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Observations on sediments and deformation characteristics, Sarawak Foreland, Borneo Island

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Abstract— Based on some 120 days of GPS-calibrated fieldwork by land and boat, attempts are made to clarify the geologic picture of the Oligocene-Neogene Sarawak Foreland, in context with the older "Rajang" sequences. Sediments of the Sarawak Foreland are molasses deposits and consist of NW-prograding, and shallowing/ coarsening -upwards sequences. Tectonics appear to be area-specific. Amount and style of deformation vary strongly between the areas of Luconia and the "Baram Delta." Inversion, folding, reverse faulting, and thrusting can be related to a NW/ SE compressive stress field that culminated at the Late Miocene/Pliocene boundary. The contact between the mildly folded Oligocene-Neogene foreland, and the intensely folded inner-Borneo KK-Eocene Rajang/Crocker mountain belt was mapped on satellite pictures and calibrated in two localities. Both mountain belt and foreland area were welded together at the end of the Miocene. The potential for alpino-type nappe tectonism within the KK-Eocene mountain belt is discussed. A case is made for one single boundary fault/thrust front running from Sarawak to Sabah.

INTRODUCTION

Large parts of the Island of Borneo are believed to form part of a larger triangular-shaped continent called "Sundaland," an area that is characterized by a predominant lack of contemporaneous seismic activity. Sundaland encompasses parts of Peninsula Malaysia, Borneo, and the South-China Sea (Figure 1A), and is, together with adjacent terrains in the NE part of the Borneo Island, surrounded by a double crescent of highly active subduction zones. The question remains how much compressive stress these zones were able to absorb, and how the remaining stress might relate to inversion, folding and thrusting as seen in Northern Sarawak (Figure 1B), and the remainder of Borneo.

As summarized in Hutchison (2005), Luconia (a part of Borneo Sundaland) and the "Dangerous Grounds" (a part of the South China Sea) are formed by attenuated crust of an estimated 15 to 25 km thickness. The thickness of continental crust under areas of Brunei and Sabah remains uncertain, but it could be argued that a relatively thin continental crust might have behaved less rigidly than the areas attributed to Sundaland located further west, and hence explain variations in folding style. Borneo's noted absence of frequent contemporaneous seismic activity, however, is not corroborative for active plate boundaries, and the few shallow quakes that are seen cannot be tied to any trans-Borneo lineament with confidence. There is certainly no seismic evidence (perhaps with the exception of SE Sabah) for active subduction below Borneo. There is no Holocene/recent volcanic activity in Borneo, with the possibly exception of Mt. Bombalai on the Semporna peninsula (website of the Smithsonian Institute, http: // www.volcano.si.edu).

A 10 years GPS study (Simons *et al.*, 2007) is indicative for small yet potentially significant movements along several fault zones/ lineaments that possibly cross the inner core of Borneo, an area known for its remoteness and data scarcity. According to this study, Sundaland is shown to move independently with respect to South China, the eastern part of Java, Sulawesi, and the north-eastern tip of Borneo. The differences of movement and vector between Sundaland/Borneo and Northeastern Borneo, as shown in Figure 6 of the quoted publication, are relatively small, and rely on 2-3 data points only. Possibly these movements are relatively young, given the Rajang/Crocker mountain belt runs uninterrupted from Sarawak to Sabah, indicating that older (Palaeogene) deformation must have affected both parts of Sundaland, and NE Borneo terrains simultaneously.

Summarizing the above, Borneo appears to lack subduction, yet is shaped by various amounts of deformation, and competing compressive stress fields. The fieldwork area of this paper covers the eastern edge of Sundaland, dealing with terrains located in Northern Sarawak, of which the crustal affiliation remains uncertain to date.

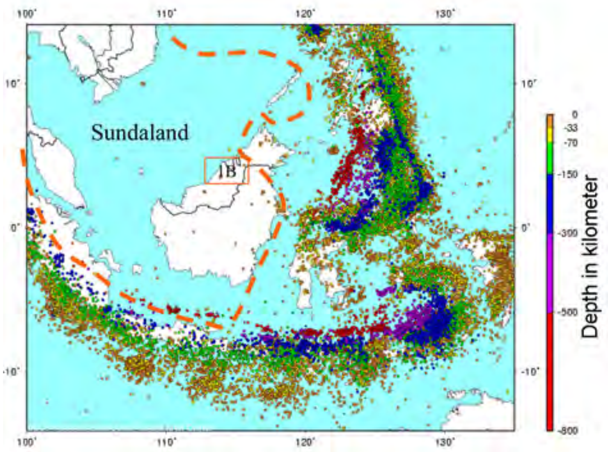


Figure 1A: Seismic activity in the area of Sundaland (dashed orange line, after Simons at al 2007), adjacent terrains. The tectonic context between Sundaland Borneo and NW Borneo terrains remains poorly understood. The figure shows all earthquakes recorded in the time range 1990-2007. The earthquakes are colour-coded in respect to the depths of the epicenters. It shows several subduction zone belts that surround Borneo. These are located but at some distance to the island. Major tectonism (translating into seismic activity) appears to be absent in the Borneo Islands's very recent geological history. Figure from the USGS database.

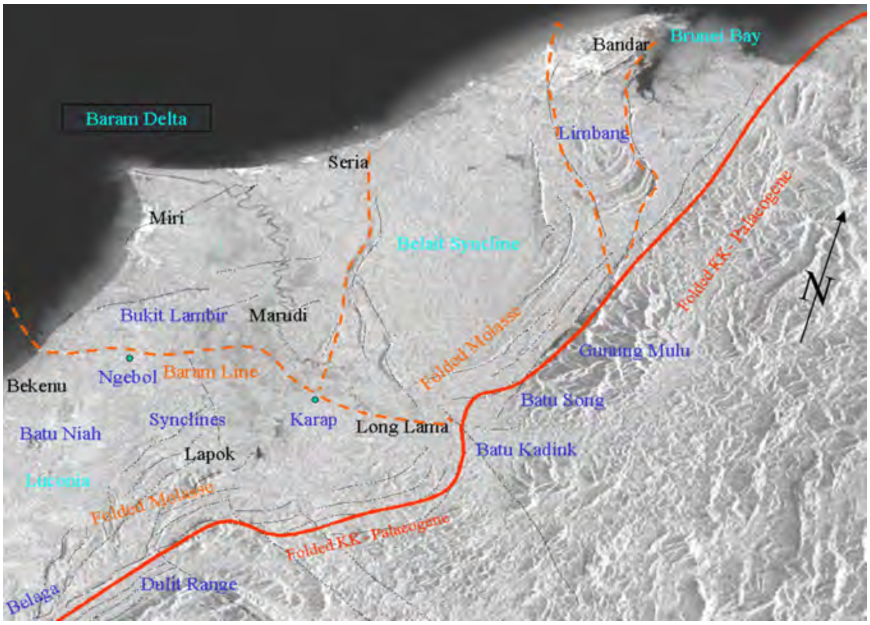


Figure 1B: Radar image index map of North-Western Borneo.
Legend: In black letters: city, village; in dark blue letters: geological fieldwork areas; in light blue letters: geological area names; dotted black lines: form surface features; dotted orange lines: lineaments/regional faults (from satellite images); solid red line: divide Palaeogene/Molasse; green dots: mud volcanoes.

OBJECTIVES AND METHODOLOGY

One can study and attempt to resolve regional geology problems either from the (sequence)-stratigraphic approach, or, alternatively, from the angle of tectonic organization. A glance through the geologic literature shows that Borneo is overloaded with a crushing amount of both ill-defined formation and locality names. This is further aggravated by a rapid degradation of fresh outcrop surfaces, to the point that classic outcrop locations can't be studied any longer. Outcrop areas often fall prey to the development of new oil palm plantations. Carbonate buildups such as Batu Niah, and Batu Kadink resist weathering a lot better. A simplified stratigraphic scheme is shown in Table 1. Objectives of the fieldwork were as follows: to understand the tectonic architecture and dynamics of both "Baram Delta" area, and the timing of fault generation and fault mechanics; to review the context of the Neogene molasse foreland with the mountainous hinterlands of Borneo; the main fieldwork was carried out along three traverses, with the view of resolving tectonic patterns: Bintulu-Belaga; Lambir-Beluru-Lapok; and Kuala-Baram-Marudi-Long Lama.

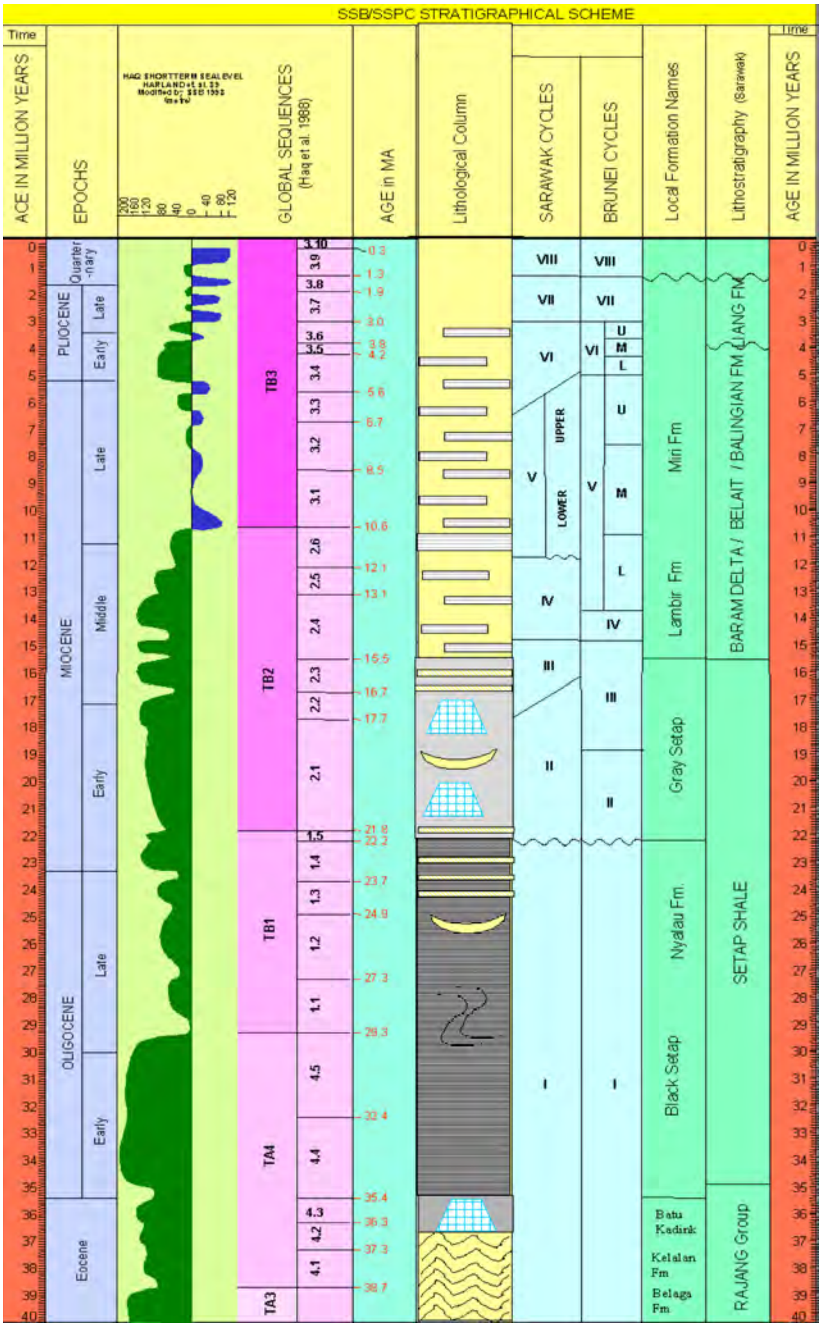
Further mapping was carried out in the Bukit Lambir, Limbang, and Batu Song areas (Figure 1B). Using satellite pictures (Landsat and Google Earth), pictures were studied, interpreted, and calibrated by fieldwork. Some 350 localities were visited.

KK- PALAEOGENE SEDIMENTS, PALAEOGENE DEFORMATION

In the accessible coastal areas, the area of Sibu-Tatau offers several new outcrops exposed along the new coastal road. In the mountainous interior, good outcrops are only found along a few river sections and road cuts. Access is a general problem. These outcrop areas, based on literature and my own fieldwork, are:

The Belaga- Bakun Dam road, in the SW corner of the index map (Figure 1B), that reaches 125 km deep (counting from the Bintulu- Miri road junction) into the island's interior; several road and river profiles in the surroundings of Long Lama, in particular Batu Kadink;

Table 1: Stratigraphic scheme of Sarawak and Sabah modified/adapted to include a lithographic column, after Morrison and Wong 2003. The boundary between the Rajang Group and the younger rocks is seen as a tectonic contact in places



the principal logging road section near the Tamalla camp, near Long Lama; the waterfalls sections in the Batu Song area near Long Bedian; several sections in the Mount Mulu National Park; sections along the Tinjar- and Long San roads; and headwaters of the Limbang River.

Rocks belonging to the "Belaga Fm." and "Rajang Group," were described by Liechti *et al*. (1960) and Adams (1965), and interpreted as deep-marine clastics of Late Cretaceous to Eocene age range. These findings were confirmed in recent studies in the Sibu and Tatau areas by Zainol Affendi Abu Bakar *et al*. (2007).

(Meta)-Sediments belonging to the "Rajang" and "West Crocker," a unit in Sabah outside the area of study, are characterized by intense folding, faulting and thrusting. Folding and faulting within the "Rajang," are likely to be the result of both Palaeogene compression, and a Neogene overprint. Yet, distinction between Palaeogene and Neogene deformation in rapidly weathering outcrops appears difficult if not impossible.

At the road leading to the Bakun Dam site, the main boundary fault zone between folded Palaeogene and folded molasse is not well exposed, but can be inferred as a structural boundary given the radically different tectonic deformation styles (Figure 2B) observed on either

Figure 2A: Banded sandstone/claystone sequence of the "Belaga Fm," "Rajang Group," outcropping near sample point 3 on the map below. These rocks are strongly cemented, compared to the rather soft and largely unconsolidated clastic rocks of the molasse foreland.

side. On the KK-Eocene mountain belt side, strongly folded siliciclastics of the Belaga Fm. are seen, typically formed by banded sequences of hardened sandstone and black shale (Figure 2A), whereas strongly folded, but comparatively soft rock sequences composed by Black Setap shale and sandy Nyalau are seen outcropping at the edge of the molasse basin.

In Batu Kadink (also spelled Batu Gading, figures 3 and 4), a clear case for Late Eocene/Early Oligocene compression and tectonism can be made. "Rajang" sediments in the outcrops are either tilted (Figure 4A), or strongly deformed, showing high-frequent Chevron folds (Figure 4B). Work summarized by Liechti *et al*. (1960), Ngau (1989) and Hutchison (2005) point out that deformation originated, and stopped near the Eocene/Oligocene border. Age determination (Adams 1965) of foraminifera within the "Rajang" sediments, and the overlying Eocene reef complex, as well as the shift from deep marine Eocene "Rajang" to post-tectonic Eocene-Oligocene reef carbonates speak for a rapid, and intensive phase of deformation, followed by uplift and the establishment of a stable shelf environment.

OLIGOCENE- NEOGENE SEDIMENTS, NEOGENE DEFORMATION

Oligocene-Neogene sediments form a blanket in the Sarawak foreland, and little is known about the underlying rocks. There is no proof that "Rajang"- type rocks are present at deeper levels of the foreland. Deep wells such as the old Sarawak Oilfields wells Bulat Setap 1, 2 and 3 reached Total Depth in Black Setap shale, at a depth reaching some 12000'. Cores of anticlines in the Lapok area expose the same (Oligocene?) black shale. Neogene deposits are relatively well exposed. The following areas were visited: the greater area of Bukit Lambir, Lambir Hills, notably along the Bintulu-Miri Road, the Coastal Road, the Kampong Beraya road, and the coastal cliff section called Tanjung Batu between Pantai Bungai and

Figure 2B: Form Surface Map, Belaga area. The pink dotted line divides the areas of Eocene/ EarlyOligocene? folding and thrusting (Lower part of picture), and Neogene folding and thrusting (Upper part). The pink line is inferred to be part of a larger boundary fault zone that marks the contact between the consolidated Late Cretaceous to Eocene "Rajang/Crocker" mountain belt (nappes?), and the Neogene Molasse foreland. Major (Neogene) folding and thrusting is seen in the area of the Dulit Range (NE corner), formed mainly by black shales belonging to the Setap Fm. Note the difference of strike patterns in the folded "Rajang Group" south of the dotted line. Sample point 3, 4 are located just North of the Bakun Dam, and are close to the main tectonic boundary. Faults are shown in red. Sample points along the Bakun Dam road are as follows: 1= Deltaic deposits (Nyalau Fm.); 2= Deltaic deposits, (Nyalau Fm.); 3= Quartzitic sandstone, "Belaga Fm.", "Rajang Group"; 4= Thin-bedded sand and shale deposits, "Rajang Group"

the Tusan headlands; the area of Miri City, the so-called "Miri Anticline"; the roadflanks from Miri to Marudi, and Miri to Long Lama; a network of temporary logging roads around Bukit Song, Beluru; the Batang Baram, and also her tributaries such as Sungai Bakong and Sungai Karap; road sections in the Bintulu area; good summaries describing sediments and formations are given in Hutchison (2005) and Tate (2001). The stratigraphic context is shown in Table 1.

Nyalau Fm. (mainly exposed in parts of Luconia). A sequence formed by deltaic sandstone, thin-bedded shale; probably Late Oligocene to Early Miocene. Prominent in the area of Bintulu, Cape Silimandjau, and along the road to the Bakun Dam. Syn-sedimentary faulting is described by Mazlan Madon and Abd Rahman (2007); reverse faults and thrusts originated in the Anau-Nyalau Fault Zone.

Black Setap shale (mainly exposed in Luconia outcrops, and tested by a few old Bukit Lambir wells). Being the laterally most widespread facies unit, it forms a thick bottom-fill layer within a shallowing-upwards mega-sequence. The Black Setap can be described as a sequence of mainly anoxic brittle dark shale, and minor channels that probably accumulated in an upper slope environment. The formation frequently displays features

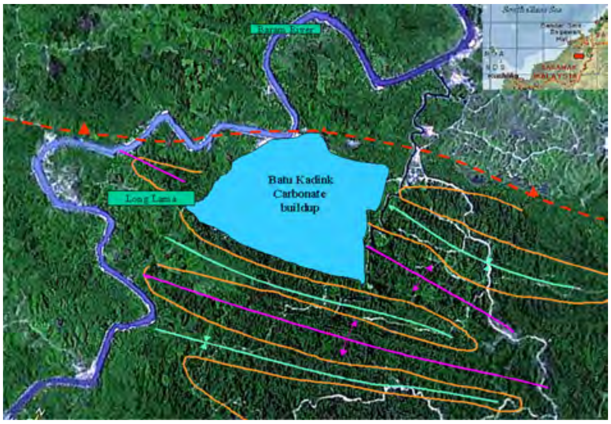


Figure 3A: Satellite picture with geologic interpretation of the Long Lama/Batu Kadink area, and a sketch section through the reef complex. Batu Kadink stands out as an area of high relief, and covers an area of intense Eocene-Early Oligocene? folding, here interpreted as NW-Se striking sequence of narrow anticlines and synclines. Alternatively, it might be interpreted as a successive series of parallel overthrusts.

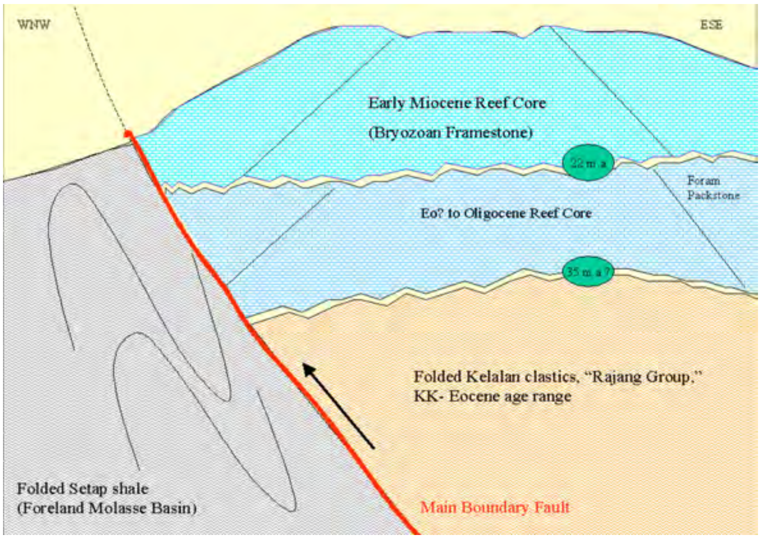


Figure 3B: Schematic section through Batu Kadink; the shown lateral distance is about 2km, whereas the vertical profile height is in the order of 100m. In this interpretation, the Batu Kadink directly overlies "Rajang" sediments, hence belongs to the "Rajang/Crocker" mountain belt. The contact between Batu Kadink and the foreland (Luconia block) is shown as a steep reverse fault boundary. It remains unknown if folded "Rajang" or unfolded time-equivalent strata underlie the Black Setap shale in this part of Luconia. Reef architecture after Ngau (1989) and own work.

Figure 4A: Batu Kadink quarry. The shown section lies in the core of the reef, and is dominated by Bryozoa framestone.

Figure 4B: Chevron-folded thin-banded sandstones and shales of the Kelalan Fm. According to Liechti (1960) and Ngau (1989) these sequences contain Late Cretaceous to Eocene fauna, and characterize deep marine environments.

Figure 4C: A less tectonized Kelalan Fm. outcrop, located immediately below reef complex on roadflank descending to Long lama. The profile consists of well-sorted medium-grain sandstone with several continuous reddish shale beds of about 1.5 inch thickness.

sandstones (Figure 7B) contain also minor amounts of rounded volcanic ash and heavy minerals, based on thin sections. Age and Formation of the described sandstones remains uncertain.

Mid-late Miocene "deltaic" sediments, called Lambir Fm., Miri Fm., and Belait Group. These sequences were deposited NE of the "Baram Line," and reach a thickness of more than 10000' in the SW Lambir area, and the offshore "Baram Delta." Interpreted as predominantly prograding deposits of fluvio-marine and shallow-marine siliciclastics, blocky sandstone and claystone beds laterally inter-finger with meandering sandy channel deposits. The most complete profile is exposed along the coastal section between Pantai Beraya and Pantai Bungai (Figure 8A). Seen from a sedimentological standpoint, the Late-Miocene deltaic sands look very similar, and are composed by coarse-to-fine graded sandstones. Several amalgamated, and cross-bedded sandstone units are seen in the Tusan area (Figure 8B). Micro-conglomerates and coarse sandstone beds are very common in the Lambir Fm., whereas fine-grained sandstone dominate the Brunei outcrops. The sandstones are predominantly clean, but contain often claystone pebbles or coal clasts, whereas clays are rich in coal, amber and volcanic ash.

Sandy Plio- Pleistocene deposits (Tukau Fm) are seen overlying the Lambir Fm. above a marked angular unconformity, in the area along the NW flank of Bukit Lambir. The sandbodies are lenticular-shaped and may have formed in a shoreface environment.

Cross-bedded sands, with high organic content, fossil wood, roots (frequently coated by iron/manganese oxides) and volcanic ash outcrop in a ca. 500 m wide strip along the new coastal Miri-Bintulu road. The common elevation is ca. 10-20 m above sea level. These horizontally- lying sediments were deposited on a terrace that appears to be eroded by marine coastal erosion.

Conclusion: During the Oligocene-Neogene clastic deposition competed with reefal carbonates in a shallow marine environment under the influence of a gradually weakening subsidence. As clastic and prograding sedimentation gradually outpaced subsidence, we can observe a shoaling in the basin. The assemblage of Oligocene-Neogene sediments in the Sarawak Foreland Basin can be described as marine molasse (James 1984, Koopman 1996, Mazlan Madon and Abd Rahman 2007). As different stratigraphy records are observed on either side of the "Baram Line," it makes sense to divide the (Neogene) area of studies (Figure 9A) into (I) "Baram Delta" and (II) "Luconia."

"BARAM DELTA" DEFORMATION

Normal faults: General patterns: Most normal faults plot in a large scatter field of N/S, NE/SW, NW/SE and E/W strike directions. Normal faults parallel to the anticline axis of Bukit Lambir probably originated late in the evolution of the area, and may have resulted from outer arc extension; like most of the synclines and anticlines, these strike with 60° SW/NE. This strike is also the dominant direction of both normal and compressive faults in the offshore part of the "Baram Delta," as shown in Tan *et al.* (1999).

Most faults in the greater Bukit Lambir area are clay-gauged, typically when cutting through deltaic sequence with soft shale intercalations. Distinction is made between normal faults that have multiple, often sub-parallel gliding planes, and razor-sharp ones. On several occasions one can see soft clay material being injected from the strata into the fault planes. Amber and also coal are frequently found imbedded in the gauge clay – an explanation needs to be found. Micro-faulting occurs in general only one meter on either sides of the prominent fault zones, and a few centimeters, or millimeters in the case of minor faults.

Folding and thrusting: Folding is closely related to thrust faulting. Both synclines and anticlines strike 60 deg NE/SW. Anticlines tend to be relatively narrow. Anticlinal folds are observed in:

The Bukit Lambir area: Bukit Song, Bungai, Riam and Buri anticlines. A schematic section through Bukit Song is shown in Figure 10A. The Bungai anticline is possibly related to an over-thrust, and the anticline's shaly core (Figure 6A) is exposed along the new coastal road between Kampong Beraya and Bekenu. A plunging isoclinal feature, its strike changes from NE/SW to E/W in the vicinity of the "Baram Line." Wells in the narrow Riam and Buri anticlines logged oil shows in the near-surface reservoir section.

Miri-Seria fold-and-thrustbelt. Several thrust faults are described in the literature.

Regional uplift**:** Incision of rivers (Baram, Bakong, Karap) into the eastern part of the Bukit Lambir plateau by some 15 meters suggests an uplift of coastal "Baram Delta" Borneo during the recent past. This is roughly the same amount as the height of the main terrace in the Bakam and Miri areas. Hence, a case is made for a Holocene uplift for parts of the "Baram Delta."

LUCONIA DEFORMATION

Normal faults: No normal faults were measured in the field. The apparent absence of normal faults may partly be due to weathering/ vegetation in the claystone-dominated areas of Luconia.

Folding and thrusting: Synclines are isoclinal-symmetrical, with reverse faults between the synclines. On the road between Bakong/Beluru and Lapok, four synclines (Slapin, Grabit, Lapok and Tinjar) are intersected (see Ismael & Abu Hassan, 1999; Kessler 2005, 2006). The magnitude of deformation is seen increasing from the coastal areas towards the inner part of the island:

A coastal strip of Luconia in the Bekenu area shows no signs of deformation.

A little further inland in SE direction, at Bukit Peninjau in the Bakong area, gentle rolling hills are observed. Here, the structural dip hardly exceeds 15 deg,

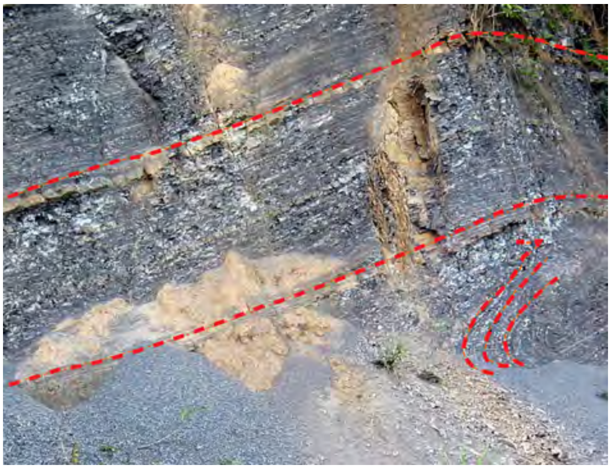


Figure 5A: Black Setap shale on the Beluru to Lapok road, just before the Lapok village. The upper part of the shale sequence formed by parallel, flat-lying beds, the lower most section is characterized by intense folding, caused probably by submarine sliding.

Figure 5B: Black Setap shale, outcrop on road flank of new road track between Lapok and Long Lama. The big boulders seen on the picture in the lower-left corner are formed by fluvio/deltaic to shallow marine sandstones. These belong to a yellowish bed of olistoliths shown in the upper right corner. The sandstone blocks point to the presence of a near-coastal and sand-prone shelf, probably located toward the Southeast, and now either eroded or overthrusted by the "Rajang/Crocker" mountain belt.

Figure 6A: Steep-dipping Gray Setap shale, in an outcrop located in the centre of the Bungai anticline, on the new coastal rad between Tusan and Pantai Bungai junction. The shown sequence lies an estimated 150 m below the base of the sand-dominated Lambir Fm. The shown sequence is largely devoid of fossils, apart from the horizons in the centre of the picture. These grey and red-coloured beds contain ample and well-preserved remnants of bivalves, suggesting brief episodes of benthic colonisation, combined with a favourable diagenesis for shell preservation. This Setap outcrop area is one of the very few in the "Baram Delta Block."v

Figure 6B: Gently dipping Gray Setap shale, as seen along the Miri to Lapok Road, some 10 km before the village of Beluru. The sequence of grey, marly and silty claystones is incised by a sandy channel-fill. This outcrop belongs to the Luconia block.

Figure 7A: Sandstone outcrop on the flank of the gravel road between Beluru and Lapok. Sandstones are generally rare in this part of the Luconia Block, and confined to the youngest strata outcropping along the Beluru-Lapok road. Located in the central part of the Grabit syncline, the sandstone incises older coal beds, and Gray Setap shale, as shown by the sketch. Vitrinite reflectivity measurement in a coal sample from immediately below the shown massive sandstone yielded a vitrinite reflectivity value 0.43 (SSB). The age of the sandstone sequence remains uncertain, given the lack of fossils, but might be Mid-Late Miocene or younger, given its position above the Gray Setap shale. Possibly, this sandstone sequence belonged to a feeder system of rivers carrying sand from the Belaga Mts. to the "Baram Delta" province.

Figure 7B: The sandstone is formed by well-sorted middle-fine grained quartz, and cross-bedding is observed. The sandstone sequence also contains rounded clasts of volcanic ash (based on thin sections analysis carried out in SSB) and also minor amounts of heavy minerals.

Figure 8B: The Headland II sandstone cliff (Lambir Fm., late Miocene, upper part of shown section, is formed by a massive, amalgamated and cross-bedded sandstone deposit and largely devoid of clay layers.

of sub-sea slumping, sliding, and even folding (Figure 5A). The shale contains surprisingly few fossils. Slumped deltaic sandstone blocks are found embedded in the Setap, some 15 km SW of Long Lama along the 'new' road track (Figure 5B). This might suggest that sand-dominated shelf environments were close. The Black Setap's thickness may exceed 11000' feet in areas of the Luconia platform. Sediments of similar character, but somewhat richer in distal turbidites, are seen underlying the Mid-Late Miocene deltaic sequences in Limbang.

Carbonate buildups. Three buildups are known from the studied area: Batu Niah, Gunung Mulu, Batu Kadink. These form the only hard rock in the foreland basin, and overly "Rajang" sediments in Batu Kadink and Gunung Mulu. The latter two are located close to the boundary fault between Ol-Neogene foreland and the "Crocker-Rajang" mountain belt. The Miocene section of the studied Batu Kadink reef is formed by Bryozoa framestone and nummulite packstone (Ngau, 1989; see sketch on Fig. 3B, and outcrop shown in Figure 4a).

Gray Setap shale (Luconia Block and Baram Delta Block). Similar to the above described Black Setap, but younger (quoted Mid-Miocene, often marly, and rich in micro-fossils and trace fossils, Sibuti member). A particularly trace-fossil rich section along the 'old' Miri Bintulu road between the Petronas petrol station and the road junction to Beluru/Long Lama. Surprisingly, such fossiliferous layers are very limited in vertical range, suggesting a rapid, but short-lived change from hostile to benign benthonic conditions. Figure 6A shows such an interval. It contains grey-coloured and red-coloured beds rich in bivalve clasts. Occasionally, small Ostreid patch reefs occur, seen as slump blocks on Pantai Bungai. Intercalations of turbidite siltstone and sandstone deposits are common. Figure 6B shows a lenticular channel-cut in the Gray Setap near Kampong Beluru. Massive channel fill sandstone, and its related thin-bedded levee associations are exposed near Kampong Lipu, and the Empresa Palm Plantation road on the Miri-Long Lama road a few kilometers ahead of Lapok. Again, along the same road, fluvial-shallow marine sandstones are seen outcropping in the centre of synclines. Near Kampong Lipu, these fine-medium grained and cross-bedded sandstones incise older coal beds and the Setap shale (Figure 7A). The

Figure 8A: Panoramic view over the Lambir Fm. outcrops along the Pantai Beraya to Pantai Bungai beach section. The strike of the formation is at low angle to the coastline.

and only minor inverse faulting/thrusting is seen.

Further inland, dips of the synclines are much steeper, in the order of 45 deg, and reverse faults are common. The contact between the synclines is by reverse faulting/overthrusting, and anticlines are largely missing.

Mud volcanoes. These intriguing, and poorly understood features seem to have formed along the "Baram Line." This zone, roughly two kilometers wide coincides with the fertile valley along the Sibuti River near Bekenu.

Conclusion. Neogene tectonics shaping the Sarawak foreland offer different styles of compression. The significant variety of normal faults, anticlines and synclines as observed in the "Baram Delta" is obviously lacking in Luconia. There remains ambiguity about the age of faulting, and a minor strike-slip overprint on normal faults is conceivable in the vicinity of the "Baram Line". The latter, obviously an old lineament of complex tectonic history, has acted as a divide for both sedimentary and tectonic realms, but the amount of lateral and vertical offset requires further study.

DISCUSSION

During my fieldwork I came across a number of unresolved problems. For the benefit of future work I would like to list and discuss these:

Age determination of rocks. These often stem from the 1950's and 1960's, and apply often only to particular facies types. Timelines for the correlation of different formations/facies (such as Nyalau Fm. versus Setap shale, and also with the Lambir Fm.) need to be improved. Moreover, a biostratigraphic review seems necessary, particularly in context of many formation names quoted in the literature. Regarding sediments of the "Rajang Group" and the "West Crocker Fm.," there is mounting evidence that these rocks are predominantly of KK- Eocene age, as quoted in a recent study (van Hattum et al., 2003). The age and facies context between the "Rajang" and "West Crocker" need to be further explored.

Timing of Palaeogene tectonism. "Rajang Group" sediments where folded during the Late Eocene/ Early Oligocene. The timing of thrusting against the molasse foreland is uncertain, but possibly of Late Miocene age. Further work is needed to confirm that.

A review of sedimentary environments. Formations such as the Setap shale are often quoted as "deep marine" sediments. This seems to be questionable.

Where does the "Rajang" stop? Does folded "Rajang" underly the Oligocene-Neogene foreland molasses basin, or is it confined to the "Rajang/Crocker mountain belt?" Seismic analysis may help here. On Sabah offshore seismic, the "Crocker" clearly stands out as a particular seismic facies on the shallow shelf, stops at a fault trend and is not seen further offshore.

Differentiating Neogene from older tectonism in the southern "Rajang" and "West Crocker" foldbelts remains a daunting task. There is a distinct possibility,

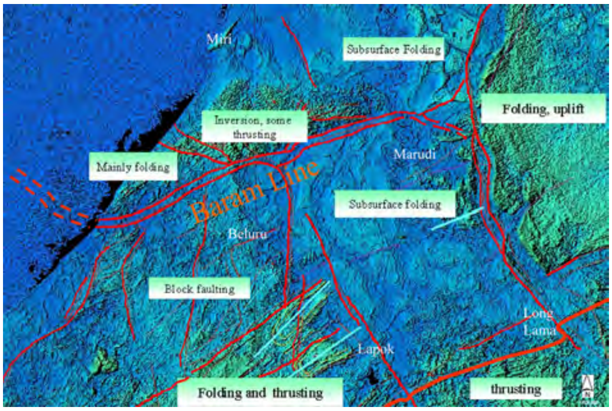


Figure 9A: The area of studies is formed by several sub-blocks of particular tectonic signature. The foreland area can be divided in three segments: "Baram Block", located North of the Baram Line; Luconia, located South and West of the Baram Line; the Belait syncline area, east of the Kalejau fault system running from Marudi to Long Lama.

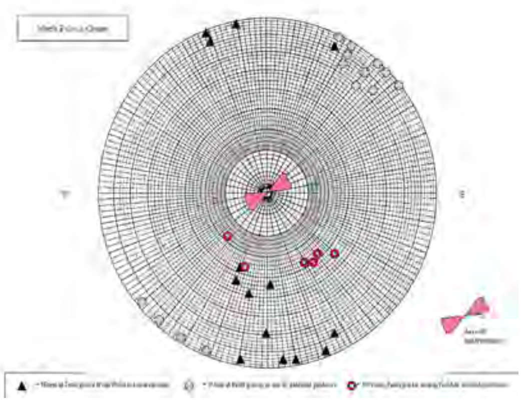


Figure 9B: Polar projection of faults, fold poles and their relation to axis of anti- and synclines.

that the KK-Palaeogene rocks ("West Crocker," outside of the area of studies, and "Rajang") are actually organized in nappes, partially super-imposing or overlapping each other. More work, however, is needed to either confirm or reject this hypothesis.

The author wishes to thank Prof. C. Hutchison, Mr. R. Tate, Prof. Eswaran Padmanabhan, Kim-Kiat Liauw, Maarten Wiemer, Raymond Franssen and colleagues from PETRONAS for stimulating discussions.

The opinions, views and conclusions expressed in this paper are the author's and do not necessarily reflect the view of his employing company.

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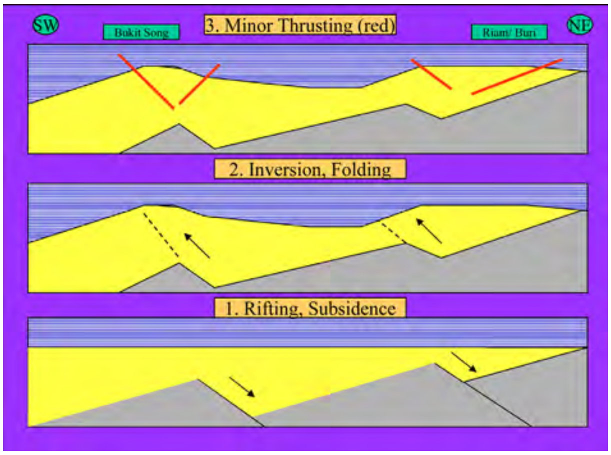

Figure10A: Schematic oblique cross-section through the Lambir Hills (Bukit Lambir), on an E-W line from the coast over Bukit Song toward the Buri wells. This work hypothesis relies on an extensional phase (half-grabens), inversion and folding, and, finally, some thrusting.

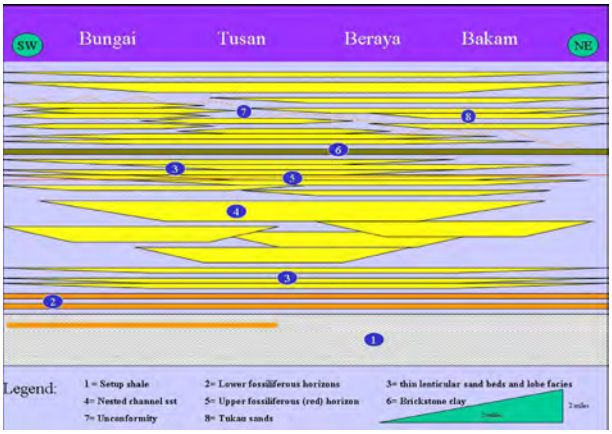

Figure 10B: Work hypothesis for sand/claystone distribution and lithofacies characteristics, coastal cliff section from Bungai to Bakam (aerial view shown in Figure 8A).

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A discussion on the paper – 'Age and MORB geochemistry of the Sabah ophiolite basement by Graves *et al*. (2000)'

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INTRODUCTION

This note discusses the geological results in Graves *et al*. (2000). It aims to 'set the geological records straight' on the major contributions to the Sabah pre-Tertiary geology by Geological Survey Department. A concurrent paper by Hutchison *et al*. (2000) relevant to this note is also referred.

BACKGROUND

The word *'spurious'* has been used by University of Malaya Emeritus Professor Dr C.S. Hutchison in Hutchison (1988, 1989) for the Jurassic radiometric age data of the acid igneous rocks (tonalites) of the Crystalline Basement in Upper Segama area, Sabah, published in Kirk (1964a,b;1968) and Leong (1971, 1974), without the presentation of any new and independent radiometric age data. Both Kirk (1968) and Leong (1974) are for-sale publications of the Ministry of Natural Resources and Environment Minerals and Geoscience Department, formerly known as the Geological Survey Department.

The word *'spurious'*, synonymous with *fraudulent, fake, phony, forged, bogus* or in colloquial language, *cooked-up*, undoubtedly comes under the law of defamation, libel and slander. Omang and Barber (1996) have aped the word *'spurious'* against Leong (1974) without new radiometric age data, and assigned a Miocene age to the acid igneous rocks in Upper Segama area, again without new evidence (Leong 1998).

Leong (1998), not referred in Graves *et al*. (2000) and Hutchison *et al*. (2000) but discussed in Milsom *et al*. (2001), has challenged the validity of the *'spurious'* word used against the Sabah Geological Survey Jurassic radiometric age data and Leong (1974) in Hutchison (1988, 1989), and the validity of Hutchison (1989) conclusion on the *'extremely low potassium values'* as the basis for the *'genetic relationship'* of the acid igneous rocks to the ophiolites. The appropriateness of the term '*ophiolite basement*' used in Hutchison *et al*. (2000), also in Graves et al (2000), has been questioned and discussed in Milsom *et al*. (2001).

KEY GEOLOGICAL RESULTS IN GRAVES *ET AL*. (2000)

Leong (1974) has been vindicated by ARCO International Oil and Gas Co of USA investigation work, research and analysis, the results given in Graves *et al*. (2000):

1) *The oldest K:Ar radiometric age determined from a granitoid in the nearby Kawag Gibong river, is 210 Ma ±3 Ma (Early Jurassic) (Leong, 1974). We have added some additional dating to this province, which supports a Jurassic age.*
2) *The acidic rocks (from Leong, 1974) belong to the calc alkaline series…and could not have been derived from the ophiolites.*

Thus, the following conclusions in Hutchison (1989) have been invalidated:

1) *The metagabbro K:Ar radiometric dates as old as 210 Ma (Early Jurassic) have to be spurious for the gabbro and metagabbro conformably (or structurally) underlie the Chert-Spilite Formation as integral layers of the same patchily metamorphosed ophiolite.* (Hutchison had regarded the acid igneous rocks as gabbro and metagabbro)
2) Apart from the samples in Litog Klikok Kiri area (high potassium content which supports the hypothesis of a continental lithosphere), *"their extremely low potassium values show that they are genetically related to the ophiolites"*.

Unlike Graves *et al*. (2000), the above major geological conclusions in Hutchison (1989) have not been based on field investigation work in Upper Segama area, thus, no samples had been collected for independent geo-chronological work, additional radiometric age determination, and chemical analysis. Not only had actual results of geo-chronological work in Kirk (1968) and Leong (1974) been dismissed as *'spurious'* , but also results of chemical analysis of several acid igneous rocks available in Leong (1974) ignored (Leong 1998). The non-acceptance or rejection of any pre-Cretaceous age in Sabah geology could have been a continuation of a similar thesis in Hutchison (1968), but reviewed and questioned in Dietrich (1968). Thus, the major geological conclusions on Sabah pre-Tertiary geology in Hutchison (1968, 1988, 1989) have not been based on new and independent geo-chronological and chemical analysis, let alone any geological field investigation work in Upper Segama area. Graves *et al*. (2000) have concluded based on the brief duration geological investigation field work limited to only the Litog Klikok Kiri area, as follows: *'only limited exposures of calc-alkaline granite are known in the Klikog Kiri vicinity of Ulu Segama'*. Ulu Segama or Upper Segama is a vast area and granites and other acid igneous rocks occur west of Litog Klikog Kiri area (Leong 1974).

EXAMPLES OF NON-DISCLOSURE AND NON-ACKNOWLEDGEMENT OF GEOLOGICAL RECORDS

The above stated Hutchison (1989) invalidated conclusions and Hutchison (1988, 1989) dismissal of Sabah Geological Survey Jurassic radiometric age data, including Leong (1974), as *'spurious'* and *'have to be spurious'* seem to have been made frivolously. These considered major conclusions on Sabah pre-Tertiary geology in Hutchison (1989) have not been disclosed in Graves *et al*. (2000) and Hutchison *et al*. (2000). Thus, the defamatory word *'spurious'* remains uncorrected.

The records in Kirk (1968) and Leong (1974) on Sabah Crystalline Basement acid igneous rocks Jurassic radiometric ages as old as 210 Ma, and their distinct and older relationship to the ophiolites are 'foundation building blocks' for any hypothesis on the evolution of the pre-Tertiary of Sabah. Graves *et al*. (2000) have acknowledged Kirk (1968) and Leong (1974). These records in Kirk (1968) and Leong (1974) have not been disclosed in Hutchison *et al*. (2000). In Hutchison *et al*. (2000), Kirk (1968) and Leong (1974) are cited, but not in reference to the Jurassic K:Ar age data.

The reference to a Jurassic radiometric age in Hutchison *et al*. (2000) is in the following statement: "*Early Jurassic K:Ar ages have been determined for these granites (Graves et al., in press)*", giving the impression Jurassic K:Ar age data had not existed prior to ARCO's determinations. A reference to Kirk (1968) and Leong (1974) Jurassic K:Ar ages would expose Hutchison (1988, 1989) rejection of Sabah Geological Survey published Jurassic K:Ar ages, but acceptance of the same determined by ARCO in Hutchison *et al*. (2000). A reference to Kirk (1968) and Leong (1974) Jurassic K:Ar ages would also have been a professional admission that Hutchison (1988, 1989) had made a grave mistake in rejecting the Jurassic K:Ar ages and Leong (1974) as *'spurious'*.

Another example of non-acknowledgement and non-disclosure is evident as per the statement in Graves *et al*. (2000): *'However, Hutchison (1978) has shown that even the most metamorphosed rocks contain igneous relicts'*. Only Hutchison (1978) publication is cited, giving the impression (misleading) that Hutchison (1978) has been the first and only geological record available on recognition of igneous relicts in metamorphic rocks in east Sabah. Not acknowledged and disclosed is the recognition of igneous relicts in metamorphic rocks in Leong (1974, pp 48, 56, 226) and invalidation of the metamorphic granulite facies published in Dhonau and Hutchison (1966) and Hutchison and Dhonau (1969). The metamorphic granulite facies has been based on relict igneous hypersthene mineral in Hutchison and Dhonau (1969) and Dhonau and Hutchison (1966).

ON REVISED AGE OF SABAH RADIOLARIAN CHERT

The Sabah Geological Survey, when it embarked on the modern technique for radiolarian chert re-determination in mid-70s, had been fully prepared for any possible change and revision. Some 25 years after change and revision had been recognized (Leong, 1975), Hutchison and Bergman, Graves and Swauger delivered the following message in Graves *et al*. (2000): *'the palaeontological determinations in the older literature , based improperly on thin section identifications, may be confidently discounted'*.

In the 50s, 60s and early 70s, thin section identifications of radiolarian chert samples were carried out by the British Museum of Natural History, London for Sabah Geological Survey. The thin section identifications had yielded Cretaceous and Late Cretaceous ages. In the mid 70s, the Sabah Geological Survey initiated age re-determination of radiolarian chert samples and sought help from then world foremost radiolarian expert Dr R. Riedel of USA, who extracted whole well preserved radiolarian from the Sabah chert samples and determined an Early Cretaceous age for a sample. The Early Cretaceous age determination result by Dr Riedel was shared with the geological community (Leong, 1975, 1977). More Lower Cretaceous radiolarian chert samples from various areas of Sabah have been determined from 1985 (Basir Jasin *et al*., 1985; Basir Jasin, 2000).

Dr Riedel generously and without hesitation agreed to assist the Sabah Geological Survey based on a request in a letter from the writer, (though both Dr Riedel and the writer had never met previously), resulting in a breakthrough contribution to Sabah geology.

SUMMARY AND CONCLUDING REMARK

The contributions of the Sabah Geological Survey in the 60s and 70s published in Kirk (1968) and Leong (1974, 1975) include the Jurassic K:Ar radiometric age data as old as 210 Ma (close to Triassic-Jurassic boundary), the Sabah Crystalline Basement granites and other acid igneous rocks as distinct and older than the ophiolites, the chemical analysis results of the Sabah Crystalline Basement acid igneous rocks of medium to high potassium values, the recognition of igneous relict minerals in metamorphic rocks and the subsequent invalidation of metamorphic granulite facies, the age revision of the radiolarian chert to Early Cretaceous, and the palaeontology and micropalaeontology of the pre-Tertiary Madai-Baturong Limestone and Chert-Spilite Formation (an update is given in Leong, 1999).

The case of the K:Ar dated oldest acid igneous rocks in Sabah has come full circle. These published accounts are relevant: Kirk (1964a, b; 1968), 150 Ma, concept of Crystalline Basement; Hutchison (1968), ophiolites and Cretaceous oldest in Sabah; Dietrich (1968), validity of Hutchison (1968) questioned; Leong (1971,1974), 210 Ma; Hutchison (1988), '*Leong (1974) spurious*'; Hutchison (1989), *'the dates as old as 210 Ma have to be spurious'*; Omang and Barber (1996), '*Leong (1974) spurious*'; Leong (1998), validity of word *'spurious'* challenged; Hutchison *et al*. (2000), Jurassic K:Ar dates determined by ARCO, but Jurassic dates in Kirk (1968) and Leong (1974) not disclosed; Graves *et al*. (2000), *'We* (ARCO) *have added some additional dating… which supports a Jurassic age'.* Thus, the literature on pre-Tertiary geology of Sabah based on rejection of Jurassic radiometric dates can be considered not valid.

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PROGRAM

Sunday 1st March 2009

4:00 – 6:00pm	**Registration** (sponsored by Mitsubishi Corp.) Foyer outside Conference Hall 1

DAY-1: Monday 2 March 2009

9:00 – 10:30 am	**Opening Ceremony** (sponsored by PGS) Banquet Hall, 3rd Floor (see previous page)	
10:30 – 11:00 am	**Coffee Break** (sponsored by CGG-Veritas) Exhibition Hall Foyer **Onsite Registration Begins**	
	GEOPHYSICS Rooms 304-305 **Session 1** Theme: Rock Physics & Seismic Attributes	**GEOLOGY** Plenary Theater **Session 1** Theme: The Malay Basin Fields
11:00 – 11:20am	Geophysics Paper 1 Rock Physics Analysis for Quantitative Interpretation in Malay Basin **Nurhakimah Mohamud and Yeshpal Singh (PCSB)**	Geology Paper 1 North Malay Basin 3D Mega Merge Project **LAI Kar Wei, Theresia Heru, Kuswardhany (PMU) and LIM Peng Kuan (PGS)**
11:25 – 11:45 am	Geophysics Paper 2 Rock Physics Modeling Application for Seismic-Well Tie Improvement in Angsi Field, Malay Basin **Yusliza M Sufian and Yeshpal Singh (PCSB)**	Geology Paper 2 PM323 East Belumut Field: Developing an Oil Transition Zone Overlain by a Large Gas Cap **Mark Lambert, Rob Barraclough, and Chandra Velu (Newfield)**
11:50 – 12:10 pm	Geophysics Paper 3 Qualitative Use of Post Stack Seismic Attributes for the New Play Exploration, in Malaysia **Norhafizah Mohamad (PMU) and Hamdan Mohamad (PCSB)**	Geology Paper 3 Structure Framework of Tenggol Arch, Offshore Peninsular Malaysia: A Revisit **Suhaileen Shahar (PCSB)**
12:15 – 12:35 pm	Geophysics Paper 4 Interpretation of Amplitudes for Hydrocarbon Prediction in Malay and Adjacent Basins and Related Pitfalls **Deva P Ghosh (PRSB) and Martin S Brewer (PCSB)**	Geology Paper 4 Reservoir Characterization Towards Optimizing the Group K Reservoir Development in T Field, Malay Basin **Mohd Shahir Mohd Adnan, Eric Tioe, Mohd Rohani Elias, Hock-Kuang Lim and Yue Choong Lye (ExxonMobil)**
1:00 – 2:00 pm	**LUNCH** (sponsored by ExxonMobil) Ballrooms 1 and 2 (3rd floor)	

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

2:05-2:30 pm	**KEYNOTE PAPER 2: Plenary Theater** Adapt or Go Extinct - The Rapid Evolving E & P Landscape **Dr. Lawrence Bernstein, Lawrence Bernstein, VP of Exploration and New Ventures Talisman Malaysia Limited**	
	GEOPHYSICS Rooms 304-305 **Session 2** Theme: Seismic for Opportunity Generation and Reservoir Monitoring	**GEOLOGY** Plenary Theater **Session 2** Theme: Fractured Basement Reservoirs
2:35 – 2:55 pm	Geophysics Paper 5 Optimizing the Application of Time-Lapse Seismic in the L Field **Yue Choong Lye, David H Johnston, Michael B Helgerud, Lee Wamsteeker, Yap Siew Chee and Nor Ainulhuda Nor Rahmat (ExxonMobil)**	Geology Paper 5 – Abstract on Page 85 Fractured Basement Formation Evaluation using Borehole Data **Adriaan Bal, Ali Baradi, Fermin Fernandez-Ibanez, Javier Franquet, Stephen Dymmock, and Robert Maddock (Baker Atlas)**
3:00 – 3:20 pm	Geophysics Paper 6 L Field: Unraveling a Complex Oil and Gas field with Integrated Reservoir Characterization and Time Lapse Seismic **Yap Siew Chee, Nor Ainulhuda Nor Rahmat, Nasarene Majeth, Yue Choong Lye and Lee Wamsteeker (ExxonMobil)**	Geology Paper 6 Hydrocarbon Potential of Strike-Slip Fault Related Fractured Basement Reservoirs, Offshore Malay and Cuu Long Basins **Wan M Sharif, Mohamed Taha, Fazili Ilias, Sudirman Dawing and Mohd Talmizi Sanek (PCSB)**
3:25 – 3:45 pm	Geophysics Paper 7 – Abstract on Page 47 Reservoir Monitoring, 4D signal, and Fiber-Optic Technology **Steve Maas, Rune Tenghamn, Brett Bunn, Natasha Hendrick, and Mazin Farouki (PGS)**	Geology Paper 7 Fractured Granite/Metasediment Oservations at Redang Island and Surrounding Areas : an Analogue for Exploring HC in Factured Basement over Malay Basin **Mohamad Kadir and Hamdan B. Mohamad (PCSB)**
3:50 – 4:10 pm	**TEA BREAK** (sponsored by Nippon Oil) Exhibition Hall Foyer	
	GEOPHYSICS Rooms 304-305 **Session 3** Theme: Seismic Processing Enhancement	**GEOLOGY** Plenary Theater **Session 3** Theme: Carbonate Reservoirs
4:15 – 4:35 pm	Geophysics Paper 8 Standardization and Improvement Requirements in Seismic Processing **Mehmet Ferruh Akalin (PCSB)**	Geology Paper 8 Controls on the Development, Distribution and Characteristics of Late Eocene to Late Miocene Carbonates in the Sarawak Basin – A Regional Synthesis **Mohammad Yamin Ali (PRSB), Prof Howard D. Johnson and Dr Cedric M. John (Imperial College)**

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

4:40 – 5:00 pm	Geophysics Paper 9 – Abstract on Page 51 Beam Depth Migration for Imaging of Complex Geology **Karl Schleicher, John Sherwood (AGS), Lynn Comeaux and Mazin Farouki (speaker) (PGS)**	Geology Paper 9 Permeability Estimation in Vuggy Carbonates **Kumar, M., Altunbay, M. (Baker-Atlas), and Arina W. (PCSB)**
5:05 – 5:25 pm		Geology Paper 10 Depositional Facies of Two Adjacent Carbonate Buildups, Central Luconia Province, Offshore Sarawak **Asiah Mohd Salih (PRSB)**
5:45 – 7:00 pm	**Special Keynote Address and Forum: Plenary Theater** The Geologist Act (2008) of Malaysia **Seet Chin Peng (Malaysian Institute of Geologists)** **Session Chairman and Moderator: Chris Howells (Talisman)** Jointly organized by PGCE, IGM and KL Explorationists	
7:15-9:30 pm	**ICEBREAKER (sponsored by Newfield) Exhibition Hall Foyer**	

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

DAY-2: Tuesday 3rd March 2009

Session IV	GEOPHYSICS Rooms 304-305 Session 4 Theme: Electromegnatics & Resistivity	GEOLOGY Plenary Theater Session 4 Theme: Geosciences in Development & Production
8:30 – 8:50 am	Geophysics Paper 10 Marine Electromagnetic Exploration : Problems and Prospects with Emphasis on Malaysian Basins **Max A. Meju, M. Faizal Abd. Rahim, Awg Amirul Zakry Awg Bujang, Deva Ghosh (PRSB), Sandeep Kumar (PCSB) and Robert Wong Hin Fatt (PMU)**	Geology Paper 11 Fault Seal Analysis to Predict Risk and Column Height Distribution in Stacked Reservoir Sands **John P Brown and Suriani Mustahim (PCSB)**
8:55 – 9:15 am	Geophysics Paper 11 – Abstract on Page 55 Mitigation of Drilling Risk using Controlled Source Electromagnetic Surveys: CSEM Workflow and Case Study **Lars Lorenz (Reliance), A. Muralikrishna, Anil Kumar Tyagi, Rabi Bastia (EMGS), and Hans E. F. Amundsen (EPX AS)**	Geology Paper 12 Migration Models, So Many to Choose! A Comparative Study of Ogaden Basin, Ethiopia **Puteri Maizura Razali and Peter Abolins (PCSB)**
9:20 – 9:40 am	Geophysics Paper 12 – Abstract on Page 59 Marine Magnetotelluric (Mmt) Mapping of Basement and Salt Bodies in the Santos Basin, Brazil **Sergio L. Fontes, V.R. Pinto, E.F. La Terra (Observatorio National, Rio), P. de Lugao (StratalImage), Max A. Meju (PRSB), E.U. Ulugergerli (Canakkale Onsekiz Mart University) and L.A. Gallardo (CICESE)**	Geology Paper 13 The Remaining Prospectivity of Oligocene Sequence of Blocks 01 & 02, Cuu Long Basin, Vietnam- From Sequence Stratigraphy Perspective **Irdawati Lokman (PC Vietnam) , Othman Ali Mahmud (PCSB), Tran Xuan Thang, Herculito Balasbas Caalim (PC Vietnam) and Shamsudin Jirim (PRSB)**
9:45 – 10:05 am	Geophysics Paper 13 – Abstract on Page 60 Near Surface Resistivity Responses to Lithostratigraphy and Fluid Contents **Zuhar Tuan Harith, Ani Aiza Ashaari (UTP) and Rosli Saad (USM)**	Geology Paper 14 – Abstract on Page 86 Building more Predictive Geological Models **Carl Hedvall and Mark Sams (Fugro-Jason)**
10:10 – 10:30 am	Geophysics Paper 14 – Abstract on Page 63 The Effect Of Resistivity Anisotropy On Earth Impulse Responses **Bruce Hobbs, Folke Engelmark and Dieter Werthmüller (PGS)**	Geology Paper 15 – Abstract on Page 89 The Monte Carlo Myth, or Why a Reservoir isn't a Roulette Wheel **Stephen Tyson (UNSW, Paradigm)**
10:30 – 11:00 am	**COFFEE BREAK** (sponsored by the UZMA Group) Exhibition Hall Foyer	

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

11:00 – 11:25 am	**Keynote Paper 3: Plenary Theater** Keys to Success in Unconventional Shale Gas Resource Plays **William Schneider, Senior Vice President International, Newfield Exploration**	
	GEOPHYSICS Rooms 304-305 **Session 5** **Theme: Case Studies**	**GEOLOGY Plenary Theater** **Session 5** **Theme: Unconventional Resources and CO_2**
11:30 – 11:50 am	Geophysics Paper 15 Fluvial Depositional Systems in the Malay Basin: Reconstructing Pliocene-Quaternary Rivers on the Sunda Shelf Using 3D Seismic Data **Faisal A. Alqahtani, Chris A-L. Jackson, Howard D. Johnson (Imperial College) and M. Rapi B. Som (PRSB)**	Geology Paper 16 – Abstract on Page 93 Unconventional Gas Resources – Do Paradigms Need to Change? **Doug Kenaley (ExxonMobil)**
11:55 – 12:15 pm	Geophysics Paper 16 Regional Correlation in Balingian Province Using 3D Mega Merged Data **Ahmad Fahrul Januri, Azani Manaf, Harminzar Mansor, Arthur Van Vliet and Robert Wong (PMU)**	Geology Paper 17 – Abstract on Page 94 Coalbed Methane (CBM) Prospect in Jamalganj Coal Field, Bangladesh **Md. Habibur Rahman (University of Dhaka, Bangladesh)**
12:20 – 12:40 pm	Geophysics Paper 17 Geopressure Estimation – an Integrated Approach **Sanjeev Bordoloi (PCSB)**	Geology Paper 18 Selecting Aquifer for CO_2 Sequestration – a Case Study in Tangga Barat Cluster **Naqzatul Shima Hashim, Ahmad Syrhan Musa, Abdoerrias, David Martyn Ince, Keith Theseira, A Razak Yakob (PCSB) and Dewanto Surja (RML)**
12:45 – 1:05 pm	Geophysics Paper 18 – Abstract on Page 67 Offshore Geohazards Investigation - Can We Do Without? **Ouzani Bachir (Orogenic**	Geology Paper 19 – Abstract on Page 95 Relationship between Gas (CO_2) Traps and Structural Styles in the Al Jamouse Area, Melut Basin, Sudan **Huzaifa A. Baseeiry and Shahrul Amar Abdullah (Petrodar)**
1:10 – 2:00 pm	**Lunch (sponsored by Shell)** **Ballrooms 1 and 2 (3rd floor)**	

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

	GEOPHYSICS Rooms 304-305 Session 6 Theme: Seismic Studies	GEOLOGY Plenary Theater Session 6 Theme: Sabah-Sarawak Basins
2:05 – 2:25 pm	Geophysics Paper 19 – Abstract on Page 70 Genetic Inversion: an Innovative Combination of Neural Nets and Genetic Algorithm for Seismic Inversion **Jumain Marzuki, Jimmy Klinger, Ivan Priezzhev, Trond H. Bo and Gaston Bejarano (Schlumberger)**	Geology Paper 20 Basin Evolution, Stratigraphy and Petroleum System of the NE Sabah Basin: Based on Integrated Onshore and Offshore Studies **Allagu Balaguru (PCSB)**
2:30 – 2:50 pm	Geophysics Paper 20 – Abstract on Page 71 Coaxing Subtleties from Seismic by Means of an Intelligent Integrated Approach – a Case Study **Ahmad Bukhari Ibrahim, John Ross Gaither, Irmawaty Abdullah (CPOC), Vincent W.T.Kong (speaker), Alexis Carrillat, Nina M. Hernandez, Md Ramziemran Abdul Rahman (Schlumberger)**	Geology Paper 21 Structural Styles associated with Shale Remobilization in Block H, Offshore NW Sabah **Yin-Hoe Chan (speaker) and Michael R. Lennane (Murphy)**
2:55 – 3:15 pm	Geophysics Paper 21 Time Variant Q-filtering and Seismic-Well Tie in Tanjung-Pulai Field, Malay Basin, Malaysia **Yeshpal Singh (PCSB)**	Geology Paper 22 NW Sabah Deepwater Delta Tectonics: A Genetic Link Between Contrasting Deepwater Structural Domains **James Clark (Murphy)**
3:20 – 3:40pm	Geophysics Paper 22 – Abstract on Page 76 Rapid Multiple-Scenario Depth Structure Risk Analysis Case Study in Cuulong Basin, Vietnam. **Hong Shien Lee (speaker) and Nguyen Xuan Nam (Landmark)**	Geology Paper 23 The Middle Miocene Unconformity (MMU): Neither Middle Miocene nor Unconformity? **Krebs, W. N. (PCSB) and Van Vliet, A. (PMU)**
3:45 -- 4:05	Geophysics Paper 23 – Abstract on Page 81 Geomechanical Modelling, Seismic Pore Pressure Prediction and Wellbore Stability Analysis: Key Elements Demonstrated by an Offshore Exploration Case Study **Adrian White, Sunil Nath, Katharine Burgdorff (GMI) and Norbert van de Coevering (CGG Veritas)**	Geology Paper 24 The Middle Miocene Unconformity (MMU) and Globigerinid Sands in Deepwater Sarawak **Kevin Robinson, Paul Baltensperger, Andrew Thomas (Newfield) and Steve Noon (Corelab)**
4:10 – 5:10 pm	**Closing Ceremony** Plenary Theater	
5:10 -- 5:30 pm	**TEA BREAK** (sponsored by Talisman) Exhibition Hall Foyer	

PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convention Center, 2 – 3 March 2009

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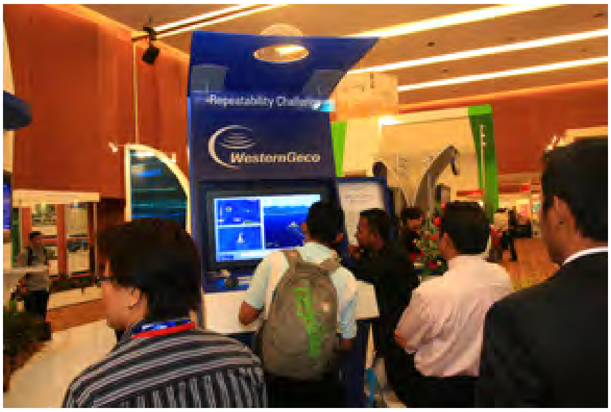

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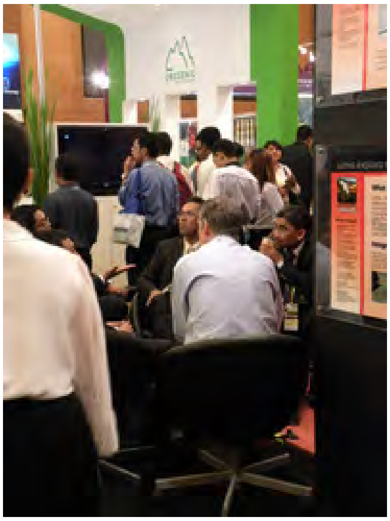

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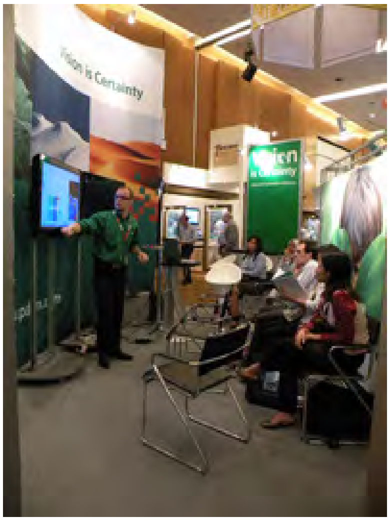
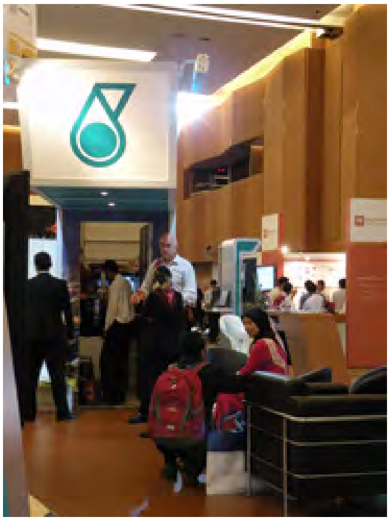
Kuala Lumpur Convention Center, 2 – 3 March 2009





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PETROLEUM GEOLOGY CONFERENCE & EXHIBITION 2009

Kuala Lumpur Convension Center, 2 – 3 March 2009

CERAMAH TEKNIK TECHNICAL TALK

DETAILED TECTONIC HISTORIES FROM FOSSILS: THE ISLE OF WIGHT, UK

PROF. ANDREW SCOTT GALE

2nd January 2009
Department of Geology, University of Malaya

On 2nd January, Professor Andrew Gale gave the first Technical Talk for the year 2009 at the Department of Geology, University of Malaya. His talk on the detailed tectonic histories of the Isle of Wight, UK based on evidences from fossils was attended by a small group of about 15 academic staff and students from the University of Malaya.

Characteristics of earthquake belts and examples of tectonic activity in the greater Sundaland Area counting from the Tertiary

FRANZ L. KESSLER

8th January 2009
Department of Geology, University of Malaya

Dr. Franz L. Kessler works as a senior production geologist for Shell Tech India, particularly for reserves booking in Brunei, Oman, Pakistan. His talk entitled "characteristics of earthquake belts and examples of tectonic activity in the greater Sundaland Area counting from the Tertiary" was well attended by the academic staff and students of the Department of Geology, University of Malaya. The abstract of the talk is given below:

Abstract: Many papers published in the past have inferred a highly complex history of the area defined as Sundaland - an area that encompasses most of Malaysia, as well as large parts of Indonesia, the Philippines as well as large portions of the South China Sea. All studied data (these being: earthquake activity, volcanicity, Bouguer Gravity, geological fieldwork) suggest a rather simple picture - a large subcontinent, attached to Vietnam/Southern China, formed by thick continental crust, and surrounded by a crescent of active subduction zones that date back at least to the Cretaceous in a strip North of Java Island. Depth of quake foci vary from 5 to 900 km depth. The eastern margin of Sundaland looks highly complex, with several stacked sheets of oceanic crust being present. Since the Early Tertiary, Sundaland has seen several phases of limited extension and re-compression, the most prominent among these being of Intra-Eocene and Late-Miocene ages.

MALAM JURUTERA 2009

18 FEBRUARY 2009, DEPARTMENT OF GEOLOGY, UNIVERSITY OF MALAYA

REPORT

"Malam Jurutera 2008" featured 2 speakers, namely Sdr. John Kuna Raj from University of Malaya and Sdr. Ng Chak Ngoon from Subsufface Engineering. Sdr. John spoke on preventing slope failure related disasters in the granitic bedrock areas of Peninsular Malaysia. Sdr. Ng discussed geology behind the landslides.

As usual, the talks were followed by various questions and discussions from the floor.

Tan Boon Kong,
Chairman, Working Group on Engineering Geology, Hydrogeology and Environmental Geology.

CHAIRMAN'S LECTURE No. 14

ENGINEERING GEOLOGY OF ROCK SLOPES – SOME RECENT CASE STUDIES

SDR. TAN BOON KONG

22 January 2009, Department of Geology, University of Malaya

Mr. Tan Boon Kong, Chairman of the Working Group on Engineering Geology, Hydrogeology and Environmental Geology delivered the 14th Chairman's Lecture entitled "Engineering Geology of Rock Slopes – Some Recent Case Studies". The lecture was chaired by Prof. Teh Guan Hoe and was well attended by geologists from the academics, public and corporate sectors.

KEAHLIAN MEMBERSHIP

Ahli Penuh / Full Member

1. Christopher Gareth Howells
2. Lim Kok Keong
3. Alain Morash
4. Cheikh Ahmed Ould Ahmed Benan
5. Patrick Ravaut
6. Baudot Gautier
7. Serena Jean-Michel
8. John Mccallum
9. Nasrul Hisham Bakar
10. Chee Ka Hoe
11. Richard Anthony Jones
12. Agus Norman Abdul Rahman
13. Peter Brian Woodroof
14. Tan Boon Hu
15. Nor Dalila Desa
16. Liong Chun Chieh
17. Devendran Arumugam
18. Remi Bosc
19. Ramany A/L Maniam
20. Dibie Anak Mama
21. Nurul Ashikin Anor binti Omar
22. Manan bin Che Jid

Ahli Bersekutu / Associate Member

1. Sreejit Raghu, No. K/P: 770705-08-7339
2. Azhana Osman, No. K/P: 820329-01-6272

Ahli Penuntut / Student Member

1. Nur Farhana binti Salleh, UM
2. Nur Anizawati binti Zulkifly, UM
3. Fadhilah binti Abtholuddin, UM
4. Nur Hidayah Arshad, UM
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22. Nurul Nabihah Hussin, UM
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26. Nurul Shamira Mohd Rosdey, UM
27. Nurul Huda Basiron, UM
28. Mohd Adib Kamaruddin, UM
29. Farith Farhan Mohd Pajri, UM
30. Lee Khye Keat, UM
31. Madeehah Rasid, UM
32. Asnidar Zina'ali, UM
33. Syafrina Mohd Yusop, UM
34. Noradiba Prayitno, UM
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36. Muhammad Zulfadli Tenang Zambri, UM
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40. Banuprevathy Panjateharam, UM
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53. Siti Humaira Mohammad, UM
54. Mohd Yazid Zulkeply, UM
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67. Muhammad Lokman Dato' Mohamed Amin, UM
68. Suhaila Suleiman, UM
69. Abdulmumini Nura Yelwa, UM
70. Yeow Boon Sim, UM
71. Fatimah Az Zahra' Abdul Hamid, UM
72. Ahmad Faiz Salmanfarsi, UM

Ahli Institusi / Institutional member

1. Curtin University of Technology, Miri, Sarawak

PERTUKARAN ALAMAT CHANGE OF ADDRESS

1. Chai Ted Sing, 354, Taman Phoenix, Lorong 3d, Jalan Batu Kawa, 93250 Kuching, Sarawak
2. Anil Nair, No. 6, Jalan Sungai Beranang, 32/58A, Bukit Rimau, 40460 Shah Alam
3. Sreejit Raghu, 23, Lintasan Perajurit 2, Taman Perak, 31400 Ipoh
4. Lim Wei Gian, 92, Jalan SS23/21, Taman Sea, 47400 Petaling Jaya
5. Franz L. Kessler, Jalan Lautan 1 Oceanpark, Lot 4810, 98000 Miri

ADDRESS WANTED

1. Boniface Bait
2. Mirza Arshad Beg

UPCOMING EVENTS

June 15-19, 2009: Petroleum Project Management: Principles and Practices. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

June 29-July 3, 2009: Operations Geology, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 13-17, 2009: Development Geology, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 13-17, 2009: 18th IMACS World Congress MODSIM 09, Cairns, Australia: Session G3: Modelling and Simulation of Dangerous Phenomena, and Innovative Techniques for Hazard Evaluation. Contact: G. Iovine, Tel: +39 0984 835 521; Fax: +39 0984 835 319; email: g.iovine@irpi.cnr.it . Website: www.mssanz.org.au/modsim09/

July 20-24, 2009: Introduction to Seismic Stratigraphy: A Basin Scale Regional Exploration Workshop, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Basic Petroleum Engineering Practices, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Advanced Seismic Stratigraphy: A Sequence-Wavelet Analysis Exploration-Exploitation Workshop, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

July 27-31, 2009: Basic Reservoir Engineering, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

August 3-7, 2009: Seismic Imaging of Subsurface Geology, London, UK. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

August 3-7, 2009: Well Log Interpretation, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

August 3-14, 2009: Applied Reservoir Engineering, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

August 10-14, 2009: Shaly Sand Petrophysics, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

August 11-15, 2009: AOGS 6th Annual General Meeting, Singapore. Session IWG01: Modelling and simulation of dangerous phenomena and innovative techniques for hazard evaluation, mapping, mitigation. Contact: G. Iovine, Tel: +39 0984 835 521; Fax: +39 0984 835 319; email: g.iovine@irpi.cnr.it . Website: www.asiaoceania.org/aogs2009

August 17-21, 2009: Sandstone Reservoirs. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

September 5, 2009: Curtin Sarawak: 1st Symposium on Geology 2009. Contact: Secretariat, 1st Symposia on Geology 2009, Department of Science and Mathematics, School of Engineering & Science, Curtin University of Technology, Sarawak Campus, CDT 250, 98009 Miri, Sarawak, Malaysia. Tel: +60 85 443826; Fax: +60 85 443837; email: sg12009@curtin.edu.my. Website: www.curtin.edu.my/SG12009/index.html

September 7-12, 2009: Sustainable development and management of groundwater resources of hard rock terrains – Joint IAH/IAHS International Convention combing 37th IAH Congress and 8th IAHS Scientific Assembly, Hyderabad, India. Contact: email: iahs@ensmp.fr or w.struckmeier@hgr.de

September 9-11, 2009: VII Forum GEOITALIA 2009, Rimini, Italia. Session B4: Innovative approaches for landslide hazard evaluation and risk mitigation. Session B7: Landslide forecasting. Contact: G. Iovine, Tel: +39 0984 835 521; Fax: +39 0984 835 319; email: g.iovine@irpi.cnr.it .

September 14-18, 2009: Carbonate Reservoirs. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

September 28 –October 2, 2009: Introduction to Offshore Oil and Gas Systems. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

September 28-October 2, 2009: Petroleum Geochemistry: Tools for Effective Exploration and Development. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

October 5-9, 2009: Turbidite Sandstones, London, UK. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

October 5-9, 2009: Structural and Stratigraphic Interpretation of Dipmeters and Borehole-Imaging Logs, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

October 14-16, 2009: Deepwater Southeast Asia Congress 2009, Parkroyal, Kuala Lumpur, Malaysia. Contact: Neoventure, Suite 1802, Block F, Shanghai Everbright Convention & Exhibition Centre, 86 Caobao Road, PR China 200235. Tel: 86 21 5108 6710; Fax: 86 21 5108 6712; email: marketing@neoventurecorp.com

October 19-23, 2009: Seismic Interpretation, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel:

+1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

October 19-23, 2009: Coring and Core Analysis, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

November 2-4, 2009: Capillarity in Rocks, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

November 9-13, 2009: Basic Petroleum Geology. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

November 9-13, 2009: Wireline Formation Testing and Interpretation, Kuala Lumpur, Malaysia. Contact: Petroskills, P.O. Box 35448, Tulsa, Ok 74153-0448. Tel: +1 918 828 2500; Fax: 918 828 2580; email: training@petroskills.com/ap-enquiries@petroskills.com

November 14-17, 2009: SAGE2009 Conference – "Southeast Asian Gateway Evolution", Royal Holloway University of London. The Second Circular is available at http://sage2009/rhul.ac.uk/SAGE2009_2nd_Circular.pdf.

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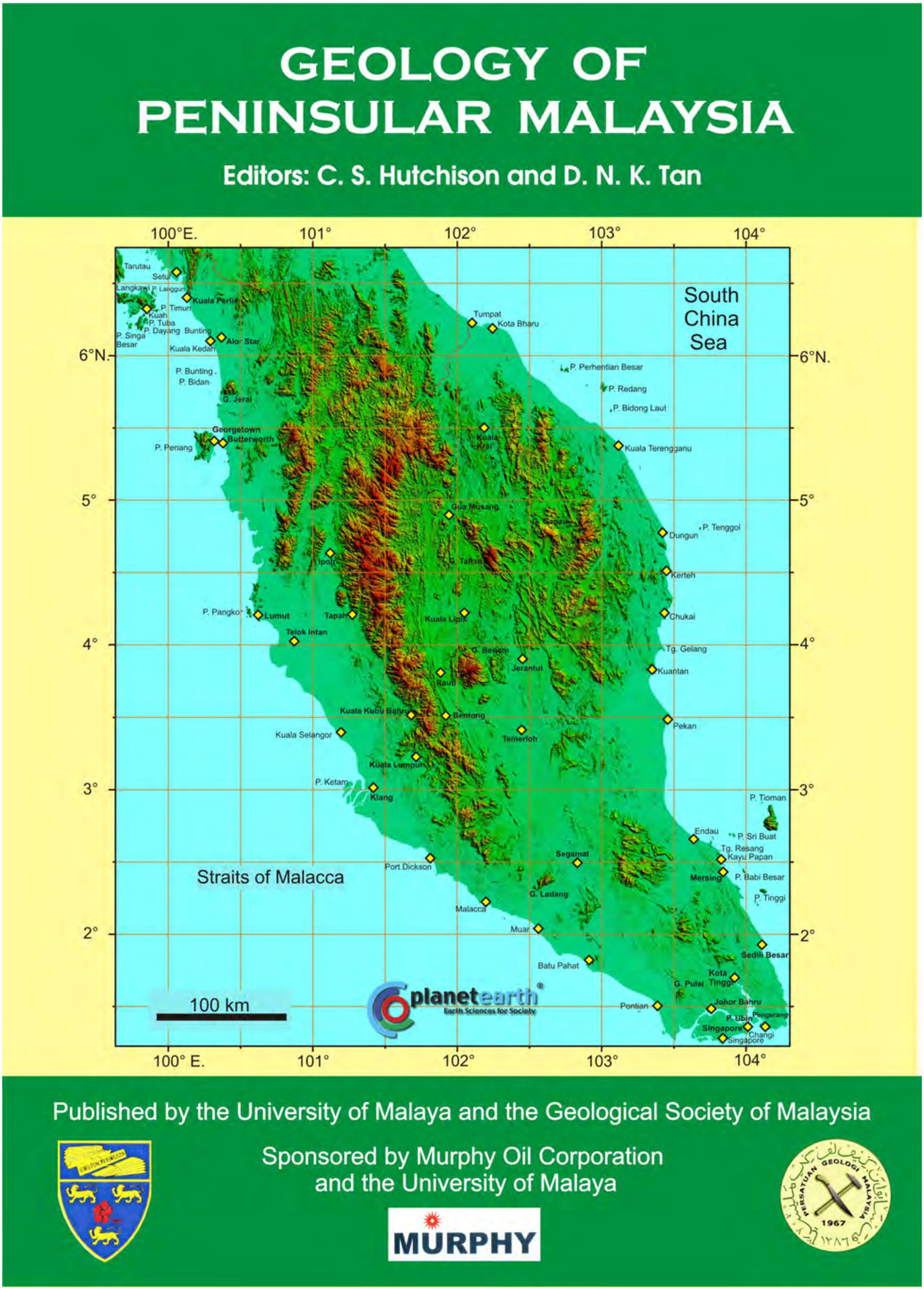
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