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Peat biomass degradation: Evidence from fungal and faunal activity in carbonized wood from the Eocene sediments of western India

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Abstract

An integration of reflected light and transmitted light study of Eocene lignite along with Scanning Electron Microscope (SEM) examination of carbonized wood from Kapurdi lignite of the Barmer Basin has yielded abundant fungal components and arthropod appendages. The carbonized wood section under SEM shows tyloses, a physiological process as a response to fungal infection. Scolecodonts and annelid body parts were also recovered from the studied sediments, indicating the peat biomass was a thriving habitat for detritivores. In petrographic examination of the lignite beds which underlay and overlay the carbonized wood section, the funginite is found to be associated with resinite, indicating that the funginite inclusion was not accidental but encapsulation of fungi by exuded resin of the plant as a defense mechanism. Funginite is found in higher percentages in detrohuminite (attrinite) groundmass in lignites. The degradation of the humic matter is attributed to the fungal infestation as well as faunal activity in the peat mire. This fungal–faunal interaction resulted in alteration of the organic matter and origin of macerals belonging to inertinite group.

Keywords: Fungal–faunal interaction; Carbonized wood; Tyloses; Kapurdi mines; Barmer Basin

1. Introduction

Accrued peat biomass constitutes a complex habitat of fauna, flora, bacteria, algae, and fungi, all of which play an important role in degradation and decomposition of organic matter (Hower et al., 2009, 2011, 2013). The studies on plant–insect associations thus far have demonstrated the ecological diversity in many sedimentary domains including peat mires. This topic has enabled many workers worldwide to decipher the biodiversity of terrestrial as well as marine ecosystems from the Devonian to recent (Winslow, 1959; Stormer, 1970, 1976; Rolfe, 1980; Shear et al., 1984; Bartram et al., 1987; Jeram, 1994; Braun, 1997; Stankiewicz et al., 1998; Labandeira, 2006; Jurgens et al., 2009; Haug et al., 2014). Generally, the most apparent interface among fungi and other organisms involves the breakdown of plant and animal tissues (Taylor and Osborn, 1996). The most important role of fungi in extant ecosystems is delignification and degradation of wood and nutrient cycling in their habitat.

The rate of impact of these floral and faunal components on the peat biomass influences the development of macerals in lignite/coal. The nexus between plants, fungi, and insects is revealed by the abundance of detritivore body parts, cuticles, and appendages recovered from the samples (Hower et al., 2011, 2013). These ecological associations of accumulated organic matter and their insect herbivores have provided basic details on the role of detritivore insects and their role in size characteristics of macerals during peat formation. As suggested by Hower et al. (2011, 2013), the peat particle size is directly proportional to the detritivore faunal/floral activity and, in particular, the increase in volume percentage of macrinite/micrinite.

The significance of funginite (lignite/coal petrography) in degradation of plant tissues has been discussed by many workers (Waksman, 1930; Barghoorn, 1949, 1952; Teichmullar, 1958; Benes, 1959, 1960, 1969; Benes and Kraussova, 1964, 1965;

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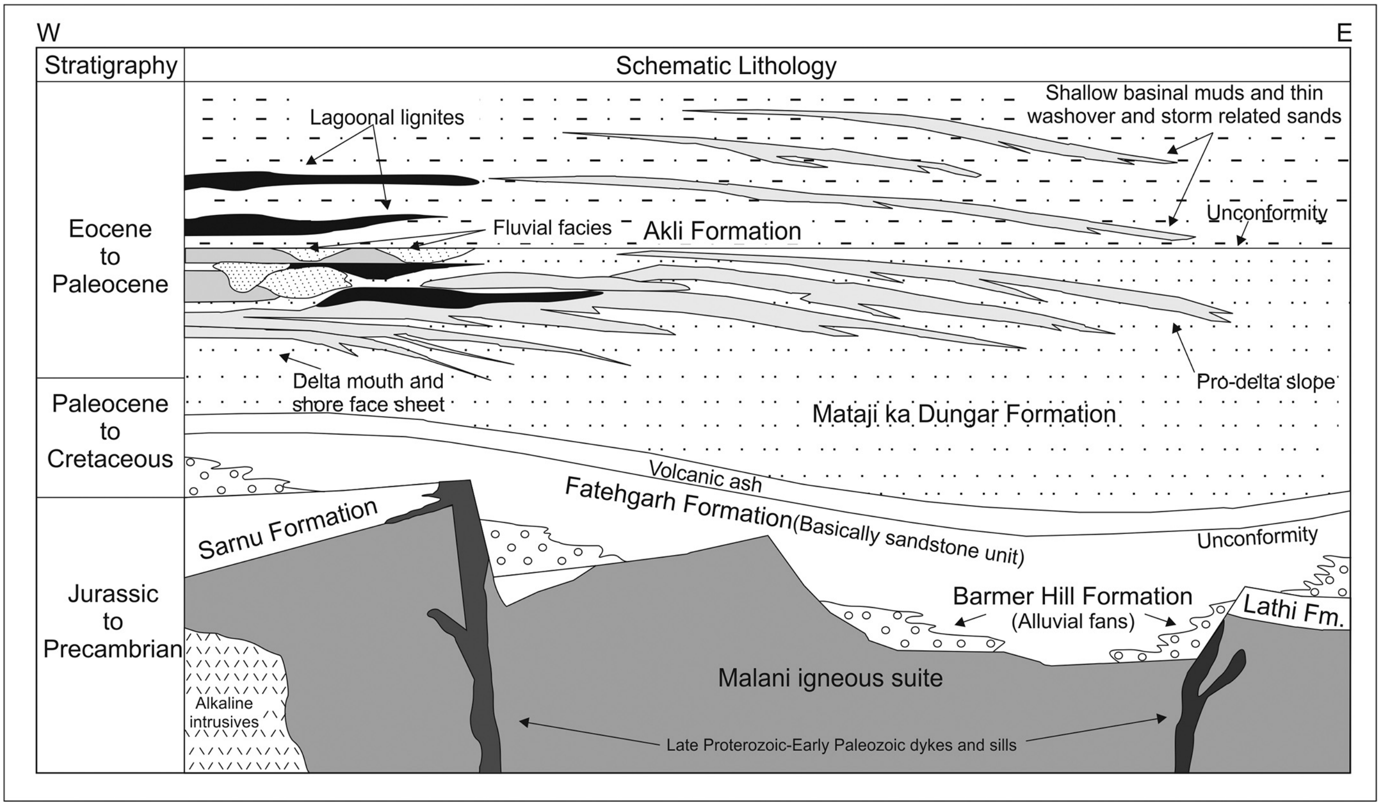

Fig. 1. Stratigraphic succession of the Barmer Basin (after Sisodia et al., 2005).

Webb, 1977; Hower et al., 2010; Taylor and Krings, 2010; O'keefe and Hower, 2011). Hower et al. (2011) discussed the destruction of lignin and cellulose by white-rot fungi and brown-rot fungi respectively, which helped easy ingestion of wood by detritivores. The main objective of the study is limited to establish a relationship between plant–animal interactions in the peat forming environments and climate change with a note on the petrographic characterization of fungi and its role in organic matter degradation.

2. Geological framework

The Barmer Basin in western Rajasthan is a narrow north–south-trending graben comprising sediments of the Middle Jurassic to Lower Eocene age (Dasgupta, 1977; Pareek, 1981; Misra et al., 1993; Sisodia et al., 2005). This basin was formed as a result of the breakup of Indian craton in the latest Cretaceous–early Paleocene that led to the formation of the Cambay rift and the constituent basins (Sisodia and Singh, 2000). The stratigraphic succession in the Barmer Basin is given in Fig. 1.

The Lathi Formation lies unconformably over the Malani igneous suite and contains sandstone, limestone, marl, and conglomerates. The Fatehgarh Formation of Upper Cretaceous–Lower Eocene age is deposited unconformably over the Lathi sediments. Overlying the Fatehgarh Formation is the Akli Formation comprising bentonites, bentonitic clays, and sandstones with intercalation of a number of lignite seams. The Mandai Formation succeeds the Akli sediments and is represented by ferruginous sandstones, ball clay, and conglomerates. The Kapurdi Formation, comprising fuller's earth rich in fossils, overlies the Mandai Formation.

The Kapurdi Lignite Block is situated at 18.5 km north of Barmer town on National Highway–15 in the district of Barmer (Fig. 2). The area around the coalfield is extensively covered by a thick blanket of aeolian desert sand and sand dunes. The Paleogene sediments of the Kapurdi area is represented by sandstone, sand, siltstone, conglomerate, bentonite, fuller's earth, carbonaceous clay, and lignite. The lignite in this mine is confined to three zones viz., Top, Middle, and Bottom lignite horizon (Gowrisankaran et al., 1987; Mukherjee et al., 1992).

3. Material and methods

The material for the study, carbonized wood, was collected from the 2 m thick sand bed between lignite seams M4 and T1 (Fig. 3). This sand bed hosted many lumps of carbonized wood, much of which was inaccessible due to the possibility of caving in of sediments. However, some of the accessible carbonized wood pieces were collected and it was noticed that the pith of the wood was completely replaced by whitish clay (Fig. 3A, B) and the outer portion of the wood was embedded with grains of grit.

Petrographical study was carried out on lignites overlying and underlying the sand bed (Fig. 3) to understand the funginite and huminite relationship. The pellets for petrographic analysis were prepared as per the ISO 7404-2 (2009). Vitrinite reflectance and maceral analysis was carried out under oil immersion as per standard ISO 7404-5 (2009) and ISO 7404-3 (2009) respectively.