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Original article

Lignites of Kutch, western India: Dinoflagellate biostratigraphy and palaeoclimate

Les lignites du Kutch, Inde occidentale : biostratigraphie des dinoflagellés et paléoclimat

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Abstract

The Eocene epoch in the Indian subcontinent was marked by widespread deposition of lignite and coal. While several of these deposits formed during the Early Eocene, corresponding to Early Eocene hyperthermal events, the lignites of Kutch in western India formed later during the Middle Eocene. An integrated biostratigraphy based on dinoflagellates and foraminifera assigns a Bartonian age to the succession, which likely corresponds to the time of the Middle Eocene warming. The spores, pollen, dinoflagellates and foraminifera suggest a restricted marine, near shore depositional environment adjacent to tropical rainforest. The lignites of Kutch suggest high precipitation during or just preceding the warm climate of the Middle Eocene.

Keywords: Dinoflagellate; Foraminifera; Palynology; Kutch; Eocene palaeoclimate

Résumé

L'époque Éocène se caractérise sur le sous-continent indien par de vastes dépôts de lignite et de charbon. Alors que l'essentiel de ces dépôts se sont formés durant l'Éocène inférieur, et correspondraient à l'expression des événements hyperthermaux de l'Éocène inférieur, les lignites de Kutch en Inde occidentale se sont formés durant l'Éocène moyen. Une biostratigraphie integrée, basée sur les dinoflagellés et les foraminifères, attribue à la série un âge Bartonien, et correspond probablement à l'intervalle de réchauffement climatique de l'Éocène moyen. Les spores, pollens, dinoflagellés et foraminifères mettent en avant un environnement marin, proche du littoral et à proximité de forêts tropicales. Les lignites de Kutch suggèrent une période de précipitations intenses durant ou juste avant l'intervalle climatique chaud de l'Éocène moyen.

Mots clés : Dinoflagellés ; Foraminifères ; Palynologie ; Kutch ; Paléoclimat de l'Éocène

1. Introduction

Lignites and coals occur extensively in the Indian subcontinent. They extend from Cambay, Kutch, Barmer and Bikaner in western India and through the trans-Indus Ranges in Pakistan to Jammu, Shimla and Solan in the north and Meghalaya and Bangladesh in the east (Fig. 1a). The stratigraphy suggests that lignite and coal in these widely separated basins developed during the Eocene. The Eocene epoch was marked by global warming in the Early and Middle Eocene followed by cooling during the Late Eocene (Zachos et al., 2001). Lignite being an important climate indicator, its precise timing of formation is significant in context of the dynamics of Eocene palaeoclimate. The lignite of Cambay basin is of Early Eocene age corresponding to shallow benthic zones SBZ7 (upper) – SBZ10 (Garg et al., 2008; Punekar and Saraswati, 2010). A tropical rainforest vegetation characteristic of humid climates (Dutta et al., 2012) and hyperthermal events of the Early Eocene are established in this

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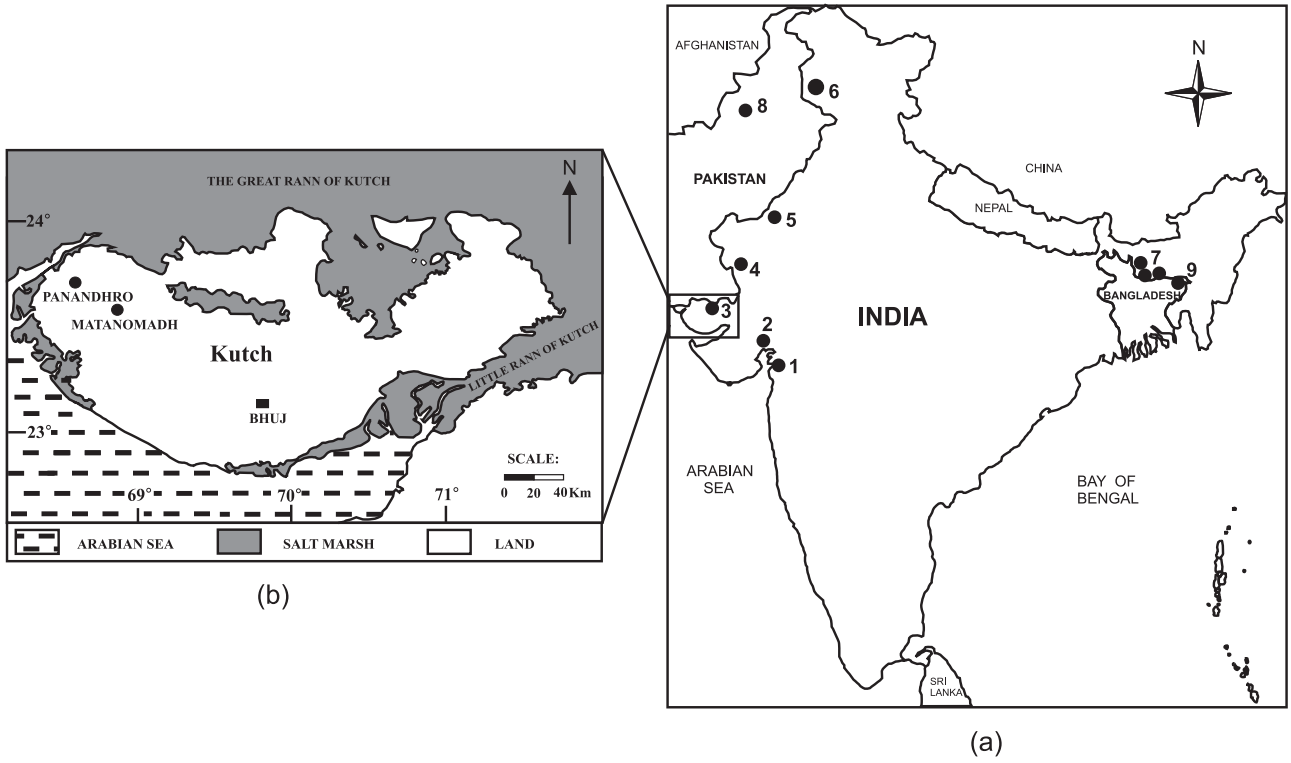

Fig. 1. a: Palaeocene–Eocene lignite and coal deposits of Indian subcontinent: 1. Vastan, 2. Rajpardi, 3. Panandhro, 4. Barmer, 5. Bikaner, 6. Kalakot, 7. Garo, Khasi and Jaintia Hills, 8. Rakhi Nala, 9. Sylhet; b: location of study area.

section (Samanta et al., 2013). Is the lignite of Kutch further evidence of warm and humid climates of the Early Eocene in western India? Or, does it represent humid climate of the later warming in the Middle Eocene?

The age of the lignite overlying the Deccan traps in Kutch has long been controversial as it lacks a datable fauna. It was initially assigned to the Naredi Formation (Biswas, 1992), although lignite does not occur in the type locality of the Naredi Fm and neither of the two mine sections contains animal fossils typical of the Naredi Fm. The Naredi Formation is assigned an Early Eocene age ranging from SBZ6–SBZ11 (Saraswati et al., 2012) on the basis of its foraminifera. On the basis of long-ranging palynomorphs of Palaeocene–Eocene age, the lignite has been considered to be Early Eocene in age (Biswas, 1992). Recently reported Middle Eocene larger benthic foraminifera in beds overlying lignite from the Matanomadh and Panandhro mines constrains its age as Late Lutetian–Early Bartonian (Saraswati et al., 2014). The absence of foraminifera in shale beds between the lignite seams has led to the present study to investigate other microfossils in the lignite sections for precise age of the time of formation of lignite. The samples of the two lignite mines examined by Saraswati et al. (2014) have been re-examined for dinoflagellates and an integrated dinoflagellate–foraminifera biostratigraphy is presented here. Spore and pollen are also studied to compliment the palaeoenvironmental and palaeoclimatic conditions interpreted on the basis of dinoflagellates and previously reported foraminifera from the same beds.

2. Material and methods

The samples were collected from lignite mine sections at Matanomadh (N 23°30′; E68°55′) and Panandhro (N 23°42′; E 68°46′) in Kutch, in Gujarat state of India (Fig. 1b). As mentioned above, the samples examined in this study for dinoflagellate were previously also studied for foraminifera (Saraswati et al., 2014). The approach enabled integration of dinoflagellate and foraminifera biostratigraphy to firmly establish the age. The lignite-bearing succession overlies the Deccan basalt. The section in Matanomadh consists of two lignite seams intercalated with carbonaceous shale in the lower part. Green shales overlie the second lignite seam, which grades into mudstone and clay in the upper part of the profile. The Panandhro mine consists of lignite with alternating carbonaceous shale in the lower part and green shales and limestone in the upper part. The lithological details and sample positions indicating dinoflagellate assemblage are given in Figs. 2 and 3.

For separation of palynomorphs, about 20 g of each sample was treated with dilute HCl followed by the treatment with HF and HNO_3. After staining the macerate with safranin O, the slides were prepared in polyvinyl alcohol and mounted in Canada balsam. For quantitative analysis of the assemblage, a minimum of 200 palynomorphs was counted from each productive sample, which was taken as “Total count”. Percentage frequencies of each palynomorph or group of palynomorphs were calculated with respect to the “Total count”. The percentage frequency has been displayed in Figs. 4 and 5, which were