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Petrographic characteristics and palaeoenvironment of the Permian coal resources of the Barapukuria and Dighipara Basins, Bangladesh

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ABSTRACT

Twenty-seven coal samples from the Barapukuria and Dighipara Coal Basins of Bangladesh were analysed for their maceral content, petrographic characteristics and vitrinite reflectance. The most predominant maceral was the inertinite group (mean 40%), followed by vitrinite (mean 31%) and liptinite (mean 22%), with considerable amounts of mineral matter (mean 7%). Semifusinite, fusinite and inertodetrinite were the most common macerals of the inertinite group. Collotelinite, collodetrinite and vitrodetrinite were the most frequently found macerals of the vitrinite group, while sporinite and cutinite were the most common in the liptinite group. Clay minerals occurred in higher concentrations than other minerals. The measured vitrinite reflectance values (%R_o) ranged from 0.71 to 0.80, indicating a high volatile bituminous B ranking.

Facies modelling using maceral composition and maceral indices suggested an environment of forest swamps with alternating oxic–anoxic depositional conditions. Microlithotype-dependent depositional modelling indicated evolution in limno-telmatic zones under fluvio-lacustrine control, accompanied by the development of upper to lower deltaic plain conditions. A terrestrial origin with dry forest to piedmont plain conditions was suggested by the Gelification Index (GI) and Tissue Preservation Index (TPI). The lateral variation of the measured TPI values indicated an increase in the rate of basin subsidence. A cross-plot of the Ground Water Index (GWI) vs. the Vegetation Index (VI) suggested mires under ombotrophic to mesotrophic hydrogeological conditions containing herbaceous plants.

1. Introduction

The Gondwana succession of the Bengal Basin (Bangladesh) is very important because of its preserved coal deposits. To date, it has been estimated to contain 3 billion tons of coal resources (Farhaduzzaman et al., 2008). The coal deposits of these two basins occur at shallow depths (Imam, 2005). Petrography is an important method, commonly used to evaluate the facies and palaeoenvironmental interpretation, that is used worldwide by numerous researchers and for various geological ages (e.g., Amijaya et al., 2006; Daulay and Cook, 1988; Hower et al., 2008; Jasper et al., 2010; Kalkreuth et al., 1999; Querol et al., 2001; Singh and Singh, 2004; Toprak, 2009; Wan Hasiah, 2003; Wan Hasiah and Abolins, 1998).

No systematic work has as yet been carried out on the Permian Gondwana coals of Bangladesh. Published studies have covered: the petrography of the Barapukuria coal using the new analytical technique of reflectance scanning (Bostick et al., 1991); the palynomorphs of the Permian Gondwana coals of Barapukuria (Akhtar and Kosanke, 2000); the potential source rock of the Gondwana coals of Bangladesh (Shamsuddin et al., 2001); a study of the Barapukuria coal, focussing on the geochemistry and techno-environmental issues related to mining (Islam and Kamruzaman, 2006); an analysis of the lithofacies and cyclicity of the Gondwana succession of the Barapukuria Basin, Bangladesh (Islam and Hossain, 2006); the methane resource potential of the coal beds of the Gondwana Barapukuria Basin, Bangladesh (Islam and Hayashi, 2008); the proximate analysis and coal rank of the Gondwana coals of Bangladesh (Farhaduzzaman et al., 2008); and tectonic subsidence modelling based on the Gondwana coals from the Kuchma, Singra and Hazipur wells of Bangladesh (Frielingsdorf et al., 2008). The present paper evaluates the palaeofacies and palaeodepositional environment on the basis of the petrographic characteristics of the Permian coal deposits of Bangladesh.

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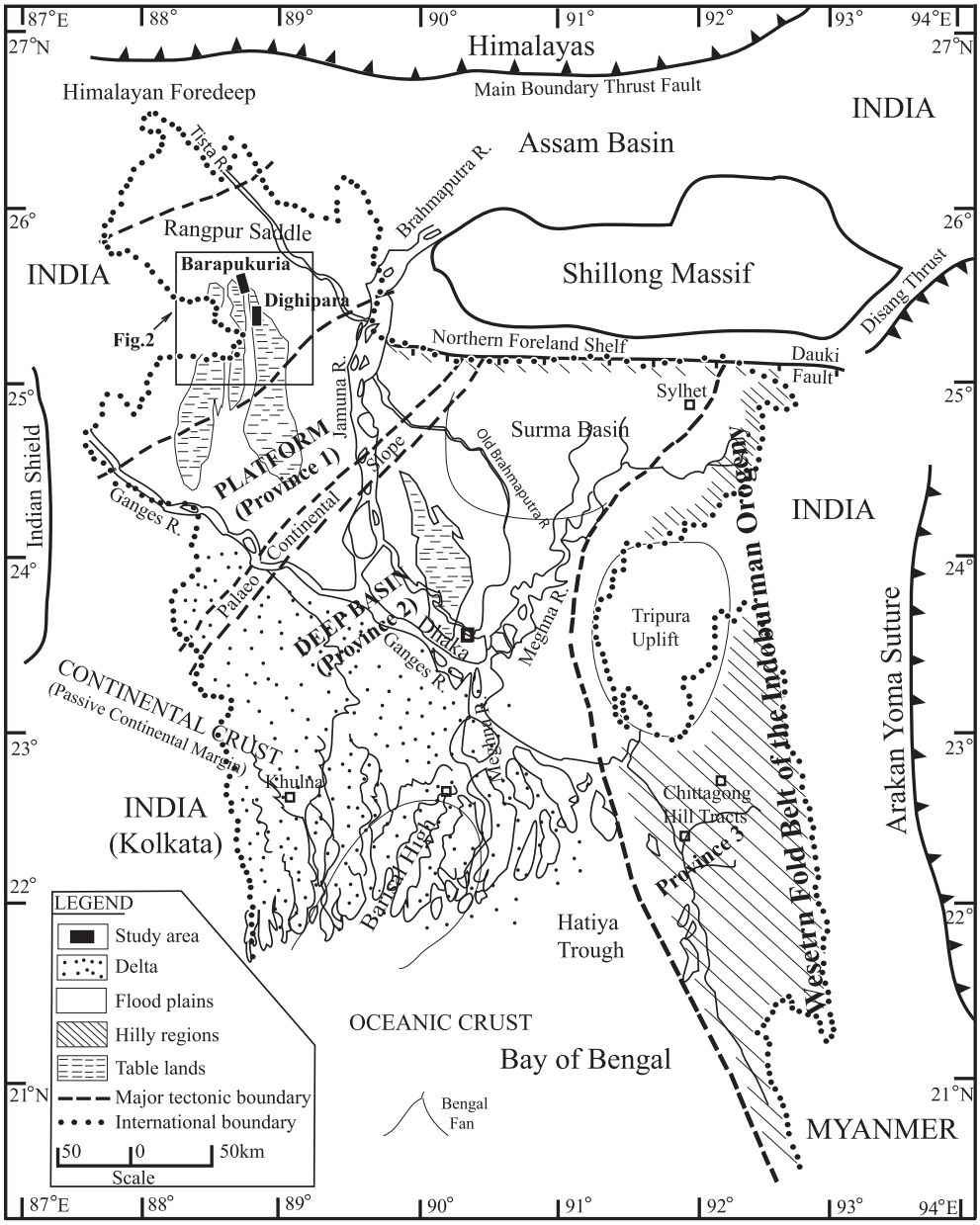

Fig. 1. Location map of the study area (Barapukuria and Dighipara Coal Basins) showing the tectonic elements and physiographic divisions of Bengal Basin (modified after Alam et al., 2003; Imam, 2005; Islam, 2009; Khan, 1991; Rahman and McCann, 2012; Reimann, 1993; Shamsuddin et al., 2004).

2. Geological background

The Bengal Basin (Fig. 1) has evolved tectonically from the collision of the Indian and the Asian plates (Alam et al., 2003; Guha, 1978; Khan, 1991; Reimann, 1993). The tectonic framework of Bangladesh can be broadly divided into two main units: the Platform and the Deep Basin (Imam, 2005; Khan and Chouhan, 1996; Uddin and Lundberg, 2004) (Fig. 1). The geology of the Platform unit is entirely different from that of the Deep Basin unit (Imam, 2005). A number of small half-graben basins (Fig. 2), such as Barapukuria, Phulbari, Khalaspir, Dighipara and Jamalganj, which contain coal-bearing Gondwana formations, occur over the basement in northwestern Bangladesh (i.e., the Platform unit). These sedimentary shallow basins lie over the Basement Complex (at 400 m approximately), within which the Permian sediments have been preserved in half-graben troughs subsequently infilled with unconsolidated Tertiary and Quaternary sediments.

In the Barapukuria Basin, the Archaean Basement Complex is overlain by a sedimentary succession comprising the Permian Gondwana Group, Pliocene Dupi Tila Formation and Plio-Pleistocene Barind Clay Formation at the top (Armstrong, 1991; Farhaduzzaman, 2010; Islam and Hayashi, 2008; Islam and Hossain, 2006; Islam and Sultan-ul-Islam, 2005; Islam and Kamruzaman, 2006). The Basement Complex (Archaean) consists of various veined gneissic metamorphic and metaigneous rocks. The Gondwana Group (Permian) succession below Seam VI is somewhat different from the Gondwana succession above. Its lower part consists of a fairly rapidly interbanded succession of sandstones, siltstones and mudstones, with occasional thin coal bands. Most of the sandstones above Seam VI are to some extent weathered and moderately weak, with decomposition of the feldspars to kaolinitic clay ranging from slight to complete. The sandstones below Seam VI are mostly unweathered, less feldspathic and moderately strong. Units of fluviatile sandstones and interbanded