



Provenance and paleoenvironment of organic matter within the Fika sediments in Chad (Bornu) Basin, northeastern Nigeria: An integrated organic geochemical and palynofacies approach



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ABSTRACT

The Upper Cretaceous Fika sediments in the Chad (Bornu) Basin were characterised to define paleoenvironment and source of the organic matter, using an integration of organic geochemical analyses and palynofacies observations. The present-day TOC contents of the Fika sediments are in the range of 0.41–2.37 wt%, while the Hydrogen Index (HI) values are largely below 200 mg HC/g TOC, suggesting that the sediments generally have fair to good generative potential and contain mainly Type III and Type IV kerogens. This is supported by palynofacies observations whereby the kerogen is characterised by large amounts AOM and phytoclasts. The Fika sediments have vitrinite reflectance and T_{max} values in the range of 0.70–1.34% and 429–465 °C, respectively, indicating early-mature to late-mature stage of oil-window. The level of organic maturation in Fika sediments was further supported by the several biomarker maturity indicators.

Biomarker distributions and palynofacies data provide evidence for a mixed aquatic algae and terrigenous organic matter input deposited in a marginally marine, moderate salinity, proximal setting with a strong influx of terrestrial plant under environmental conditions that were mostly suboxic. Compound specific isotopic analysis of *n*-alkanes fraction were also used for the paleoenvironmental inferences. The flat portion pattern of the *n*-alkane profile between *n*-C₂₁ and *n*-C₂₆ in Fika samples is an indication of marine environment and it shows that Fika sediments consist of both terrestrial and marine organic matter deposited in fluvial/deltaic to shallow marine settings.

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1. Introduction

Chad Basin, also known as Bornu Basin, is one of Nigeria's frontier inland sedimentary basins where exploration activities are currently being undertaken (Fig. 1). These inland basins constitute parts of a series of rift basins in Central and West Africa whose origin is linked to the separation of the African crustal blocks in the Cretaceous as part of the West and Central African Rift System (Fairhead 1986; Genik 1992, 1993) (Fig. 1). Apart from Chad (Bornu) Basin and other inland basins in Nigeria, commercial hydrocarbon deposits have been discovered in the other part of the rift trend in neighbouring countries of Chad (Doba, Doseo and Bongor fields), Niger (Termit-Agadem Basin) and Sudan (Muglad Basin), which are genetically related and have the same structural settings (Mohammed et al. 1999; Obaje et al. 2004). According to them, the major source rocks and reservoirs in the Muglad Basin discoveries are in the Aptian-Albian-Cenomanian continental

deposits of the Abu Gabra and Bentiu Formations respectively, which are similar and correlatable to the well-developed Bima Formation in the Nigerian sector of the Chad Basin and the Upper Benue Trough. Of the 23 exploratory wells drilled in the Nigerian part of the basin by the Nigerian National Petroleum Corporation, minor gas shows were encountered in only two of the wells. This has however triggered intensive studies of the area.

The poor knowledge of the evolution of the subsurface rocks in the Chad (Bornu) Basin, especially with respect to the characteristics and the depositional conditions of the organic matter within the potential source rocks may have been responsible for the unsuccessful exploration attempts within the basin. This paper focuses on the integration of detailed organic geochemical and palynofacies approach to study the Fika Formation sediments, in order to provide further insights on the organic matter provenance and the environment of deposition.

The gas chromatography–isotopic ratio/mass spectrometry (IRM–GC–MS) technique, which is one of the methods applied in this study, has been one of the most important analytical developments in organic geochemistry in the past decades. The method enables improvement of

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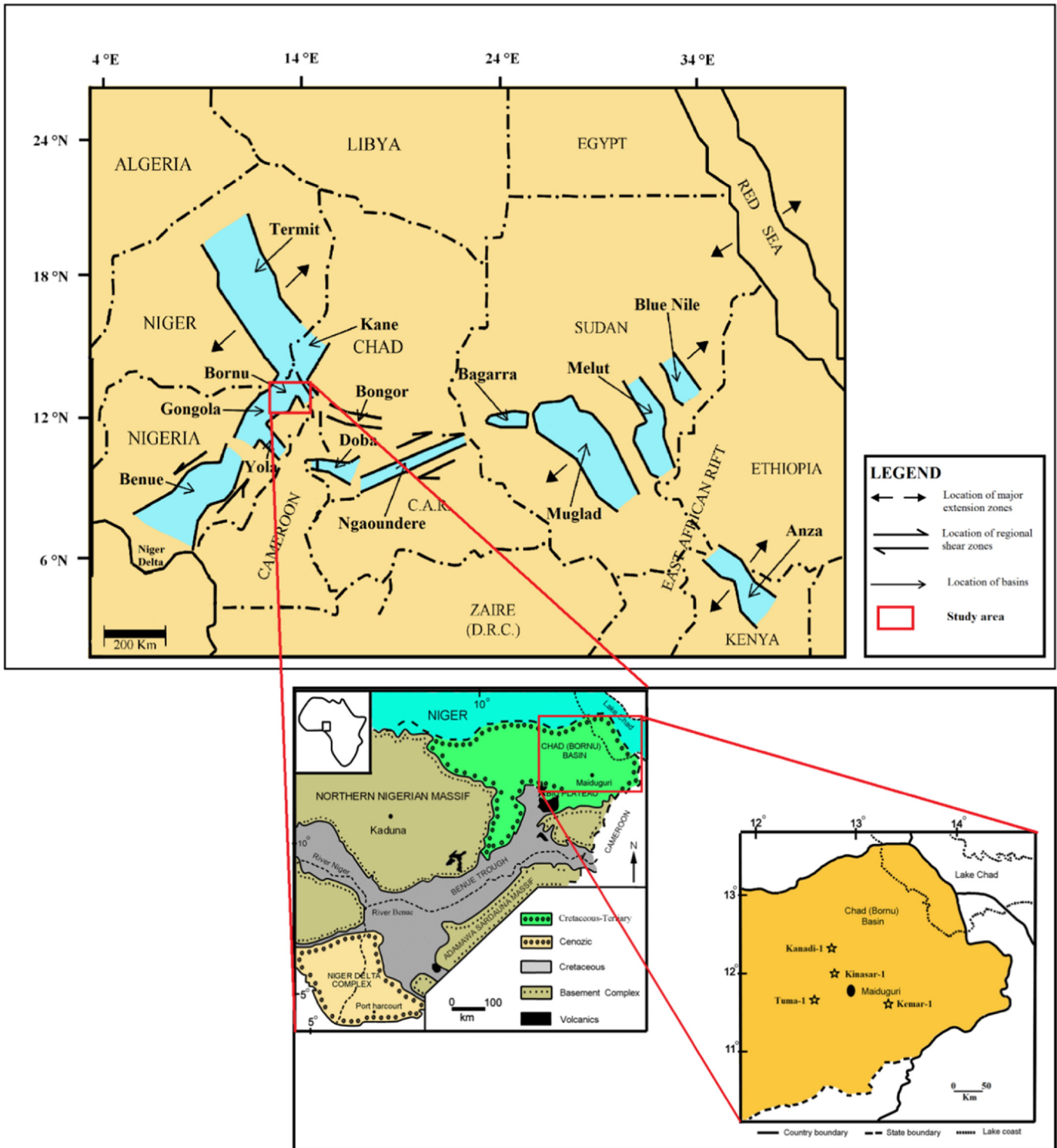


Fig. 1. Regional tectonic map of western and central African rifted basins showing the relationship of the Chad (Bornu) Basin to the Benue, Muglad, Doba and East Niger Basins and the geological map of Nigeria, showing the location of Chad (Bornu) Basin and the studied exploratory wells: Kinasar-1; Kanadi-1; Tuma-1; Kemar-1 (after Whiteman 1982; Schull 1988).

the reliability of organic source characterisation as well as its depositional environment (Schoell 1984; Sofer 1984; Hayes et al. 1987; Hayes et al. 1990; Philp 1996; Cortes et al. 2010). This detailed study is aimed at re-appraising and validating the potentials of the Fika Formation sediments as potential source rocks, and hence ultimately provides further insight into the geology of the basin, for future petroleum exploration programme and resource assessment in the region.

2. Geology of Chad (Bornu) Basin

The Chad Basin is an extensive structural depression, occupying an area of about 2,335,000 km² in Chad Republic, Niger Republic and extending into Cameroon, Central Africa Republic, Sudan and northeast Nigeria. The Nigeria sector of the basin (also known as Bornu Basin), which represents about one-tenth of the total area extent of the Chad Basin, is believed to be genetically linked with the Benue Trough, thus

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