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CENOZOIC STRATIGRAPHY OF PENINSULAR MALAYSIA

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INTRODUCTION

The Cenozoic underlies slightly more than 20 percent of the land area of Peninsular Malaysia of which the majority of the sediments are Quaternary age (Figure 1). The Cenozoic in Peninsular Malaysia has been relatively stable tectonically with activity confined to epeirogenic uplift and tilting, some fault movements and localised gentle downwarps.

The known Cenozoic deposits vary in thickness but an average thickness of 10,000 m has been noted for sediments in the Malay Basin (DuBois, 1980). The offshore deposits are also included for discussion and correlation in view of their economic importance. Figure 2 gives the Cenozoic correlation chart for Peninsular Malaysia.

The Tertiary rocks are distributed either as isolated lacustrine basins between the Main Range and the west coast or underlie the Quaternary deposits in the lowlying coastal and offshore areas. Localised granitic and basaltic rocks of Tertiary age have also been mapped. The Quaternary deposits however consist mainly of unconsolidated to semi-consolidated gravel, sand, clay and silt occupy the coastal terrains and floors of some of the inland valleys. Besides these sediments there are basaltic lava flows, ash deposits, laterite and bauxite of Quaternary age.

TERTIARY

Radiometric dating by the Rb/Sr technique indicates that the granitic rocks in the Mt. Ophir area, Malacca and the Gunung Pulai area, Johore are the oldest known Tertiary rocks in the peninsula. According to Hutchison (1973) the Bukit Senggeh granite, and the Batang Melaka granite, in Malacca, have ages ranging from Lower Cretaceous to Early Tertiary. Besides the granitic rocks, the Segamat basalts of Johore have been dated by K/Ar method to be of Lower Tertiary (62 m.y.) age (Bignell, 1972).

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* Since this paper was written, some new information which has a bearing on some aspects of this papre has become available. These new data will be incorporated in the oral presentation at the Workshop and in the Workshop report.

FIGURE I. DISTRIBUTION OF THE CENOZOIC IN PENINSULAR MALAYSIA (modified from Stauffer, 1973)

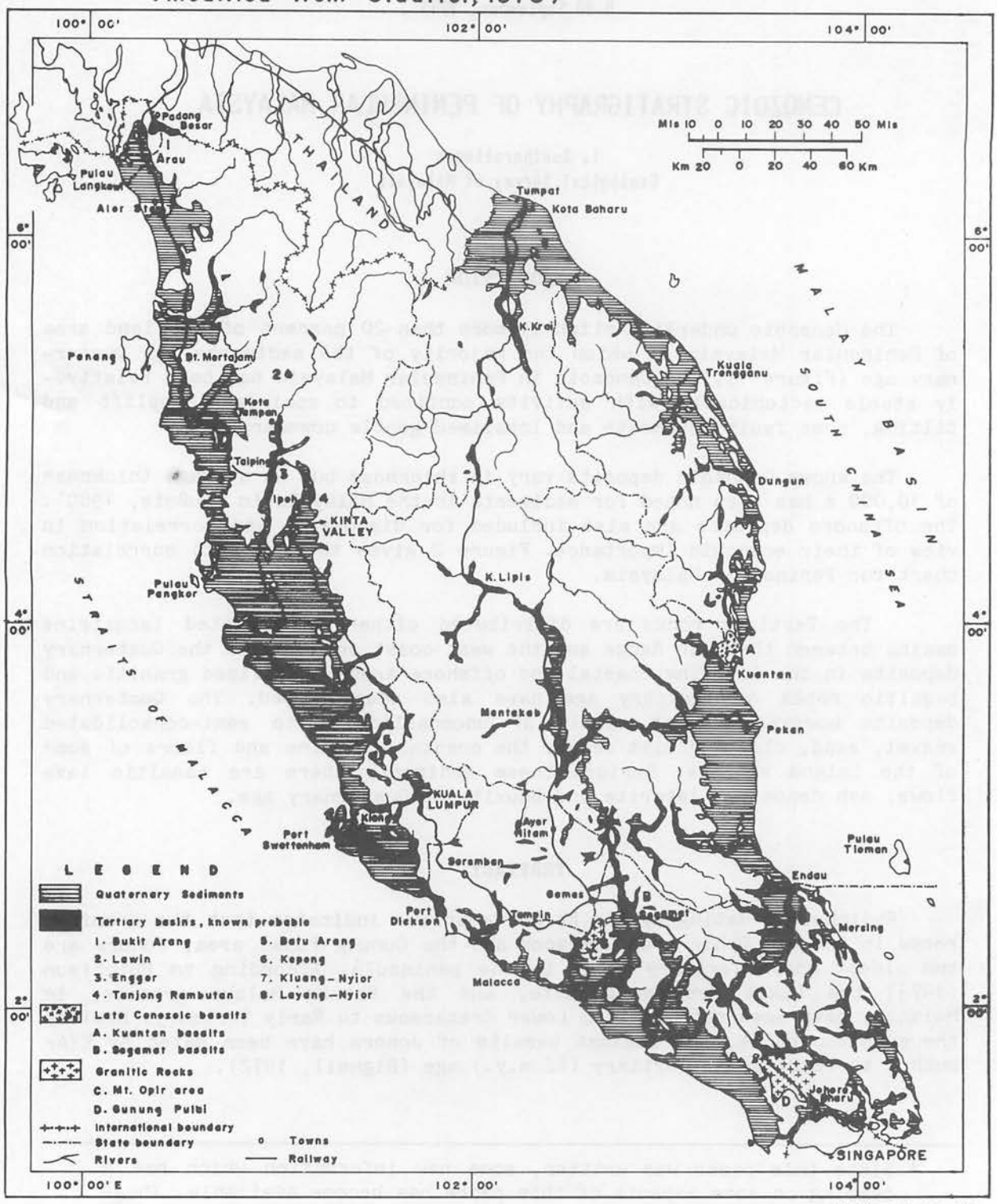
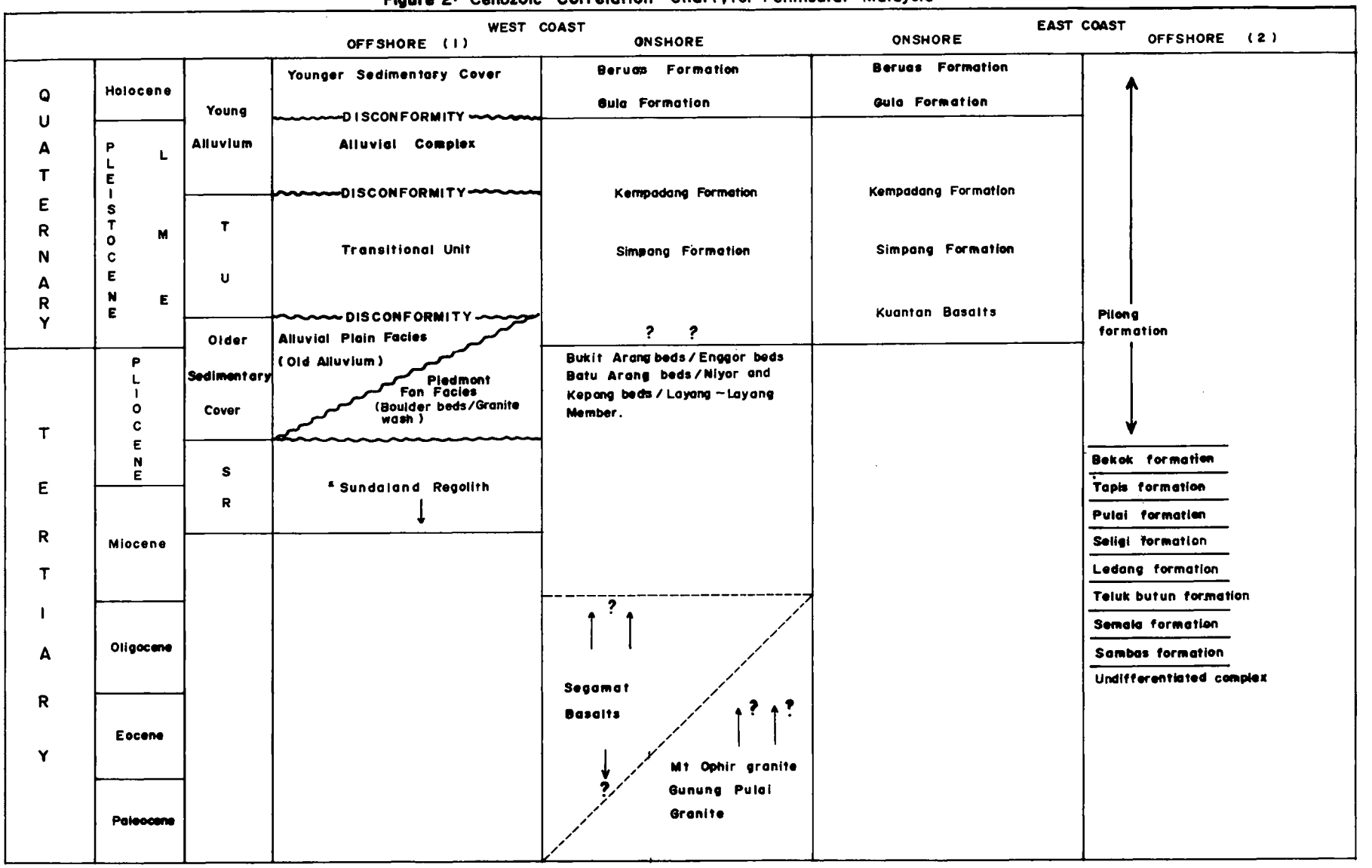


Figure 2: Cenozoic Correlation Chart, for Peninsular Malaysia



Source (1) Batchelor, B.C. (1979) (2) After Armitage and Viotti, 1977 — South Malay Basin.

However, the oldest known Tertiary (Oligocene) sedimentary deposits in Peninsular Malaysia are found off the east coast of the peninsula in the Malay Basin.

Onshore areas

Renwick and Rishworth (1966) reported that the Tertiary rocks distributed as isolated lacustrine basins occur at Bukit Arang-Betong, Enggor, Batu Arang, Kepong and the Kluang-Nyior areas (Figure 1). According to Stauffer 1973) these basins appear to be the southward extension of the series of Tertiary basins in peninsular Thailand. The general characteristics of these deposits have been summarised by Stauffer (1973) as follows:

(a) The sediments are of partly consolidated gravel and sand; soft shales, often carbonaceous; seams of low-grade coal (lignite); and rare calcareous shale and limestone.

(b) The thickness varies and generally are more than 100 m. The maximum thickness reported is for Batu Arang where it is 470 m.

(c) The sediments are mainly, and probably entirely, continental, lacustrine, paludal and fluvial nature.

(d) They are generally almost flat-lying, but dips of 30 - 40 occur and asynclinal or basin structures have been demonstrated for some of the Tertiary areas.

(e) All lie unconformably on much older, Paleozoic to early Mesozoic rocks which are generally folded and invariably metamorphosed.

The sediments overlying the bedrock in the low-lying and coastal areas have been reported to be Late Tertiary to Holocene in age. A Pliocene to Early Pleistocene age has been suggested by Burton (1965), Sivam (1969) and Batchelor (1979) for the Older Alluvium. Mohamad (1970) reports that the presence of the pollen *Podocarpus imbricatus* gives a late Plicocene and younger age for the sediments at Sungei Besi, Selangor. Yeap (1980) states that the fluviatile, poorly stanniferous gravelly clayey sand and sand with sandstone pebbles occurring in the Kuala Langat area Selangor could be Miocene to Pleistocene in age. Senathi Rajah (1970) also states that on paleobotanical grounds the Badak shale member of the Layang Layang formation, which consists of soft shale, sandy clay, clay loam and grey clay, is probably Pliocene to Pleistocene age. It can be concluded therefore that the Tertiary sediments underlying the Quaternary deposits are not localised but are extensive and cannot be differentiated from the Quaternary deposits.

Offshore areas

Limited information is available on the Tertiary sediments off the west coast of Peninsular Malaysia. The Tertiary sediments are mainly gravels or pebbles in sand and sandy clay and appear similar to those of

the onshore areas (Batchelor, 1979). Seismic studies carried out in the offshore areas indicate a strong reflector surface at depths of 70 to 100 m. This surface probably indicates the Tertiary/Quaternary boundary (J. Ringis, personal communication).

However, in the offshore areas along the east coast of the peninsula the Tertiary has been studied in some detail by various oil companies. The Malay Basin (Figure 1) contains as much as 10,000 m of sedimentary rocks which are dominantly non-marine clastics but with marine influences increasing to the southeast (Du Bois, 1980). The oldest generally known sediments are the non-marine sandstones and shales of questionable Oligocene age.

Du Bois (1980) states that stratigraphically the Malay Basin resembles those of the Thai Basin. To the northwest, the three-cycle system of correlation of the Thai Basin has been extended into the adjacent parts of the Malay Basin (Du Bois, 1980). Du Bois who quotes Woolands and Haw (1976) gave the following succession for the northwest Malay Basin.

Cycle I — The oldest known sediments consist of undated red beds with fluvial channel sandstones of possible Oligocene age.

Cycle II — Early to Middle Miocene age. Begins with a thin sequence of brown shale and sandstone of fluviomarine environment, followed by a thick series of interbedded dark grey to black shale, sandstone and abundant coal, representing coastal-swamp, deltaic and tidal environments. This is in turn followed by coarser sands, moderately to well sorted, with interbedded shales and frequent coal beds. The environment is a delta plain with distributary channels and marsh deposits. Cycle II terminates above with a coarse porous sandstone containing thin limestone beds.

Cycle III — The basal beds (late Miocene) of the overlying transgressive Cycle III consist of a coarse lag deposit of poorly sorted pebbles sandstone with abundant rounded shale pebbles, followed by littoral sandstones with interbedded limestones containing benthonic foraminifera. No marked structural discontinuity has been recognised at the contact of Cycles II and III. The basal beds (of Cycle III) are followed by interbedded sandstone and siltstone, and clay with interbedded lignite. Environment of deposition is coastal mangrove swamp alternating with shallow marine.

At the southern end of the Malay Basin, however, the following stratigraphy has been quoted by Du Bois (1980) from the work of Armitage and Viotti (1977):

"The oldest known non-metamorphosed sandstone, shale and siltstone

have been grouped into the Undifferentiated Complex of probable Oligocene age. The undifferentiated complex is overlain by sandstone and shales suggesting an environment which is non-marine but with some coastal influences, terminating above with clastic rocks laid down in brackish water. The age of the sediments is upper Oligocene - lower Miocene. The rocks represented are included wihtin the massive Sambas Shale Formation, and the Semala and Telukbutun Formations, each of which consists fo a lower sandstone member and an upper shale member. The Semala and Telukbutun Formations comprise the Natuna Group.

The Telukbutun formation is followed by a series of 4 formations (Ledang, Seligi, Pulai and Tapis) each of which consists of a lower sandstone member and an upper shale member. Together they comprise the Trengganu Group which is of middle to early Miocene age. The overlying Bekok formation is of claystone, siltstone and sandstone if middle Miocene. Overlying this is the Pilong formation which is early Pliocene to Holocene and consists of claystone with interbeds of lignite, sandstone and dolomite. The formation was deposited under shallow marine conditions."

QUATERNARY

Systematic mapping of the onshore Quaternary deposits has been carried out by the Geological Survey of Malaysia. The offshore sediments, however, have been investigated with technical assistance from West Germany and the Netherlands. Besides these several other offshore investigations have been carried out as well by mining and oil companies.

Onshore

Four stratigraphic units have been delineated on the bases of lighology, heavy mineral content and to a lesser extent, on paleoenvironment (Suntharalingam and Teoh,1982). They are the continental Simpang Formation (mainly fluviatile deposits of Pleistocene age and equivalent to the Older Alluvium of Walker, 1955), the Kempadang Formation (an older marine formation of Pleistocene age which was first observed south of Kuantan, Pahang and subsequently also mapped in the Lumut area of Perak). Gula Formation (a Holocene marine unit) and the continental Beruas Formation (mainly fluviatile and lacustrine deposits of Holocene age and equivalent to the Young Alluvium of Walker, 1955).

A brief description of the units is as follows:

Simpang Formation

This unit is made up of gravel, sand, clay and silt overlying the bedrock. The formation is divided into two members i.e. the Lower Sand Member which consists of sand and gravel and the Upper Clay Member which is mainly clay. The thickness varies from a few metres to more than 50 m and the bulk of placer tin of Peninsular Malaysia is derived from Lower Sand Member of this formation.

Kempadang Formation

This unit is made up of mainly marine clay with shells and sand. Cassiterite has been recorded in the sand fraction.

Gula Formation

This formation is made up of mainly grey to greenish grey marine to estuarine clay and subordinate sand. The term Matang Gelugor Member was introduced for the subordinate sand occurring as beach ridges along the coastal areas. The term Port Weld Member has been introduced for the brown grey to green clay with abundant mangrove and riverine nipah deposits. The maximum thickness recorded is 20 m.

Beruas Formation

This unit consists of fluviatile - estuarine - lacustrine deposits made up of clay, sandy clay, sandy gravel, silt and peat. The term Pengkalan Member was introduced for the inland fresh water swamp deposit which is made up of clay, peat and silt.

Besides these stratified units volcanic rocks have also been recorded in the peninsula. A compact, microcrystalline, black to greenish black vesicular olivine basalt overlies and surrounds the granitic rocks and Upper Paleozoic sediments north and northwest of Kuantan. K/Ar datings show the age to be 1.6 my. (Bignell, 1972).

Rhyolitic ash has also been recorded at several localities in Perlis, Perak, Selangor and Pahang. Fission track determination on zircon from the ash deposits at a few localities gave an age of around 30,000 years (Nishimura and Stauffer, 1981). It therefore supports the inference that the various Quaternary ash occurrences in the Malay Peninsula represent a single catastrophic eruption of the Toba volcano of Sumatra.

Offshore

The stratigraphy of the offshore deposits of the west coast of peninsula have been studied from seismic techniques and boreholes drillings by mining companies. Batchelor (1979) who has examined the data indicates the stratigraphic sequence to be as shown in Figure 2. These deposits can be correlated with the onshore deposits (Fingis and Suntharalingam, in preparation).

This is, however, little information available regarding the Quaternary studies off the west coast of peninsula because of the limited interest to oil companies. The Pilong Formation which is mainly clay extends from early Pliocene to Holocene (Du Bois, 1980). Biswas (1973) from the studies of the various punch cores off the east coast states that the Holocene sediments are invariably unconsolidated clays of a greenish or yellow green colour. Sand and gravel have also been observed in several localities (Oele and Yong, 1976). Biswas (1973) states that below the

Holocene - Pleistocene contact the clay is generally more consolidated, being either claystone or clay, decidedly less plastic than their Holocene counterparts. The Bujang No. 1, punch core in the Malay Basin indicates the Holocene to be about 2.7 m in thickness and the Besar Sea Floor Core indicates the Pleistocene to be about 114 m (Biswas, 1973).

The writer is of the opinion that the various stratigraphic units in Peninsular Malaysia extend into southern Thailand and can be correlated. The Simpang Formation is observed in the Phuket area of South Thailand where it could be divided into two members (CCOP Report).

ECONOMIC GEOLOGY

The Cenozoic mineral deposits have given and are still giving immense revenue to the Government of Malaysia. Hydrocarbons are commonly associated with middle and upper Miocene rocks. Gas in commercial amounts occur generally towards the central and northern parts of the Malay Basin whereas oil is found in the southern part of the basin. Du Bois (1980) states that gas is derived from coals and associated carbonaceous debris within the middle Miocene Bekok Formation and correlative beds of the Cycle II sequence of the Thai Basin.

Tertiary coal deposits have been mined in Peninsular Malaysia e.g. Batu Arang coalfield. Coal has, and is being mined in South Thailand but recent investigations show that these deposits are isolated and there is no likely extension of them into Perlis or Kedah (AW, 1982).

Current studies show that the bulk of the onshore and offshore placer tin are derived from the Simpang Formation. Since existing alluvial mineral deposits are being depleted more detailed investigations should be carried out to delineate this unit for the possible future source of placer tin and associated minerals.

Unlimited amounts of gravel, sand and clay are available in the Cenozoic which could be used for industrial and other purposes.

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