The Paleogene of East Borneo and its Facies Distribution

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INTRODUCTION

Paleogene age rocks are exposed over about 40% of Borneo island, mainly in the central or core part. The geologic map (Figure 1) shows that more than half of those Paleogene exposures are grouped as a melange unit and the rest are a mix of sediments and meta-sediments (Tate, 2002; Hutchison, 1989). The majority of the melange unit is exposed in Malaysian Sabah and Sarawak. The Paleogene sediments are exposed more in the Indonesian (Kalimantan) side.

Within the sedimentary basins around Borneo, the Paleogene interval lies buried deep and is poorly understood. Seismic images covering the Paleogene interval are poor and the number of Paleogene well penetrations is limited. Most well penetrations stopped within the Neogene interval only, where significant hydrocarbon accumulations have been found (Figure 1).

Several authors have provided a regional overview of the basins in East Borneo, namely: Barito, Kutei and Tarakan (e.g. Satyana et al., 1999; Darman & Sidi (eds.) 2000 and Netherwood, 2000). Recently the Paleogene in East Kalimantan became a petroleum exploration target (Saller & Vijaya, 2002; Satyana & Biantoro, 1996 and Guritno & Chambers, 1999), unfortunately no significant accumulations have yet been found.

This short article summarizes the distribution of Paleogene rocks in the east of Borneo Island based on recent exploration data. A series of proposed paleogeographic maps for the Eocene and Oligocene sections are prepared based on these recent data and understanding. These maps are aimed to facilitate discussions and set up a starting point for further work in the future.

DATA DISTRIBUTION

The Barito Basin Paleogene in the southeast of Borneo island has more wells than the Kutei and Tarakan basins in East Kalimantan. The wells are located in two main areas, around the Pertamina-operated field in the north, drilled between 1938 and mid-60's, and another cluster located in the southern part of the Barito basin, drilled between 1937 and the mid-80's (Figure 1). The wells in the south found hydrocarbon shows without economic discoveries. The seismic data available for this study is limited. The wells in Pertamina Fields area cover the Tanjung, Kambitin, Tapian Timur and Warukin Fields. Some seismic sections in this area have been published by Satyana (1995).

Unocal, Lasmo and Pertamina, respectively, operated blocks in the Kutei Basin and they shot seismic in the 90's. Some of their seismic surveys were followed by drilling into the Paleogene target intervals (Figure 1). Seismic sections of the Paleogene interval in Kutei Basin were published and incorporated into the preparation of the paleogeographic maps (e.g. Satyana & Biantoro, 1996; Saller & Vijaya, 2002). Moss and Finch (1997) have collected outcrop data from Upper Kutei area.

The Tarakan basin has the least data for the Paleogene compared with the other two basins in East Kalimantan. However, it has the latest data, from Bella-1 well, (drilled by ACG PTE Ltd in 2013), which penetrated Eocene volcanics. There are a few older wells drilled close to the basin margin, targeting the Paleogene interval and only two wells encountered the Eocene section, Bella-1 and Bunyut-1 (drilled in 1975). Seismic data for the Paleogene interval is also limited for this basin.

STRATIGRAPHY

The three sedimentary basins of East Borneo, the Barito, Kutei and Tarakan basins, contain many hydrocarbon accumulations (Figure 2), with the most in the Kutei. Virtually all those accumulations are hosted within the Neogene interval. Barito is the only basin which produces oil from the Paleogene interval (i.e.Tanjung and Kambitin fields) and one gas accumulation has been discovered in the Kutei Basin (Kerendan field). Up to now no significant hydrocarbon accumulation has been reported from the Paleogene interval in the Tarakan Basin.

Well penetrations show that Cretaceous granitic rock and melange underlie the sedimentary basins in East Borneo, as economic Basement. A regional unconformity occurs above this and the Paleocene interval is missing in all these basins. Only limited data indicates Early Eocene occurrence in the area and those wells have limited stratigraphic constraint. In general, the oldest Paleogene section deposited is Middle to Upper Eocene in age.

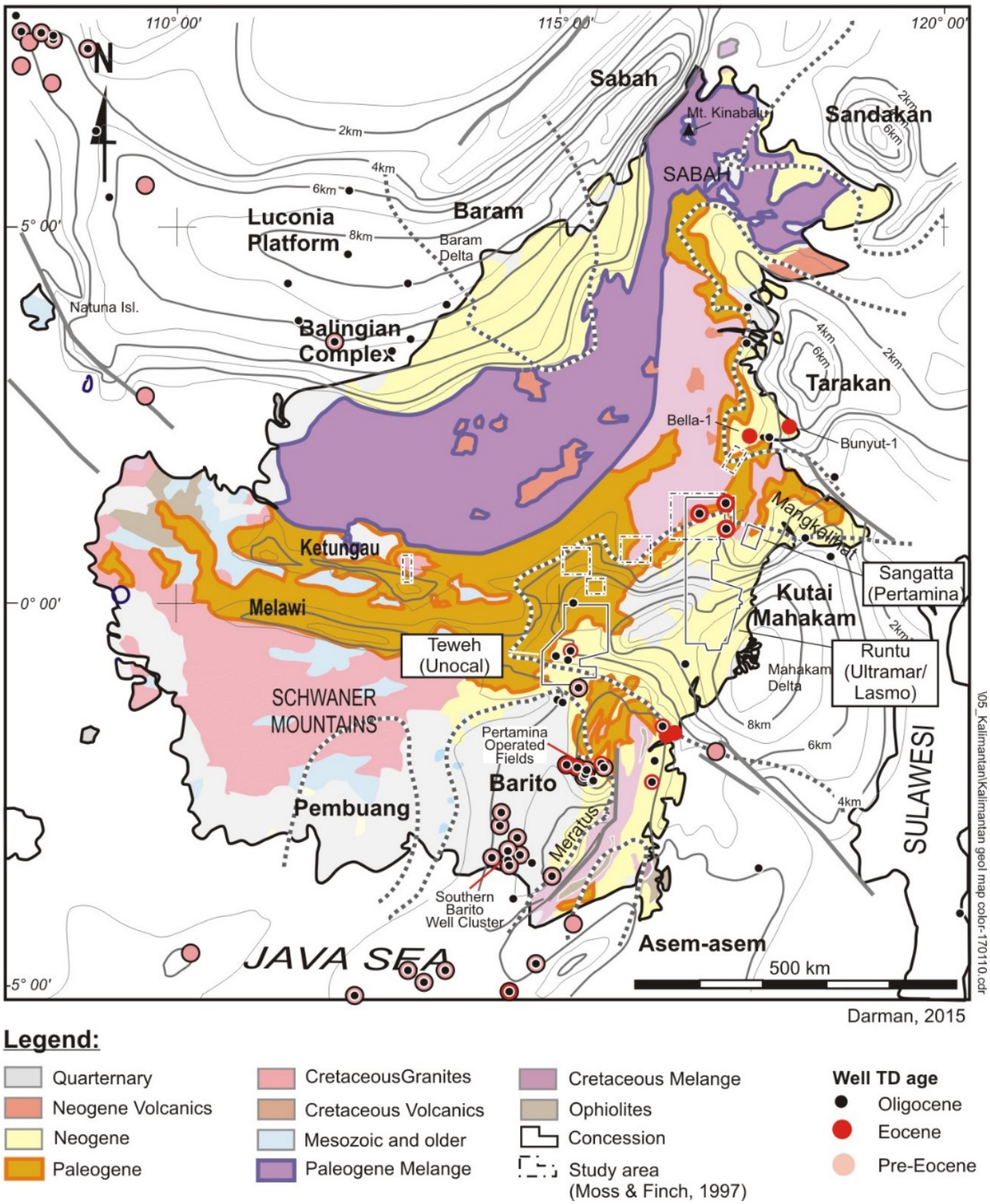
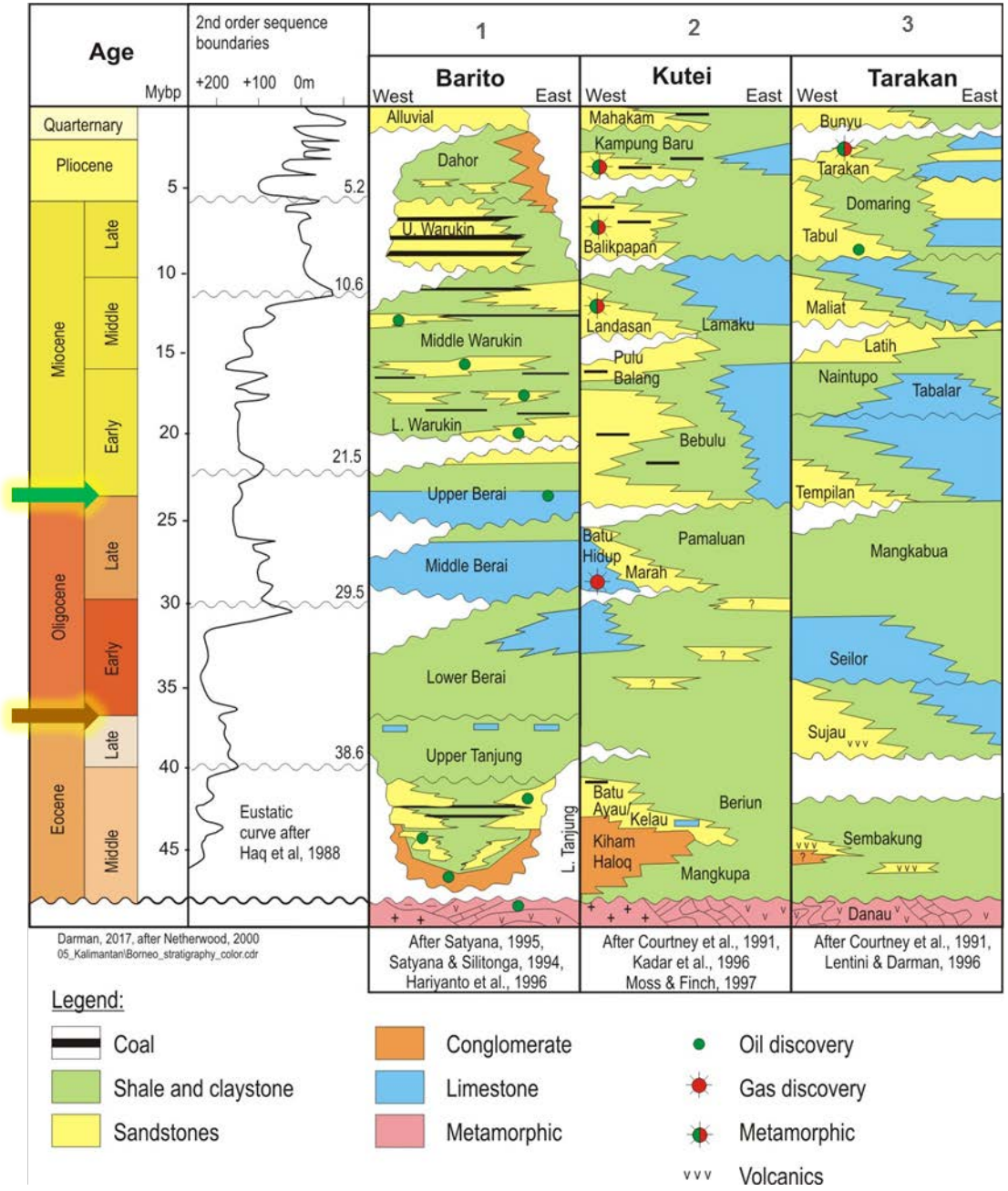


Figure 1. *Simplified geologic map of Borneo Island, showing the distribution of the Paleogene units, well control points and study areas.*



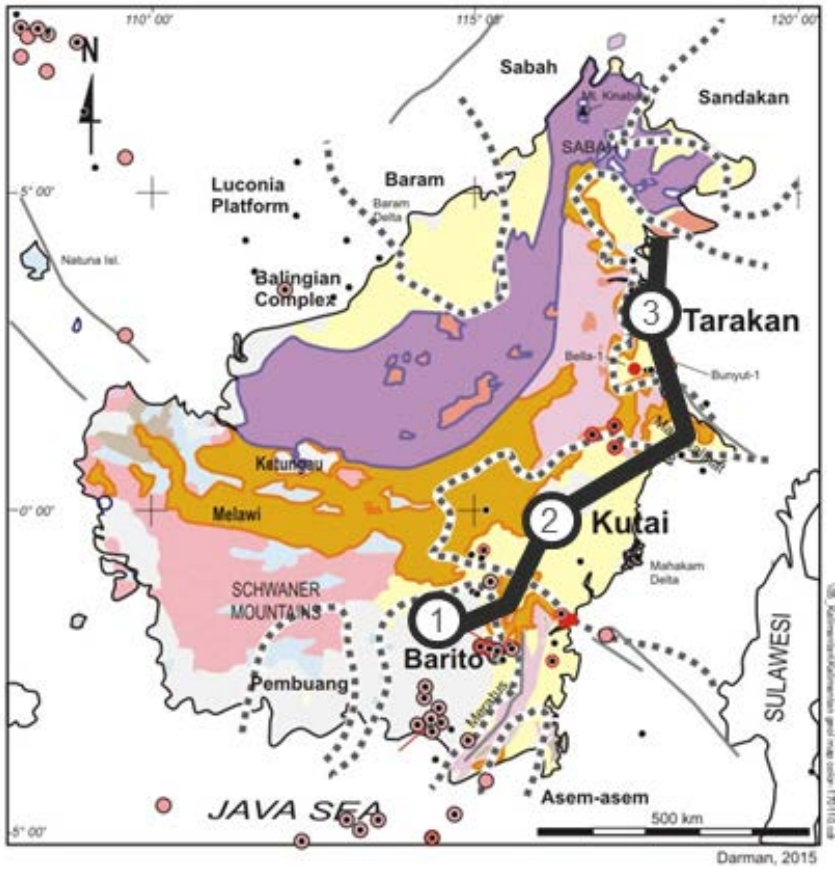


Figure 2. *Stratigraphic scheme of the East Borneo Basins, modified after Netherwood, 2000.*

Figure 3 shows a schematic cross section of the three basins in East Borneo, from the Barito Basin in the south to the Tarakan Basin in the north. The Adang Flexure separates the Barito from the Kutei Basin and the Mangkalihat Arch separates the Kutei from the Tarakan Basin.

Regional cross sections in the north of the region were derived from regional offshore seismic sections, which provide a better regional view of the area, especially in the Tarakan Basin (Figure 4, after Sunaryo et al., 1988 and Noon et al., 2003). A key well for the Eocene section, shown in both sections in figure 4, is Bunyut-1. Noon et al. (2003) interpreted a series of horsts and grabens at the base of the basin. Sunaryo et al. (1988) showed a section which correlates the Paleogene of the Kutei with that of the Tarakan Basin, across the Mangkalihat High. A few wells in the south of the Mangkalihat High penetrated Oligocene and Eocene sections (e.g. Kariorang-1, NE Kariorang-1 and Saka-1). In the Tarakan Basin, Karang Besar-1, Segiti Tiga-1 and Bunyut-1 targeted the Paleogene interval but only Bunyut-1 encountered an Eocene section.

Schematic paleogeographic maps of the Eocene and Oligocene are prepared based on subsurface data, works done by Daley (1993), Darman et al. (1996), outcrop works by Moss and Finch, 1997, and other additional in-house study reports.

Eocene

The Lower Eocene interval is covered by limited data, as many sections are missing, probably due to non-deposition and erosion, indicated by a major unconformity above Basement. The oldest paleogeographic map prepared in this study is for the Middle Eocene interval. Although the data is limited for this interval, previous studies have incorporated outcrop mapping data (e.g. Daly 1993 and Darman et al., 1996). Apart from the challenge of little subsurface data, the dating of the interval is also an issue. Most of these sections have volcanics and/or fluvial deposits, which have insufficient fauna for accurate age-dating.

The Middle Eocene, Tanjung Formation in the Barito Basin is dominated by a fluvial system, a syn-rift sequence which developed on top of the basement (Figure 5A). It is assumed that the lower braided river system is located more towards the depocentre of the basin, and later surrounded by an upper braided river system around the basin rim. The basin contains abundant coal layers, as reported by several authors e.g. Campbell et al. (1988) and Satyana (1995) indicated a swampy environment during deposition.

In Upper Kutei Basin, the Middle Eocene interval is dominated by alluvial – fluvial deposit called the Kiham Haloq Formation (Figure 2), changing to a shale dominated interval of Mangkupa and Beriun Formations to the east (Figure 2; Moss & Finch, 1997). Daly (1993) grouped the system into lower and upper braided river systems, indicating the proximal and distal parts, respectively, of the fluvial system. In the Tarakan Basin, the Middle Eocene section is dominated by volcanic clastic / tuffaceous units (Darman et al., 1996) with constrained stratigraphic control.

The Upper Eocene paleogeographic map (Figure 5B) shows the Barito and Kutei basins were covered by more marine deposits during this time. In the Barito Basin, a coastal to marginal marine environment covered the northern part and gradually changed to a shallow shelf environment southwards. In general, the Kutei Basin was open to the southeast but the shallow shelf is separated by a ridge (interpreted by Wain and Berod, 1989) based on gravity data. This ridge was probably covered by coastal to marginal marine environments. Since most of the data are available from the basin rim, the facies distribution at the centre of the basin is interpreted. During the Upper Eocene, the Tarakan Basin opened eastward, with proximal deposits in the west and bathyal units in the east.

Oligocene

Figure 6 shows a schematic facies distribution during Upper and Lower Oligocene times. During the Lower Oligocene, the Barito Basin had coastal to marine deposits, but the regional facies distribution is poorly understood due to lack of data control (Figure 6A). A clastic system covered the northern part and a carbonate shelf occurred in the south. The Upper Kutei was dominated by shallow shelf—changing to a bathyal system eastward, thus indicating an eastwards-opening basin. The Tarakan basin was covered by a coastal, stable carbonate shelf environment. The carbonate-dominated Selor Formation was distributed widely, bounded by coastal to marginal marine facies belts in the west.

In general there are limited data on the Barito Basin available to construct an Upper Oligocene paleogeographic map (Figure 6B). The northern part was covered by the Upper and Middle Berai carbonate formation with its edge at the NW-SE oriented Paternoster fault zone. The shallow shelf facies belt in the Kutei Basin is much narrower, possibly due to a relative sea level rise as suggested by Haq et al. (1988, Figure 2). Several reef build ups were identified on seismic and they are located in the outer shelf (Figure 6B). Saller and Vijaya (2002) reported the Kerendan Reef of Middle Oligocene age, based on their seismic studies. Maau-1 well in the north Runtu Block encountered a limestone interval (Guritno and Chambers, 1999). The basement ridge which separated the Upper and Lower Kutei Basin (Wain and Berod, 1989) is indicated on this map as a shallow shelf ridge with some carbonate buildups and volcanic deposits.

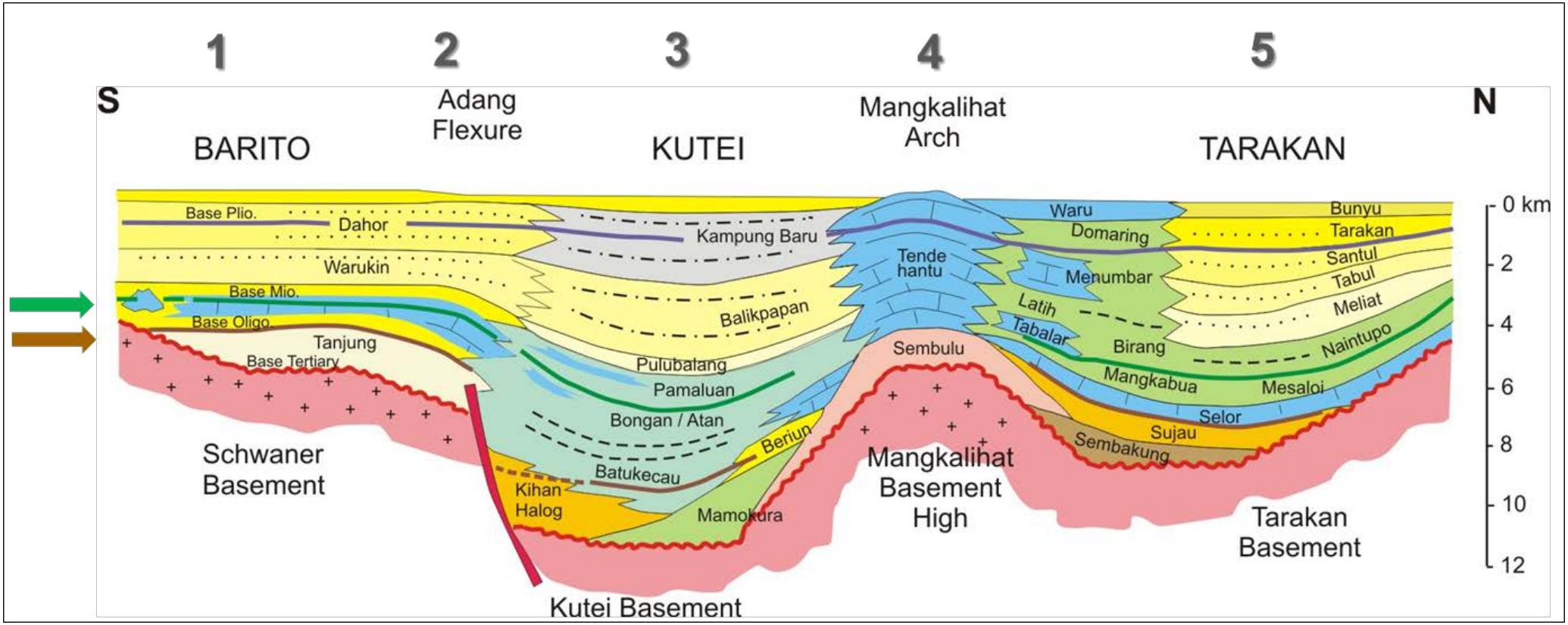


Figure 3. *Schematic geological cross section of the Barito, Kutei and Tarakan Basin, modified after Satyana et al. (1999). Green arrow and horizon indicates the top of Oligocene interval and brown arrow and horizon indicate the top of Eocene interval.*

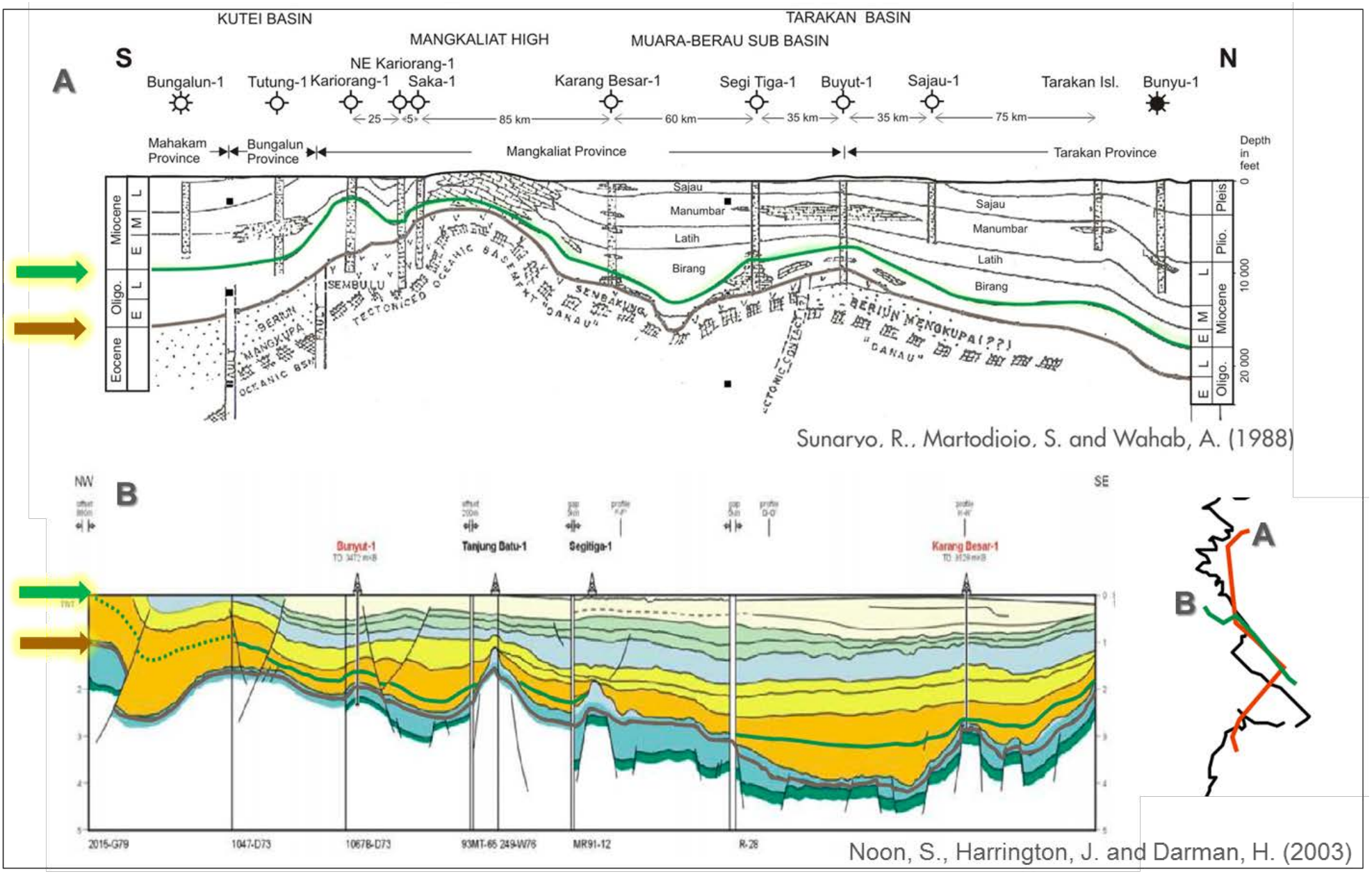


Figure 4. *A) A section across the northern part of Kutei Basin to the Tarakan Basin across Mangkalihat High. B) A geological section of the southern part of Tarakan Basin (Berau and Muara sub-basin). Green arrow and horizon indicates the top of Oligocene interval and brown arrow and horizon indicate the top of Eocene interval.*

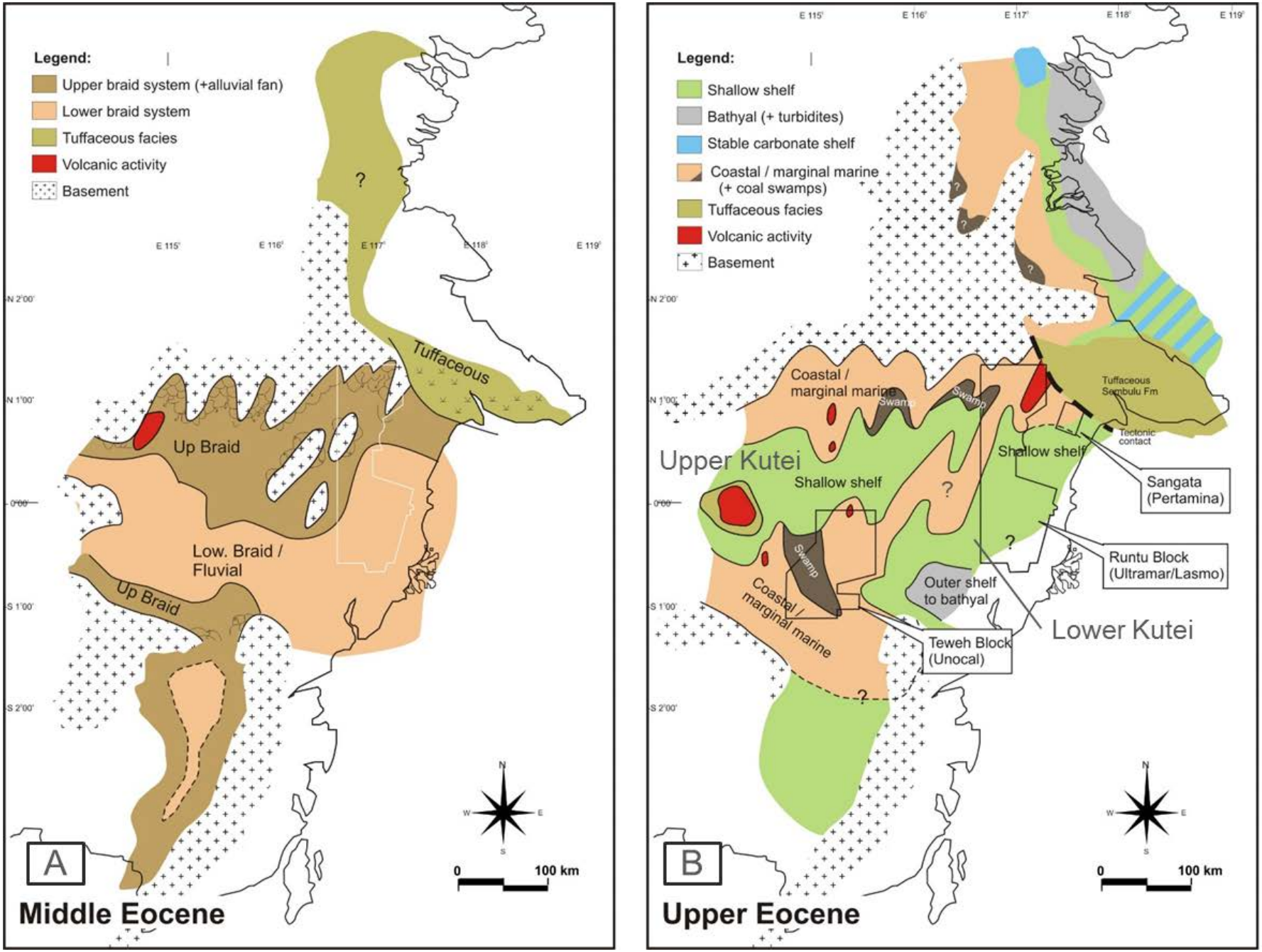


Figure 5.

A) Middle Eocene paleogeographic map shows fluvial system dominated the eastern part of Borneo Island.

B) Paleogeographic map shows the facies distribution in East Borneo Basins during the Upper Eocene.

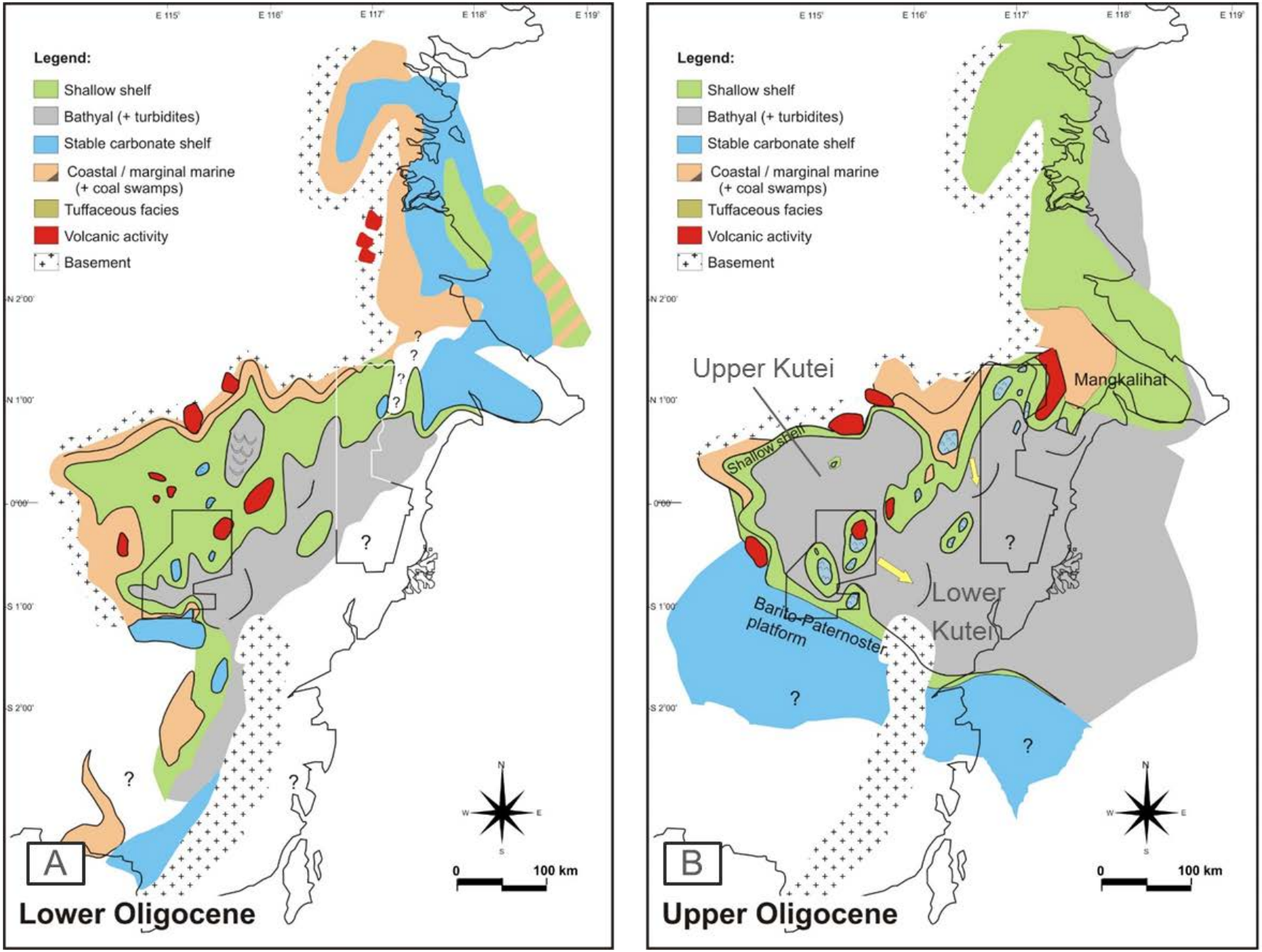


Figure 6.

A) Lower Oligocene paleogeographic map.

B) Upper Oligocene paleogeographic map.

In the north of the study area, the majority of the Tarakan Basin was covered by shallow shelf deposits. This facies change to bathyal to the east, as the basin was opening eastward (Figure 6B).

CONCLUSION

The three basins in East Kalimantan, called the Barito Basin in the south, the Kutei Basin in the central part and the Tarakan Basin in the north, contain Paleogene sediments which range in age from Middle Eocene to Upper Oligocene. The paleogeographic map shows that the Middle Eocene is dominated by fluvial settings, while the Upper Eocene deposits were coastal to shallow shelf. Carbonates developed during the Lower Oligocene in the north and in the south, whilst the central part (Kutei Basin area) was dominated by shallow shelf to bathyal clastic environments. In the Upper Oligocene, the carbonate in the south developed, while the Kutei Basin was dominated by deeper marine settings, contrasting with the shallow shelf clastics which covered almost the entire Tarakan Basin. The paleogeographic environments interpretation can be understood better by integration with robust tectonic restorations (especially in areas which have undergone tectonic inversion), for each time period. More outcrop data may help in refining these paleogeographic maps, especially for the onshore Tarakan Basin, which needs further refinement with updated outcrop studies. Good integration with Sabah (Malaysia) studies will also probably bring a better geological understanding.

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