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Climatic control on primary productivity changes during development of the Late Eocene Kiliran Jao lake, Central Sumatra Basin, Indonesia

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ABSTRACT

A 102 m long core section of the late Eocene Kiliran Jao oil shale has been studied by means of palynofacies and inorganic geochemistry to examine the role of climate change on the development of the Kiliran Jao paleo-lake. Climate changes during deposition of the studied oil shale are interpreted from the abundance variation of fungal remains. Higher abundance of fungal remains in the middle part of the oil shale profile indicates relatively warmer climate during deposition. The warmer climate is thought to have led to changes in lake productivity. Carbon isotopic compositions of organic matter ($\delta^{13}C$) range from −27.0 to −30.5‰. These are generally more depleted in the middle part of the profile indicating lower primary productivity of the lake during deposition. *Botryococcus braunii* varies from 3 to 16% and is generally more abundant in the middle part of the profile. This is consistent with the less trophic preference of this algal blooming. The warmer climate is thought to have induced stratification, limiting the introduction of recycled nutrients to the epilimnion, thereby reducing the lake productivity.

1. Introduction

The late Eocene Kiliran Jao oil shale is an immature organic-rich shale which was deposited in the Central Sumatra Basin. Sedimentological investigation revealed that the oil shale was deposited in lacustrine and anoxic environments (Sunardi, 2015). In a more regional framework, geochemical and palynological studies indicate that paleoclimate was responsible for the deposition of Paleogene source rocks in the Central Sumatra Basin (Cole and Crittenden, 1997; Rodriguez and Philp, 2012). The authors discussed that the tropical paleoclimate controlled the chemical stratification of the water column and thus bottom water anoxia of lakes in the basin. Although paleoclimate has been identified as the significant factor on source rocks deposition, a detailed discussion of the links between climate change and sediment deposition in Indonesian basins has been less reported previously.

In the present study, the depositional environment changes of Kiliran Jao oil shale are investigated using palynofacies and geochemical analyses in order to characterize the organic matter and geochemical composition of the oil shale. Based on these results, an improved reconstruction of the climatic conditions governing the Kiliran Jao paleo-lake is provided.

2. Geological setting of the study area

Three main basins developed in Sumatra during the Paleogene: the North, Central and South Sumatra Basins (NSB, CSB and SSB respectively) (Fig. 1a). The Central and South Sumatra Basins are considered as one large basin with many troughs and grabens, as they show similar and related geological histories (Crow and Barber, 2005; de Smet and Barber, 2005). The area of the present study is located in the Kiliran Jao Sub-basin, one of source rock depocenters at the transition of the Central and South Sumatra Basins (Fig. 1b). The Kiliran Jao Sub-basin is referred as part of the Central Sumatra Basin, since it shows analogous sediment successions (Sunardi, 2015).

2.1. Central Sumatra Basin

The geological setting and history of the Central Sumatra Basin have been described in detail by Crow and Barber (2005), Darman and Sidi (2000), de Smet and Barber (2005) and Doust and Noble (2008). This

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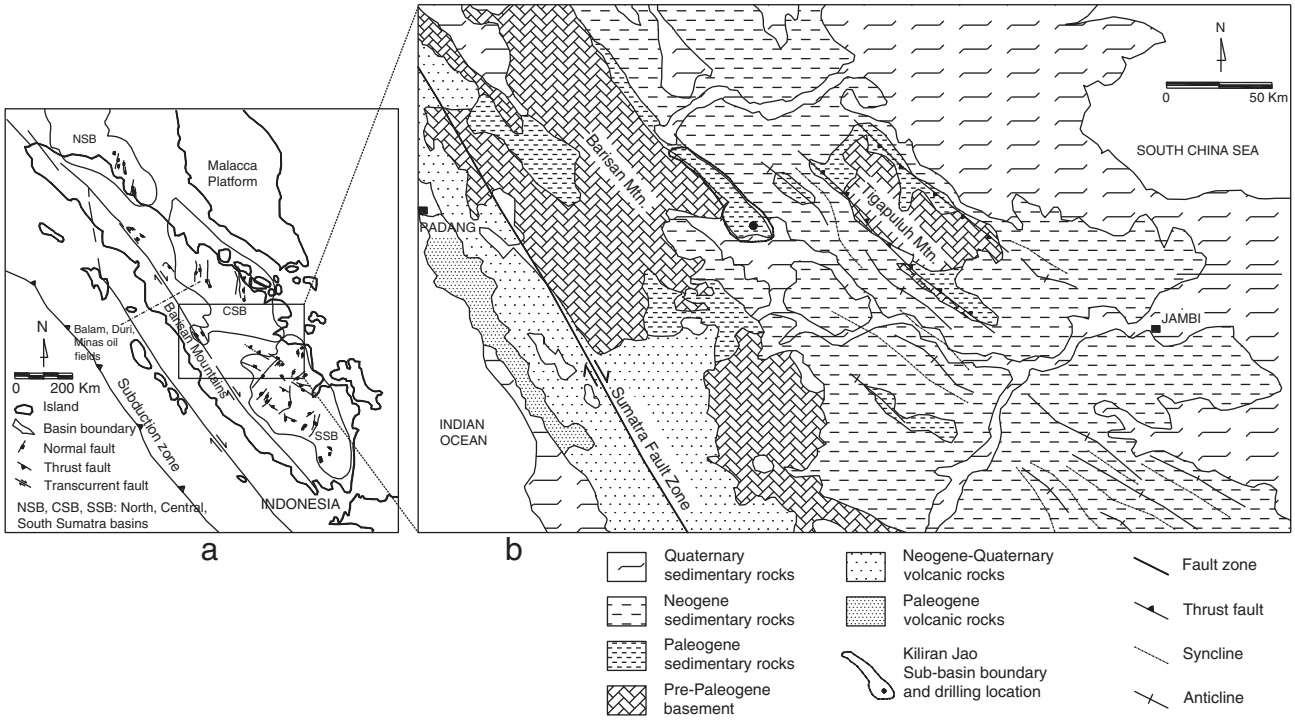

Fig. 1. Map of Sumatra Basins with main graben structures (a), enlargement of the transition of Central and South Sumatra Basins showing the Kiliran Jao Sub-basin and drilling locations (b), modified after Darman and Sidi (2000).

basin is situated in a tectonically active region and originated as a result of the subduction of the Indian-Australian plate beneath the Eurasian plate. The basin development can be divided into four stages of tectonostratigraphic evolution which were responsible for petroleum system formation (Fig. 2a): early synrift (late Eocene to Oligocene), late synrift (late Oligocene to early Miocene), early postrift (early to

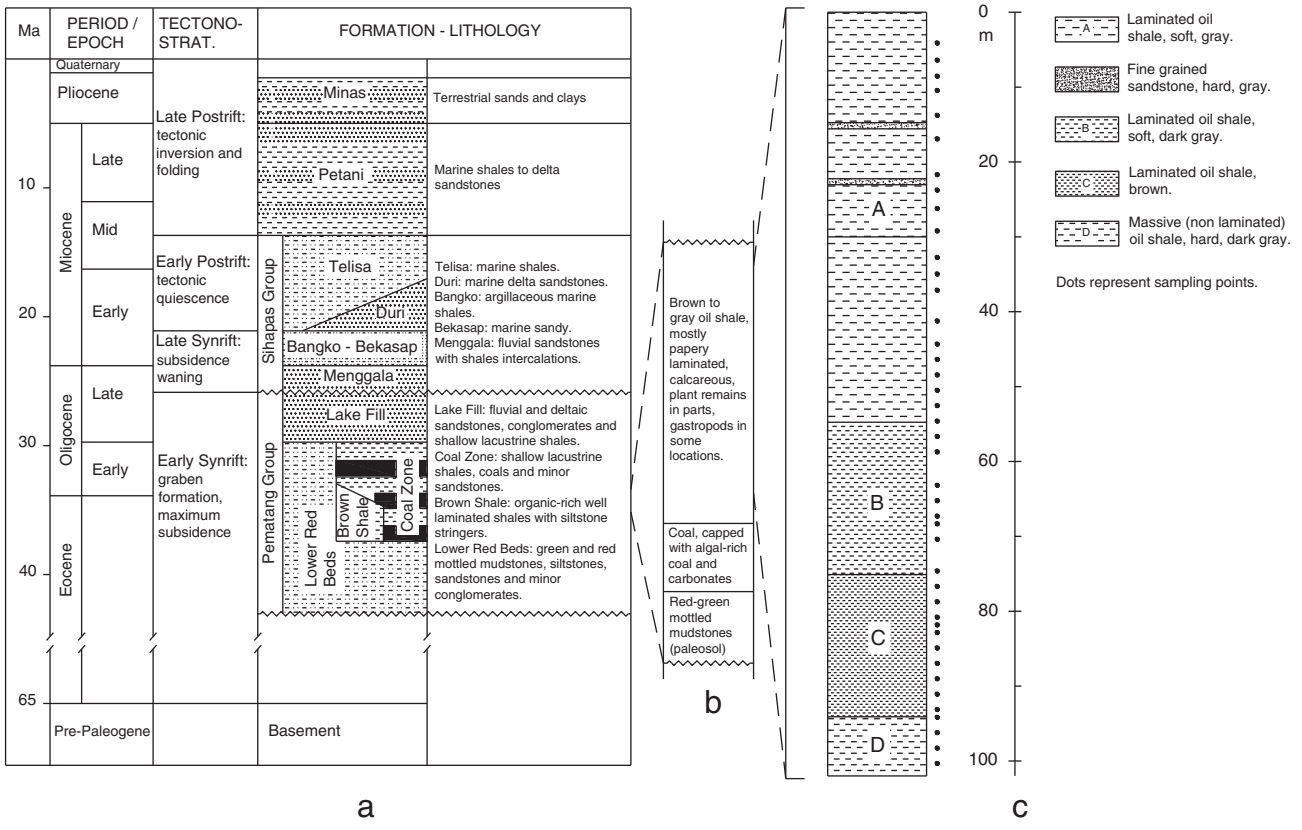

Fig. 2. Generalized stratigraphic column of the Central Sumatra Basin (adopted from Doust and Noble, 2008; Williams and Eubank, 1995) (a) and Kiliran Jao Sub-basin (based on Iqbal et al., 2014; Sunardi, 2015; and the references therein) (b), and drill core profile of the oil shale in Kiliran Jao Sub-basin (c).