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Facies analysis, palaeoenvironmental reconstruction and stratigraphic development of the Early Cretaceous sediments (Lower Bima Member) in the Yola Sub-basin, Northern Benue Trough, NE Nigeria

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ABSTRACT

The Benue Trough of Nigeria is a major rift basin formed from the tension generated by the separation of African and South American plates in the Early Cretaceous. It is geographically sub-divided into Southern, Central and Northern Benue portions. The Northern Benue Trough comprises two sub-basins; the N–S trending Gongola Sub-basin and the E–W trending Yola Sub-basin. The Bima Formation is the oldest lithogenetic unit occupying the base of the Cretaceous successions in the Northern Benue Trough. It is differentiated into three members; the Lower Bima (B1), the Middle Bima (B2) and the Upper Bima (B3). Facies and their stratigraphical distribution analyses were conducted on the Lower Bima Member exposed mainly at the core of the NE–SW axially trending Lamurde Anticline in the Yola Sub-basin, with an objective to interpret the paleodepositional environments, and to reconstruct the depositional model and the stratigraphical architecture. Ten (10) lithofacies were identified on the basis of lithology, grain size, sedimentary structures and paleocurrent analysis. The facies constitute three (3) major facies associations; the gravelly dominated, the sandy dominated and the fine grain dominated. These facies and facies associations were interpreted and three facies successions were recognized; the alluvial–proximal braided river, the braided river and the lacustrine–marginal lacustrine. The stratigraphic architecture indicates a rifted (?pull-apart) origin as the facies distribution shows a progradational succession from a shallow lacustrine/marginal lacustrine (at the axial part of the basin) to alluvial fan (sediment gravity flow)–proximal braided river (gravel bed braided river) and braided river (channel and overbank) depositional systems. The facies stacking patterns depict sedimentation mainly controlled by allogenic factors of climate and tectonism.

1. Introduction

The opening of the Atlantic Ocean which started at the beginning of the Mesozoic triggered the crustal fragmentation of the West and Central African craton into rift systems. The Benue Trough is one of the major rift basins formed from the tension generated by the separation of the African and South American plates (Fig. 1). It is a NE–SW trending, intra-continental, Cretaceous sedimentary basin in Nigeria that extends about 1000 km in length and 50 km in width (Fig. 2). It extends from the Niger Delta in the southwest to the Chad (Bornu) Basin in the northeast (Maurin et al., 1985).

Several authors have presented tectonic models for the genesis of the Benue Trough (Abubakar, 2014). King (1950) proposed tensional movement resulting in a rift while Stoneley (1966) proposed a graben-like structure. The RRF triple junction model leading to plate dilation and opening of the Gulf of Guinea was proposed by Grant (1971). Olade (1975) considered the Benue Trough as the third failed arm or aulocogen of a three armed rift system related to the development of hotspots. Benkhelil (1982, 1989) and Guiraud and Maurin (1992) considered wrench faulting as the dominant tectonic process during the Benue Trough evolution and defined it as a set of juxtaposed pull-apart basins generated along the pre-existing N60°E strike-slip faults.

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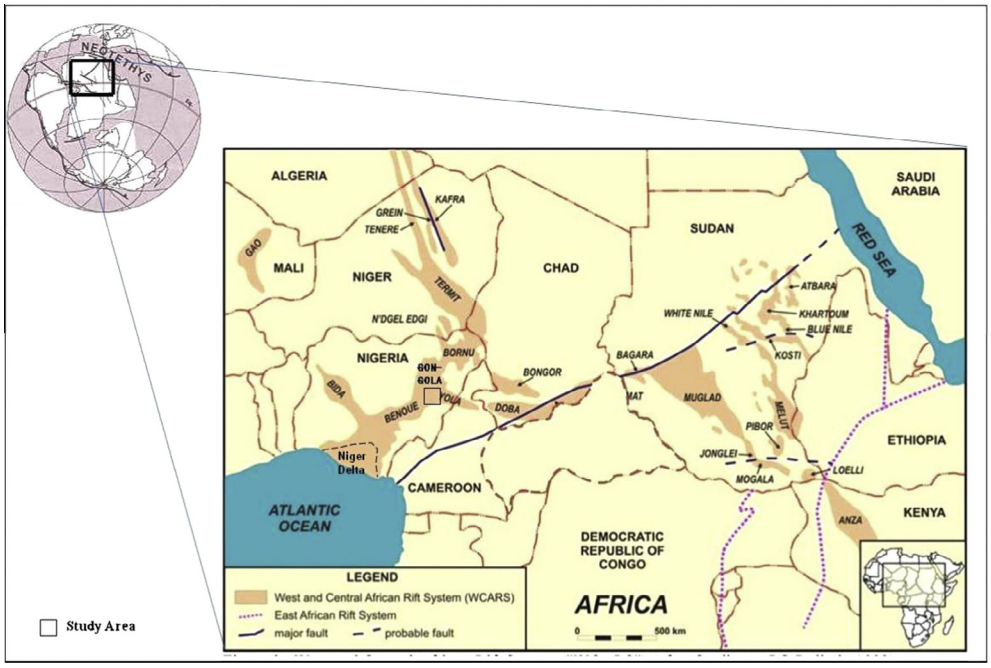

Fig. 1. West and Central African Rift System showing the Nigerian Benue Trough modified (from United Reef Limited Report, 2004).

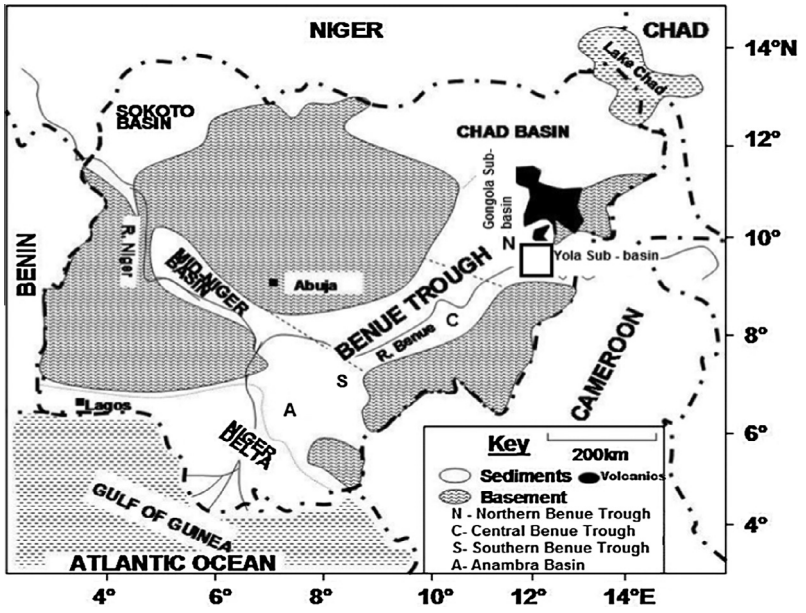

Fig. 2. Generalized geological map of Nigeria showing the study area represented as open square (from Abubakar et al., 2008).

The Benue Trough is geographically sub-divided into Southern, Central and Northern portions (Nwajide, 2013). The Northern Benue Trough is made up of two major sub-basins; the N–S trending Gongola Sub-basin and the E–W trending Yola Sub-basin. Carter et al. (1963), Offodile (1976), Benkhelil (1989), Zaborski et al. (1997), Obaje et al. (2000), and Abubakar (2006) have described in detail the geology and stratigraphy of the Northern Benue Trough. The stratigraphic succession in the Yola Sub-basin of the Northern Benue Trough (Fig. 3) comprises the continental Lower Cretaceous Bima Formation, the Cenomanian transitional marine Yolde Formation and the marine late Cenomanian–Santonian Dukul, Jessu, Sekuliye formations, Numanha Shales and Lamja Sandstones (Carter et al., 1963; Abubakar, 2006).

This article describes and analyses the lithofacies of the Early Cretaceous continental sediments of the Bima Formation (Lower Bima Member) and their stratigraphical affinities with an objective of identifying palaeodepositional environments, reconstruction of stratigraphical architecture and depositional model so as to provide an impetus to research on the viability of Early Cretaceous petroleum system in the Yola Sub-basin of the Northern Benue Trough. This study is important for the tectonosedimentary understanding of Early Cretaceous sedimentation in the Bima Formation in its relation to similar formations within the West and Central African Rift System (WCARS) proven as good petroleum systems in the Muglad Basin of Sudan and in the Termit Basin of Niger and Chad Republics (Abubakar, 2006).