica* (Aliev), *Thanarla pulchra* (Squinabol), *Archaeodictyomitra vulgaris* Pessagno, *Archaeodictyomitra brouweri* (Tan Sin Hok), *Pseudodictyomitra carpatica* (Lozyniak), *Pseudodictyomitra* cf. *leptonica* (Foreman), *Eucyrtis elido* Schaaf, *Eucyrtis micropora* (Squinabol), *Parvicingula boesii* (Parona), *Parvicingula rothwelli* Pessagno, *Parvicingula cosmoconica* Foreman, *Lithomitra pseudopinguis* Tan Sin Hok, *Sethocapsa cetia* Foreman, *Sethocapsa cribrata* (Hinde), *Xitus spicularius* (Aliev) and *Hemicryptocapsa pseudopilula* Tan Sin Hok. This assemblage also indicates the range from Valanginian to Barremian.

Several species of radiolaria were identified from the chert samples of Telupid area. They are *Conosphaera tuberosa* Tan Sin Hok, *Archaeodictyomitra pseudoscalaris* (Tan Sin Hok), *Archaeodictyomitra vulgaris* Pessagno, *Pseudodictyomitra carpatica* (Lozyniak), *Stichomitra asymbatos* Foreman, *Thanarla conica* (Aliev), *Thanarla pulchra* (Squinabol), *Xitus spicularius* (Aliev), *Hemicryptocapsa pseudopilula* Tan Sin Hok, *Archaeodictyomitra* sp., *Lithomitra pseudopinguis* (Tan Sin Hok), *Pseudodictyomitra lilyae* (Tan Sin Hok), *Sithocapsa cribrata* (Hinde), *Xitus alievi* (Foreman), *Siphocampium davidi* Schaaf, *Archaeodictyomitra brouweri* (Tan Sin Hok), *Hagiastrum* sp., *Higumastra* sp., *Paronaella* sp., *Alievium* sp., *Spongodiscus* sp., *Orbiculiforma* sp., *Pseudodictyomitra* sp., *Acaeniotyle umbilicata* (Rust), *Acaeniotyle diaphorogona* Foreman, *Staurosphaera septemporata* Parona and *Ultranapora* sp. This assemblage indicate the same age from Valanginian to Barremian.

The dating of radiolarian chert from these four places has given a consistence range of age from Valanginian to Barremian. This age may extend up to Albian (Rangin *et al.*, 1990). The age of the chert is definitely Early Cretaceous and no younger chert was found from this complex.

The age of mafic-ultramafic rocks is not known. It seem that these rocks are very much older than the chert sequence. It is assumed that the age of the rocks must be older than Early Cretaceous, most probably Late Jurassic. No radiometric dating has been carried on these rocks. This mafic-ultramafic rock association was probably the oldest oseanic crust which formed during the early period of rifting and the age of the rocks is probably equivalent or slightly younger than that of crystalline basement which was dated approximately 210 Ma, Lower Jurassic (Leong, 1974).

STRATIGRAPHICAL RELATIONSHIP

The relationship between Sabah Complex and Madai-Baturong limestone in the northern part of Semporna Peninsula is not very clear. Adam and Kirk (1963) considered the Madai-Baturong limestone as a member the Chert-Spilite Formation. The age of the limestone was not established. Some foraminifera indicate a Late Cretaceous age and some algae suggest an Early Cretaceous. Adam and Kirk (1963) considered that the age of limestone was Early

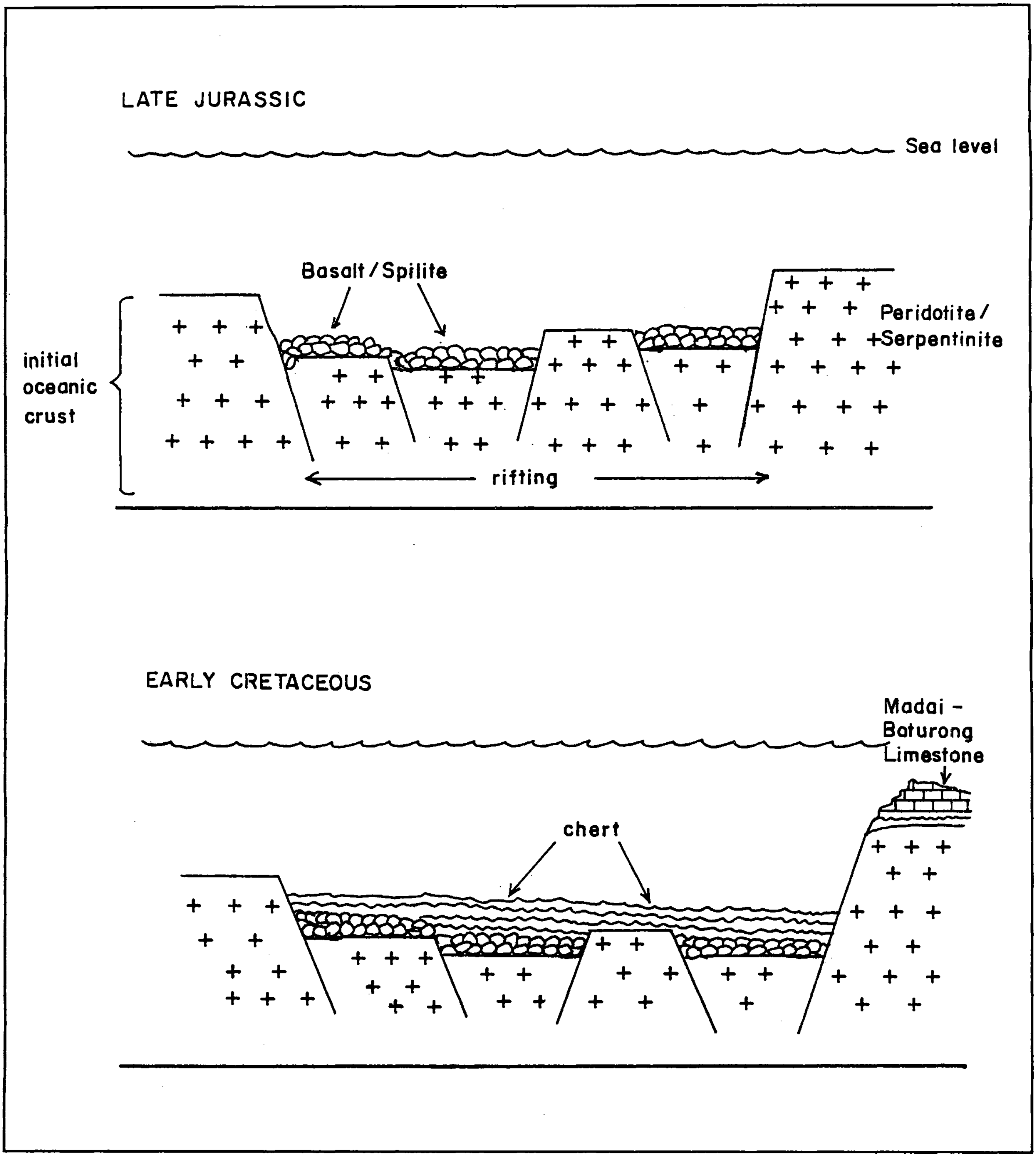

Figure 2: Development of the Sabah Complex.

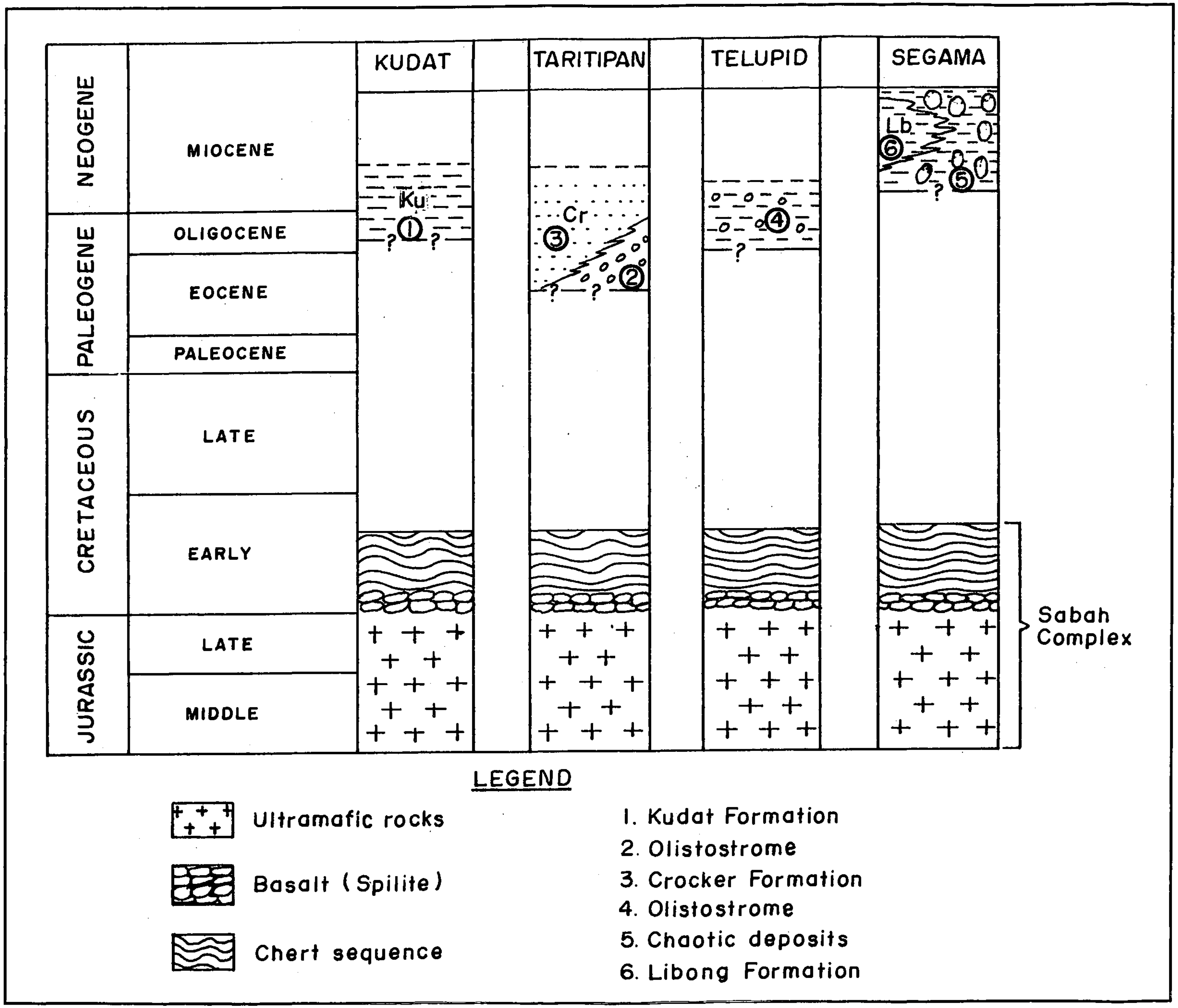

Figure 3: Stratigraphic relationship between the Sabah Complex and the overlying clastic sedimentary rocks.

Cretaceous because they thought that the limestone was overlain by the Late Cretaceous-Eocene Chert-Spilite Formation. In Madai area, the limestone is underlain by the chert-spilite association. This suggests that the limestone must be younger than the chert. It was probably deposited during the Late Cretaceous. A detailed study of microfossils is required in order to determine the precise age of the limestone. This limestone was probably deposited on a horst which was surrounded by deep sea graben (Fig. 2). This limestone is now considered to be separate formation and cannot be included in the Sabah Complex.

The chert sequence of the Sabah Complex is stratigraphically separated from the overlying sediments by a long ranging hiatus (Fig. 3). The hiatus ranges from the Late Cretaceous to Late Eocene and in some places it may extend to Miocene. This stratigraphic gap was probably related to the extensive tectonic activities which caused the thrusting or obduction of the oceanic floor to form dismembered ophiolite sequence prior to the deposition of Tertiary clastic sediments.

CONCLUSION AND SUGGESTION

The Sabah Complex is a lithodemic unit consisting of an assemblage of chert sequence, mafic and ultramafic volcanic rocks which represents a dismembered ophiolite sequence. The sequence was a part of initial oceanic crust which developed as a result of early rifting or spreading of the seafloor. The oceanic crust was faulted to form grabens and horsts. Most of the chert was probably deposited in grabens (deep-water environment) and the limestone (Madai-Baturong) was deposited on a horst (shallow water environment). The rocks have undergone extensive tectonic activities during the Late Cretaceous-Early Paleogene time and this has resulted in the obduction of the dismembered ophiolite sequence prior to the deposition of overlying clastic sediments.

The Chert-Spilite Formation was proposed without a type section. In order to formalised the Sabah Complex a type section must be assigned. A detailed study is required to find the most complete section. I would like to suggest the Telupid area as a type area where all major rock types of the Sabah Complex such as peridotite, serpentinite, spilite, and chert are widely exposed.

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Manuscript received 23.8.91

PERTEMUAN PERSATUAN
Meetings of the Society

Petroleum Geology Seminar '91 – Laporan (Report)

The 15th in the series of Annual Petroleum Geology Seminar organised by the Society was held on the 26th and 27th November 1991 at the Shangri-La Hotel, Kuala Lumpur. It was declared open by YB Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department.

Once again, there was an increase in turnout at this year's premier Petroleum Geology Seminar; well over 400 participants were at this annual get-together. The programme included 2 keynote addresses, one by Brian R.H. Anderson and the other by Dato' Karl F. Swensen and 26 interesting papers with contributors from the local oil companies, service companies, Petronas Petroleum Research Institute and the local universities.

The cocktail on the first evening was sponsored by Schlumberger Overseas S.A., while Halliburton, Sierra Geophysics and Vann System hosted lunch on the first day and Nippon Oil, Japan Taiyo Oil, Malaysia Baram Oil and Idemitsu were the lunch hosts for the following day. Teas were hosted by Petronas, Geoeast, Racal Survey and EPMI. We have these organisations and others to thank for their firm support and financial contributions to the success of the Society's Annual Petroleum Geology Seminars.

G.H. Teh

Petroleum Geology Seminar 1991

1-2.	The crowd at the registration desk.
3.	Arrival of the Guest-of-Honour.
4.	Khalid Ngah, Chairman of Organising Committee.
5.	GSM President, Ahmad Said with his speech.
6.	YB Dato' Wong See Wah with the Opening Address.
7.	A token of appreciation for the Deputy Minister.
8-13.	The audience at the Opening Ceremony.
14.	Brian R.H. Anderson with his Keynote Address.
15.	Mohamed Taha with his paper.
16.	Chu Yun Shing on reservoir sandstones.
17.	Raidi Hashim presenting his paper.
18.	H.D. Tjia presenting a joint paper.
19.	Ismail Che Mat Zin on the Tembungo Field.
20.	John Huong on ditch-cutting analysis.
21.	Lunch.
22.	Fred A. Dix Jr. on AAPG activities.
23.	S.P. Sivam with a joint paper.
24.	Abdul Jalil Muhamad on Tembungo oils.
25.	Ho Chee Kwong with his paper.
26.	Zuraida Mat Isa on Dulong Field.
27.	K.K. Kee posing a question.
28.	J.B. Blanche on Cambodia and Laos.
29.	D.M. Angstadt on shipboard processing.
30.	Craig J. Beasley with his paper.
31.	Bahari Md. Nasib on biostratigraphy.
32.	H.P. Hazebroek with a comment.
33.	Peter Chia on marine data.
34.	Dato' Karl F. Swensen with his Keynote Address.
35.	Leong Lap Sau with his joint paper.
36.	Nik Ramli on pore space reducing clays.
37.	John A. Hill on clay mineralogy.
38.	Duncan C. Barr stressing a point.
39.	Peter B. Woodroof with his presentation.
40.	Idris M.B. on SW Luconia.
41.	Charles S. Hutchison on Tertiary Basins.
42.	K.R. Chakraborty on tectonism in Borneo.
43.	N.S. Haile with his presentation.
44.	Talib Ak Buyok with his paper.
45.	Ng Tong San with the Closing Remarks.

PETROLEUM GEOLOGY SEMINAR '91


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PETROLEUM GEOLOGY SEMINAR '91

Welcoming Speech
by
Encik Ahmad Said
the President of the Geological Society of Malaysia
at the
Geological Society of Malaysia Seminar on Petroleum Geology
at Shangri-La Hotel on November 26, 1991

Mr. Chairman,

Y. Berhormat Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department

Dato' Dato'

Distinguished guests

Ladies and gentlemen

On behalf of the Geological Society of Malaysia, I take great pleasure in welcoming Yang Berhormat Dato' Wong See Wah, Deputy Minister in the Prime Minister's Department and all our distinguished guests and participants to the opening of the Society's Annual Petroleum Geology Seminar.

We are indeed very honored to have Yang Berhormat Dato' Wong See Wah who has taken time off his busy schedule to be present here with us this morning to officiate at the opening of this seminar.

Ladies and gentlemen,

This seminar is the 15th in the series of Petroleum Geology Seminars organized by the Geological Society of Malaysia. This year's Petroleum Geology Seminar will have a total of 26 technical papers by authors from oil companies, service companies, universities, consultants and research institutions. We would like to thank all the authors for their efforts in making up the interesting technical programme. We will also have the pleasure of listening to 2 keynote addresses by Y. Bhg. Dato' Karl Swenson, the Managing Director of Esso Production Malaysia Inc. and Dr. Brian Anderson, the Managing Director of Sarawak Shell Berhad/Sabah Shell Petroleum Co. Both these gentlemen are strong supporters of the high-tech Exploration efforts in this country and we certainly look forward to their talks. Also, it is always a pleasure listening to engineers tell us what a great job we explorationists are doing or maybe they are going to tell us that most of us geologists can be replaced by interactive workstations.

Ladies and gentlemen,

The Geological Society is indeed very proud to have organized a significant number of conferences, seminars, workshop, fieldtrips and technical talks over the past years. This year the Society hosted its 6th Annual Geological Conference in Kuching which was an outstanding success. Over 150 delegates attended and we had over 40 technical papers presented. Four fieldtrips were also conducted in conjunction with the Conference, including a 3-day landtrip from Kuching to Miri. Next year's Annual Geological Conference is planned to be held in Kuantan and we are sure that this will be a great success as well.

The Society is currently preparing for 2 major international conferences to be hosted by the Society in 1992 and 1994.

A symposium on Tectonic Framework and Energy Resources of the Western Margin of the Pacific Basin will be held from November 29 – December 2, in Kuala Lumpur. This major conference, which is jointly organized with the Circum Pacific Council for Energy and Mineral Resources, is expected to make a significant contribution to the geology of this region. The response to papers for this conference has been most gratifying so far and a number of distinguished geologists have agreed to give keynote addresses. This symposium will be held in lieu of the petroleum Geology Seminar next year and I am sure the Society can count on the support of the people here today who have supported the Petroleum Geology Seminar to be here again with us for the Symposium next year.

The 1994 AAPG International Convention will also be held in Kuala Lumpur in August of that year. Dr. Khalid Ngah will be the General Chairman for the convention and I am sure he can look forward to your support for this convention. In this connection, I am pleased also on behalf of the Geological Society to welcome Mr. Fred Dix Jr., Executive Director of AAPG, who id here with us today.

Ladies and gentlemen,

I would like to thank the numerous individuals and organizations which have so faithfully supported the Geological Society in the running of the Seminar and also the other activities of the Society. Our thanks are due to Organizing Committee headed by Dr. Khalid Ngah for this excellent organization of this seminar.

I would like to thank all of you for being here with us today and it is with great pleasure that I call now upon Yang Berhormat Dato' Wong See Wah to say a dew words and officially declare open the seminar.

Thank you.

Opening Address

by

Hon. Dato' Wong See Wah
Deputy Minister in the Prime Minister's Department

at the

Geological Society of Malaysia Seminar on Petroleum Geology

at Shangri-La Hotel on November 26, 1991 at 9.00 am

Mr. Chairman,

Encik Ahmad Said

President Geological Society of Malaysia,

Dr. Khalid Ngah

Seminar Organising Chairman,

The Honourable Guests,

Ladies and Gentlemen,

First of all, I would like to extend a very warm welcome to all of you to this seminar. The seminar will address many aspects of petroleum geology, for examples, how oil and gas were formed; what is the relationship between oil and gas generation and trap development. some of you will take this opportunity to share and express your ideas and even your experiences, with always one objective in mind: to explore for and discover more oil and more gas.

But really, I am very pleased to be here with you all today. I recalled being present in the very same petroleum geology seminar at PWTC last year. All the same, this seminar enables me to share some of my concerns of the future of oil and gas reserves of the world, and in particular, the oil and gas reserves of this country.

We all know that the world has limited oil and gas resources. Much of petroliferous areas of the world have been explored; much of their oil and gas potentials have been assessed and much of their reserves discovered and produced. We also know that the world consumes more than 60 million barrels of oil and 200 billion cubic feet of gas per day. And these rates of consumption of oil and gas are enormous. Some experts predict that, if the world in consuming oil and gas at these excessively high rates, the presently known world reserves would be exhausted in about 50 years. That is to say, unless we can continue discovering more oil and gas at the rates that we are consuming, the world will have to rely on other materials for its sources of energy and petrochemical products.

The Honourable guests, ladies and gentlemen,

This is indeed a very sad scenario, this sad scenario will have the greatest impact on developing countries, like Malaysia. This country relies heavily on oil and gas revenues to supplement its development. And you know that Malaysia has limited oil and gas resources. Malaysia's known oil reserves is about 3.6 billion barrels and the gas reserves is about 59 trillion cubic feet, and we are producing about 630 thousand barrels of oil and 1.7 billion cubic feet of gas per day. Using a very simple arithmetic, this oil reserved cannot take Malaysia very far. And if no additional and substantial discoveries are made within the next decade, and if no prudent reservoir management is introduced now to extend the lives of existing fields, Malaysia will need to import oil (and gas) to meet the demand.

The government understands this problem very well. It has encouraged and will continue to encourage intense exploration in this country. You will recall that through its encouragement, Petronas introduced new PSC terms in 1985, and the response by oil companies to these PSC terms has been very encouraging. There are now more than 35 multi-national oil companies exploring for oil and gas. Many of these companies are in their midst of completing their work commitments. Some have been successful, making significant discoveries, and many are still exploring. I wish to take this opportunity to express my sincere thanks to these companies for making efforts to explore for more oil and gas, and for companies that are still exploring, I wish them every success.

The Honourable guests, ladies and gentlemen,

The government has also encouraged Petronas to become a truly international company, and to explore for oil and gas outside Malaysia. With this encouragement, Petronas Carigali Sendirian Berhad made its first oversea ventures in Myanmar, China and Vietnam.

At the moment, all of the hydrocarbon exploration and production activities in Malaysia, focus on the continental shelf areas. Recent seismic activities carried out by Petronas outside the continental shelf, in the deep water areas but within the Malaysia territorial waters, indicates that these deep water areas are also equally attractive. Petronas realizes that development of discoveries in the deep water areas can be very expensive. Huge capital investment would be required. In order to attract potential investors into this high risk venture, Petronas is now examining the best and most appropriate PSC package for the areas.

The Honourable guests, ladies and gentlemen,

I believe this gathering will be beneficial to you and to companies exploring for oil and gas in this region and I sincerely hope that you will use this opportunity to formulate a new strategy for exploration, in the hope that both oil and gas will continue to flow, and our future generations will continue to enjoy the benefits. With this remarks, I declare this yearly seminar on Petroleum Geology as officially open.

Thank you.

GEOLOGICAL SOCIETY OF MALAYSIA
PETROLEUM GEOLOGY SEMINAR'91

••• *Shangri-La Hotel, Kuala Lumpur* •••
••• *26 & 27 November 1991* •••

PROGRAMME

26th November 1991 (Tuesday)

08:00 : Registration

08:50 : Arrival of Invited Guests

09:05 : Welcoming address by Chairman of Organising Committee

09:10 : Speech by the President, Geological Society of Malaysia

09:20 : Opening address by Hon. Dato Wong See Wah,
Deputy Minister in the Prime Minister' Department

90:30 : **COFFEE BREAK**

Session I

Session Chairman: Hoh Swee Chee *(PETRONAS Carigali Sdn. Bhd.)*

10:00 : **Keynote Address:** 3D Seismic: an indispensable tool to delineate hydrocarbons.
Brain R.H. Anderson *(Sarawak Shell Bhd./Sabah Shell Petroleum Co.)*

11:00 : Fullbore Formation MicroImager: an advanced technology toward solving exploration and production problems
Mohamad Taha *(Schlumberger Malaysia Sdn. Bhd.)*

11:25 : Petrographic and diagenetic studies of the reservoir sandstones of the Malay Basin
Chu Yun Shing *(University of Malaya)*

11:50 : 3D seismic interpretation of shallow gas hazards to optimize casing design in development drilling
Raidi bin Hashim *(EPMI)*

12:15 : Pre-Tertiary structural patterns: implications for formation of the Malay and Penyu basins
Khalid Ngah *(PETRONAS PRI)*, H.D. Tjia *(Universiti Sains Malaysia)* and Mazlan Madon *(PETRONAS PRI)*

12:40 : **LUNCH BREAK**
Luncheon Address: AAPG activities and its plans for 1994
Fred A. Dix Jr. *(AAPG, Tulsa)*

Session II

Session Chairman: A. Suzuli *(Nippon Oil)*

14:00 : Hydrocarbon identification by ditch-cutting analysis
John Huong Yiu Tuong *(Sarawak Shell Berhad)*

14:25 : Seismo-stratigraphy of the Miocene turbidites in the Tembungo Field, offshore Sabah
Ismail bin Che Mat Zin *(PETRONAS Carigali Sdn. Bhd.)*

14:50 : Diapirism and basin development in Sabah
Lee Chai Peng & S.P. Sivam *(University of Malaya)*

15:15 : **TEA BREAK**

15:45 : Possible source for the Tembungo oils: evidences from biomarker fingerprints
Abdul Jalil Muhamad & Mohd Jamaal Hoesni *(PETRONAS PRI)*

16:10 : Sedimentary facies and clay minerals study of the Upper Miocene strata of the Tembungo Field, offshore Sabah
Ho Chee Kwong *(PETRONAS PRI)*

16:35 : Integration of 3D and site survey seismic data in analysia of near surface hazards to platform location at Dulang Field
Zuraida Mat Isa *(EPMI)*, Hamzah Yunos *(PCSB)* and F.W. Richards *(EPMI)*

17:00 : Shipboard processing and interpretation
D.M. Angstadt & D.J. Richards *(Texaco Exploration Penyu Inc.)*

19:00 : **COCKTAIL**

27th November 1991 (Wednesday)

Session III

Session Chairman: Tony Blunden *(Schlumberger Malaysia Sdn. Bhd.)*

08:00 : An overview of the exploration history and hydrocarbon potential of Cambodia and Laos
J.B. Blanche *(Blanche Oil and Gas Consultants)*

08:25 : Migration of velocity spectra: an example from the Philippines
Craig J. Beasley & Rolf Klotz *(Western Geophysical Co.)*

08:50 : Problems in biostratigraphy of Malaysian Tertiary basins
Bahari Md. Nasib, Awaludin Harun & Azmi Mohd. Yakzan *(PETRONAS PRI)*

09:15 : Multiple aliasing problems in marine data
Peter Chia, Kuek Chiaw Oi, Peter Ward & Lee King Sim *(Sarawak Shell Berhad)*

09:40 : **COFFEE BREAK**

10:10 : **Keynote Address:** Technology application to sustain exploration success
Dato' Karl F. Swensen *(Esso Production (M) Inc.)*

11:10 : Tau-P seismic data processing: fast slant stack using the Hartley Transform
Leong Lap Sau *(Universiti Sains Malaysia)* and Ng Tong San (*PETRONAS Carigali Sdn. Bhd.)*

11:35 : Pore space reduction clays formed in deltaic and nearshore reservoirs of a humid tropical restricted to semi restricted basin
Nik Ramli *(FORAD)*

12:00 : Clay mineralogy in subsurface sandstones of Malaysia and the effects on petrophysical properties
John A. Hill, Danny K.Y. Soo & Thilagavathi Veeriah *(Core Laboratories (M) Sdn. Bhd.)*

12:25 : Understanding reservoir behavior through an integrated geological and engineering studies
Duncan C. Barr *(Core Laboratories Sdn. Bhd.)*

12:50 : **LUNCH BREAK**

Session IV

Session Chairman: Mohamad Ali Hassan *(University of Malaya)*

14:00 : Intergration of borehole dips and seismic data
Peter B. Woodroof *(British Gas (M) S.A.)*

14:25 : CO_2 and N_2 contamination in J32–1, SW Luconia, offshore Sarawak
Idris M.B. *(Sarawak Shell Bhd.)*

14:50 : A digital telemetry system implementation of the dual-sensor bottom cable method
F.J. Barr, J.I. Sanders & D.A. Chamberlain *(Halliburton Geophysical Services)*

15:15 : **TEA BREAK**

15:45 : Palaeocene palaeogeography of Borneo: constrains on tectonic modelling of Tertiary basins
Charles S. Hutchison *(University of Malaya)*

16:10 : Tectonism in Borneo: subduction-collision or diapiric vertical?
K.R. Chakraborty *(University of Malaya)*

16:35 : Relationship of gabbro and pillow lavas in the Lupar Formation, West Sarawak: implications for interpretation of the Lubok Antu Mélange and the Lupar Line
N.S. Haile *(PETRONAS PRI)* and S.K. Lam *(Geological Survey Department, Kuching)*

17:00 : Temana Jacket-W development — an intergrated approach
Talib Ak Buyak, P.W. Vincent, A.H.M. ten Have & J.A. Lopez Lopez *(Sarawak Shell Berhad)*

17:25 : **CLOSING REMARK**

GEOLOGICAL SOCIETY OF MALAYSIA
PETROLEUM GEOLOGY SEMINAR'91
••• *Shangri-La Hotel, Kuala Lumpur* •••
••• *26 & 27 November 1991* •••

ABSTRACTS OF PAPERS

3D Seismic: an indispensable tool to delineate hydrocarbons

BRAIN R.H. ANDERSON
Sarawak Shell Bhd./Sabah Shell Petroleum Co.

Shell Companies are involved in Exploration and Production operations in more than 50 countries all over the world. As operators for themselves and their partners, they are responsible for producing some 3.5 MMbbls of oil and 12 billion cubic feet of gas per day.

With such extensive activities, Shell Companies are major users of seismic and therefore heavily involved in developing the technology.

One of the first 3D seismic surveys was acquired by Shell in the Netherlands in 1975 and since then Shell Companies have carried out some 250 surveys over some 70,000 km^2, in different environments.

Since 1984 SSB/SSPC has embarked on a phased 3D seismic acquisition campaign over the major hydrocarbon accumulations and prime exploration acreages in her contract area. This has resulted in an extensive 3D coverage of some 4,000 sq. km.

It is generally accepted that the subsurface picture provided by the interpreted results of 3D surveys is generally more precise and detailed than those obtained with 2D seismic.

The main objectives of shooting 3D seismic are to delineate geologically complex structures and if possible to predetermine fluid contacts and content in order, to optimise targetting of our exploration, appraisal and development wells, to reduce the uncertainties in structural interpretation and to reduce the risk of sub-optimal field development.

New reserves of hydrocarbons will be found more and more in smaller accumulations and in geologically more complex areas.

It is only through application of this technology combined with the professional who masters it, that one can be in a better position to find and produce these reserves economically.

Fullbore Formation MicroImager: an advanced technology toward solving exploration and production problems

MOHAMAD TAHA
Schlumberger (Malaysia) Sdn. Bhd.

The Fullbore Formation MicroImager (FMI) is the successor generation of the Formation MicroScanner (FMS) tools. It represents a considerable step forward of delivering borehole electrical imagery of higher vertical resolution (0.2") and larger borehole coverage (80% in 8.5" borehole).

The tool carries 192 resistivity buttons on four arms. Each arm contains 48 resistivity buttons that were installed on a pad and a flap. Due to its large number of resistivity curves, the tool operates only with the Digital Telemetry System (DIS) and the Maxis 500 as a surface recording unit.

During its testing phase in Malaysia, the tool shows its superiority in defining clearly the various aspects of the structural and sedimentological features that are intersected by boreholes. Integrating such information to other data, open-hole logs, cores and seismic, has resulted in enhancing our capacity in dealing with plays of complex structural and sedimentological setting.

The high resolution images prove to be of a great help in evaluating laminated reservoirs and turbidite sediments. In addition, it has been found that such images information, together with testing results, can add to our understanding of reservoir heterogeneities.

The basic limitation of this tool is related to the nature and/or mud resistivity.

Petrographic and diagenetic studies of the reservoir sandstones of the Malay Basin

CHU YUN SHING
Institute for Advanced Studies, University of Malaya

The properties of the Malay Basin sandstones as potential reservoirs, and their characteristics depend on primary depositional facies and burial diagenesis. Petrographic studies and classification using the EPRco format have shown significant differences in the texture and mineralogical content in the samples of different sandstone groups, namely E, I, J and K which are divided by seismic horizons. The older sandstone, group K was deposited in braided stream environment and contains coarse to medium-grained sands. The J sandstone was deposited in brackish to shallow marine environment, associated with well sorted medium-grained sands. The group E and I sandstones, which were deposited in estuarine environment, are fine to very fine-grained and mineralogically consistent, associated with high detrital matrix content.

The original mineral content of the sandstones had influenced the trend of the post-depositional diagenetic changes. Higher primary porosity is generally present in the mature or clean sandstones. Usually, the loss of porosity in these sandstones are mainly due to quartz cementation and precipitation of authigenic clays. The effect of mechanical

compaction and pressure dissolution on the sandstones were mild, as deduced from the cathodoluminescence studies, where the area of core contacts is minimal and the present interlocking grain boundaries were actually caused by quartz overgrowths. The immature sandstones are associated with either high percentages of detrital clays or unstable rock fragments or both. Mechanical compaction caused the main diagenetic damages resulting in a major loss of intergranular porosity through deformation of ductile grains and formation of allogenic clay matrix. An early loss of porosity and permeability had slowed down or inhibited further diagenetic events, thus explaining the rarity of quartz overgrowths and other cement precipitations in these sandstones.

Secondary porosity generated by the dissolution of grains, especially feldspar grains, played an important role in the contribution to the total porosity. The investigation of grain and pore morphologies using the scanning electron microscope revealed a high percentage of micro-porosity preserved in between the clay matrix and newly formed authigenic clays, especially kaolinite. Other diagenetic changes observed are calcite and siderite cementations as well as formation of glauconite, chlorite and smectite.

3D seismic interpretation of shallow gas hazards to optimize casing design in development drilling

Raidi bin Hashim
Esso Production (M) Inc.

At Seligi Field, a 3-D seismic survey shot in 1987 has provided benefits in field development over and above the main objective of reservoir mapping. At the Seligi D platform, a procedure was developed to optimise the use of shallow casing in development wells by fully utilizing the 3-D seismic data set and interpretation techniques available on a seismic interpretation workstation. This procedure enables EPMI to make considerable cost savings in the development of Seligi, without jeopardising operational safety.

The optimisation procedure was as follows :

Firstly, shallow gas in exploration and development wells was calibrated against seismic amplitude, highlighting the gas occurrences in colour, on the workstation. Secondly, planned well trajectories provided by reservoir and drilling engineers were converted to time and put into the workstation. This then enabled the intersections and proximity of the well trajectories to shallow gas to be interpreted with a facility and accuracy not previously attainable.

Two types of display were examined for this purpose :

- Vertical seismic lines extracted from the 3-D data set along each planned well bore and tying to calibration points at nearby exploration wells.
- Horizontal timeslices at 4 msec intervals, each showing all 32 planned well bores from the D platform as well as the exploration wells.

Both displays used colour amplitude to highlight shallow gas.

In addition to the seismic analysis, safety margins were developed through discussions with the drilling engineers to accommodate the limitations inherent in the seismic data.

This procedure will enable casing design optimisation at future platforms to be achieved much more rapidly and accurately than was possible using previously available methods. It also provides a case history of an unexpected benefit of 3-D seismic data, which will produce cost savings far in excess of the original cost of the survey.

Pre-Tertiary structural patterns: implications for formation of the Malay and Penyu basins

KHALID NGAH[1], H.D. TJIA[2] & MAZLAN MADON[1]
[1]PETRONAS Petroleum Research Institute
[2]School of Physics, Universiti Sains Malaysia

Present geological knowledge suggests that many of the NW-SE and N-S faults in Peninsular Malaysia were active in Cretaceous and pre-Cretaceous times. Seismic data in the offshore areas off the east coast of the Peninsula indicate that there appears to exist some relation between the basement fault systems of the Malay and Penyu basins, and the NW-SE and N-S faults in the Peninsula.The major basement faults in the basins are predominantly NW-SE and E-W, but in the northern half of the Malay basin, the N-S faults are more dominant. This N-S fault system has been reported to dominate in pre-Tertiary basement in the north and central part of Sumatra.

The N-S faults are considered the oldest pre-Cretaceous regional faults based on field evidence. Their origin, however, is unknown. But the NW-SE faults seem to have formed as strike-slip faults, and are associated with regional Mesozoic stress that formed the dominant structural features on the Peninsula. The E-W faults are originally extensional fractures believed to be genetically related to the NW-SE faults. The dolerites dykes in Terengganu, east Pahang and on the Tenggol Arch may have intruded into pre-Tertiary basement along these weak fracture zones.

The E-W and NW-SE faults were active in the Malay and Penyu basins throughout much of Oligocene and Miocene, during which very thick sediments, probably continental, were accumulated. The faults in the offshore areas constitute major growth faults. During late Miocene to Pliocene, the area experienced compressional stress in the NW-SE direction. Subsequent basinal readjustment resulted in displacement along some of the E-W and NW-SE faults. Associated structural features related to this adjustment are structure inversions and anticlinical folds.

The Pliocene to Holocene was a period of general tectonic quiescence and although the Malay and Penyu basins continue to subside and receive sediments, localised residual stress within the basins caused some of the tectonic structures to grow.

Hydrocarbon identification by ditch cutting analysis

JOHN HUONG YIU TUONG
Sarawak Shell Berhad

Ditch cutting analysis allows the well site geologist to recognise and differentiate various types of hydrocarbons (gas, condensates, producible and residual oil) in a real-time basis (during drilling operations).

This paper outlines a systematic and effective approach for the recognition of hydrocarbons based on numerous years of experience in the subject and will be illustrated with a number of real cases.

The method described herein includes five specific interdependent steps, under the keyword **AEDES**:

i) Acquisition of good quality rock cuttings;
ii) Examination and description of samples;
iii) Diagenetic evaluation of the formation;
iv) Evaluation of hydrocarbon vs rock fluorescence;
v) Saturants type analysis

Identification and differentiation of hydrocarbons can then be carried out by a number of independent techniques, the main one being ultraviolet luminescence analysis, which involves six main distinctive confirmatory tests:

a) Distribution of natural fluorescence;
b) Intensity of natural fluorescence;
c) Colour of hydrocarbon fluorescence;
d) Chlorothene's solvent cut colour;
e) Chlorothene's solvent cut fluorescence;
f) Acetone/water reaction test.

Tests (a) to (e) are used for hydrocarbon differentiation ranging from 10 to 45 API oils, whereas the acetone's test is extra sensitive for condensates and gas.

Gas is always characterised by a weak to moderate whitish blue natural fluorescence and a slightly translucent acetone reaction test.

Condensates generally exhibit a wide range of natural fluorescence, from bluish to creamy-white and a brilliant white solvent (chlorothene) cut accompanied by a translucent to slightly opaque acetone reaction test.

Oil shows a wide range of natural colour fluorescence, from white to green, yellow, gold, orange, brown, coffee and violet. Formation of streamers during the making of the solvent cut is an excellent diagnostic for an oil test. Natural fluorescence of oil in the transition zone, above the free water level in the reservoir, is always mottled in appearance with dulling of the primary oil natural fluorescence. Finally, residual oil produces a violet natural fluorescence and almost always a solvent (chlorothene) cut colour is present.

Seismo-stratigraphy of the Miocene turbidites in the Tembungo Field, offshore Sabah

ISMAIL BIN CHE MAT ZIN
PETRONAS Carigali Sdn. Bhd.

Seismo-stratigraphic study of the Tembungo area, offshore West Sabah provided a depositional model for the hydrocarbon-bearing Stage IVD turbidite sequence in the Tembungo Oilfield. The model suggests that the turbidite sequence, characterised by an oblique seismic reflection pattern was deposited in a sedimentary bypass system tract as a result of wrench-related uplift of the Bunbury-St Joseph area. The uplift and subsequent removal of Stage IVC-IVA coastal fluviomarine and lower coastal plain sediments during the Shallow Regional Unconformity followed by active Stage IVD deltaic progradation provided a huge volume of sediment input to the confined Tembungo depression beyond the contemporaneous shelf edge. The deltaic sediments with good reservoir and source rock properties have contributed to the hydrocarbon potential of Stage IVD turbidites in the Tembungo Oilfield.

Diapirism and basin development in Sabah

LEE CHAI PENG & S.P. SIVAM
University of Malaya

The absence of suitable volcanic arc associations and any significant island-wide fold trends in the post-Eocene suggest that existing subduction-related tectonic models are inadequate to elucidate the geology of Sabah.

In the search for a more satisfactory explanation for these anomalies a plot of the strike ridges in Sabah reveals a pattern of concentric ridges between which are present in many places broken chaotic formations. Such distributions suggest an origin based on gravity tectonics where diapiric deformations resulted in broad synclinal depressions fringed by squeezed-up anticlinal ridges. This, however, does not negate interpretations that the concentric basins are related to basement faulting and tectonics because the latter may predetermine zones of pressure release and also enhance the effectiveness of differential loading. An assumed thin lithosphere in Borneo, would favour rapid response to vertical movement and loading because the zone of isostatic adjustment is at very shallow depths due to the shallow occurrence of low viscosity layer(s). In thick sediment piles over such thin lithosphere with high heat flow, the lower layers are more metamorphosed and tend to become overpressured in the early stages. Metamorphic convection could be set up aided by the influx of mantle fluids. Granitization could occur in siliciclastic sequences with attendant volume increase, thus destablising the vertical stress system and aid diapirism. In areas of high heat flow with significant uplift, major areas of tension are created in the lithosphere which give rise to horsts and grabens for the accumulation of thick sedimentary piles suitable for the development of diapiric structures.

The prime requirement for vertical diapiric tectonics is for density inversion to occur within the sedimentary pile and/or in the basement. Such a density inversion occurs where denser sandy sediments are deposited rapidly over less dense overpressured clayey sediments. It is further enhanced where great differences in thickness exist causing significant uneven loading. This is common in Sabah where equal-aged sediment piles of variable thicknesses are found in an active margin setting as deltas and turbidite fans. The overriding of Borneo over the South China Sea caused massive uplift of Sabah in a warm humid climate condusive to rapid weathering and erosion. This provided large quantities of rapidly sedimented, undercompacted and overpressured clay layers for the development of basinal load structures where they were overlain by denser sandy sediments. Such depocentres once created are self-sustaining in growth as they attract the further deposition of sand in the depressions created by loading. This occurs until most of the underlying clay is diapirically squeezed out following which the basins will rapidly fill with sands till they overflow the edges of the basins and create new depocentres downslope.

The significance of this model to petroleum exploration in Borneo is twofold. Firstly, rapid and uneven changes can occur in the thermal maturity of a sequence in a rapidly subsiding basin. The same bed or formation can be overmature, mature or immature depending on its location in the basin. It can be overmature at the centre and become progressively less mature at the edges due to different depths of burial. The same source rock which is overcooked or undercooked in places might be suitable in other instances. Secondly, if the anticlinal structures are of diapiric origin, they would tend to be more clay-rich and tectonized than the basin interiors and thus are less suitable as prospects for drilling.

Possible source for the Tembungo oils: evidences from biomarker fingerprints

ABDUL JALIL MUHAMAD & MOHD JAMAAL HOESNI
PETRONAS Petroleum Research Institute

The Tembungo field located offshore Sabah is a highly faulted anticlinal structure where oil and gas accumulations occur in different fault blocks. This paper discusses the source rock potential, organic matter type, thermal maturity, oil-oil and oil-source rock correlations, biodegradation and migration of the crude oils in the Tembungo field.

The shales of the Tembungo wells have poor to fair source rock potentials, mainly of Type III with minor contributions from Type II organic matter. Maturity data show that the organic matter in the Tembungo well sections are immature.

Tembungo crude oils from the different fault blocks are genetically similar, being paraffinic and contain low sulphur and wax, with moderate API gravity. The presence of C_{24} - tetracyclic terpanes, 18(H)- and 18ß(H)-oleananes, resin triterpanes compounds and predominance of C_{29} -steranes in all the samples suggest that the oils were derived from source rocks of terrigenous origin containing different mixtures of land-plants organic matter including resins. GC and GCMS analyses indicate that the crude oils produced from the same fault block have a similar biomarker distributions but some variations occur in oils from different fault blocks. These variations are interpreted as due to the effect of migration and biodegradation whereby each fault block has a separate fluid system and there was no intermixing between oils of the different blocks.

Oil-source rock correlation between Tembungo oils and extracts from the field and adjacent wells indicate that the oils were not generated *in-situ*, but had migrated from deeper sources.

Sedimentary facies and clay minerals study of the Upper Miocene strata of the Tembungo Field, offshore Sabah

HO CHEE KWONG
PETRONAS Petroleum Research institute

Sedimentary strata in the producing zone of the Tembungo field are being interpreted as deep marine turbidites based on their faunal and sedimentary features. Isopach and isolith maps of different horizons and sand units show fan-shaped lobes. Based on gamma ray log shapes, the strata are divided into several sedimentary facies, interpreted as deposits of a deep marine turbidite fan complex. The succession shows a change from basin plain facies to middle fan facies and, to slope shade facies at the top. These deep marine strata are overlain by shallow marine sediments. The overall progradation of the sequence suggesst lowering of sea level during early late Miocene.

Clay mineral analysis was carried out on claystones samples from five wells. A plot of illite + expandable clay to kaolinite + chlorite (I+Ex/K+C) ratio shows a trend that reflects changes in depositional environment. A consistently low ratio around 5000 feet depth indicates abundant continental sediment influx, which coincides with a drastic change of depositional environment from bathyal to shallow marine.

Integration of 3-D and site survey seismic data in analysia of near- surface hazards to platform location at Dulang Field

ZURAIDA MAT ISA[1], HAMZAH YUNOS[2] & F.W. RICHARDS[1]
[1]Esso Production Malaysia Inc.
[2]PETRONAS Carigali Sdn. Bhd

Site survey work at Dulang, which is operated by Carigali in partnership with EPMI, was conducted by integrating data from the 3-D seismic survey, shot for exploration and field development purposes, with the site survey data, acquired specifically to address the seabed and near surface. This approach provides a quicker and more comprehensive interpretation than would have been achieved by the more conventional approach of interpreting the site survey data alone.

The 3-D seismic survey comprised about 1100 km of digitally recorded and proposed multichannel data, with a 75 m line spacing. The site survey comprised the following four data sets with a 100 m line spacing:-

- High resolution digital seismic data. The shooting parameters were designed for high resolution in the uppermost 500 - 1000 m. The source, a high resolution air gun array, gave frequencies from about 10 to 250 Hertz.

- Boomer data. Employing an implosive source, these analogue data, recorded on paper, had peak frequencies in the range 2-7 kiloHertz, which provided very high resolution but limited penetration (about 60 m into the seabed).

- Sidescan sonar data. These very high frequency analogue data were generated by transducers, which emit 105 kiloHertz pulses. The sidescan sonar imaged the seafloor obliquely, about 100 m on either side of the ship's track.

- Echo Sounder data. The echo sounder data provided detailed water depth information, using a high frequency transducer source.

The main hazard to platform location at Dulang was identified to be a Pleistocene channel, about 500 m wide, which cuts from near the seabed to about 80 m below the seabed. Soil borings showed the channel-fill to comprise dominantly stiff clays, but with significant organic material and some coarse clastics at its base. Generation of timeslices on the 3-D workstation enabled essentially instantaneous mapping of this channel and its associated point bar. With the additional resolution provided by the Boomer data, it was possible to identify rising gas plumes, sourced from biogenic degradation of organic matter, in the sediments at the channel margins. In concert with the sidescan sonar data, these could be seen to have caused up to 5 m seafloor depressions where they have reached the seabed. Evacuation of water and gas has caused proliferation and coalescence of seafloor pockmarks above the channel margins.

Two potential platform locations were identified on the basis of this interpretation, an optimum location (for drilling considerations) at the channel centre and an alternative outside the channel. Subsequent soil borings and engineering tests showed both locations to be acceptable, and the A platform was successfully installed at the optimum location without encountering any hazards.

Shipboard processing and interpretation

D.M. Angstadt & D.J. Richards
Texaco Exploration Penyu Inc.

In the fall of 1990, Texaco completed an innovative 4300 km seismic acquisition program which included processing, interpretation, and preliminary structural mapping by using an onboard portable processing system, two processing geophysicists and an interpreter. A firm reconnaissance program was laid out with the option of shooting infill during the same survey if promising lead areas were uncovered during the shipboard interpretation of stacked and even some migrated-stacked sections of key lines. One of the new lead areas of complex block faulting was identified, infilled and, after final office-based interpretation of the entire data set, matured into a drillable prospect scheduled to spud this fall.

By using this unconventional technology, Texaco saved the time and expense of mobilizing a second survey to mature new leads and furthermore, it allowed the explorationist a chance to begin the block evaluation process months ahead of schedule as good quality (albeit not final quality) record sections were made available during the shooting phase, not well after its completion as tapes are transported and processed onshore.

An overview of the exploration history and hydrocarbon potential of Cambodia and Laos

J.B. BLANCHE
Blanche Oil and Gas Consultants

The petroleum geology and hydrocarbon potential of both Cambodia and Laos is virtually unknown with Laos being totally frontier, whilst Cambodia has had only three wells drilled in the offshore.

No oil and gas concessions have been held in Cambodia since the revolution in 1975. The last foreign licences were the Elf/Esso and the Marine Associates groups, which both held acreage on the Khmer Shelf.

The Cambodian authorities stated in May 1990 that, under the terms of the Foreign Investment Law promulgated in July 1989, they hoped to sign contracts with major oil companies to undertake exploration for hydrocarbons on the Cambodian Shelf (Gulf of Thailand).

Consequently, the Cambodians, in association with the Soviet Union prepared six separate data packages corresponding to blocks available for licence for review and purchase by interested parties prior to submitting competitive bids for both onshore and offshore acreages.

Prior to the award of acreage to western companies in the Savannakhet basin in 1989, no exploration had been undertaken in Laos since a French consortium carried out reconnaissance exploration surveys in the Savannakhet Basin during the period 1959-60.

In 1989, the Laotian government actively began discussing acreage awards with four international oil companies. Following negotiations, three companies signed Production Sharing Contracts for acreages in the Vientiane, Savannakhet and Saravane-Attopeu basins. Exploration in Laos by three operators is currently ongoing.

It is considered that the hydrocarbon potential of the Mesozoic and Cainozoic basins of both Laos and Cambodia, although frontier and high risk, is worthy of further investigation by the industry.

The paper sets out to review the history of exploration as well as the petroleum geology and hydrocarbon potential of both Laos and Cambodia.

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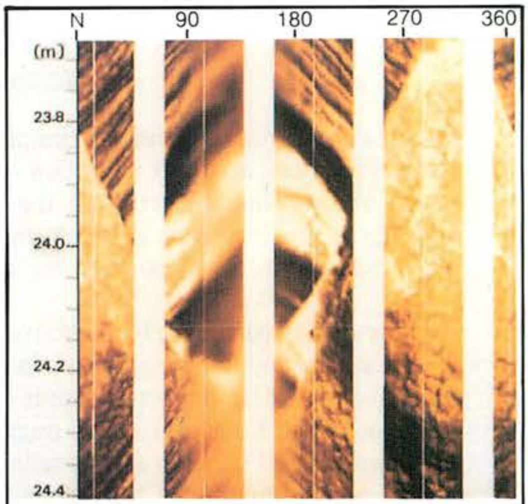
Fullbore Micro Imager*

Formation imaging using microelectrical arrays has benefited the oil industry since its introduction in the mid-80s. The FMI*, Fullbore Formation MicroImager tool, is the latest-generation electrical imaging device. It belongs to the family of imaging services provided by the MAXIS 500* system with its digital telemetry capability.

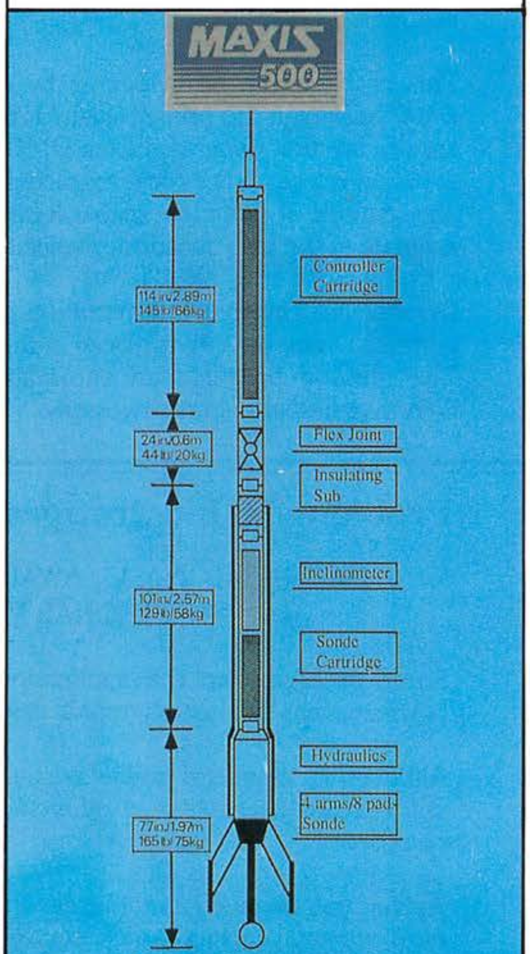
The FMI log, in conductive muds, provides electrical images almost insensitive to borehole conditions and offers quantitative information, in particular for analysis of fractures.

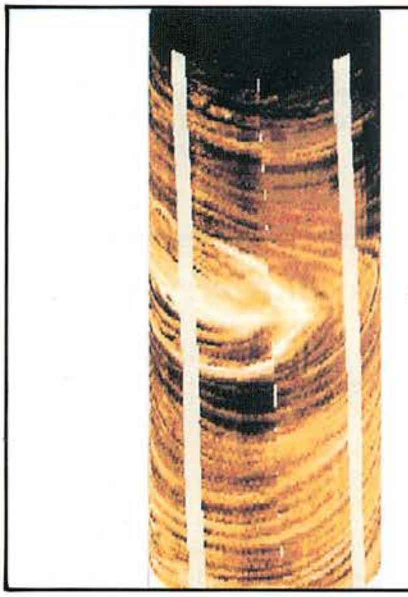
The FMI tool combines high-resolution measurements with almost fullbore coverage in standard diameter boreholes, thus assuring that virtually no features are missed along the borehole wall. Fully processed images and dip data are provided in real time on the MAXIS 500 imaging system.

The tool's multiple logging modes allow wellsite customization of results to satisfy client needs without compromising efficiency.



Fault without associated drag





3D-VIEW

"Bullseye" structure

Schlumberger

Migration of velocity spectra: an example from the Philippines

CRAIG J. BEASLEY & ROLF KLOTZ
Western Geophysical Co.

Successful seismic imaging of complex geology such as that found in the Philippine Islands requires accurate migration of the seismic data to collapse diffractions, image faults, and position reflectors in the correct spatial location. While today's migration algorithms are in theory generally quite accurate, in practice, migration accuracy for steep dips is critically dependent on the migration velocity.

An approach used routinely to estimate the migration velocity is to minimize the effects of dip and azimuth by applying dip moveout (DMO) to the data. However, velocity derived from DMO corrected data is located at an unmigrated position and thus should be repositioned prior to use as a migration velocity. The effect of this phenomenon will be demonstrated through an example from the Visayan Sea region of the Philippines in which, prior to migration, reflections from the steep flanks of a low-velocity shale diapir conflict with those from a deeper low-relief carbonate resulting in poorly resolved velocity analyses.

This problem can be overcome by employing conventional migration to *migrate the DMO velocity* to the proper spatial location prior to migrating the seismic data. Velocity spectra are first generated from DMO corrected data on a regular spatial grid and then common-velocity slices are extracted and migrated. Finally, the migrated velocity is reassembled at common spatial locations into velocity spectra which provide a better estimate of the true subsurface velocity.

By applying conventional migration principles to migrate velocity derived from DMO corrected data, velocity is placed at the correct spatial location as required for migration. The method provides an automated, efficient, and accurate procedure for the determination of migration velocity.

Problems in biostratigraphy of Malaysian Tertiary basins

BAHARI MD. NASIB, AWALUDIN HARUN & AZMI MOHD. YAKZAN
PETRONAS Petroleum Research institute

Some problems on the application of foraminifera, calcareous nannofossils and palynomorphs in biostratigraphic studies of Malaysian Tertiary basin are discussed.

Although foraminiferal studies are quite established, correlation across exploration blocks still remains a problem as different schemes are being used by different exploration companies.

As for calcareous nannofossils, their application is very much restricted by the environmental factors which control their distribution. The disappearance of species due to changes in environment could be mistaken for evolutionary changes. Post-depositional dissolution also causes problems. Some reported marine sediments are found to be barren. Published zonation schemes are not totally applicable. Certain marker species of some zones are not very common or totally absent. This has led to problems in age determination and correlation.

Palynological age dating for this region is limited to a few long-ranging species of pollen and spores. A single zonation scheme, like those for nannoplanktons and foraminifers, is not available for palynology mainly because different parts of the basin are characterized by unique palynological assemblages. A complete account of fossil and Recent pollen/ spores has never been published for the Southeast Asian region. This is because of the proprietary nature of the data, which remain in the oil companies' files. Moreover, little palynological research is done at local universities.

These problems could probably be solved by carrying out detailed study on all microfossil groups and establish a uniform biostratigraphic framework applicable for the whole region. For palynology, each basin or sub-basin has to be studied separately to identify their characteristic assemblages. A unified scheme for the whole region can then be established for correlation purposes.

Multiple aliasing problems in marine data

PETER CHIA, KUEK CHIAW OI, PETER WARD & LEE KING SIM
Sarawak Shell Berhad

Linear noise has been observed to be closely associated with marine seismic data whenever the shot spacing is double that of group interval (e.g. 50 m shot interval and 25 m group spacing). This noise is noticed to be more severe at shallow depth (above 500 m). Not much attention has been given to it in the past as normally the zone of interest is below 500 m. However the noise occurring on recently acquired 2D deep water data and 3D data seems to penetrate deeper and is more disturbing than as seen on data in the past. It has been found that this noise is related to aliased multiples, especially sea bottom multiples. This paper discusses the basic multiple related problem and suggests ways to solve it.

Technology application to sustain exploration success

DATO' KARL F. SWENSEN
Esso Production (Malaysia) Inc.

Exploration in the Malay Basin began over 25 years ago, when regional geologists realized that a deep sedimentary basin could lie beneath the South China Sea. Since the very beginning, the application of improving technology has been integral to the discovery of over 1-1/2 billion barrels of oil in the basin.

The existence of a sedimentary basin with oil potential was recognised by Esso explorers during the mid 60's when aeromagnetic surveys were conducted over the area. The first Offshore Petroleum Licence for the Malay Basin was awarded to Esso in April 1968. Later that year, Esso recorded its initial seismic survey, on a widely spaced, regional grid, which showed a maximum sediment thickness of over 10 km, as well as a broad trend of anticlines within the centre of the basin. Esso spudded its first exploration well, Tapis-1, in May 1969, and since then has drilled 186 exploration wells in the Malay Basin. 22 major oil and gas fields have been discovered within the 1976 PSC area, and during the last 18 months, 5 oil fields in PM-5/8.

During the initial phases of Malay Basin exploration, the most obvious prospective targets were identified and evaluated. The current exploration phase is requiring a much more intensive application of the best geoscience technology to sustain exploration success. Prospect are smaller, more subtle, structurally more complex, stratigraphically more variable, and spread out over a larger area than the oil fields found during the 70's. To address this problems, EPMI will record over 60,000 km high resolution 2-D and 3-D seismic during the first three and a half years of PM-5/8 exploration. This compares to 28,000 km of 2-D data that EPMI recorded in the Malay Basin during the 10 years prior to 1978, when oil started to flow from the basin.

Technology has improved substantially during the past 25 years, in the areas of basin geological analysis, seismic acquisition and processing, seismic modelling, drilling, formation evaluation, sequence stratigraphy and, of course, computing. All these advances have enabled the explorationist to develop an increasingly clear picture of the subsurface. Some new techniques have contributed significantly, but in most cases the key has been incremental improvements in the integration of new and existing technology in an environment of progressively smaller and more difficult to find discoveries. Included in this , are the improvements being made in the way we carry out our business through organizational effectiveness and team building.

The Malay Basin still holds significant undiscovered oil potential, but this will be much more difficult to find than in the past. The challenge is to discover and develop this potential in a cost-effective and efficient manner. Technological breakthroughs cannot be completely relied upon for future discoveries. Instead, rigorous, integrated application of existing and new exploration tools will enable future successful explorers to unlock the basin's remaining secrets.

Tau-P seismic data processing: fast slant stack using the Hartley Transform

LEONG LAP SAU[1] & NG TONG SAN[2]
[1]Universiti Sains Malaysia
[2]PETRONAS Carigali Sdn. Bhd.

A primary objective of seismic data processing is to recover the reflection series from a recorded trace. In this aspect slant stacking provides a computational procedure to compose and decompose wave expansions of the data. For example, a VSP section transformed to the T-P plane assigns the upgoing and downgoing wave fields to different T-P quadrants according to their dips. Either wave field can be reconstructed by an inverse transform after windowing in the T-P plane. Cylindrical slant stack procedures permit a plane-wave decomposition with amplitude preservation thus eliminating the need for spherical divergence corrections. This property is useful for amplitude based analysis.

Unlike the Fourier analysis of 2-dimensional seismic data which examines the transformed waveform in the f-k domain, slant stack analysis looks at the intercept time (T) versus horizontal phase velocity or the ray parameter (P) instead. Here, linear refraction arrivals and simple hyperbolic reflection curves are transformed into spatially assigned points and ellipses respectively. In the T-P domain a variety of seismic processing methods can be applied to filter and interpret the original input data (e.g. selective muting, velocity analysis, NMO, migration, inversion). The Radon transform (RT) or slant stack gather (T-P) as commonly used in exploration geophysics is related to the Fourier transform (FT) by the projection slice theorem. This states that the 1-D FT of the RT yields the 2-D FT along a line (slice) in the 2-D frequency plane. The RT can be calculated using three 1-D FT applications (row-column decomposition and then along a line k_x = pw). In the process storage space must be created for double the input array. The Hartley Transform (HT), described by Bracewell (1984, 1986), was developed as a FT substitute in cases where the input data are in the real domain. This condition is compatible with acquired seismic field data.

Applying the above properties, an alternative method for computing the slant stack using the Hartley Transform instead is introduced here. The projection slice property connecting the 2-D Fourier transform with the Radon transform is extended here to connect the 2-D Hartley transform with the Radon transform. Slant stack of seismic data can be computed by a triple application of the 1-D Hartley transform. The useful formulation of the Hartley transform without the need for complex arithmetic reduces memory space and decreases program execution time when compared with the Fourier transform applied three times during calculation of a slant stack gather.

The fast slant stack using the Hartley Transform could be the answer in lowering processing costs. Hence, it can encourage hydrocarbon exploration companies to utilise the many benefits of fast slant stack in routine processing.

Pore space reduction clays formed in deltaic and nearshore reservoirs of a humid tropical restricted to semi restricted basin

NIK RAMLI
FORAD

Humid tropical terrain generates abundant clays during tropical weathering processes. These clays may eventually end up as general clay matrix in sandstones. Detrital clays will tend to accumulate in paleogeographic lows (e.g. inner bends of fluvial channels, interbar areas of nearshore and offshore bars) or be redistributed during sedimentation by organisms during bioturbation.

Sandstones with a higher proportion of mineralogically unstable grains (e.g. feldspars, glauconite, rock fragments) may, through diagenesis form a clay matrix called "altered grain matrix" due to the diagenetic alteration of unstable grains into clays and other associated minerals. The composition and structure of these altered grains provided for easy dispersion and migration of their alteration products. In addition to the clays formed diagenetically within pore space or on surfaces of framework grains, the alteration products in altered grain matrix could also be a source of permeability impairment due to pore plugging by the migration of fines.

Clay mineralogy in subsurface sandstones of Malaysia and the effects on petrophysical properties

JOHN A. HILL, DANNY K.Y. SOO & THILAGAVATHI VEERIAH
Core Laboratories (M) Sdn. Bhd.

Clay minerals are common constituents of the subsurface sandstones in Malaysian sedimentary basins. Kaolinite, illite, mixed-layer illite/smectite, chlorite, and smectite have all been identified.

To date, petrophysical analyses of sandstone formations in the various basins indicate that clay content is the most prevalent control of porosity and permeability. Not only is the total amount of clay important but also the mineralogy, distribution, and morphology.

For reserves estimation, the ability to determine from wireline logs the total clay content in hydrocarbon-bearing reservoirs is very important. This ability often relies on the (sometimes erroneous) assumptions that the surrounding shales comprise clay only and that the sandstone formations contain clays of similar mineralogy and morphology to the surrounding shales.

Our investigations indicate significant variation of clay mineralogy occurs, not only between basins but also within individual basins and within individual wells. This leads to significant variation of porosity, permeability, and wireline log response and demonstrates the need for a systematic study of clays during the exploration and development phases of a field.

Understanding reservoir behavior through an integrated geological and engineering studies

DUNCAN C. BARR
Core Laboratories (M) Sdn. Bhd.

In order to determine the character and behaviour of reservoir rocks, geological and engineering data need to be gathered, intergrated and understood. This paper illustrates how such a multi-disciplinary approach has been applied to a suite of sandstone reservoir rocks and how particular questions about reservoir behaviour were answered.

Samples were chosen for detailed study from a successful oil and gas producing well in the South East Asian Region. Two differing formations were sampled, the lowermost of which was given a pessimistic prognosis based on V_{shale} calculations. A program of Advanced Rock Properties tests and detailed sedimentological and petrographic analyses was carried out on the chosen samples. The results showed that a large proportion of the clay encountered in the lowermost formation was contained within grains, rather than in the matrix as had been initially assumed, explaining the better than expected reservoir performance.

Intergration of borehole dips and seismic data

PETER B. WOODROOF
British Gas (M) S.A.

High quality dip values for fault and bedding planes penetrated in boreholes can now be derived from wireline electrical imagery. It is therefore important to combine these data as far as possible with both surface and borehole-recorded seismic profiles. The methodology and results of such integration are described and illustrated with examples from two boreholes.

The first example derives from a vertical well. Fault and structural dip information from this borehole were projected as apparent dips onto several seismic line orientations that crossed the well. These dips were then corrected for horizontal versus vertical scale exaggeration; the latter scale varying with depth and being derived from well velocity data. These twice-corrected dips from various depths were then assigned to a 2-way time value using check-shot data. Seismic lines and the V.S.P. from the well were reinterpreted using these seismically-adjusted fault and structural dips with the aid of appropriate clear-film overlays. The occurrence of faults and fault orientations not observed on the original seismic interpretation allowed for the recognition of additional fault blocks and a revised structural picture for what was originally interpreted to be a single tilted fault block.

The second example comes from a deviated well. The fault and structural dip data were seismically-adjusted as in the first example, but were additionally positioned to take account of borehole deviation before being displayed as overlays. These dip data were integrated with surface seismic as well as a rig-source V.S.P. and a moving source (zero offset) V.S.P. An improved understanding of the structure and of sonic log calibration anomalies, was gained.

Seismically-adjusted borehole dip data used in an overlay format can provide an important tool to aid reinterpretation and better understanding of drilled areas. Dip overlays could also be made available for use with interpretation workstations to allow even greater manipulation and integration of borehole and seismic data.

CO_2 and N_2 contamination in J32-1, SW Luconia, offshore Sarawak

IDRIS M.B.
Sarawak Shell Bhd.

The SW Luconia area, offshore Sarawak, is seemingly prone to CO_2 and N_2 contamination. The level of CO_2 contamination is alarmingly higher (>60%), especially in the carbonates, when compared to other areas in the Sarawak Basin. This is further evident from the recent exploration well, J32-1, drilled by SSB in the area. The well discovered five separate gas-bearing reservoirs in Neogene sands and limestones. Analysis of the gas from all the reservoirs indicate contamination of CO_2 (2-76%) and N_2 (1-12%). A high concentration of CO_2 was observed in the limestones and an even higher level was recorded in the overlying reservoir sands.

Although these contaminants (CO_2 & N_2) are generally thought to be basement derived, the vertical gas distribution trends of J32-1 identify the sudden influx of CO_2 in these reservoirs as late *in situ* inputs. It is possible that the gas was released from low temperature reactions of the carbonates with formation waters and from the oxidation of methane in oxygenated waters. This is possible as fluid samples from the reservoirs suggest freshwater conditions and the higher heat flow experienced by the region. The invasion of meteoric water may have occurred during the Pliocene major uplift when Sundaland emerged in the South China Sea. The distribution trend of N_2 suggests another possible origin, from humic organic matter which is in abundance in Oligocene deposits. However, the probable inputs from surface via dissolved atmospheric N_2 and from humic acids of peat swamps cannot be ruled out. The presence of the contaminants in the well is apparently in general agreement with the overall CO_2 and N_2 contamination trend seen in the area.

A digital telemetry system implementation of the dual-sensor, bottom-cable method

F.J. BARR, J.I. SANDERS & D.A. CHAMBERLAIN
Halliburton Geophysical Services

The bottom-cable method of seismic reflection data acquisition has been used for many years in shallow water and in areas densely populated by obstacles, where towed streamer marine vessel access is rendered impossible or risky. And as production and drilling platform obstacles have moved to deeper and deeper water, the application of the bottom-cable method has moved with them.

The location of the method's sensors at the water-bottom causes each recorded reflection wavelet to be followed by a series of water-column reverberations. As the water depth increases, the reverberation period increases proportionately, attended by a significant reduction in the ability of deconvolution methods to remove the reverberations during processing. In the frequency domain, this phenomenon manifests itself as notches which are introduced into the reflection wavelet's amplitude spectrum.

To eliminate this reverberation problem during the data acquisition and preprocessing stage, the dual-sensor method has been implemented. This method places a gimbal geophone unit with each hydrophone in the bottom-cable. The signals from the geophone and hydrophone arrays are recorded on separate channels for combination during data preprocessing. Prior to retrieving the bottom-cable for redeployment, the shooting vessel performs an additional pass. Firing the source directly over each set of geophone/hydrophone arrays creates an artificial "ghost". The resulting data provides the information necessary to combine the geophone and hydrophone signals optimally at each receiver location to cancel reverberation energy in the production reflection data.

Since the introduction of the method, several opportunities have arisen to compare directly dual-sensor, bottom-cable data to conventional towed streamer data. In each case, the dual-sensor data has proven to be of equal or higher quality.

The most recent enhancement to the dual-sensor, bottom-cable method has been the development and deployment of a telemetry bottom-cable recording system. This new version of the MDS-18X recording system consists of an impulse source complement of recording subsystems in the recording cab. And the line equipment has been completely redesigned for operation under water.

The eight-channel remote units have been re-shaped to a cylindrical steel housing with bottom-cable connectors at each end. This housing is designed for operation at depths up to 200 metres. The remote units are powered from a 200 VDC power source through conductors in the bottom-cable. The cable is approximately 2.54 centimeters in diameter and contains data and control transmission pairs, seismic signal pairs, power conductors and strength members.

Each remote unit receives and digitizes four seismic channels from each of the two bottom-cable segments to which it is attached. Two channels are dedicated to each receiver station, one for the hydrophones and the other for the geophones. So each remote unit processes the data for its closest four receiver stations. The hydrophone/ geophone pairs are physically contained in a single package which is fabricated in the Netherlands. Both detectors have a natural frequency of ten Hertz.

Upgrading the dual-sensor, bottom-cable operation to a digital telemetry recording system results in higher fidelity data and higher production rates. The production rate increase stems from the increased available recording channels compared to a conventional system, allowing simultaneous recording from multiple, parallel bottom-cables.

Palaeocene palaeogeography of Borneo: constrains on tectonic modelling of Tertiary basins

CHARLES S. HUTCHISON
University of Malaya

In Early Palaeocene time, the whole of south and east Borneo was a broad peninsular landmass extension of Sundaland, along whose northern margin the Rajang Group (Belaga and Crocker formations) was sedimented.

The pre-Tertiary outcrops of Thailand, Peninsular Malaysia and Sumatra comprised Palaeozoic and Mesozoic strata and extensive S-type granites and acid volcanic rocks. This part of Sundaland and its Tertiary basins may therefore be classified as cratonic.

By contrast, the pre-Tertiary outcrops of the Borneo Sundaland peninsula comprised predominantly Cretaceous volcanic and I-type plutonic rocks (Schwaner Mountains), uplifted imbricated ophiolite complexes and associated Cretaceous deep water strata (e.g. Meratus, Semitau Ridge, Upper Kutei, Labuk-Darvel Bay). The pre-Cretaceous basement is fragmentary and unrecognized throughout much of the region. The Peninsula therefore was not cratonic, and its Tertiary basins cannot be so classified. No primary (igneous) source has ever been found for the placer diamonds, which have been dispersed by the Late Cretaceous and Cainozoic fluvial system. Their primary source must lie within the cratonic part of Sundaland from which the rivers flowed.

The record of subaerial weathering and erosion of the Early Tertiary landmass is preserved in the Palaeocene to Mid Eocene early graben phase of the Tertiary basin evolution. The first sediments preserved are granite-provenenced commonly redbed coarse clastics e.g. in Sumatra, Thailand, Malay, Natuna (The cratonic part). Equivalent redbed sediments occur extensively in the Borneo basins (e.g. Upper Kutei, Meratus, Kangean). Locally-derived ophiolite provenance is characteristic. All Sundaland basins, from north Thailand to eastern Borneo, contain important Palaeogene lacustrine source rocks. A mature drainage system carried siliciclastics from cratonic Sundaland through the Borneo grabens to be deposited as turbidites off the rapidly shelving coast.

The Rajang Group of Sarawak and Sabah should be correlated with the Palaeogene continental-deltaic deposits. Turbidites should also exist along the other margins of the Peninsula, but they have been involved in ongoing accretionary tectonics and not yet uplifted. The Rajang Group is readily identifiable because it has been compressed and uplifted as an orogenic belt between the Sundaland Peninsula and the Luconia - Dangerous Grounds microcontinent, pushed southwards by the opening South China Sea Basin, and concomitant anti - clockwise rotation of the Sundaland Peninsula. Only when the Rajang Orogenic Belt was significantly uplifted, did it become a new provenance for Miocene siliciclastics deposited in the basins of Sarawak, Brunei and Sabah.

The basins of Kalimantan should be classified in their early development together with those of Cratonic Sundaland (e.g. Malay, Gulf of Thailand, Sumatran, Sunda). The later development of the non-cratonic Sundaland Peninsular basins experienced important vertical tectonics, in which ophiolite and melange belts rose up within and subdivided the basins during Late Miocene time (e.g. Meratus, Semitau). The "circular" Miocene basins of Sabah are also a product of vertical tectonics and larger basins became subdivided by melange ridges. Melange is extensive in Borneo, but should not be equated with accretionary tectonics. For example, the Semitau Ridge cannot be interpreted as an accretionary prism, because it contains blocks of granitoids. The extensive Late Oligocene - Miocene melange and volcanism of Borneo are both products of the non-cratonic nature of the basement. Thin lithosphere and high heat flow resulted in dramatic vertical instability causing subsidence, topographic inversions and marginal basin development. These events cannot readily be accommodated within conventional plate tectonic models, which are based on the normal thickness lithosphere and heat flow of cratonic regions.

Tectonism in Borneo: subduction-collision or diapiric vertical?

K.R. CHAKRABORTY
University of Malaya

Tectonic evolution of Borneo is as yet poorly understood. Over the last two decades it was mainly discussed in terms of convergent plate margin settings including arc-continent collision. Various lines of geologic evidence, however, cannot readily be reconciled with such tectonic interpetations. Magmatism in time and space, in particular, does not conform to the postulated subduction zones (e.g. North Borneo Trough, Lupar Line).

Evolution of Borneo as an intergral part of a larger Sundaland, can alternatively be interpreted within the framework of vertical tectonics and diapirism coupled with strike-slip movements. Based on observed geologic features including subsidence patterns (basin development), magmatic events, melanges and chaotic complexes, it is suggested that episodic diapirism of different orders took place in this region.

Northeastern Borneo probably represents a diapirically uplifted marginal(?) basin with highly attenuated crust formed by an earlier stretching. North Borneo Trough is not a subduction trench. It is interpreted as a submerged extensional basin overridden by materials derived by gravity spreading of the uprising Northeastern Borneo.

Relationship of gabbro and pillow lavas in the Lupar Formation, West Sarawak: implications for interpretation of the Lubok Antu Mélange and the Lupar Line

N.S. HAILE[1] & S.K. LAM[2]
[1]PETRONAS Petroleum Research Institute
[2]Geological Survey Department, Kuching, Sarawak

The Lupar Line is generally agreed to be a major suture which has resulted from plate movements that largely determined the Cretaceous to Paleogene history of northern Borneo. Never-the-less, there remain many uncertainties regarding the relationship of the various belts and rock types that have been distinguished. Most of the many attempts to reconstruct the history of Borneo and the South China Sea involve the incorporation of a model of the nature and timing of events along the Lupar Line. Thus new factual observations in this area are of regional significance.

The excellent geological map by the Survey Department (D.N.K. Tan, 1979, Report 13) shows a series of NW-SE or WNW-ESE belts in the Lupar Valley, which are, from north to south:

Belaga Formation, Layar Member (part of Rajang Group):
Thick flysch succession: slaty to phyllitic argillite, metagreywacke sandstone. Bathyal, probably distal turbidites. Intensely folded. Upper Cretaceous.

Lupar Formation:
Flysch succession: greywacke, slaty argillite and mudstone. Bathyal, probably proximal turbidites. Strongly folded, with slumping. Upper Cretaceous.
Included in this belt are elongated bodies of basic lava (including pillow lava) and gabbro.

Lubok Antu Mélange:
Typical mélange, with blocks, lenses, boulders, pebbles and granules of sandstone, radiolarian chert, basic igneous rocks, and limestone, in a sheared argillaceous matrix. Tectonic mélange. Age of blocks ranges from Lower Cretaceous to lower Eocene; the matrix is in part at least Eocene.

Silantek Formation:
Shale, mudstone, sandstone, and coal. Shallow marine to fluviatile and lacustrine. Upper Eocene to ? Miocene.

The gabbro and pillow lavas within the Lupar Formation have been interpreted as faulted-in slices of oceanic crust, and by implication as older than the Lupar.

A brief examination of quarries and excavations made in the areas of dams and quarries constructed for the Batang Ai Hydroelectric Project has shown that at least some of the gabbro within the bedded flysch typical of the Lupar Formation is intrusive, and pillow lava interbedded, contrary to the view that they represent older oceanic crust emplaced tectonically as faulted slices with the Lupar. The evidence for this is:

a) Unfaulted contacts of concordant sills of gabbro within the formation, which is thermally metamorphosed for at least 50 m at the contact.
b) Pillow lavas in contact with and concordant with the Lupar Formation along an unfaulted contact.

This implies that the lavas are contemporaneous with the Upper Cretaceous Lupar Formation, and at least some of the gabbro is probably also of the same age, although it could be younger, if unrelated to the lavas.

Consideration of this evidence, and of the results of recent mapping in adjacent parts of Kalimantan to the south, suggests that:

i) the gabbro and pillow lava are not oceanic crust, but intrusive into and extrusive within the Lupar Formation;
ii) the junctions between the Lubok Antu Mélange and the Lupar Formation, and that between the Lupar and Layar Formation, may be major sutures, whereas the Lupar Valley itself may only be a fault zone within a broad mélange belt that extends south beneath the Silantek Formation, which forms the northern rim of the Ketungau Syncline..

Temana Jacket-W development — an intergrated approach

TALIB AK BUYAK, P.W. VINCENT, A.H.M. TEN HAVE & J.A. LOPEZ LOPEZ
Sarawak Shell Berhad

The Temana Field is situated in the northeast of the Balingian Basin, some 30 km west of Bintulu, offshore Sarawak. Its main prospective sequence, of early Miocene age (Cycles II and III) consists of fluvial channels and flood plain sequences deposited in a narrow low relief coastal/ deltaic plain environment.

The area of interest (Blocks 54/99 in the northern part of Temana Central) was originally planned to be developed by three wells with an expected ultimate recovery of 4.7 MMbbls. The primary development objective was the 160 fluvial channel reservoir which was interpreted to have a WNW/ESE orientation based on sparse appraisal well data.

An infill 2D seismic survey was acquired over the Blocks 54 and 99 area in August 1989 with the objective to optimise the development well locations and fault pattern. The seismic interpretation led to changes in the structural map. This indicated, together with the subsequent drilling of appraisal well TE-59 and detailed reservoir geological evaluation, including dipmeter studies (indicating a N/S channel trend), the presence of a combined stratigraphic and structural closure at 160 reservoir level. As a result expectation reserves increased from 4.7 MMbbls to 12.7 MMbbls. Consequently, the project scope was increased to six wells.

Drilling results of the six TEJT-W development wells confirmed the geological interpretation and the reserves estimate. The results demonstrated the importance of an integrated approach to development planning of small fields. Proper understanding and uncertainty assessment of both the structural configuration and sedimentological model has been essential to optimise the development plan for this complex field.

W.K. Fletcher: Behavior of gold in stream sediments

Laporan (Report)

Prof. Dr. W.K. Fletcher of Geology Department, University of British Columbia, Vancouver, Canada, presented the above talk to a large audience of about 50 on the 11 December 1991 at the Department of Geology, University of Malaya, Kuala Lumpur.

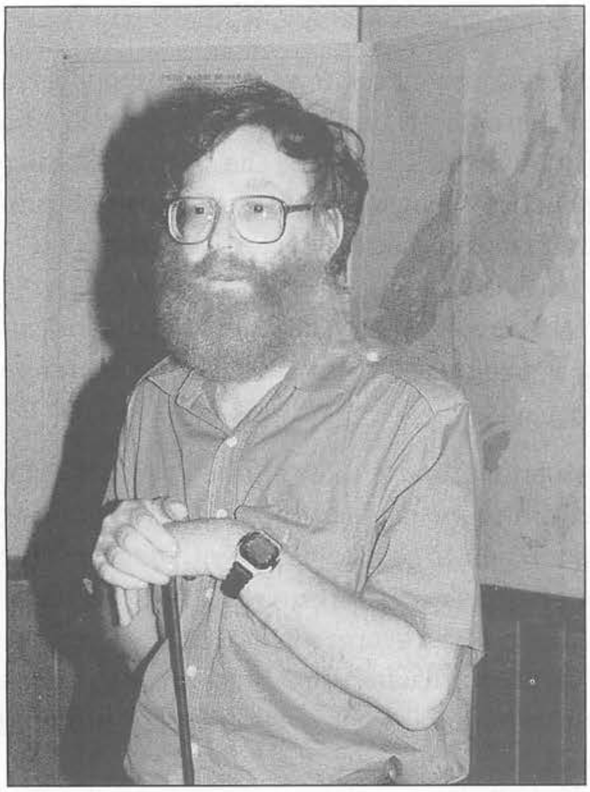
Professor Fletcher began his talk by indicating to the audience that gold anomalies in drainage sediments are often erratic. This reflects both rarity of gold particles and hydraulic effects whereby gold is concentrated at favorable sites along the stream. Studies of gold in drainage sediments in British Columbia have shown that: (i) concentrations are controlled by hydraulic and sedimentological conditions that lead to its selective accumulation in high energy environments, and (ii) that this can result in concentrations of gold increasing downstream away from their bedrock source. These findings have important implications for the design and interpretation of stream sediment surveys and therefore need to be tested under a wide range of conditions.

Next, Professor Fletcher touched on investigation to evaluate gold in a small stream in NE Thailand. The Huai Hin Laep, a third order stream, drains a region of gently rolling hills 40 km east of Loei. Gold mineralization is thought to be associated with quartz veins in the stream's headwaters. Climate is monsoonal with a rainy season from May to October. Soils are laterites and podzols that developed under a mixed evergreen forest. However, the forest has been removed and land converted to agricultural use. Probably as a consequence of deforestation and increased soil erosion, stream sediments are clay-rich gravels containing only very minor amounts of medium to fine sand.

Bulk sediment samples, consisting of approximately 40 kg of -12 mm material, were collected from bar and pavement sites along an 8 km study reach. Samples were wet sieved into eight size fractions. The five fractions between 420 µm and 53 µm were then processed to obtain heavy mineral concentrates (SG >3.3). gold content of all fractions finer than 420 µm was determined by fire assay-atomic absorption.

Concentrations of gold in the heavy mineral concentrates typically range from 10,000 to 50,000 ppb (maximum 198,000 ppb) whereas the corresponding light mineral and -53 µm fractions generally contain <5 ppb gold. Within the heavy mineral fraction concentrations of gold generally increase downstream away from their supposed source and are higher at pavement than at point bar sites. Variations in abundance of gold between point bar sites can be related to stream characteristics (such as width, velocity and bed roughness) that are indicative of changing energy conditions and of the ability of the stream to winnow light minerals from its bed.

Estimates of the median number of gold particles in the heavy mineral concentrates increase from less than one at 212-420 µm to about three in the 53-106 µm size range. However, because of dilution by the light mineral and -53 µm fractions, the probability of a 30 g analytical subsample containing a particle of gold is so low that thirteen out of sixteen -150 µm sediment samples failed to detect the gold anomaly. Insofar as this results from dilution by large quantities of -53 µm sediment, failure of conventional sediment samples to reliably detect the anomaly is probably a consequence of deforestation and land usage.



With respect to exploration it is apparent that use of heavy mineral concentrates from pavement and other high energy sites will be much more reliable than conventional sediment samples in detecting gold anomalies like that in the Huai Hin Laep. This has the advantage of requiring a low sample density but, because anomaly contrast may increase downstream, requires careful interpretation during follow-up.

G.H. Teh

W.K. Fletcher

BERITA-BERITA PERSATUAN
News of the Society

Keahlian (Membership)

The following applications for membership were approved:

Full Members

1. Gordon H. Packham
7 Gladys Ave., Frenchs Forest, NSW 2086, Australia.

2. Ling Hsin Yi
Dept. of Geology, Northern Illinois University, Dekalb, I11., USA.

3. Abd. Rahim Md. Arshad
PRI, Lot 1026 PKNS Ind. Est., 54200 Ulu Kelang.

4. Abu Bakar Zainal
Jabatan Geologi, Universiti Kebangsaan Malaysia, 43600 Bangi.

5. Mahadi Isa
Petronas, P.O. Box 12444, 50778 Kuala Lumpur.

6. Muzli Hussain
Petronas Carigali, P.O. Box 12407, 50776 Kuala Lumpur.

7. Andrew Cheng
Petronas, P.O. Box 12444, 50778 Kuala Lumpur.

8. Colin H. Ford
P.O. Box 735, Epping, NSW 2121, Australia.

9. Baharudin Isa
Petronas Carigali, P.O. Box 12407, 50776 Kuala Lumpur.

10. Edward C. Cox
Simon - Robertson, Llandudno, Gwynedd, LL30 1SA, U.K.

11. Anyi Ngau
Sarawak Shell, XGO/2, 98100 Lutong, Sarawak.

12. Jeciel Benavidez
The Philodrill Corp., 125 Pioneer St., Mandaluyong, Philippines.

13. Mohd. Khalid Embong
Petronas Carigali, P.O. Box 12407, 50776 Kuala Lumpur.

14. Eric N. Beyer
RGC Exploration Pty. Ltd., TB 3211, Block D, Taman El-Nysa, jalan Kabota, 91000 Tawau, Sabah.

15. David R. Muerdter
Sierra Geophysics, 150 Beach Road, 28-08 Gateway West, S'pore 0718.

Institutional Member

1. Enterprise Oil Plc.
Gran Buildings, Trafalgar Square, London SC2N 5EJ, UK. Attn: Ms. Jane Beniston.

Associate Member

1. Stanislaw A.A. Grodynski
c/o Magnetic Pulse Asia-pacific Pte. Ltd., Loyang Offshore Supply Base, Loyang Crescent, S'pore 1750.

Pertukaran Alamat (Change of Address)

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

1. Robert Eise Hulsbos
P.T. Corelab Indonesia, Bld. 303, Cilandak Commercial Estate, Jalan Cilandak K.K.O., Jakarta 12560, Indonesia.
2. Haji Wan Anuar bin Ibrahim
Permint Minerals Sdn. Bhd., 14th Floor, Menara Permint, Jalan Sultan Ismail, 20200 Kuala Terengganu, Terengganu, Malaysia.
3. Rodziah Bte Daud
Malaysianization Unit, Exploration and Production Division, Tingkat 17, Kompleks Dayabumi, Jalan Hishamuddin, P.O. Box 12444, 50778, Kuala Lumpur.
4. Seet Chin Peng
Geological Survey Malaysia, Bangunan Tabung Haji, Tingkat 19-21, Jalan Tun Razak, Peti Surat 11110, 50736 Kuala Lumpur.
5. Mohammed Hatta Abd. Karim
Pejabat Penyiasatan Kajibumi, Tingkat 9, Bangunan Mayban Trust, Jalan Tun Sambanthan, 30000 Ipoh, Perak Darul Ridzuan.
6. J. Redfern
53 St. Lesmo Road, Edgeley, Stockport, Chesmire, Sk3 OTX, U.K.

Pertambahan Baru Perpustakaan (New Library Additions)

The Society has received the following publications:

1. Commonwealth Science Council, July-Aug 1991.
2. Suggestions to authors of the Reports of the United States Geological Survey. 7th ed. 1991.
3. Journal of the Geological Society of the Philippines, vol. XLI, nos. 1-4, 1987; vol. XLV, nos 1-4, 1990, and vol. XLVI, nos 1-2, 1991.
4. Special publications of the Central Geological Survey no. 5, 1991.
5. Santana Fossils: an illustrated atlas edited by John G. Maisey 1991.
6. AAPG Explorer, Oct & Nov 1991.
7. Annual Report 1990, Geological Survey of Malaysia, 1991.
8. Science & Technology, vol. 1, no. 1, 1991.
9. Mineralogia Polonica, vol. 19, nos 1 & 2, 1988, vol. 20, nos. 1 & 2, 1989, vol. 21, nos. 1-2, 1990.
10. Chronique de La Recherche Minere, nos. 504 & 505, 1991.
11. Geology and mineral resources of the Taiping-Kuala Kangsar area, Perak Darul Ridzuan by Foo Khong Yee, 1990.
12. Geology & mineral resources of the Hulu Lepar area, Pahang Darul Makmur by Lee Ah Kow, 1990.
13. SOPAC News, vol. 8, nos. 2, 1991.
14. Geological Survey of Japan, Bulletin vol. 42, nos. 8 & 9, 1991.
15. CCOP Technical Bulletin, vol. 21 (1990), vol. 22 & 23 (1991).
16. Journal of water resources, vol. 8, no. 2, 1989.
17. Principal Scienctific and technical results, 1989.
18. USGS Bulletin: 1991: 1940, 1787-p, 1916, 1942, 1949, 1904-F, 1986, 1878, 1977, 1956, 1928, 1980-A, 1919, 1857-I, 1917-E, 1917-D, 1943, 1904-C, D, 1953, 1947, 1989, 1948.
19. USGS Bulletin: 1990: 1895, 1923, 1787-N, 1887, 1950, 1728-G, 1951.
20. USGS Circular: 1990: 1058, 1056, 930-J.
21. USGS Circular: 1991: 1063, 1065.
22. USGS Professional Paper: 1991: 1391, 1501, 1494, 1513-D, 1409-D, 1273-F, 1430, 1506-B, 1406-C, 1505-B, C.

BERITA-BERITA LAIN
Other News

MOUNTAIN SCIENTIFIC EXPEDITION SERVICE
INSTITUTE OF GEOLOGY
ACADEMIA SINICA
Beijing, China

PREFACE

Qingzang Plateau, Hengduan Range and a great number of other famous mountains and rivers in China, Have long been fascinating to scientists all the world over. And Qingzang Plateau, so-called "the Roof of the world", has a special appeal to the world of geology since its lifting bears so much to the formation and development of our earth, the distribution and evolution of plants and animals, and the formation and interaction of regional climate and the climate on a global scale. Many remain mysterious to this day to the world's scientific mind, though the past century has seen pertinacious efforts being made and tremendous costs paid by a good many scientists, expeditors and mountaineers both at home and abroad.

Along with the implementation of China's opening policy, the number of scientists, expeditors and mountaineers who venture to explore or travel the areas in question for scientific purposes at their own expenses are increasing rapidly with earth passing day. This will no doubt benefit the cause of science in general, and the development of high mountain expedition in particular.

With the sanction of the Chinese Academy of Science, the Mountain Scientific Expedition Service, Institute of Geology, Academia Sinica, (MSES, as shortened hereinafter), was officially founded in January, 1985.

AIM

The aim of establishing MSES is:

1. to promote scientific researches of all scientists throughout the world on Qingzang Plateau and other regions in the People's Republic of China;
2. to promote and strengthen friendly cooperation and academic exchange between the Chinese Academy of Sciences and the counterparts and colleagues all over the world;
3. to provide services for self-supporting organizations or individuals the world over who propose to come either for scientific research or science orientated in the People's Republic of China.

EXPERIENCE

During the past four years since the founding of MSES, it has successfully organized the following expeditionary activities; a joint mountaineering and investigation in Tibet and a comprehensive scientific survey with botany as a focus from Sichuan all the way to Lhasa sponsored by Kobe University (Japan) and Tohoku

University (Japan); Kulun Range mountaineering expedition and a comprehensive biological survey focused on vegetables and fruit trees in Xinjiang sponsored by Shizuoka University (Japan); Kobe University's investigation specially focussed on the Quaternary plateau lakes in Tibet; Yimaguchi University's (Japan) mountaineering and scientific expedition to the Tanggula Range; Kyoto University's (Japan) Kulun Range mountaineering and scientific expedition; Marco Polo scientific survey-retracing the Silk Road and Mt. Xixiabangma Range mountaineering and scientific expedition, sponsored by a British scientific institution; French scientists' survey of karst in Guizhou and a scientific tour in Tibet to finalize the international symposium on sedimentology of mineral deposits.

Thanks to the join efforts of China and foreign scientists, they discovered some species of plants and animals that were unknown to us before and would definitely better the existing systematic botany and zoology. For the first time they succeeded in drilling in lakes on Qingzang Plateau and acquired valuable data which help interpret the evolution of the Plateau. These findings of geoscience and bioscience greatly enhanced our knowledge of the Qingzang Plateau and appreciated by the scientists, foreign or Chinese. Among these, some have been published and others are still in print. The results obtained so far will play a positive role in and make a significant contribution to the research of Qingzang Plateau.

PRINCIPLE

Since research work involves data, results, samples and the like, MSES would assign Chinese scientists or experts to participate all the research activities. Individuals will be selected in accordance to the specific research subjects decided by the visiting team or any organization who come to China for scientific expeditions on their own expenses. Fees caused accordingly by the Chinese participants will be covered by the visiting party. Our stipulations are: joint field work; share of the data and information concerned; and respective storage of specimens and samplings only after inspection by Chinese authorities.

TASKS

MSES is oriented primarily towards organizing scientific expeditions and tours, both general and professional, related to geoscience or bioscience or any relevant interdisciplinary matter. The main items of service we offer range as follows:

1. Administer and process application from individual or organization for scientific survey, mountaineering scientific expedition and scientific research programs be implemented.
2. Assist in getting scientific data, specimens and samplings, films and video tapes through inspection and the shipping abroad.
3. Provide with daily life service and technical advice for those individual/ organization that come at their own expenses

---

Sponsors:
Institute of Geology, Academia Sinica

Science Advisors:
Professor Liu Dongsheng,
Division member of the
Chinese Academy of Sciences
Professor Wang Sijing,
Director, Institute of Geology,
Academia Sinica

Manager:
Associate Professor Zheng Xilan

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Cable: 6347, Beijing
Tel: 446551 — ext. 462
Telex: 22474 ASCHI CN
c/o Institute of Geology
Fax: 861 401 4031

Kursus-kursus latihan & bengkel-bengkel (Training Courses & Workshops)

1992

November 18–22
GEOLOGY AND GEOPHYSICS FOR THE RESERVOIR ENGINEER (Rueil-Malmaison). Language: French (English, if number of participants allows).

December 2–13
WELL LOG ANALYSIS (Rueil-Malmaison). Language: French (English, if number of participants allows).

MINING MANAGEMENT (Kensington, New South Wales, Australia). Master's and graduate diploma degrees in Mining Management, as well as individual short courses. (Courses may be presented at other locations by arrangement.) For Information: Dr. Mike Katz, Associate Director, International Key Center for Mines, University of New South Wales, P.O. Box 1, Kensington NSW 2033, Australia.

PROFESSIONAL DEVELOPMENT SEMINARS IN MINERAL ENGINEERING AND MINERAL ECONOMICS. Conducted by the Department of Mining and Metallurgical Engineering, McGill University. Language: English. For Information: Lorna McFadden, Department of Mining and Metallurgical Engineering, McGill University, 3480 University Street, Montreal, Quebec H3A 2A7, Canada.

SHORT COURSES IN PETROLEUM GEOLOGY AND RELATED DISCIPLINES. Conducted by IHRDC. Language: English. For Information: IHRDC Instructional Programs, 535 Boylston Street, Boston, MA 02116, USA.

SWEDISH INTERNATIONAL UNIVERSITY CONSORTIUM (Stockholm, Sweden). Master's degree programs lasting three semesters, including a Master's thesis project. Courses in applied Geophysics and Geochemistry at Lulea. Language: English. For Information: Dr. Bjorn Ohlander, Economic Geology, Lulea University of Technology, S-951 Lulea, Sweden.

TWAS ITALIAN AWARDS SCHEME. A series of grants for developing-country geoscientists of proven ability to work and study for periods up to 10 months at the following Italian universities: Florence, Milan, Padua, Pisa, Rome, Trieste, Turin, and CNR Pisa. For Information: Executive Secretary, Third World Academy of Sciences, International Centre for Theoretical Physics, P.O. Box 586, Strada Costiera 11, I-34100 Trieste, Italy.

WEDC (Water, Engineering and Development Centre). Concerned with urbanization and urban infrastructure. Courses offered range in duration from 6 weeks to 12 months, deal with a wide variety of water, engineering, developmental, environmental, and management topics, and lead to certificates, diplomas, or MSc degrees. For Information: Professor John Pickford, WEDC, Loughborough University of Technology, Leicestershire LE11 3TU, UK. Phone: 0(44) 509 222390; telex: 34319 UNITECG; fax: 0(44) 509 610231.

THE ROBERTSON GROUP plc, Llandudno, Gwynedd, UK, attention: Dr. C.J. Burgess, Manager, Petroleum Training Centre. Phone: 44(0) 492 581811; fax: 44(0) 492 583416; telex; 61216 ROBRES G.

U.S. GEOLOGICAL SURVEY, Office of International Geology, Training Section, 917 National Center, Reston, Virginia 22092. USA.

KALENDAR (CALENDAR)

1992

October 17–22
HYDROLOGY AND HYDROGEOLOGY, mtg., Portland, Ore. (American Institute of Hydrology, 3416 University Ave. S.E., Minneapolis, 55414-3328. Phone: 612/279-1030)

October 18–23
LATE PRECAMBRIAN TECTONICS AND THE DAWN OF THE PHANEROZOIC, GSA Penrose Conference, Death Valley, Calif. (Ian W.D. Dalziel, Institute for Geophysics, University of Texas, Austin, 78759-8345. Phone: 512/471-6156. Fax: 512/471-8844)

October 19–21
BIO-LEACHING MINERALS AND MINERAL-LAND RECLAMATION, mtg. and workshop, Sacramento, Calif. (Yung Sam Kim, Nevada Institute of Technology, Box 8894, Campus Station, Reno, Nev. 89507. Phone :702/673-4466)

October 25–30
IN-SITU MINERALS RECOVERY, mtg., Santa Barbara, Calif. (Engineering Foundation, 345 E. 47th St., New York, 10117. Phone : 212/705-7835. Fax: 212/705-7441)

October 26–28
EXTRACTIVE METALLURGY OF GOLD AND BASE METALS, int'l. mtg., Kalgoorlie, Western Australia. (V.N. Misra, Kalgoorlie Metallurgical Laboratory, Box 881, Kalgoorlie, 6430, Australia. Phone: (090) 220 120. Fax: (090) 912 762) Papers invited.

October 26–29
GEOLOGICAL SOCIETY OF AMERICA (Annual Meeting), Cincinnati, Ohio, USA. (Jean Kinney, GSA Headquarters, P.O. Box 9140, Boulder, Colo. 80301, USA. Phone: (303) 447-2020).

November 8–13
WATER RESOURCES AND ENVIRONMENTAL ENGINEERING, mtg., Santa Barbara. Calif. (C.V. Freiman, Engineering Foundation, 345 E. 47th St., New York, 10017. Phone: 212/705-7835. Fax: 212/705-7441)

November 29–December 2
TECTONIC FRAMEWORK AND ENERGY RESOURCES, mtg., Kuala Lumpur, Malaysia. (Secretariat, c/o Dept. of Geology, University of Malaya, 59100 Kuala Lumpur, Malaysia)

November 30–December 3
OFFSHORE SOUTHEAST ASIA, mtg., Singapore. (Society of Petroleum Engineers, Box 833836, Richardson, Texas 75083-3836. Phone: 214/669-3377. Fax: 214/669-0135)

December 28–31
GEODYNAMICS OF THE ARABIAN LITHOSPHERE, int'l. mtg., Baghdad. (Sahil Alsinawi, Dept. of Geology, College of Science, University of Baghdad, Jadiryah, Iraq)

1993

April 17–20
EXPLORATION AND DISCOVERY, mtg., Denver, by Society of Economic Geoloiists, Society of Exploration Geophysicists, and others. (J. Alan Coope, SEG Conference '93, Box 571, Golden, Colo. 80402. Phone: 303/837-5819. Fax: 303/837-5851)

April 25–28
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, ann. mtg., New Orleans. (AAPG, Box 979, Tulsa, Okla. 74101-0979. Phone: 918/584-2555. Fax: 918/584-0469)

May 16–20
ENVIRONMENTAL HYDROLOGY AND HYDROGEOLOGY, mtg., Washington, D.C. (Secretariat, Americal Institute of Hydrology, Second USA/USSR Conference, 3416 University Ave. S.E., Minneapolis, 55414-3328. Phone: 612/379-1030. Fax: 612/379-0169)

May 17–19
GEOLOGICAL ASSOCIATION OF CANADA/MINERALOGICAL ASSOCIATION OF CANADA (Joint Annual Meeting), Edmonton, Alberta, Canada. (J.W. Kramers, Alberta Geological Survey, P.O. box 8330, Station F, Edmonton, Alberta T6H 5X2, Canada. Phone: (403) 438-7644; telefax: (403) 438-3644)

May 25–June 15
BASIN TECTONIC AND HYDROCARBON ACCUMULATION, mtg., Nanjing, People's Republic of China, by Nanjing University. USGS, Society of Petroleum Geology of China, and others. (David G. Howell, MS902, USGS, 345 Middlefield Road, Menlo Park, Calif. 94025. Phone: 415/329-5430. Fax: 415/354-3224)

June 1–5
GEOTECHNICAL ENGINEERING, int'l. mtg., St. Louis. (Norma R.Fleming, 119 ME Annex, University of Missouri, Rolla, 65401-0249. Phone: 314/341-6061; 800/752-5057. Fax: 314/341-4992)

June 7–11
EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS (55th Annual Meeting and Exhibition), Forum, Stavanger, Norway. (Evert van der Gaag, Business Manager, European Association of Exploration Geophysicists, Utrechtseweg 62, NL-3704 HE Zeist, The Netherlands. Phone: (03404) 56997)

June 20–27
ZEOLITES, int'l. mtg., Boise, Idaho, by International Committee on Natural Zeolites. (F.A. Mumpton, Dept. of Earth Sciences, State University of New York, Brockport, 14420. Phone: 716/395-2635; 716/637-2324. Fax: 716/395-2416)

June 21–25
ROCK ENGINEERING, mtg. and workshop, Lisbon, Portugal, by International Society for Rock Mechanics. (Luis Ribeiro e Sousa, Portuguese Society for Geotechnique, Laboratorio Nacional de Engenharia Civil, Av. do Brasil, 101, 1799 Lisboa Codex Portugal. Phone: 848 21 31. Fax: 89 76 60)

July
ENVIRONMENTAL CONTEXT OF HUMAN EVOLUTION (International Scientific Congress and Exhibition), The Netherlands and Indonesia. (Dr. Hans Beijer, Geological Survey of The Netherlands, P.O. Box 157, NL-2000 AD Haarlem, The Netherlands. Telefax: 31 23 351614

July 18–23
CLAY CONFERENCE (10th International Conference in conjunction with Commission VII of the International Soil Science Society), Adelaide, South Australia. (Dr. Tony Eggleton, Geology Department, ANU, GPO Box 4, Canberra, ACT 2601, Australia)

August 23–29
GEOMORPHOLOGY (3rd International Conference), Hamilton, Ontario, Canada. (3rd International Conference on Geomorphology, McMaster University, Hamilton, Ontario L8S 4Kl, Canada. Phone: (416) 525-9140, ext. 4535; telefax: (416) 546-0463; telex: 061-8347)

August 23–29
COASTAL SEDIMENTOLOGY, mtg., Hamilton, Ontario. (William F. Tanner, Dept. of Geology B-160, Florida State University, Tallahassee, 32306. Phone: 904/644-3208)

September 25–October 1
INTERNATIONAL ASSOCIATION OF VOLCANOLOGY AND CHEMISTRY OF THE EARTH'S INTERIOR, mtg., Canberra, Australia. (IAVCEI ACTS, GPO Box 2200, Canberra ACT 2601, Australia. Phone: 61/6/257-3299. Fax: 61/6/257-3256)

1994

June 6–10
EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS (56th) Annual Meeting and Exhibition), Austria Center, Vienna, Australia. (Evert Van der Gaag, Business Manager, European Association of Exploration Geophysicists, Utrechtseweg 62, NL-3704 HE Zeist, the Netherlands. Phone: (03404) 56997; telefax (03404) 62640; telex:33480)

1995

May 29–June 2
EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS (57th Annual Meeting and Exhibition), Glasgow, UK. (Evert van der Gaag, European Association of Exploration Geophysicists, Utrechtseweg 62, NL-3704 HE Zeist, The Netherlands. Phone: (03404) 56997; telefax: (03404) 62640; telex: 33480)

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BULETIN PERSATUAN GEOLOGI MALAYSIA

BULLETIN OF THE GEOLOGICAL SOCIETY OF MALAYSIA

SPECIAL ISSUE ON PETROLEUM GEOLOGY VOL. V

KANDUNGAN (CONTENTS)

Editor
G.H. TEH

NOVEMBER 1990 No. 27

Price: M$40.00 (US$17.00)

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Orders should be addressed to: The Hon. Assistant Secretary
GEOLOGICAL SOCIETY OF MALAYSIA
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University of Malaya
59100 Kuala Lumpur
MALAYSIA

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Back Issues Available

Bulletin 1 (1968). 79p. 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. Price: M$3.00 (US$1.50). **Out of stock**

Bulletin 2 (1968). 152 p. Bibliography and Index of the Geology of West Malaysia and Singapore by D.J. Gobbett. Price: M$10.00 (US$5.00) — Softcover; M$15.00 (US$7.50).

Bulletin 3 (1970). 146 p. Papers in Geomorphology and Stratigraphy (with Bibliography supplement). Edited by P.H. Stauffer. Price: M$10.00 (US$5.00).

Bulletin 4 (1971). 100 p. Papers in Petrology, Structure and Economic Geology. Edited by P.H. Stauffer. Price: M$10.00 (US$5.00).

Bulletin 5 (1973). 70 p. The Search for Tungsten Deposits by K.F.G. Hosking. Price: M$10.00 (US$5.00).

Bulletin 6 (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: M$22.00 (US$11.00) — hardcover only.

Bulletin 7 (1974). 138 p. A collection of papers on geology. Edited by B.K. Tan. Price: M$12.00 (US$6.00).

Bulletin 8 (1977). 158 p. A collection of papers on geology. Edited by T.T. Khoo. Price: M$12.00 (US$6.00).

Bulletin 9 (1977). 277 p. The relations between granitoids and associated ore deposits of the Circum-Pacific region. A collection of papers presented at the IGCP Circum-Pacific Plutonism Project Fifth Meeting. 12–13 November 1975, Kuala Lumpur. Edited by J.A. Roddick & T.T. Khoo. Proce: M$25.00 (US$12.00). **Out of stock**

Bulletin 10 (1978). 95 p. A collection of papers on the geology of Southeast Asia. Edited by C.H. Yeap. Price: M$10.00 (US$5.00).

Bulletin 11 (1979). 393 p. Geology of Tin Deposits. A collection of papers presented at the International Symposium of 'Geology of Tin Deposits', 23–25 March 1978, Kuala Lumpur. Edited by C.H. Yeap. Price: M$50.00 (US$22.00).

Bulletin 12 (1980). 86 p. A collection of papers on geology. Edited by G.H. Teh. Price: M$20.00 (US$9.50).

Bulletin 13 (1980). 111 p. A collection of papers on geology of Malaysia and Thailand. Edited by G.H. Teh. Price: M$20.00 (US$9.50).

Bulletin 14 (1981). 151 p. A collection of papers on geology of Southeast Asia. Edited by G.H. Teh. Price: M$30.00 (US$14.00).

Bulletin 15 (1982). 151 p. A collection of papers on geology. Edited by G.H. Teh. Price: M$30.00 (US$14.00).

Bulletin 16 (1983). 239 p. A collection of papers on geology. Edited by G.H. Teh. Price: M$30.00 (US$14.00).

Bulletin 17 (1984). 371 p. A collection of papers on geology. Edited by G.H. Teh. Price: M$35.00 (US$15.00).

Bulletin 18 (1985). 209 p. Special Issue on Petroleum Geology. Edited by G.H. Teh & S. Paramananthan. Price: M$30.00 (US$14.00).

Bulletins 19 & 20 (1986). GEOSEA V Proceedings Vols. I & II, Fifth Regional Congress on Geology, Mineral and Energy Resources of Southeast Asia, Kuala Lumpur, 9–13 April 1984. Edited by G.H. Teh & S. Paramananthan. Price for both Bulletins 19 & 20: Members — M$50.00 (US$21.90), Non-members — M$125.00 (US$53.20).

Bulletin 21 (1987). 271 p. Special Issue on Petroleum Geology Vol. II. Edited by G.H. Teh. Price: M$40.00 (US$17.00).

Bulletin 22 (1988). 272 p. Special Issue on Petroleum Geology Vol. III. Edited by G.H. Teh. Price: M$40.00 (US$17.00)

Bulletin 23 (1989). 215 p. A collection of papers on the geology of Malaysia, Thailand and Burma. Edited by G.H. Teh. Price: M$35.00 (US$15.00).

Bulletin 24 (1989). 199 p. A collection of papers presented at GSM Annual Geological Conference 1987 and 1988. Edited by G.H. Teh. Price: M$35.00 (US15.00).

Bulletin 25 (1989). 161 p. Special Issue on Petroleum Geology Vol. IV. Edited by G.H. Teh. Price M$40.00 (US$17.00).

Bulletin 26 (1990). 223 p. A collection of papers presented at GSM Annual Geological Conference 1989 and others. Edited by G.H. Teh. Price: M$40.00 (US$17.00).

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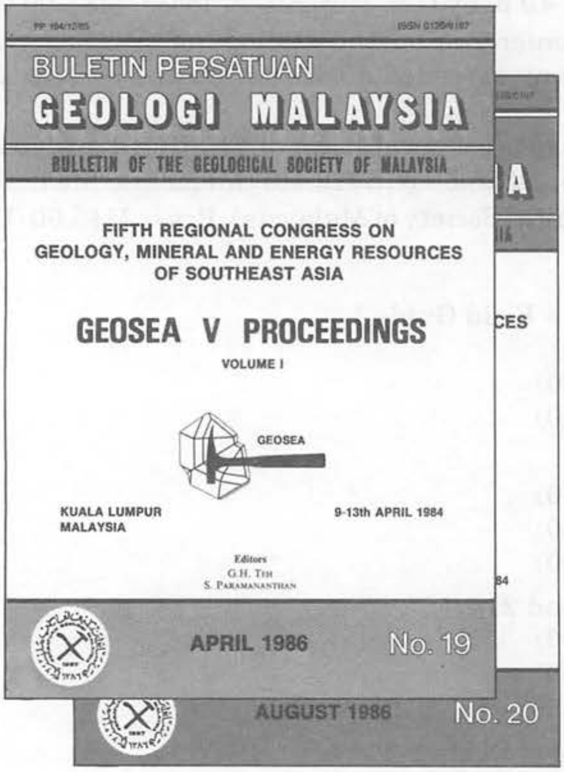

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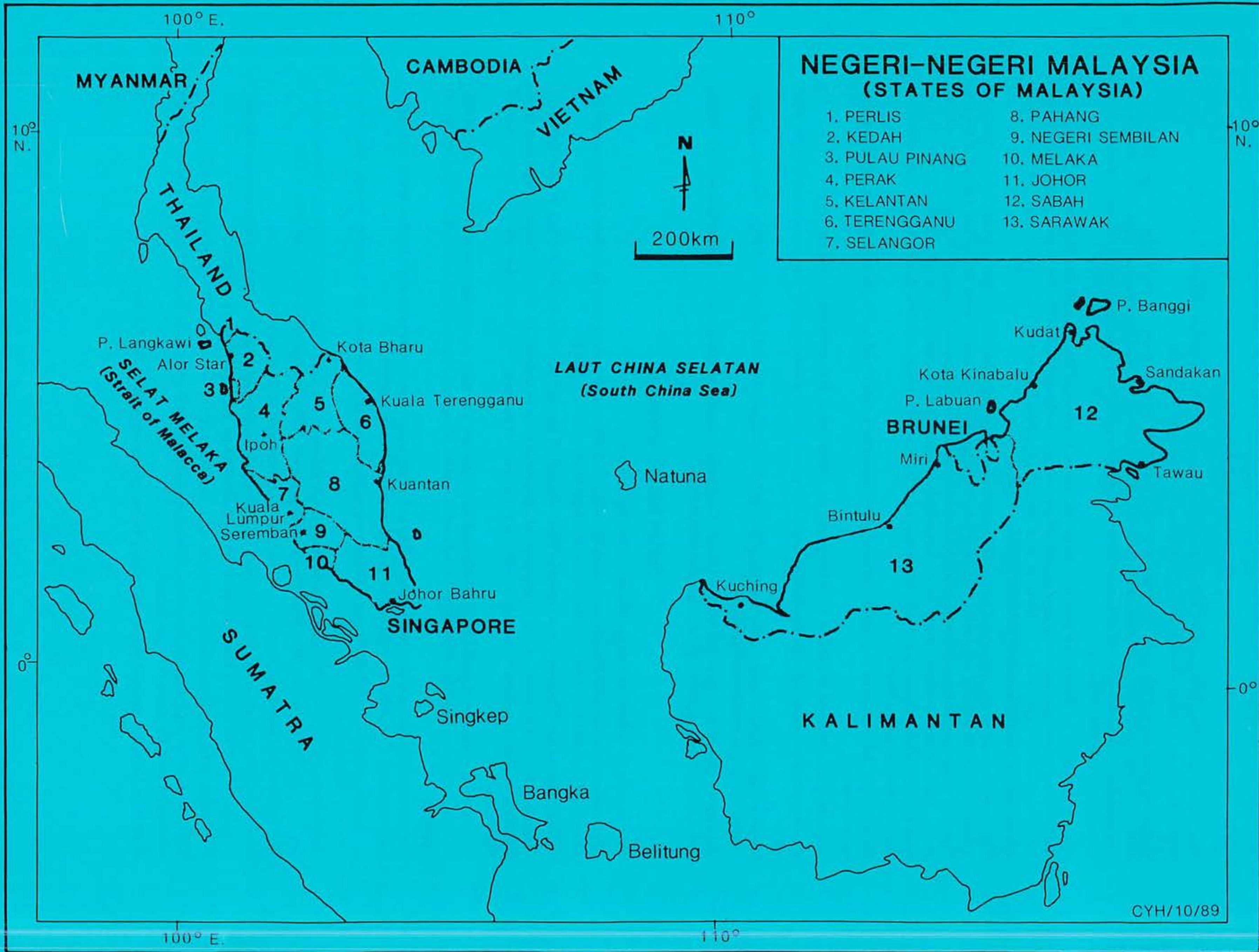
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10° N.
0°
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