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# Depositional environments of the Jurassic Maghara main coal seam in north central Sinai, Egypt

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ABSTRACT

Twenty-eight channel samples with a cumulative thickness of about 4 m collected from three sections of the Maghara main coal seam in the middle Jurassic Safa Formation have been studied for their lithotype and maceral compositions to reconstruct the character of peat swamp, its hydrological regime and the predominating type of vegetation. Lithotype composition is a combination of dully lithotypes with duroclarain (19% of total cumulative thickness), clarodurain (15%), black durain (15%), and shaly coal (15%) and bright lithotypes represented by clarain (23%), vitrain (12%) and a small proportion of wild fire-generated fusain (1%). Maceral analyses revealed the dominance of vitrinite (70.6% on average), followed by liptinite (25.2%) and inertinite (8.1%). Mineral matter content is ~ 9% on average and consists of clay, quartz and pyrite concentrate mostly at the base and the roof of the seam. Dominantly vitrinite composition of coal and extremely low fire- and oxidation-borne inertinite content, together with high Gelification Indices imply predomination of waterlogged anoxic conditions in the precursing mire with water tables mostly above the peat surface throughout most of the time during peat swamp formation. Increases in collotelinite contents and Tissue Preservation Index up the section, followed by a reversal trend in upper third of the coal section, further accompanied by a reversal trend in collodetrinite, liptodetrinite, alginite, sporinite and clay contents records a transition from dominately limnotelmatic and limnic at the lower part to dominately limnotelmatic with increase telmatic condition achieved in the middle part of coal. At the upper part of coal seam an opposite trend marks the return to limnic and limnotelmatic conditions in the final phases of peat swamp history and its subsequent inundation. The proportion of arborescent (mostly coniferous) and herbaceous vegetation varied throughout the section of the coal with tendency of increasing density of arborescent vegetation to the middle part of the coal seam section. The intercalation of coal in shallow marine strata implies that peat swamp precursor formed in a coastal setting, probably on delta plain or lagoon. Its formation was controlled by water table changes driven by sea level fluctuations that created an accommodation space necessary for preservation of peat.



## 1. Introduction

Jurassic Coal was discovered in Sinai at Gebel (Mountain) Maghara in the 1950s, and development of mining operations was realized from 1964 until 1967, when it was interrupted by the Sinai war conflict. Coal reserves in the major seam of the deposit are estimated to be about 27 million tons, of which 16 million tons are recoverable (Thomas, 2002; WEC, 2013; GESY, 2016). However, only 20% of the total coal reserve has been exploited due to technological and financial problems.

The Maghara deposit has attracted the attention of geologists since the discovery of coal-bearing strata within the lower part of the Middle Jurassic (Bathonian) Safa Formation (Jenkins, 1990; Mostafa and Younes, 2001; Abdel El-Fatah, 2016; Edress and Abd El-Fatah, 2017). Consequently, the Maghara coal has been widely studied and documented due to its economic importance for the local industry. It is a high grade, high volatile bituminous coal (Abdel El-Fatah, 2016). However, only little has been published on the petrographic composition of the Maghara coal and the character of its peat swamp precursor in terms of its depositional environment. Accordingly, we studied vertical and lateral changes in the lithotype and maceral compositions of the Maghara main coal (coal No. 5) in order to reconstruct the hydrological regime and the environment of the original peat swamp within a wider depositional context by applying maceral and lithotype-based

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indices and facies diagrams.

## 2. Geological setting and stratigraphy of the Jurassic strata in north-central Sinai

The Maghara coal deposit is located in the north-central part of the Sinai Peninsula about 50 km south of the Mediterranean coast and 250 km northeast of Cairo (Fig. 1). It is situated between 30° 35′ and 30° 50′ N and 33° 10′ and 33° 40′ E. Coal-bearing strata are part of the sedimentary succession of the East Maghara Basin, exposed in a narrow belt in the Gebel Maghara anticline structure of north-central Sinai while elsewhere they are concealed under younger Cretaceous to Eocene sediments. The coal-bearing strata of the Maghara deposit covers a ~1300 km$^2$ large rectangular area which is about 54 km long and 30 km wide with the longer axis trending NE-SW.

The origin of the Maghara coal deposit is linked to the divergent and extensional deformations between the African and Eurasian plates responsible for the opening of the Neotethys Ocean in the Eastern Mediterranean and the development of several basins in north and central Sinai during Early Jurassic times (Jenkins, 1990; Aal and Lelek, 1994; Zaghloul and Khidr, 1992; Veevers, 2004). In the East Maghara Basin a ~2000 m thick Jurassic sequence unconformably overlies Middle Triassic rocks (Eyal et al., 1980). However, the entire fill of the basin, ranging from Jurassic through Cretaceous to early Cenozoic (Eocene), reaches a maximum thickness of 3150 m. During Jurassic to Cretaceous times, this basin, together with other central Sinai sub-basins, was situated between the Arabian Nubian Shield highland to the south and the deep-water Neotethys Ocean to the north. The sedimentary record in the basin grades northwards of terrestrial and coastal plain to shallow marine carbonate platform (Jenkins, 1990; Abed et al., 1996; Osman et al., 2000; Mostafa and Salama, 2005; Kuss and Boukhary, 2008). These environments alternate also vertically, thus suggesting prominent relative sea-level changes during deposition (Fig. 2).

The Jurassic strata in the north-central Sinai are subdivided into six lithostratigraphic units (Issawi et al., 1999) (Fig. 2). Lower Jurassic formations comprise fluvial to near shore marine sandstones with subordinate coal-bearing clay and silty beds. The coarse facies of the Mashabba and Rajabian formations are interpreted as deposits of the braided fluvial system running from the southern hinterland area to the north. They alternate with shallow marine sandstone and carbonate concentrated in upper parts of the

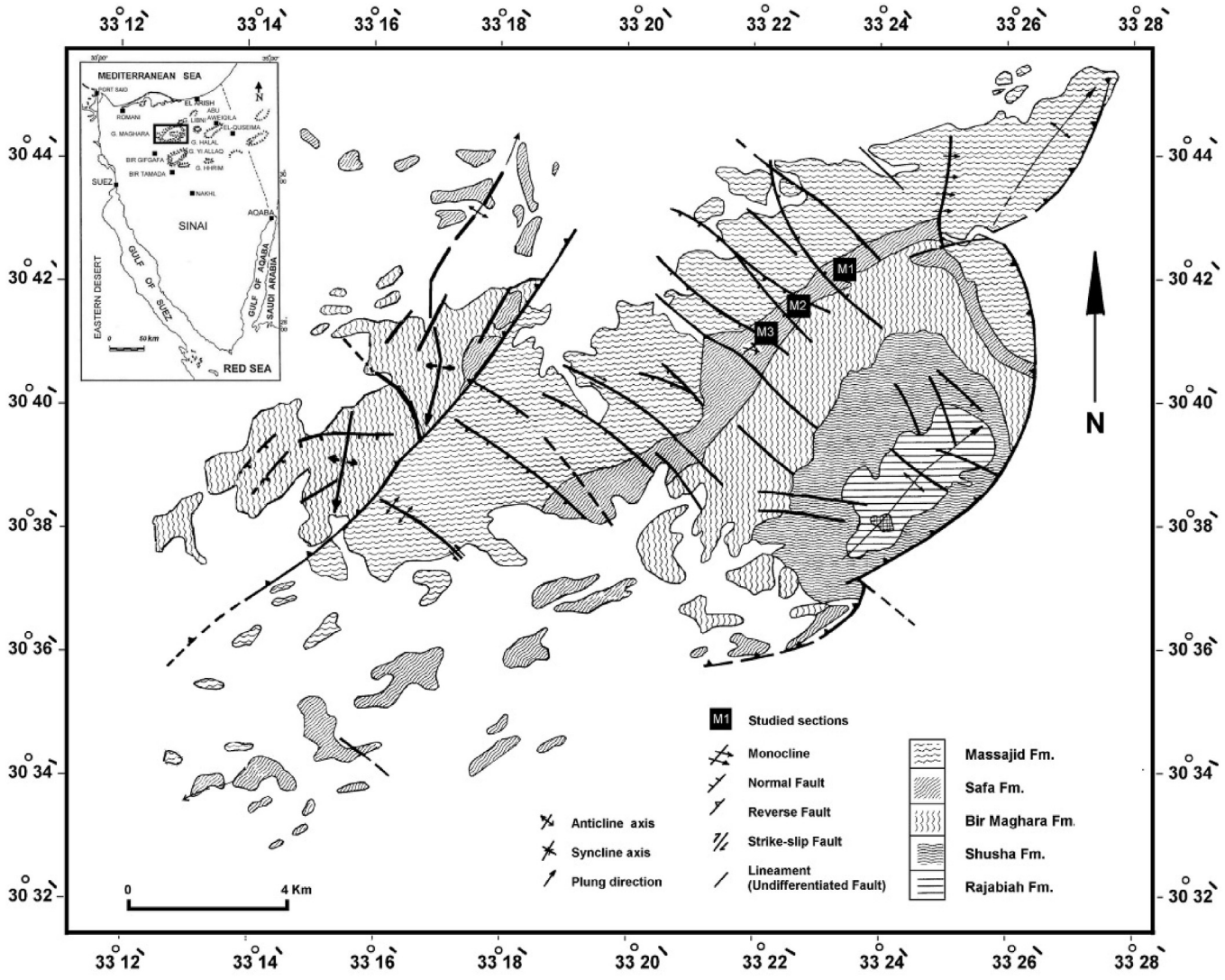


**Fig. 1.** Geological map of the Gebel El-Maghara area (After Eyal et al., 1980; Said, 1990; EGS, 1992).