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Hydrocarbon potential of Cretaceous sediments in the Lower and Middle Benue Trough, Nigeria: Insights from new source rock facies evaluation

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ABSTRACT

The Nigerian Benue Trough is an intracratonic rift structure which evolution is related to the Early Cretaceous opening of the South Atlantic Ocean and the Gulf of Guinea. Previous hydrocarbon potential assessments of the successions in the trough revealed a number of organic rich intervals capable of yielding significant quantities of hydrocarbons in the Cretaceous sections. Stratigraphic continuity of these intervals suggests their potentials for hydrocarbons if thermally mature and both oil and gas can be generated.

The present study have expanded on some previously reported source rock data of the Cretaceous formations in the Benue Trough by detailed mapping of the stratigraphic intervals with source rock potentials on the basis of their structural setting, lithologic characteristics, and depositional environments. Further characterization of the organic matter within the Cenomanian to Coniacian on one hand and the Campanian to Maastrichtian intervals were carried out to determine the geochemical character of the organic rich zones, their maturity and effectiveness to generate and expel hydrocarbons.

In the Lower Benue Trough, mature facies of the Cenomanian to Turonian Eze–Aku Formation with a predominance of Types II and III kerogen, the Turonian to Coniacian Type III dominated Awgu Formation and the Type III dominated Lower Maastrichtian sub-bituminous coals of the Mamu Formation have proven potentials as oil and gas source rocks. In the Middle Benue Basin, the preserved mature intervals of the Awgu Formation shales and coals are good gas source rocks with some oil prone units in view of the predominating Type III kerogen. Targets for hydrocarbons generated by these source rock intervals should focus on the non-emergent Cretaceous reservoirs within the pre-Santonian successions whereas, the mature equivalents of the sub-bituminous coal facies would generate and charge both Upper Cretaceous reservoirs and possibly the sub-Niger Delta successions in the sub-surface.

1. Introduction

The Benue Trough in Nigeria consists of a series of rift basins which form a part of the Cretaceous–Tertiary basins of the Central West African Rift System of the Niger, Chad, Cameroon and Sudan (Fig. 1, Schull, 1988; Genik, 1993). Basement fragmentation, block faulting, subsidence and rifting accompanying the opening of the South Atlantic Ocean led to the deposition and accumulation of sediments ranging between 4000 and 6000 m in the greater Benue Trough along the 800 km axis over a width of ca.120 km from the northern parts of the Niger Delta Basin in the south west to the margin of the Chad Basin in the north east (Fig. 2). The Benue Trough can geographically be divided into the Lower, Middle and Upper Benue Basins with the Lower Benue consisting of the Abakaliki and Anambra Basins and the Middle Benue Basin occupying the region north of the Gboko regional fracture system i.e. the Gboko Line (Fig. 2). Despite the identical processes of evolution, localized geological factors controlled the basins development and are reflected in the lithostratigraphy and ages of the facies associations. Previous work have laid emphasis on the geology of the petroliferous Anambra Basin because of the good exposures of the Cretaceous successions and exploration wells drilled by oil companies compared with the Abakaliki Basin and the adjoining Middle Benue Basin. A review of exploration activities in the inland sedimentary basins indicate that the only three exploration wells drilled in the last decade were spud on the north side of the Upper Benue Trough. The three wells; (Kolmani River-1, Kuzari-1 and Nasara - 1) were drilled in the Gongola Basin. In contrast, the Lower and

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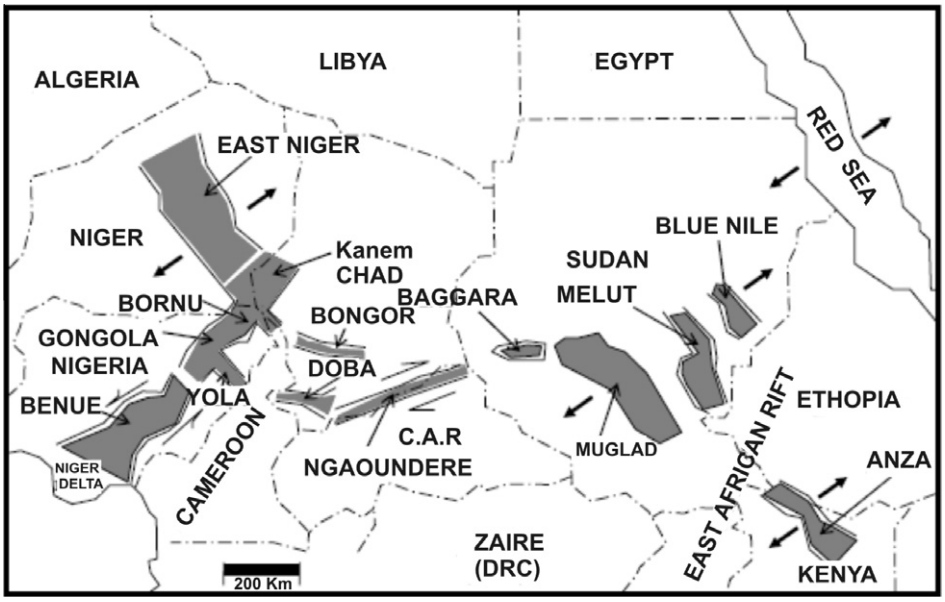

Fig. 1. The Central West African Rift System showing the trends of rift basins. Relationships of Benue Trough, the East Niger, Doba, Muglad and Melut basins are indicated (Adapted from Schull, 1988).

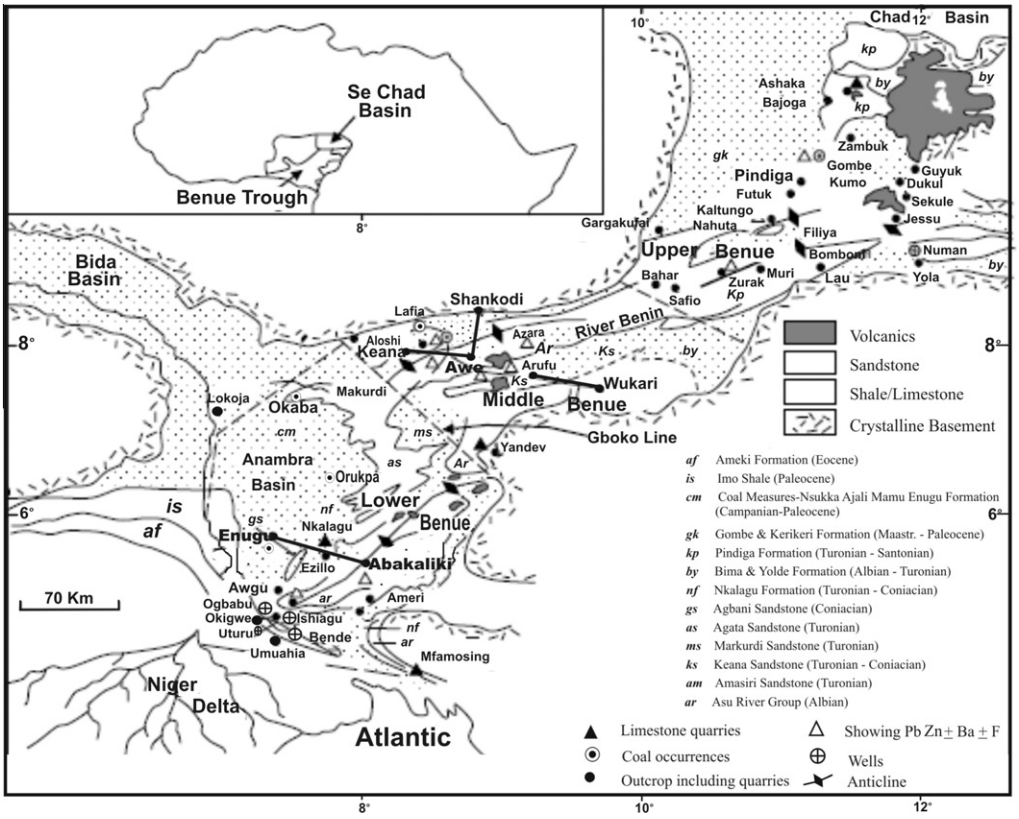

Fig. 2. Geological map of the Benue Trough showing the Lower and Middle Benue basins and traverses investigated for this study; notice the position of the Niger Delta Basin (modified from Akande, 1999).

Middle Benue Basins with obvious stratigraphic continuity were avoided despite the substantial thicknesses of the Cretaceous–Tertiary sediments in these basins. The presence of up to 8000 m of Cretaceous–Tertiary sediments in the Lower Benue Anambra Basin with substantial thicknesses of proven potential source rock facies, seals and traps and the occurrences of volatile and sub-bituminous coals in both the Lower and Middle Benue Basins (Obaje et al., 2004) support the need for more detailed exploration for the petroleum systems. Data from early drilling activities in these basins before the huge discoveries of the Niger Delta indicate both oil and gas finds in the Anambra Basin at various stratigraphic intervals including the antecedent Abakaliki and Middle Benue Basins