STRATIGRAPHIC SUCCESSION AND AGE OF CRETACEOUS SEDIMENTARY ROCKS IN THE HAWAL BASIN, NE NIGERIA.

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ABSTRACT

A stratigraphic analysis of Cretaceous sedimentary rocks in the Hawal basin, NE Nigeria, shows that the rocks are composed of sandstones, siltstones, clays, shales and fossiliferous limestones. Six lithofacies are recognized from top to bottom these are the

(i) bioturbated sandstone facies,
(ii) clay-shale facies,
(iii) calcareous sandstone-siltstone facies,
(iv) limestone - clay facies,
(v) calcareous sandstone facies, and the
(vi) pebbly sandstone facies.

The vasesoserpentin ammonite fauna occurring in the limestone-clay facies indicated an Upper Cenomanian - Middle Turonian age for the facies. Correlation with the sequence presented by the Asoko Cement quarry in Bauchi State shows that the pebbly sandstone facies represents the Bima Sandstone (Aptian-Cenomanian), the calcareous sandstone facies represents the Yolde Formation (Cenomanian), while the limestone - clay facies, calcareous sandstone facies, clay-shale facies, and the bioturbated sandstone facies represent the Gongola Formation (Upper Cenomanian - Upper Turonian).

The sediments can therefore be dated Upper Albian (?) - Upper Turonian. This represents the first detailed age-dating of the Cretaceous sedimentary rocks in the Hawal basin.

INTRODUCTION

Cretaceous sedimentary rocks of the Hawal basin crop out along a narrow E - W belt from the vicinity of Kobci at the south eastern margin of the Chad basin, to Yadi Gitam, about 200 km west of Kobci and north of Biu plateau. The rocks overlie the basement complex in the southeast and are covered in the northern and southwestern parts by the Paleocene Kerri-Korri Formation and the Quaternary Biu basalt respectively (Fig. 1). This study covers the western portion of the outcrop defined by latitudes 12°02'2"E and 12°30'3"E, and longitudes 10°55"N and 11°55"N (about 200 km², see Fig. 2).

The Cretaceous sedimentary rocks in the study area comprise principally feldsparic sandstones, calcareous sandstones and siltstones, clays, shales and shelly limestones. Poor accessibility hindered previous studies of these rocks, hence their true ages have remained uncertain. Cratchley and Jones (1965) described them as Tertiary sediments, while Dassauvage (1975) grouped them as the Aptian - Cenomanian Bima - Yolde Formation.

This investigation was therefore carried out to establish the stratigraphic succession and ages of the various Cretaceous sedimentary rock units in this area.

During the field work, stream sections and lithologic logs of boreholes and hand-dug wells were described and analyzed to established the stratigraphic succession. The various formations present in the area were identified on the basis of stratigraphic correlation with the formation occurring in the adjoining Gongila - Gombe basin, while the ages of the various lithofacies were established based on the ammonite biostratigraphy of northeastern Nigeria, and lithostratigraphic correlation.

REGIONAL STRATIGRAPHIC SETTING

Three sedimentary basins make up Gongola arm of the Benue Trough. These are the Gongola - Pindiga basin south of the Zambuk ridge, the Gombe basin north of the Zambuk ridge, and the Hawal basin southeast of the Chad basin. Direct correlation of the stratigraphic successions in the three basins have not been possible mainly due to scarcity of outcrops. In a reinvestigation of the Gongila and Pindiga Formations occurring in the Gombe - Gongola and Gombe-Pindiga basins respectively, Popoff et al., (1986) correlated their diverse lithologies and Formations.
The oldest sediments in the Gongola arm of the Benue Trough belong to the Aptian - Albian Bima Sandstone (Allix et al., 1981) which unconformably overlies the Precambrian crystalline basement complex. The sediments are fluvial and deltaic - lacustrine in origin, and consist of coarse feldspathic grits, sandstones and ironstones (Carter et al., 1963). Next in succession is a variable sequence of calcareous sandstones and shales of the Yolde Formation (Albian - Cenomanian) representing the transition from continental to marine deposition (Carter et al., 1963).

A major epoch of volcanic activity occurred in the Late Tertiary and Quaternary during which numerous volcanic plugs were emplaced, and the great lava plateau of Biu and Longuda were built. The basalts were later to be covered by the fluvio-lacustrine sands at clay of the Pleistocene Chad Formation (Raeburn and Jones, 1934; Carter et al., 1963).

**VERTICAL SUCCESSION**

A total of thirty-six exposures representing the entire sequence of Cretaceous sediments in the Hawal basin were described. Six lithofacies were identified. From top to bottom these are the

- bioturbated sandstone facies,
- clay-shale facies,
- calcareous sandstone-siltstone facies,
- limestone - clay facies
- calcareous sandstone facies, and the
- pebbly sandstone facies.

The vertical succession of these facies is shown in Fig. 3, and described below from bottom to top.
**Facies I:** The pebbly sandstone facies rests unconformably on the Precambrian crystalline basement complex. It outcrops only in the southern part of the study area where it is concealed over a large area by basalt eluvium. The total thickness of the facies is in excess of 5 m. In all its exposures the facies is seen to be dominated by pebbly and medium-grained, cross-bedded, feldspathic sandstones with minor developments of siltstones and tronstones. It is generally brown in colour as a result of extensive ferruginization. Locally it may be pinkish or chalky as a result of kaolinization.

**Facies II:** The calcareous sand facies is represented by a fining-upward sequence of calcareous, silty, medium-coarse grained sandstones and very fine-grained sandy claystones, which occur at the top of the pebbly sandstone facies. A maximum thickness of 4 m of the facies was recorded over the area studied. The facies is generally grey in colour, and becomes darker as the silt and clay content increase toward the top. It is easily distinguished on the basis of its calcareous, silty and often nodular nature.

**Facies II:** The dark grey silt/fine sandy claystones of facies II grades into the massive limestone of the overlying limestone - clay facies. The facies is an 18 m thick sequence of alternating fossiliferous limestone and blue-grey gypsiferous clay with intercalations of marl and shale. It has two main limestone horizons separated by 6 m of laminated blue-grey clay (Fig. 3).
The lower horizon is 5 m thick, and composed of a basal shelly limestone (1.0 m thick) capped by 15 cm of ferruginous crust, and successively overlain by massive fossiliferous marly limestone (1.0 m), laminated grey shale (1.0 m), and hard, yellow-creamy white massive limestone (2.0 m) dominated by bivalve and gastropod shell fragments and containing well preserved fossils of the vasconeratid ammonite, *Vascoceras* (Pl. 1(a)).

The Upper horizon consists of two oyster-type bivalve shell beds approximately 1.0, and 2.0 m thick respectively, separated by a fossiliferous hard ground, 5 cm thick, and topped by a 4 m thick sequence of gypsiferous blue-grey clay with clay-shale intercalations towards the base. The horizon yielded fossils of the *Vascoerceratid Gombeoceras*, *Paravascoerceras*, and *Nigericeras* (Pl. 1(b-d)).

The limestone - clay facies crops out in a narrow E-W belt, 8 km long, across the southern part of the study area (Fig. 4).
Facies IV: The calcareous sandstone - siltstone facies is about 10.5 m thick. The succession commences with about 1.0 m of inter-laminated, burrowed, calcareous sandstones and siltstones capped by a ferruginous crust. This is overlain by 50 cm of fine-grained sandy siltstone overlain in turn by 2.0 m of well sorted, medium grained sandstone cemented by iron-carbonate. This is in turn succeeded by 2.0 m of siltstone beds, followed by 3.0 m of medium-grained, thin bedded sandstone. Individual beds may be 30 cm to 40 cm thick. The top of the facies rests on a ferruginous crust and is composed of 2.0 m of white, laminated, kaolinitic, fine-sandy siltstone which grades upward into the clay-shale of overlying facies V.

Facies V: The clay - shale facies is a sequence of interbedded gysiferous shale, claystone and siltstone which becomes more sandy towards the top.

The basal part is mottled purple, pink and white, and composed of 1.5 m of finely laminated gysiferous shale overlain by 2 m of bioturbated claystone with bands of shale. Small-sized, well preserved bivalves and gastropod shells were recovered from this horizon. It grades upward into 2 m of increasingly bioturbated, interbedded, kaolinitic clayey siltstones and clayey sandstones.

Facies VI: The silty top of the clay - shale facies grades upward into the bioturbated sandstone facies - a sequence of alternating fine to medium grained sandstone and siltstones. A total of 6 m of this facies was studied. The sequence is generally grey-brown in colour, calcareous, cross-bedded, and abundantly burrowed. The cross-beds are essentially the tabular and trough types. Each tabular set measures between

Figure 4: Facies map of the study area.
12cm and 25cm in thickness, and dips at an angle of 30°. They alternate with sets of low - angled (5° - 8°) bidirectional cross-beds.

The burrow structures are reminiscent of the resting and dwelling structures of Crustaceans which inhabit the shallow marine (intertidal - subtidal) environments (Seilacher, 1964; Frey 1973).

The bioturbated sandstone facies is overlain by kaolinitic grey clays and grits of the Paleocene Kerri-Kerri Formation. This is identified by its characteristics lateritic top layer.

The area distribution of the six facies is shown in Fig. 4.

**Figure 5:** Stratigraphic correlation of the studied area with the quarry section at Ashaka indicating the age of the rocks.

**CORRELATION AND AGE**

The ammonite biostratigraphy of northeastern Nigeria (Barber 1957; Reyment 1965; Wozny and Kogbe 1983) has been refined and updated by Popoff et al., (1986). In a reinvestigation of the Gongila and Pindiga Formations of northeastern Nigeria at Ashaka and Pindiga localities...
respectively, they recognized and assigned seven ammonite zones to the Upper Cenomanian - Middle Turonian (Table 1).

Comparison of the stratigraphic section at Ashaka cement quarry with the section established in this study (Fig. 5) brings out the similarity of the facies and the fauna. The overall facies differentiation in the two sections is remarkably similar. The basal portion in the studied area, made up of coarse feldspathic sandstones, capped by calcareous sandstones and siltstones, correlates with the continental Bima Sandstones (Aptian - Cenomanian) and the overlying transitional marine Yolde Formation (Cenomanian) of the Ashaka section. The overlying interbedded sequence of ammonitiferous limestones and gypsiferous clays (facies III), sandstones, siltstones, clays and shales (facies IV, V and VI) represents the Gongila Formation of the Ashaka section.

**Table 1: Upper Cenomanian and Turonian ammonite zones for N.E. Nigeria**

<table>
<thead>
<tr>
<th>TURONIAN</th>
<th>Upper</th>
<th>Lower</th>
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<tbody>
<tr>
<td></td>
<td>Choffaticeras Bajomi / Pagaesi n. sp. of Spheroidalis Pseudotissotia walsi</td>
<td>Paravascoceras coostatum (condensed)</td>
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<tr>
<td></td>
<td>Pseudotissotia nigeriensis</td>
<td>Vasco ceras bulbosum</td>
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<tr>
<td></td>
<td></td>
<td>Vasco Cerar tauriac</td>
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<tr>
<td></td>
<td></td>
<td>Nigericeras gadeni</td>
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</tbody>
</table>

After Popoff et al., 1986

The fauna of the limestone - clay facies is typical of the Upper Cretaceous of northeastern Nigeria. The late Cenomanian marked by the early vascoceratid zone (Popoff et al., 1986) is identified by the occurrence of *Vascoceras* in the lower half of the sequence. The Lower Turonian marked by the late vascoceratid zone (Popoff et al., 1986) is identified by the occurrence of *Paravascoceras* higher up the limestone - clay facies. *Gombeoceras* which occurs in the uppermost portion of the facies indicates the Middle Turonian. Though the predominantly arenaceous top of the section is not apparently fossiliferous, it is possible that sedimentation continued into the Upper Turonian.

The Cretaceous sedimentary rocks occurring in the Hawal basin can therefore be dated Upper Albian (?) - Upper Turonian. Table 2, summarizes the correlation of the formations in the three sedimentary basins of the Gongola arm of the Benue Trough.

**CONCLUSIONS**

Cretaceous sedimentary rocks are exposed only in the southern half of the Hawal basin. The rocks thicken toward the north and into the Chad basin. The stratigraphic succession commences with continental facies of the Aptian - Cenomanian Bima Sandstone composed of pebble beds and coarse grained feldspathic sandstones. The sediments rest unconformably on the Precambrian crystalline basement complex, and occur in an east - west belt marking the southermost limit of Cretaceous sedimentary rocks in Hawal basin.

The Bima Sandstone is succeeded by the transitional Yolde beds comprising few meters (approximately 4.5 m) of calcareous nodular sandstones and siltstones of Cenomanian age.

The Yolde Formation passes conformably up into the basal (Upper Cenomanian) beds of the ammonitiferous Gongila Formation composed of an interbedded sequence of massive limestone, marl, shale and clay. The sequence grades upward into shell beds, blue - grey gypsiferous clay and clay-shale intercalations, and ends finally with a more arenaceous sequence of siltstones and sandstones. These upper beds of the Gongila Formation represent the Turonian sedimentation in the Hawal basin. Three levels of ferruginous crusts (5 cm - 15 cm thick) occur within the Gongila Formation in this area. These indicate breaks in the Upper Cenomanian - Upper Turonian sedimentation. The Gongila Formation elsewhere, in the Gongola arm of the Benue trough may exceed 400 m (Carter et al., 1963, Reymond 1965, Wright et al., 1985, Popoff et al., 1986), but only 28 m of the formation is recorded in this study.

The Gongila Formation is overlain in the northern areas by kaolinitic grey clays and grits of the Paleocene Kerri-Kerri Formation distinguished on the basis of its characteristic prominent laeitric top layer, while in the southern part of the region it is concealed over large area by basalt eluvium.

**ACKNOWLEDGMENT**

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Table 2: Stratigraphic sequences in the Gongola aem of the Benue Trough

<table>
<thead>
<tr>
<th>Chronology</th>
<th>Pindiga—Gombe basin</th>
<th>Gombe—Gongila basin</th>
<th>Hawal basin</th>
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<tr>
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<td>Neogene</td>
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<tr>
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<td>Campanian</td>
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REFERENCES


