

Paleoenvironments, organic petrology and Rock-Eval studies on source rock facies of the Lower Maastrichtian Patti Formation, southern Bida Basin, Nigeria

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Abstract

The southern Bida Basin in central Nigeria forms a part of the larger Bida or Middle Niger Basin, which is contiguous with the south east trending (petroliferous) Anambra Basin. These basins were major depocenters for Campanian–Maastrichtian sediments in southern and central Nigeria prior to the build up of the Tertiary Niger delta. The successions in the southern Bida Basin consist of the basal Lokoja Formation, overlain by the Patti Formation and capped by the Agbaja Formation. The Lokoja Formation is a sequence of matrix supported conglomerates and sandstones overlying the Pre-Cambrian to Lower Paleozoic basement. Depositional environments are predominantly within fluvial systems of a continental setting. The Patti Formation consists of dark grey carbonaceous shales; mudstone and siltstones representing flood plains to shallow marine deposits with likely organic rich intervals. The overlying Agbaja Formation is made up of ferruginised oolitic and kaolinitic mudstone of a marginal marine environment. Twenty samples of shales of the Patti Formation were studied by incident light microscopy and geochemical analysis to determine the maceral components, geochemical type and potential yield of the pyrolysate. Maceral analysis indicate a large abundance of vitrinite (50–85%; mean = 66%); moderate abundance of liptinites (10–33%; mean = 18%) and lesser amounts of inertinite (9–40%; mean = 16%). Total organic carbon (TOC) values vary from 0.17 to 3.8 wt.% (mean = 2.1 wt.%) with most samples having greater than 2 wt.% TOC. Three of the samples yield greater than 2 kg_(HC)/ton of rock suggesting a fair source rock potential. Most of the samples are thermally immature to marginally mature with vitrinite reflectance ranging from 0.4 to 0.6% $R_{o,m}$ and T_{max} values of 407–426 °C. Given the prevalence of the humic Type III kerogen, maturity and hydrocarbon potential yields, we conclude that the Patti Formation source rock facies have moderate to fair potential for gaseous hydrocarbons which have not yet been generated at the present day outcrop levels but could be important gas source where buried down-dip.

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1. Introduction

The Bida Basin is a NW-SE trending embayment, perpendicular to the main axis of the Benue Trough

and the Niger delta basin of Nigeria (Fig. 1). It is frequently regarded as the north western extension of the Anambra Basin, both of which were major depocentres during the third major transgressive cycle of southern Nigeria in the Late Cretaceous times (Murat, 1972). The adjacent Anambra Basin has an estimated reserve of one billion barrels of oil and about 30 trillion cubic feet of gas (Dublin-Green and Agha, 1999).

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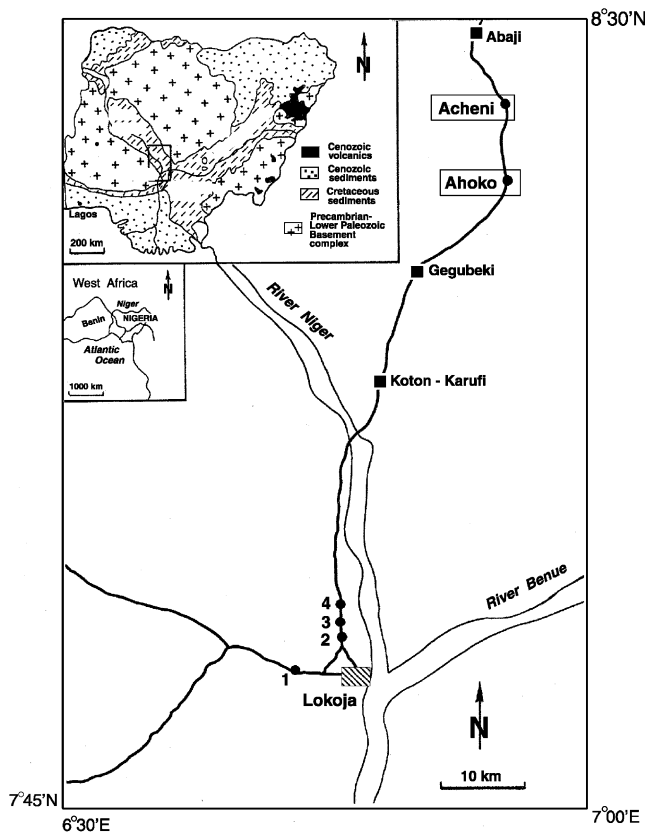


Fig. 1. Location of the study area on a simplified geological map of Nigeria (inset) as a part of the West African Sub-region (small inset map). The positions of the investigated samples are indicated. Locations 1, 2, 3 and 4 indicate the exposed sections of the Lokoja Formation; Ahoko and Acheni (boxed in Fig. 1) indicate the exposed sections of the Patti Formation that were investigated. Lokoja is situated at Latitude 7°49' N, Longitude 6°44' E.

Interpretations of Landsat images, borehole logs, as well as geophysical data across the entire Middle Niger Basin suggest that the basin is bounded by a system of linear faults trending NW-SE (Kogbe et al., 1983). Gravity studies also confirm central positive anomalies flanked by negative anomalies as shown for the adjacent Benue Trough and typical of rift structures (Ojo, 1984; Ojo and Ajakaiye, 1989; Kogbe et al., 1983). The Benue Trough is a failed arm of a triple junction (aulacogen) that existed beneath the present position of the Niger delta during the Cretaceous times. The trough is filled with over 5000 m of predominantly Aptian to Maastrichtian sediments in the lower, middle and upper Benue geographical regions. The lower Benue Trough comprising of the Anambra Basin is considered as the southern extension of the Bida Basin. Initial gravity studies in the Bida Basin put the maximum thickness of the sedimentary successions at about 3.5 km (Ojo, 1984) in the central axis. Although the hydrocarbon potential of the basin has not been properly tested with seismics and the basin remain undrilled, both ground and aeromagnetic studies by several workers have outlined the basin configuration

(Adeniyi, 1985; Udensi and Osazuwa, 2004). A recent spectral analysis of the residual total magnetic field values over several sections of the basin, reveal an average depth to the basement rocks to be ca. 3.4 km with sedimentary thickness of up to 4.7 km in the central and southern parts of the basin (Udensi and Osazuwa, 2004). In general, sediment thickness decreases smoothly from the central portion to the flanks of the basin (Udensi and Osazuwa, 2004).

Previous studies on the geology of the southern Bida Basin were reported in Adeleye (1973) and the palynological studies of Du Chene et al. (1978) which reported the palynomorphs, foraminifera associations including the interpretations of the paleoenvironments of the Lokoja and Patti Formations. These authors interpreted the paleoenvironments as ranging from continental to marginal marine and marsh environments for the Cretaceous lithofacies. Whereas the origin of the oolitic ironstones in the Bida Basin has been a principal subject of several workers e.g. Adeleye (1973), Ladipo et al. (1994), Abimbola (1997), only few investigations have been made on the petroleum source rock potentials, c.f. Idowu and Enu (1992), Braide (1992a).

In the present study, paleoenvironments of the successions based on the sedimentological characteristics, organic petrology and geochemical investigation of the source rock facies are evaluated. We have carried out a traverse from Lokoja to Abaji, in the southern Bida Basin (Fig. 1), where exposed outcrops of the Lokoja Formation and the overlying Patti Formation were mapped, described and sampled. The samples were examined and studied by incident light microscopy and geochemically analysed by the Rock-Eval pyrolysis method. This contribution is a part of an on-going study of the petroleum source rock potential evaluation of the Cretaceous Benue Trough and adjacent sedimentary basins initiated by the authors at the Department of Geology, University of Ilorin.

2. Regional stratigraphic setting and paleogeography

The stratigraphic succession of the Middle Niger Basin has been collectively referred to as the Nupe Group (Adeleye, 1973, 1989) comprising a two fold northern Bida and southern Bida or Lokoja sub-basins (Fig. 2a). The study area forms a part of the southern Bida Basin, a northwesterly extension of the Anambra Basin which extends into the northern Bida Basin area (Fig. 2a). It is underlain by a north west trending belt of Upper Cretaceous sedimentary rocks that were deposited as a result of block faulting, basement fragmentation, subsidence, rifting and drifting consequent to the Cretaceous opening of the South Atlantic Ocean. Major horizontal (sinistral) movements along the north-east—southwest axis of the adjacent Benue Trough

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