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The Upper Cretaceous Gongila and Pindiga Formations, northern Nigeria: Subdivisions, age, stratigraphic correlations and paleogeographic implications[1])

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ABSTRACT

The Upper Cretaceous Gongila and Pindiga Formations of the northeastern Benue and Gongola Troughs in northeastern Nigeria, were re-investigated near their type localities. Special attention has been drawn to the ammonites. Due to detailed studies of ammonite systematics, many of the previous "endemics" of the Benue Trough can now be identified as cosmopolitan species. Seven ammonite zones were recognized in both sections and were assigned to the Upper Cenomanian and Lower and Middle Turonian. These zones can now be easily correlated with the mid-Cretaceous ammonite zonations of the western and eastern Mediterranean. This means that a Trans-Saharan Seaway must have existed and began to connect the Benue Trough and the Maghreb area during the late Cenomanian. Possibly, another seaway existed across Sudan and Egypt, also connecting the Benue Trough with Israel, Jordan and the eastern Mediterranean.

ZUSAMMENFASSUNG

Die oberkretazischen Gongila- und Pindiga-Formationen in den nordöstlichen Benue- und Gongola-Trögen Nordost-Nigerias werden in der Nähe ihrer Typlokalitäten revidiert. Schwerpunkt der Untersuchungen bilden die Ammoniten. Eine Revision der Ammoniten-Systematik ergibt, dass viele der bisherigen «Endemismen» des Benue-Trogs heute kosmopolitischen Arten zugeordnet werden können. Sieben Ammoniten-Zonen werden in beiden Profilen ausgeschieden und Oberem Cenoman, Unterem sowie Mittlerem Turon zugerechnet. Diese Zonen können nun mühelos mit den synchronen Zonen des westlichen und östlichen Mediterrangebiets korreliert werden. Das bedeutet, dass die «Transsahara-Strasse» schon im höheren Cenoman bestanden und eine Verbindung zwischen Benue-Trog und den Maghreb-Becken hergestellt haben muss. Möglicherweise hat ausserdem eine Verbindung über den Sudan und Ägypten mit den sehr ähnlichen Schicht- und Faunenfolgen in Israel und Jordanien bestanden.

1. Introduction

Due to new field investigations in the Benue and Gongola Troughs (northeastern Nigeria) and to new exposures of the Gongila Formation in the Ashaka Cement quarry

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(Fig. 1–3) a re-investigation of their fossil content and stratigraphic range is warranted. The quarry is situated near the type locality of this formation (CARTER et al. 1963, p. 53) near the village of Gongila, in the Gongila-Gombe Basin, northern Gongola Trough. The type section of the Pindiga Formation (CARTER et al. 1963, p. 48), near the village of Pindiga was also re-investigated. Pindiga is placed (Fig. 1, 4) south of the Zambuk Ridge (CARTER et al. 1963, p. 47), a NE–SW oriented tectonic high in the NNE–SSW trending Gongola branch of the Benue Trough. The related Chad Basin extending northeastward of the area was supposedly filled during the Upper Cretaceous by waters from the Tethys and equatorial South Atlantic, which were supplied by the Trans-Saharan Seaway.

Because these beds are important for understanding the geologic history of this region, we investigated the exact age and biostratigraphic subdivisions of these two formations, their mutual relationship and that with previous biostratigraphic subdivisions, especially of the Benue Lower Turonian (BARBER et al. 1954, REYMENT 1954a, b; 1955; BARBER 1957, 1958; WOZNY & KOGBE 1983). Paleogeographic implications will be treated briefly.

Since there is some disagreement on the vascoceratid Lower Turonian ammonite zonation, especially in sections from Nigeria and the Cameroons (REYMENT 1956), Spain and Portugal (CHOFFAT 1898, WIEDMANN 1960, 1964, 1978, 1980) and Israel (FREUND & RAAB 1969; LEWY et al. 1984), this paper is also an attempt to clarify and consolidate the Lower Turonian biostratigraphy of the Mediterranean–North African region. The problem of the Cenomanian–Turonian boundary (BERTHOU & LAUVERJAT 1974, WIEDMANN & KAUFFMAN 1978, WRIGHT & KENNEDY 1981, KENNEDY 1984) is also reconsidered.

2. Regional setting and summary of previous stratigraphic data

Due to their differing lithostratigraphic records, three different paleogeographic areas were recognized in northern Nigeria. From south to north, they are a) the Upper Benue Trough, b) the "Zambuk Ridge", a basement high inside the Gongola Trough and c) the Chad Basin. Direct correlations between the diverse lithologies and their respective formations are often impossible, mainly due to the covering by vegetation and the scarcity of outcrops. Naturally, the shaly units are the most affected by covering. For the presumed correlations of the various formation names in general use, see Table 1. Around Ashaka in particular the separation of Turonian Gongila and Pindiga Formations was rather difficult. This can be seen on the 1:250000 map of CARTER et al. (1963), which is essentially the basic geological work of the region.

A. Type localities and sections

A.1 Gongila Formation

The mid-Cretaceous limestones near Gongila village were first described by FALCONER (1911). RAEBURN & JONES (1934) included these limestones from the southern Chad Basin and "Zambuk Ridge" in their "Limestone-Shale Group". Formal formation names have been given to these units by CARTER et al. (1963). They identified the Gongila Formation in the southern Chad Basin from the slightly different Pindiga Formation on the "Zambuk Ridge".

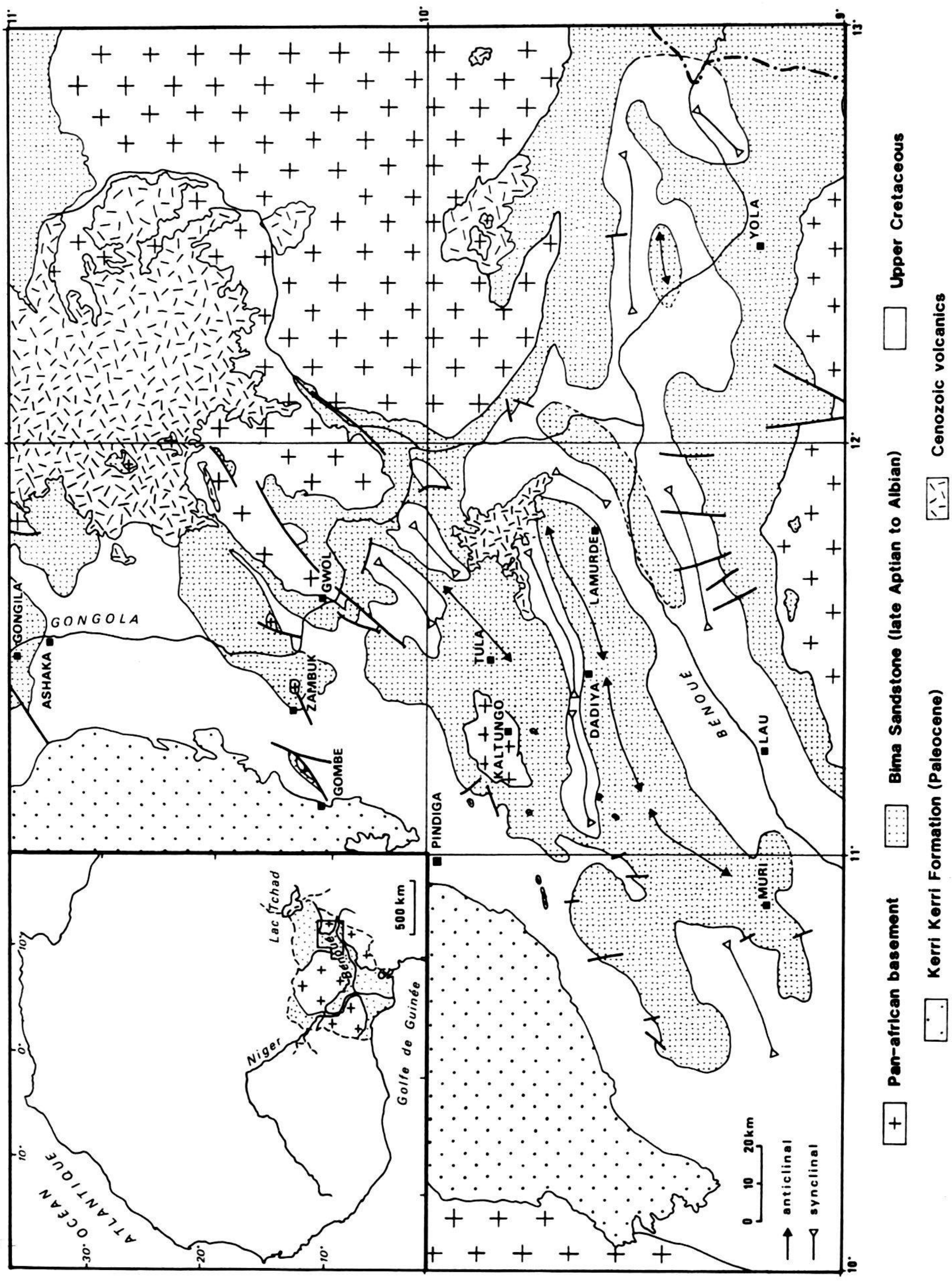


Fig. 1. Geological map of the northeastern Benue Trough (modified after DESSAUVAGIE et al. 1975).

The type locality of the Gongila Formation is a small hillside south of Gongila village near the recent quarry of the Ashaka Cement Company, approximately 80 km NNE of Gombe (Fig. 1). The thickest section is exposed in a stream south of Chole, which is considered the standard section, 16 km WNW of Gongila. The lower part of the Gongila Formation consisting of limestone, shale and marl, has been dated as Lower Turonian due to its rich ammonite content (BARBER 1957). The basal limestone overlies the Bima Formation of Upper Aptian to Albian age (ALLIX et al. 1981), and perhaps a few meters of Yolde Formation. The upper part of the Gongila Formation consists mainly of a sequence of shale and sandstone, presumably also of Turonian age.

WOZNY & KOGBE (1983) drew attention for the first time to a Cenomanian portion of the Gongila Formation. The Gongila Formation is overlain by the "Fika Shales", supposedly of ?Turonian to Maastrichtian age. This age determination also requires critical re-examination.

A.2 The Pindiga Formation

The type locality of the Pindiga Formation (CARTER et al. 1963) is situated in the Pindiga River section west and south of Pindiga, about 40 km SSW of Gombe. It was first described as part of the "Calcareous beds" and "Clay-shales" by BARBER et al. (1954).

This area belongs to the Pindiga–Gombe Basin (ALLIX 1983) where the rates of sedimentation were high from the Coniacian up to the Maastrichtian.

The lower part of the Pindiga Formation is likewise well dated using ammonite biostratigraphy. REYMENT (1965) indicated an early Turonian ("Salmurian") age for this lower portion, which consists mainly of shale but also includes a number of limestone beds. The much thicker upper part of the formation is shaly with a few very thin limestone intercalations; its age is not yet well-defined. About 6 km east of Gombe, only one well-preserved fragment of *Libycoceras ismaelis* (ZITTEL) has been found, which would indicate a Maastrichtian age (REYMENT 1955).

While the foraminiferal assemblage of the Pindiga Formation is not representative, the microflora discovered in water borehole Kumo 6, situated about 27 km ENE of Pindiga, clearly indicates a Maastrichtian age for the topmost portion of the Pindiga Formation (MOULLADE et al. 1980; LAWAL 1980, 1982). The microfloral content of another borehole near Gombe indicates a Campanian to Lower Maastrichtian age for the top of the formation (ALLIX 1983).

B. Lithostratigraphy, biostratigraphy and correlation problems

Due to the large number of formation names applied to rather limited areas of Nigeria and due to the restricted outcrops of these formations, problems arise not only in relating time-equivalent units but also in separating successive ones. One example is the "Yolde Formation" (CARTER et al. 1963, ALLIX 1983), which has been described from the Dadiya syncline south of Pindiga (Fig. 1, Table 1) as comprising transitional beds between the mainly continental Bima Sandstone (Aptian–Albian: ALLIX et al. 1981, ALLIX & POPOFF 1983) and the fully marine Pindiga Formation (Upper Cenomanian to Maastrichtian: LAWAL 1982, ALLIX 1983).

Turonian ammonites *(Coilopoceras)* have been described (BARBER 1957, REYMENT 1965) from Yolde beds, and therefore the Yolde Formation has been regarded, at least in part, to be equivalent to the Gongila Formation (DESSAUVAGIE 1975). Indeed, the Gongila Formation at Ashaka quarry (Fig. 3) seems to lie immediately over the Bima Sandstone.

Similar problems exist with the Upper Cretaceous "Fika Shale" first observed near Fika (3 km north of Gongila; RAEBURN & JONES 1934) and later described (CARTER et al. 1963) from boreholes near Maiduguri and Damagum; it is tentatively identified as Cenomanian to Maastrichtian. The Fika Shale overlies the Gongila Formation which is mainly Turonian in age; which in turn is overlain by the Gombe Sandstone, thought to be late Senonian to Maastrichtian in age (DESSAUVAGIE 1975), although it is now restricted to the Maastrichtian (ALLIX 1983).

Thus, the need of a thorough stratigraphic review of the Pindiga and Gongila Formations becomes obvious. In addition to the available macropaleontological data, the study of various microfossil groups, such as ostracodes and especially palynomorphs will be extremely useful, particularly in those parts of the sequence devoid of diagnostic macrofossils.

Due to the fact that the definition of the Cenomanian–Turonian boundary has changed in the last years, this problem also has to be treated in both sections.

Another important question is the precise dating and location of the Trans-Saharan Seaway (FURON 1935, REYMENT 1965, FREETH 1978), the wide distribution of marine sediments between the Tethys and Nigeria and the similarity of faunas at these times allow a reconstruction for the Turonian and Maastrichtian. The various sedimentary basins are separated by NE–SW fracture zones in the NNE–SSW oriented Gongola Trough, between the Chad Basin and Benue Trough. This is, therefore, a key link in answering the above question of the existence of the Trans-Saharan Seaway and in improving paleogeographic reconstructions.

3. Stratigraphic analysis

A. The Gongila Formation at Ashaka Cement quarry (Fig. 2, 3).

Due to the excavations by the Ashaka Cement Company, the Gongila Formation is perfectly exposed at Ashaka quarry. In addition the Gongila Formation is highly fossiliferous there, which facilitates biostratigraphic identification.

The lowermost 4 m of the figured section are not now exposed, since chert-bearing limestones are not adequate cement materials. But a few years ago here the base of the Gongila Formation and the contact with the underlying sandstones of the Yolde Formation were accessible.

Thus, at Ashaka quarry the following lithologies and their respective faunas can be discerned:

1. Calcareous sandstone, unconsolidated and with rare lamellibranchs, and covered by a ferruginous crust.
2. 2.50 m silty marl, calcarenite and limestone with chert with *Exogyra africana* (LMK.), *E. flabellata* GOLDF., *E. olisiponensis* SH., and *Cardium* sp.
3. 3.00 m marly and calcareous shell beds, forming the actual base of the quarry, with *Nigericeras gadeni* (CHUDEAU); moreover occur *N. lamberti* SCHNEEG., *Vascoceras* sp., *Exogyra columba* (LMK), *E.* cf. *biskarensis*

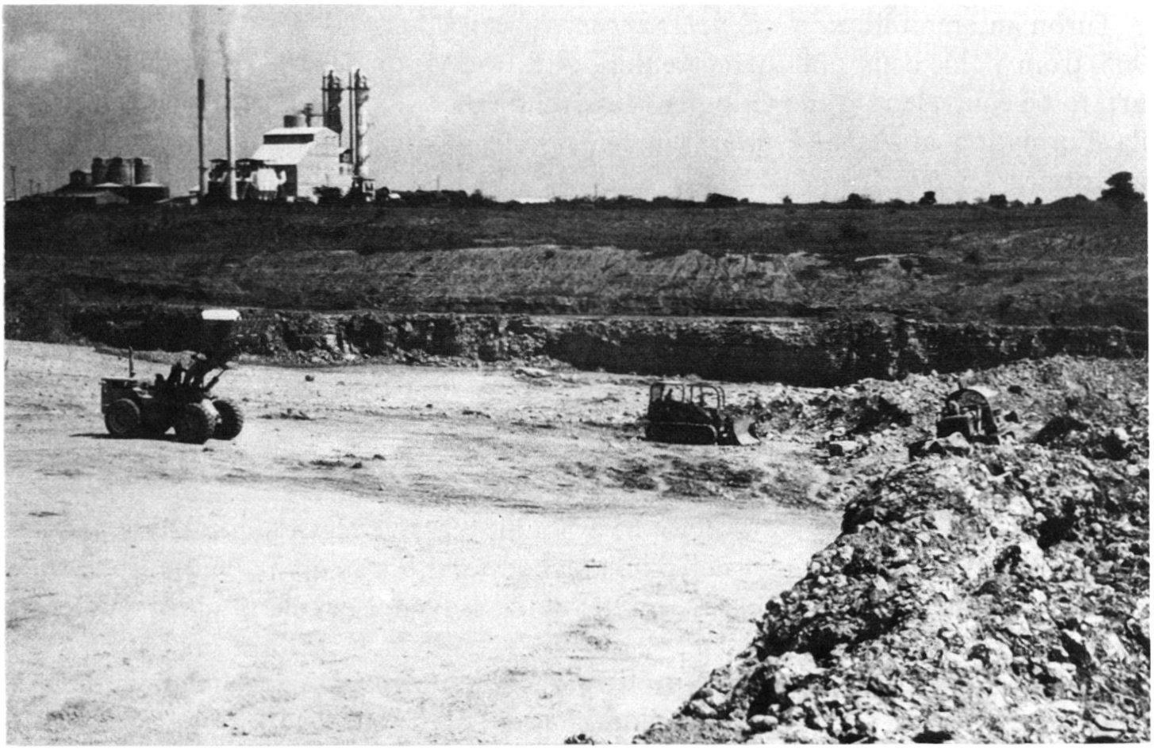


Fig. 2. General view of Ashaka Cement quarry.

Coq., *Plicatula fourneli* Coq., *Anisocardia hermitei* (Choff.), *Lucina nicaisei* Coq., *Tylostoma globosum* Sharpe, *Hemiaster souleyi* d'Orb., and stromatolites.

4. 3.00 m massive limestone beds (Fig. 3B) with *Vascoceras tavense* Faraud, *Paravascoceras evolutum* Schneeg., and *Pseudaspidoceras pseudonodosoides* (Choff.).

5. 0.50 m nodular limestone and calcareous shale with *Vascoceras bulbosum* (Reym.), *Paravascoceras evolutum* Schneeg., *Vascoceras triangulare* Faraud, *Plicatula fourneli* Coq., *Tylostoma* sp., and *Hemiaster verneuili* Desor.

6. 0.20 m massive limestone layer with top hardground, built up by ammonites and Plicatulas (Fig. 3C): *Nigericeras jacqueti* Schneeg., *Vascoceras douvillei* Choff., *Paravascoceras costatum* (Reym.), *Pachyvascoceras crassum* FURON, *P. globosum* Reym., *"Paramammites" inflatus* Barber, *"P." tuberculatus* Barber, *Thomasites gongilensis* (Woods), *Plicatula fourneli* Coq., *Pholadomya* cf. *pedernalis* Roem., and *Tylostoma globosum* Sharpe.

7. 0.10 m ferruginous hardground with *Pseudotissotia (Bauchioceras) nigeriensis* (Woods) and *Thomasites gongilensis* (Woods).

8. 2.00 m clay and bioturbated *Plicatula* layer with top hardground and *Ps. (Bauchioceras) nigeriensis* (Woods), *Thomasites gongilensis* (Woods), *Fagesia bomba* Eck, *Eotissotia simplex* Barber, *Exogyra delettrei* (Coq.), *Plicatula fourneli* (Coq.), *Anisocardia* sp., and *Rissoa* cf. *oldhamiana* Stol.

9. 0.70 m dark clay and limestone with top hardground (overgrown by Plicatulas and Exogyras; Fig. 3D); and with *Paravascoceras* cf. *chevalieri* (Furon), *Pachyvascoceras globosum* Reym., *Thomasites gongilensis* (Woods), *Ps. (Bauchioceras) nigeriensis* (Woods), *Trachycardium productum* (J. de C. Sow.), and *Rissoa* cf. *oldhamiana* Stol.

10. 2.00–2.50 dark clay and shell beds with *Benuites* cf. *spinosus* Reym., *Pachyvascoceras harttiforme* (Choff.), *Thomasites gongilensis* (Woods), *Thomasites jordani* Perv., *Ps. (Bauchioceras) nigeriensis* (Woods), *Pseudaspidoceras pseudonosodoides* (Choff.), *Plicatula fourneli* Coq., *P. auressensis* Coq., *Pholadomya* cf. *pedernalis* Roem., and *Paphia numidica* (Coq.).

11. 2.00 m dark clay and shell beds with *Thomasites gongilensis* (Woods), *Ps. (Bauchioceras) nigeriensis* (Woods), *Ps. (Wrightoceras) wallsi* (Reym.), and *Plicatula fourneli* Coq.

12. 3.00–3.50 m grey clay and nodular marl with large-scale Crustacean burrows and with *Ps. (Bauchioceras) nigeriensis* (Woods), *Ps. (Wrightoceras) wallsi* (Reym.), *Fagesia* cf. *spheroidalis* Perv., and *Panopaea nigeriensis* Schneeg.

13. 1.50 m grey clay and nodular marl with *W. (Bauchioceras) nigeriense* (Woods).

14. 4.00 m grey clay with thin gypsum layers.

15. 3.00 m fine-grained calcareous sandstone, becoming coarser and glauconitic up section, and grey marl with rare lamellibranchs.
16. 4.00 m grey clay.
17. 3.00–3.50 m fine-grained sandstone and clay, in part micaceous.
18. 1.00 m cross-bedded, fine-grained calcareous sandstone.

From this short description we can conclude that:

1. At Ashaka quarry the Gongila Formation, which consists of an alternation of marine limestone and shale/mudstone, immediately follows a calcareous sandstone (1) overlying the Bima Sandstone. A few meters of transitional Yolde beds can possibly be discerned (Table 1).

At the type locality of the Gongila Formation about 1 km northwest of Ashaka, a thicker series (10–20 m) of silty clay and calcarenite is exposed between the underlying Bima Sandstone and the first ammonite bearing beds above. This series represents the basal clastic layers underlying the Gongila Formation that could be attributed to the Yolde Formation and interpreted as sediments from a nearshore marine environment.

Near Gongila village as well as at Ashaka, these beds (2) include *Exogyra flabellata* GOLDF. and *E. africana* (LMK.) and are thought to be Upper Cenomanian. Thus, the transitional to marine Yolde Formation can be attributed to the Upper Cenomanian.

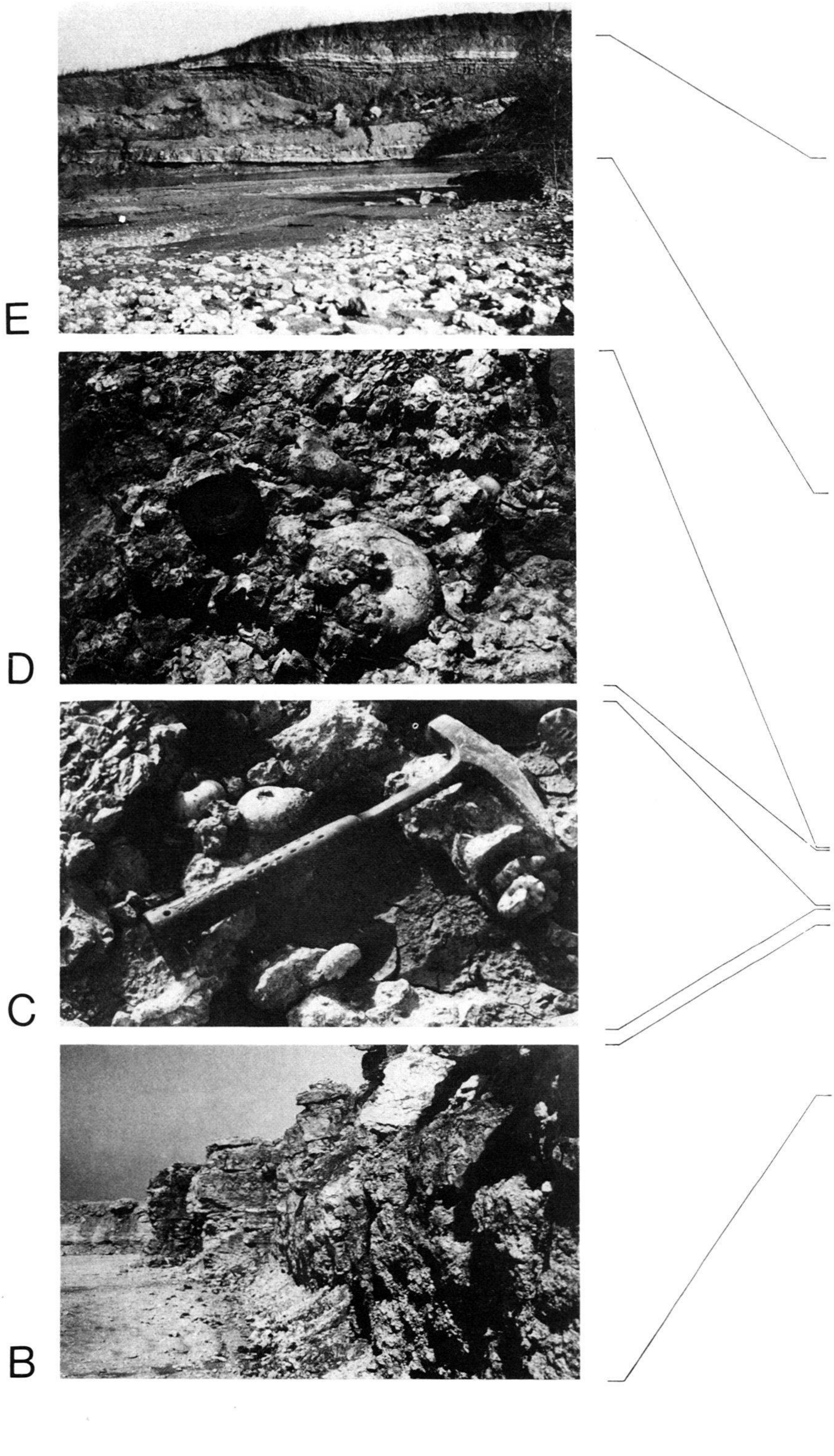
The underlying Aptian–Albian Bima Sandstone covers large areas of the Precambrian basement and was deposited during the early rifting activity of the equatorial Atlantic; therefore, it could have been locally invaded during part of the Cenomanian by a marine transgression. This transgression did not necessarily occur at the same time (late Cenomanian) everywhere, as suggested by recent data: the transgressive strata are dated as Upper Albian to Lower Cenomanian in the Pindiga–Gombe area (LAWAL 1982, ALLIX 1983), while they appear younger–Upper Cenomanian (LAWAL 1982) – on the synsedimentary high of Gombe–Zambuk. A similar situation in the Ashaka area could explain the limited thickness and possible Lower to Middle Cenomanian age of the Yolde Formation.

2. Beds 2 to 13 can be precisely dated using ammonite biostratigraphy and are thus Upper Cenomanian to Middle Turonian in age. The following zones can be separated:

Zone 7 of Fagesia n. sp. cf. spheroidalis PERVINQUIÈRE 12–13
Zone 6 of Ps. (Wrightoceras) wallsi (REYMENT) 11
Zone 5 of Ps. (Bauchioceras) nigeriensis (WOODS) 7–10
Zone 4 of Paravascoceras costatum (REYMENT) condensed layer 6
Zone 3 of Vascoceras bulbosum (REYMENT) 5
Zone 2 of Vascoceras tavense FARAUD 4
Zone 1 of Nigericeras gadeni (CHUDEAU) 2, 3

Zones 1 to 3 are Upper Cenomanian, the condensed zone 4 is of Lower Turonian age, zones 5 to 7 are Middle Turonian.

3. The lithology of beds 14 to 18 indicates a marine environment, which still fits into the general character of the Gongila Formation. No time-specific fossils were found; nevertheless, this part of the Ashaka section is tentatively dated as late Middle and Upper Turonian. The total thickness of the Gongila formation may exceed 400 m (CARTER et al. 1963, REYMENT 1965).


E
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C
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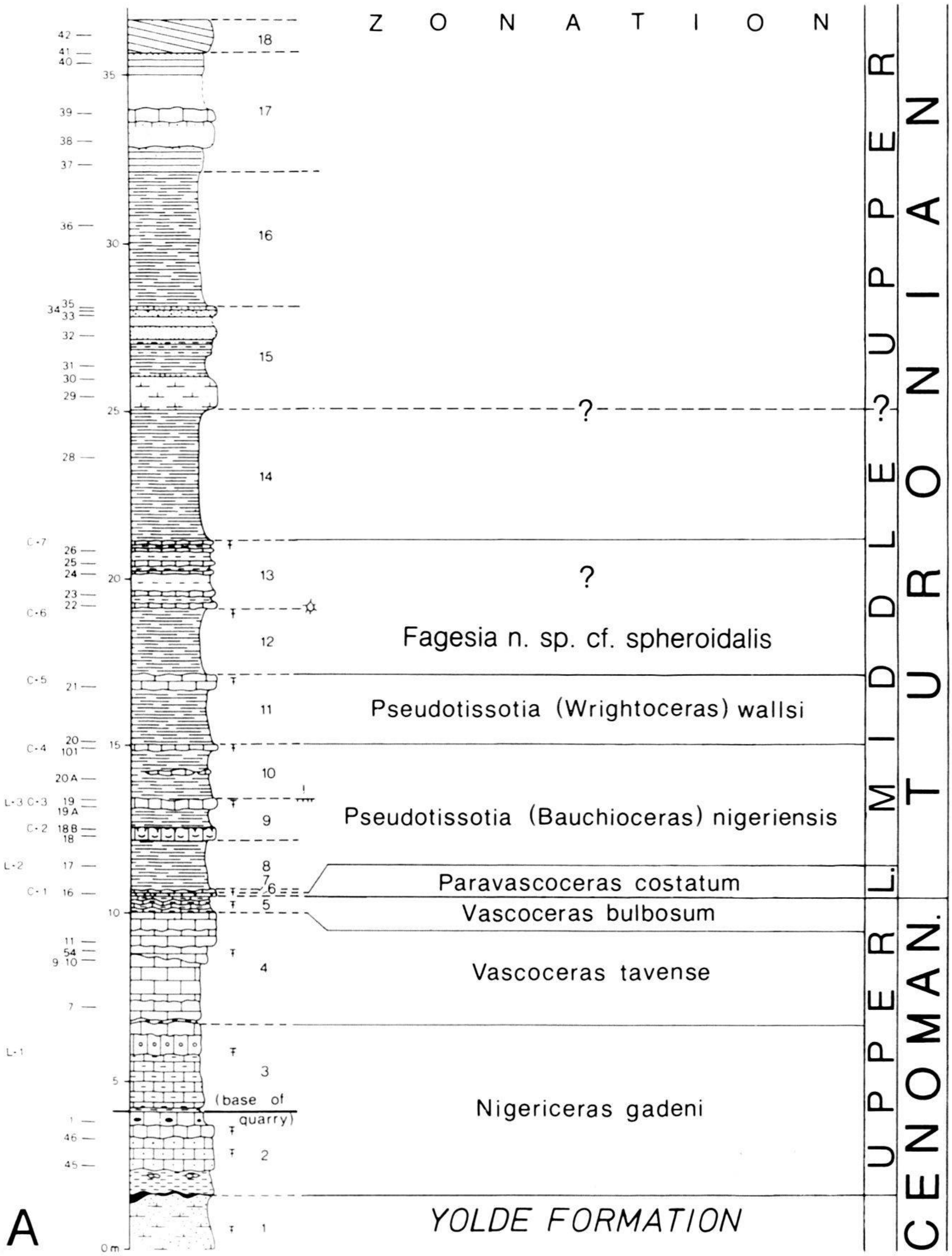
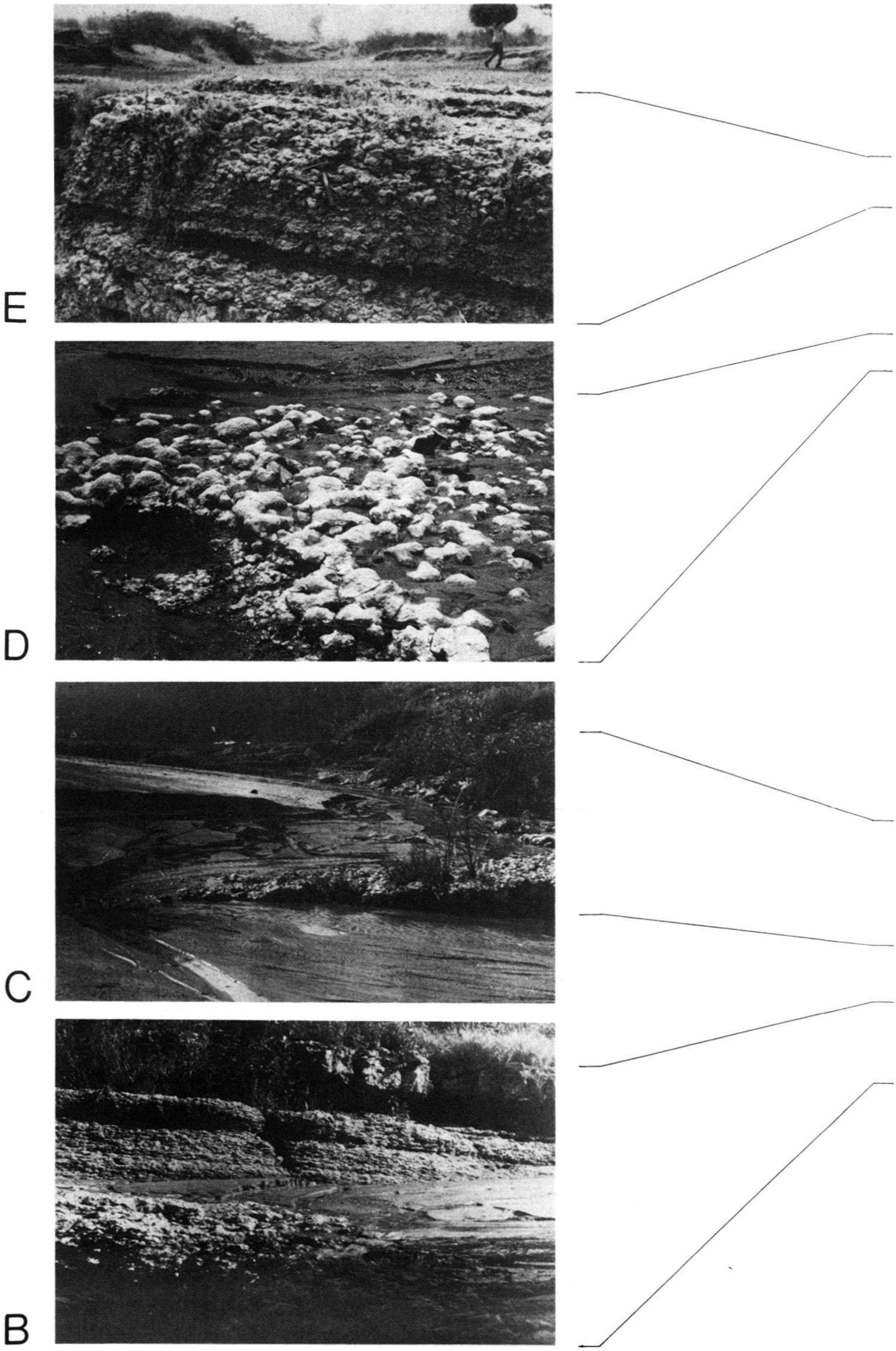


Fig. 3. Stratigraphic section of the Gongila Formation at Ashaka Cement quarry (A), and detailed parts of the sequence (B–E).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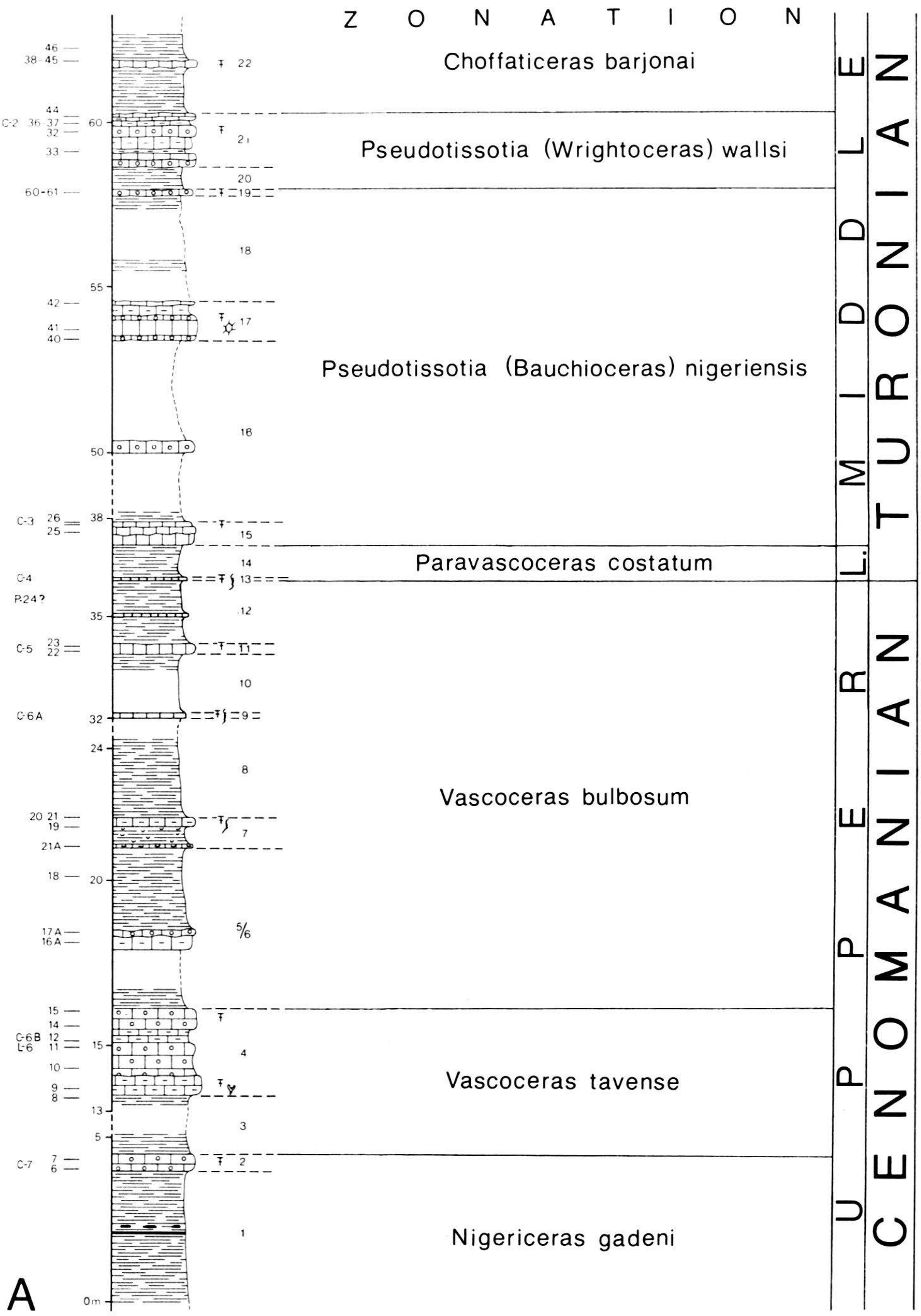


Fig. 4. Stratigraphic section of the Pindiga Formation near Pindiga village (A), and nature of outcrops (B–E).

B. The Pindiga Formation type section (Fig. 4)

The type section of the Pindiga Formation is exposed in Pindiga Creek west and south of Pindiga village. Mostly just the limestone layers are accessible here, while the predominant clay and shale are largely covered by vegetation or are eroded. The beds dip gently towards the northwest. The lithologic sequence and its faunal content are described as follows:

1. 4.00 m blue shaly clay with red calcareous concretions.
2. 0.40 m green-gray calcarenite with Exogyras (*E. africana* (LMK.)), and a few ammonites: *Nigericeras gadeni* (CHUD.), *Metengonoceras dumbli* (CRAGIN), and *Eotissotia* sp.
3. 10.00 m blue shaly clay.
4. 1.60 m well bedded calcarenite with Exogyras (*E. africana* (LMK.)), *Plicatula fourneli* COQ., *Hemiaster* sp., *Nigericeras gadeni* (CHUD.), *Vascoceras tavense* FARAUD, and bryozoan bioherms (Fig. 4B).

5–6. 5.00 m grey clay with nodular limestone layer.

7. 1.00 m massive, bioturbated limestone and marly shell bed with *Plicatula fourneli* COQ., *Nigericeras jacqueti* SCHNEEG., and *Vascoceras bulbosum* BARB. (white).
8. about 10.00 m dark clay.
9. 0.30 m marly limestone, bioturbated, with *Vascoceras bulbosum* BARB., *V. grossouvrei* CHOFF., and *Pachyvascoceras globosum* REYM.
10. 2.00 m blue clay with *Vascoceras grossouvrei* CHOFF., and *Pachyvascoceras globosum* REYM.
11. 0.20 m calcarenite, fauna as in 10.
12. 5.00 m black shaly clay.
13. 0.25 m biodetrital and bioturbated limestone with *Exogyra delettrei* (COQ.), ?*Nigericeras costatum* BARB., *Vascoceras triangulare* FARAUD, *Pachyvascoceras globosum* REYM., *Paravascoceras costatum* (REYM.), and *Thomasites gongilensis* (WOODS).
14. 1.00 dark clay.
15. 0.50 green-grey biodetrital limestone with *Exogyra delettrei* (COQ.), *E. columba major* (LMK.), *Pachyvascoceras globosum* REYM., *Thomasites gongilensis* (WOODS), and *Ps. (Bauchioceras) nigeriensis* (WOODS).
16. 15.00 m shale, mostly covered by vegetation, with *Ps. (Bauchioceras) nigeriensis* (WOODS).
17. 1.20 m bioturbated limestone and biodetrital marl with large-scale Crustacean burrows (Fig. 4D), *Astarte awensis* WOODS, *Exogyra delettrei* (COQ.), and reworked *Ps. (Bauchioceras) nigeriensis* (WOODS).
18. 3.00 m grey shaly clay.
19. 0.20 oyster limestone.
20. 0.60 m grey shaly clay.
21. 1.50 m white, nodular limestone (Waterfall, Fig. 4E) with *Ps. (Wrightoceras) wallsi* (REYM.), *Ps. (Bauchioceras) nigeriensis* (WOODS), *Eotissotia simplex* BARB., *Plicatula fourneli* COQ., *P. auressensis* COQ., *Exogyra delettrei* (COQ.), *Nerita multigranosa* V. KOEN., and *Paphia numidica* (COQ.).
22. 5.00 m dark clay and yellowish limestone with *Choffatticeras barjonai* (CHOFF.), *Eotissotia simplex* BARB. and *Thomasites gongilense* (WOODS).

The following conclusions can be drawn about the Pindiga type section:

1. No exact data are presently available on the complete thickness of the Pindiga Formation, which is subject to significant variations depending on the morphology of the sedimentary basins and the location of the centers of deposition. Three nearby boreholes drilled at the same level around Pindiga village indicate three different thicknesses for the Pindiga Formation: 168 m, 294 m and 330 m above the sandy Yolde Formation. To the east, an estimated thickness of 784 m was measured in the Kumo 6-borehole (LAWAL 1982), while in the north, different thicknesses from two other boreholes were recorded: Gombe Town with 152 m and a few miles west of Gombe with more than 460 m (ALLIX 1983).

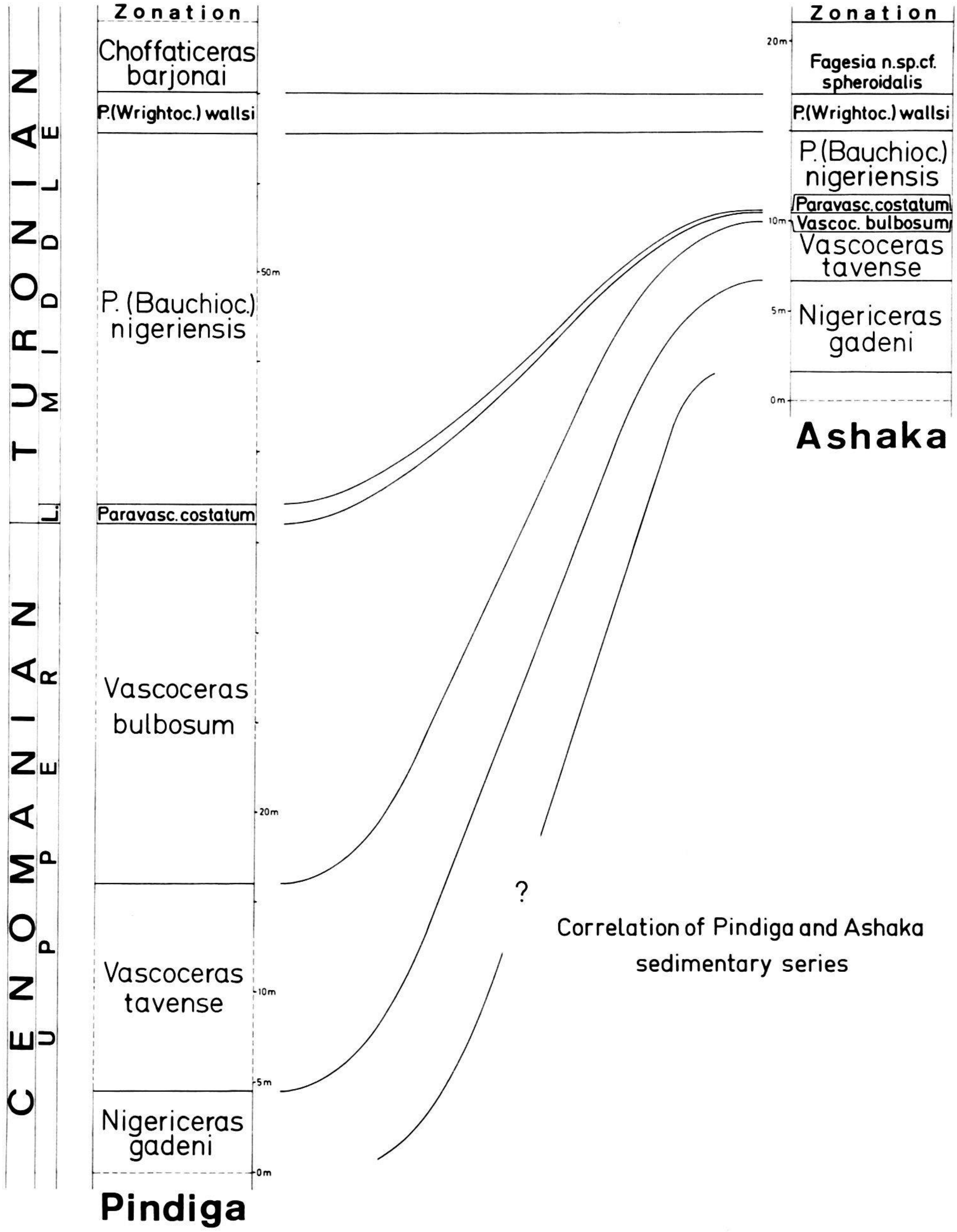


Fig. 5. Stratigraphic correlation and thicknesses of Ashaka and Pindiga sections.

These local variations in thickness imply an active tectonic framework in the Gongola Trough where NNE–SSW and NE–SW trending faults create differentially subsiding basins (POPOFF et al. 1982, ALLIX & POPOFF 1983).

2. The fossil content is concentrated in the limestone layers, but reworked ammonites occasionally also occur in the clay and shale beds. The ammonites permit the following zonation:

Zone 7 of Choffaticeras barjonai (CHOFFAT) 22
Zone 6 of Ps. (Wrightoceras) wallsi (REYMENT) 20–21
Zone 5 of Ps. (Bauchioceras) nigeriensis (WOODS) 15–19
Zone 4 of Paravascoceras costatum (REYM.) 13–14
Zone 3 of Vascoceras bulbosum BARBER 5–12
Zone 2 of Vascoceras tavense FARAUD 3–4
Zone 1 of Nigericeras gadeni (CHUDEAU) 1, 2

Zone 1 to 3 are in the Upper Cenomanian, zone 4 in the Lower Turonian, and zone 5 to 7 in the Middle Turonian. Interesting is the occurrence of *Eotissotia* at the base of the Turonian.

3. The investigated sections of the Gongila and Pindiga Formations are so similar in both lithology and fauna that they are practically synonymous. No new information is available about the upper portions of Pindiga (and Gongila) Formation from which the Maastrichtian *Libycoceras* has been recorded (REYMENT 1965, Pl. 6, Fig. 5).

4. Northeastern Nigerian correlations (Table 1, Fig. 5)

Comparison of Figures 3 and 4 demonstrate the identity of the ammonite zonations as well as the facies differentiation. It is interesting to note that the more reduced and partly condensed sequence is in the Gongila–Gombe Basin, while the more complete true basinal facies is found in the Pindiga–Gombe area SSW of the Gombe–Zambuk Ridge.

The basal portion of the Gongila Formation at Ashaka (the Nigericeras gadeni Zone), is composed of a sequence of limestone, calcarenite and marl, while at Pindiga it is exclusively marly. Moreover, at Ashaka the Gongila Formation immediately follows a reduced and probably younger Yolde Formation than at Pindiga.

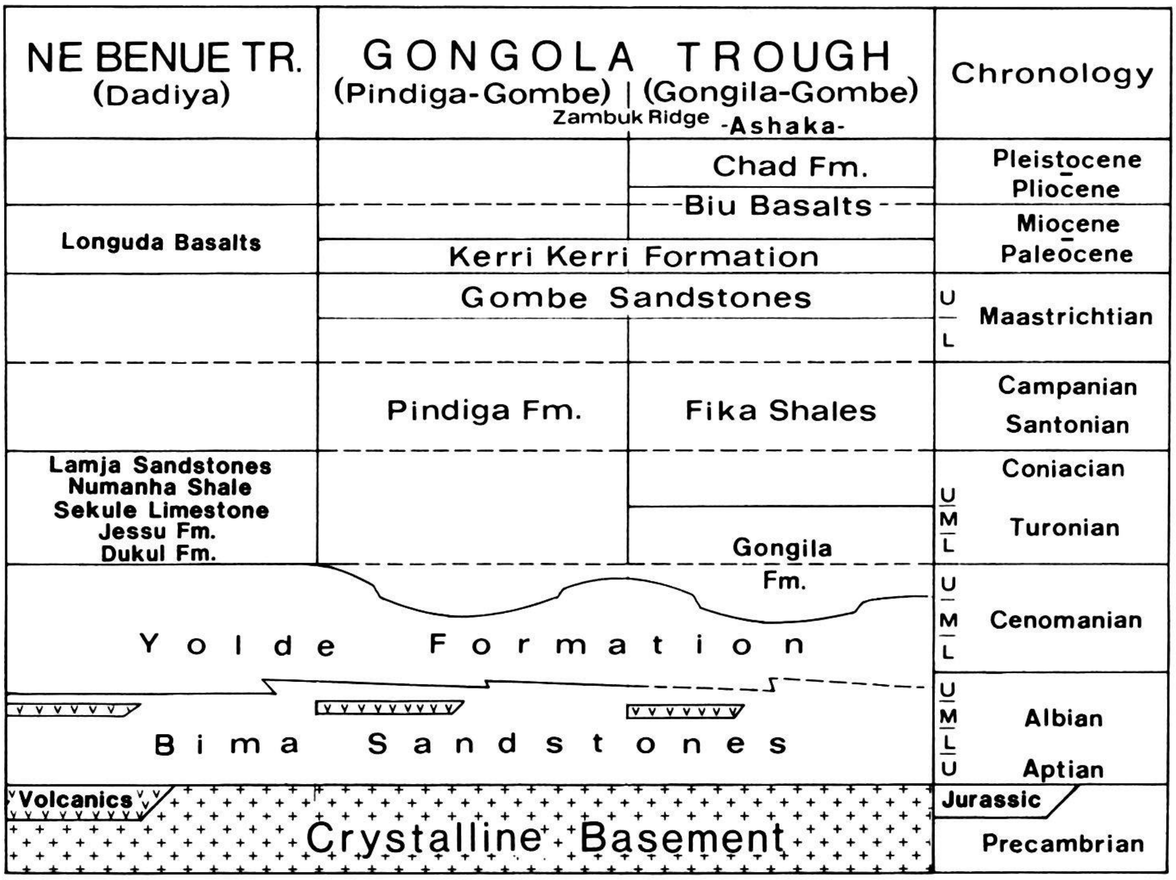
Since the bases of the Gongila and Pindiga Formations are stratigraphically equivalent, a low rate of sedimentation can be assumed for the Lower–Middle Cenomanian part of Yolde Formation (less than 10 m thick at Ashaka, but more than 100 m in the Pindiga area); some breaks in the sedimentary record, indicated by the occurrence of ferruginous crusts (Fig. 3, level 1, and Table 1), are also likely.

The overlying Vascoceras tavense Zone is more than 10 m thick at Pindiga, while it is only 3 m thick at Ashaka, where it again consists exclusively of limestone.

The most extreme discrepancy is found in the overlying Vascoceras bulbosum Zone, now thought to be uppermost Cenomanian: This Zone measures 20 m of shales at Pindiga, while it is only 0.50 m of condensed nodular limestone at the Ashaka quarry.

The base of the Turonian (the Paravascoceras costatum Zone), is condensed in both areas. The condensation is easily recognized in the 0.20 m-thick nodular "ammonite layer" at Ashaka but is much less obvious in the 1 m of dark clay at Pindiga.

Table 1: *Correlation chart of Mesozoic and Cenozoic sediments and volcanics in the northeastern Benue and Gongola Troughs.*



The Pseudotissotia (Bauchioceras) nigeriensis Zone (including beds extremely rich in *Thomasites ("Gombeoceras") gongilensis* again is much thicker at Pindiga (20 m thick) than in the Ashaka quarry (only 4 m thick). Beginning with the overlying Ps. (Wrightoceras) wallsi Zone, the general tendency seems to change; the thickness (2 m) is the same in both sections, but the sedimentation is dominated by clay in Ashaka and by nearshore limestone in Pindiga.

The ammonite-bearing facies ends with 1.50 m of clay and limestone with *Choffaticeras barjonai* at Pindiga and with 3.50 m of clay and nodular marl with *Fagesia* n. sp. cf. *spheroidalis* at Ashaka.

Despite the relatively short distance (100 km) between both sections there is a considerable degree of lithologic variation, so that they can only be correlated by means of biostratigraphy (Fig. 5). The two investigated sections thus make the difficulties of lithostratigraphic classification obvious. The separation of the Gongila and Pindiga Formations has not contributed anything to their better understanding. The Gongila, Pindiga, and Dukul Formations are largely identical and could easily be united. However, the problem still remains of whether to omit or include the overlying Fika Shales at Ashaka and elsewhere. The Fika Shale seems to extend from the Late Turonian to the Maastrichtian, when deposition of the Gombe Sandstone began. The Pindiga Formation extends directly into the Maastrichtian and is again followed by the Gombe Sandstone. In this case, the Fika Shale needs not be separated from the shaly Pindiga Formation.

The investigations of LAWAL (1982) and ALLIX (1983) now allow all Upper Cretaceous stages to be traced biostratigraphically in the Pindiga–Gombe area. The same can be said of the northeastern Benue Trough; near the village of Dadiya the complete Upper Cretaceous sequence consists of a shaly silty facies (ALLIX 1983). The shaly facies of the Jessu Formation (cf. ALLIX 1983) can be compared with the main part of the Gongila Formation (CARTER et al. 1963), e.g. the former containing abundant siltstones, and the latter containing fine to coarse-grained sandstone, both with glauconitic layers; these two clastic-rich facies correspond to continentally influenced marine gulf environments.

5. Correlations of the Cenomanian and Turonian, and of their mutual boundary (Table 2)

Table 2 demonstrates how far the ammonite zonation of the Gongila/Pindiga Formations of northeastern Nigeria can be refined and updated. REYMENT (1954a, 1954b, 1955, 1956) established the position of the Lower Turonian Paravascoceras costatum Zone, later replaced by the Pseudotissotia (Wrightoceras) wallsi (REYMENT 1965). BARBER (1957), however, proposed a three-fold subdivision of the Lower Turonian to which Gombeoceras gongilense Zone was added by WOZNY & KOGBE (1983).

Problems arose for the Lower Turonian stratigraphy since the Metoicoceras zones and "*Plenus* Marls" (WRIGHT & KENNEDY 1981) were moved to the Cenomanian; in addition BERTHOU & LAUVERJAT (1974, 1975) were able to demonstrate that the early Vascoceras zones of their type region in Portugal might also be Cenomanian. Only recently, LEWY et al. (1984) were able to confirm the co-occurrence of *Metoicoceras geslinianum* and *Kanabiceras septemseriatum* with the first appearance of *Paravascoceras cauvini* in the southern Negev (Israel). This assemblage can thus be regarded definitely as Late Cenomanian and is correlated here with the Vascoceras bulbosum Zone. Two more zones can be added in the Late Cenomanian part of the Ashaka and Pindiga sections and are tentatively correlated with the early vascoceratid zones in Spain (WIEDMANN 1960, 1978, 1980), Portugal (CHOFFAT 1898, BERTHOU & LAUVERJAT 1975), and Israel (FREUND & RAAB 1969, LEWY et al. 1984).

A total of 4 zones can be recognized in the now restricted Turonian sections. WOZNY & KOGBE'S "Gombeoceras" gongilense Zone is not adopted, since *Thomasites gongilensis* ranges through the entire mid-Turonian section. It is very difficult to say what "Middle Turonian" in the Mediterranean Realm actually means. In this paper the pseudotissotiids are regarded as Middle Turonian, while the Lower Turonian is restricted to the late true vascoceratids (*Paravascoceras, Paramammites, Ingridella, Pachyvascoceras*).

Watinoceras coloradoense, now generally accepted as an index species for the North Temperate lowermost Turonian (KENNEDY 1984), is not yet known from the Tethyan Realm. There is another problem with *Mammites nodosoides,* previously thought to represent the first Turonian index species (C. W. WRIGHT 1957, ROBAZHYNSKI & CARON 1979), but actually defining the upper portion of the Lower Turonian, at least in the North Temperate Realm (KENNEDY 1984). This species extends well into the Tethyan Turonian, co-occuring with the pseudotissotiids and neoptychitids (WIEDMANN 1960, FREUND & RAAB 1969, WIEDMANN & KAUFFMAN 1978) which are considered Middle Turonian in the present paper.

		S-Nigeria REYMENT 1955	N-Nigeria this paper	Portugal CHOFFAT 1898	N-Spain WIEDMANN 1960 ff.	Israel FREUND & RAAB 1969
TURONIAN	Upper	Romaniceras uchauxiense	—	—	Coilopoceras requienianum Romaniceras deverianum	Coilopoceras sp. Romaniceras inerme
	Middle	Kamerunoceras eschii	Choffaticeras barjonai / Fagesia n.sp.cf. spheroidalis Pseudotissotia wallsi Pseudotissotia nigeriensis	Choffaticeras barjonai +	Collignoniceras sp. Neoptychites spp. Pseudotissotia munieri	Choffaticeras luciae Choffaticeras quaasi Choffaticeras securiforme
	Lower	Paravascoceras costatum	Paravascoceras costatum (condensed)	Pachyvascoceras amieirense	Spathitoides sulcatus Ingridella malladae Paramammites saenzi	Spathitoides pioti Paravascoceras cauvini (pars)
CENOM.	Upper	?	Vascoceras bulbosum Vascoceras tavense Nigericeras gadeni	Fallotites subconciliatus Discovascoceras douvillei Vascoceras gamai Neolobites choffati	Fallotites subconciliatus Vascoceras gamai Metoicoceras geslinianum Neolobites vibrayeanus + Lotzeites lotzei	Kanabiceras sp. Calycoceras sp. Neolobites sp.

Table 2: *Upper Cenomanian and Turonian zonations and suggested correlation in the Mediterranean.*

This means that the condensed Paravascoceras costatum Zone in northeastern Nigeria may correlate only with the condensed Watinoceras coloradoense Zone of the North Temperate Realm. It probably correlates with the Spanish Paramammites saenzi Zone (and the Paravascoceras cauvini Zone in the Negev); but these are followed by one or two more vascoceratid zones, the Ingridella malladae Zone and the Spathitoides sulcatus ($\approx$ Spathitoides pioti) Zone. These two zones could in turn correlate with the US Western Interior Vascoceras birchbyi Zone (COBBAN 1984).

The three Nigerian Middle Turonian zones correspond almost exactly to the three choffaticeratid zones, as proposed by FREUND & RAAB (1969). They can also be correlated with equivalent zones in northern Spain (WIEDMANN 1960, WIEDMANN & KAUFFMAN 1968). This is the level at which *Mammites nodosoides* occurs in the Tethyan Realm. Upper Turonian is defined here as including the late romaniceratids (group of *R. deverianum*) and early coilopoceratids (Table 2).

6. Paleogeography of northeastern Nigeria during the Cretaceous

We now have a more comprehensive and convincing picture of the Cretaceous paleogeography of the Benue Trough.

The first intra-plate extension processes in the northeastern Benue Trough are documented by the extrusions of primarily alkaline and subsequent acidic volcanics during the late Jurassic (POPOFF et al. 1982), a period of rifting in the Central Atlantic. A second magmatic episode took place during the Middle Albian, related to the early opening of the equatorial Atlantic between Africa and South America (WIEDMANN & NEUGEBAUER 1978).

The first tectonic and sedimentary stage (BURKE et al. 1971, FREETH 1978) corresponds to the deposition of the alluvial Bima Sandstone, infilling the whole area of the northeastern Benue–Gongola Troughs from the late Aptian to the late Albian (ALLIX & POPOFF 1983). This is followed by the coastal and littoral sedimentation of the Yolde Formation, this occurred from the late Albian to early Cenomanian in the Didiya and Pindiga–Gombe Basins (LAWAL 1982, ALLIX 1983), continuing into the Upper Cenomanian on shoals such as Gombe and Ashaka (Table 2). During the Upper Cenomanian, further deepening of the sea affected the whole area and continued into the Turonian. The marine Trans-Saharan Seaway (FURON 1968, REYMENT & TAIT 1972, COLLIGNON & LEFRANC 1974, REYMENT 1980, KOGBE 1981, REYMENT & REYMENT 1981, DUFAURE et al. 1984) became established and allowed immigration of characteristic Tethyan faunas into the Gongola–Benue Troughs and regions further south.

Despite the slightly differing facies in the sedimentary troughs of northeastern Nigeria, we can assume that marine inner-shelf conditions persisted into the Maastrichtian, establishing a continuous faunal exchange across the Sahara. Indeed, in the Gombe area ammonites are restricted to the Lower Maastrichtian, but in the Benue Trough Coniacian and Santonian faunas exist as well, pointing to northern relationships (REYMENT 1955, 1957; WIEDMANN 1978). During most of the Upper Cretaceous another extensive seaway might have connected northeastern Nigeria with Sudan (FURON 1935), Egypt (QUAAS 1902, ECK 1914), and Israel, where very similar faunal successions have been observed (PARNES 1965, FREUND & RAAB 1969, BARTOV et al. 1972, LEWY 1975, LEWY & RAAB 1978, LEWY et al. 1984). The Maastrichtian *Libycoceras,* for example, must have used this seaway. Arguments against the Upper Cretaceous Trans-Saharan Seaway as proposed by PETTERS (1978) are not substantiated.

The late Maastrichtian delta front of the marine Gombe Sandstone coincides with the final regression, uplift and folding of the troughs at the Cretaceous–Tertiary boundary. During the Tertiary only continental and lacustrine sediments were deposited, associated with the extrusion of the important Biu Plateau basalts, thus marking the end of sedimentary basin evolution in northeastern Nigeria.

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REFERENCES

ALLIX, P. (1983): Environnements mesozoïques de la partie nord-orientale du fossé de la Bénoué (Nigéria). Stratigraphie, sédimentologie, évolution géodynamique. – Trav. Lab. Sci. Terre St-Jérôme, Marseille (B) *21*.

ALLIX, P., GROSDIDIER, E., JARDINE, S., LEGOUX, O., & POPOFF, M. (1981): Découverte d'Aptien supérieur à Albien inférieur daté par microfossiles dans la série détritique crétacée du fossé de la Bénoué (Nigéria). – C. R. Acad. Sci. (Paris) (2) *292*, 1291–1294.

ALLIX, P., & POPOFF, M. (1983): Le Crétacé inférieur de la partie nord-orientale du fossé de la Bénoué (Nigéria): un exemple de relation étroite entre tectonique et sédimentation. In: POPOFF, M., & TIERCELIN, J. J., (Ed.): Rifts et Fossés anciens (p. 349–359). – Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine 7/1.

BARBER, W. (1957): Lower Turonian ammonites from northeastern Nigeria. – Bull. geol. Surv. Nigeria *26*.

— (1958): Upper Cretaceous Mollusca from northeastern Nigeria. – Rec. geol. Surv. Nigeria *1956*, 14–37.

BARBER, W. M., TAIT, E. A., & THOMPSON, J. H. (1954): The geology of the Lower Gongola. – Annu. Rep. geol. Surv. Nigeria, *1952/53*, 18–20.

BARTOV, J., EYAL, Y., GARFUNKEL, Z., & STEINITZ, G. (1972): Late Cretaceous and Tertiary stratigraphy and palaeogeography of southern Israel. – Israel J. Earth Sci. *21*, 69–97.

BENKHELIL, J. (1982): Benue Trough and Benue Chain. – Geol. Mag. *119*, 155–168.

BERTHOU, P. Y., & LAUVERJAT, J. (1974): La limite Cénomanien–Turonien. Essai de corrélation entre la série portugaise à *Vascoceras* et les séries de l'Europe du sud-ouest et de l'Afrique du Nord. – C. R. Acad. Sci. (Paris) (D) *278*, 2608.

— (1975): Le Cénomano–Turonien à Vascocératidés dans sa région type (embouchure du Rio Mondego, Beira littoral, Portugal). Corrélations avec le stratotype du Mans et d'autres séries téthysiennes. – Newsl. Stratigr. *4*, 96–118.

BURKE, K. C. A., DESSAUVAGIE, T. F. W., & WHITEMAN, A. J. (1971): Opening of the Gulf of Guinea and geological history of the Benue Depression and Niger Delta. – Nature, Phys. Sci. *233*, 51–55.

CARTER, J. D., BARBER, W., & TAIT, E. A. (1963): The geology of parts of Adamawa, Bauchi and Bornu provinces in northeastern Nigeria. – Bull. geol. Surv. Nigeria *30*.

CHOFFAT, P. (1898): Recueil d'études paléontologiques sur la faune crétacique du Portugal. Vol. I: Espèces nouvelles ou peu connues. 2. Série: Les Ammonées du Bellasien des Couches à *Neolobites vibrayeanus*, du Turonien et du Sénonien. – Comunic. Trab. geol. Port., p. 41–86.

COBBAN, W. A. (1984): Mid-Cretaceous ammonite zones, Western Interior, United States. – Bull. geol. Soc. Denmark *33*, 71–89.

COLLIGNON, M., & LEFRANC, J. P. (1974): Mise en évidence de la communication saharienne entre Téthys et Atlantique Sud d'après les fossiles cénomaniens et turoniens du Tademaït (Sahara algérien). – C. R. Acad. Sci. (Paris) (D) *278*, 2257–2261.

DESSAUVAGIE, T. F. J. (1975): Explanatory note to the geological map of Nigeria, scale 1:1 000 000. – Nigerian Min. geol. metall. Soc. *9*/1–2, 1–28.

DESSAUVAGIE, T. F. J., & WHITEMAN, A. J. (Ed.) (1972): African Geology. – Ibadan (Geol. Dept. Univ.).

Dufaure, P., Fourcade, E., & Massa, D. (1984): Réalité des communications marines trans-sahariennes entre la Téthys et l'Atlantique durant le Crétacé supérieur. – C. R. Acad. Sci. (Paris) (2) *298*, 665–670.

Eck, O. (1914): Die Cephalopoden der Schweinfurthschen Sammlung aus der Oberen Kreide Ägyptens. – Z. dtsch. geol. Ges. *66*, 179–216.

Falconer, J. D. (1911): The Geology and Geography of Northern Nigeria. – Mac Millan, London.

Freeth, S. J. (1978): A model for tectonic activity in West Africa and the Gulf of Guinea during the last 90 m.y. based on membrane tectonics. – Geol. Rdsch. *67*/2, 675–687.

Freund, R., & Raab, M. (1969): Lower Turonian ammonites from Israel. – Spec. Pap. Palaeont. *4*.

Furon, R. (1935): Le Crétacé et le Tertiaire du Sahara soudanais (Soudan, Niger, Tchad). – Arch. Mus. natl. Hist. nat. (Paris) (6) *13*, 3–96.

— (1967): Géologie de l'Afrique. – Payot, Paris.

Hirano, H. (1983): Revision of two vascoceratid ammonites from the Upper Cretaceous of Nigeria. – Bull. Sci. Eng. Res. Lab. Waseda Univ. *105*, 44–79.

Kennedy, W. J. (1984): Ammonite faunas and the "standard zones" of the Cenomanian to Maastrichtian stages in their type areas, with some proposals for the definition of the stage boundaries by ammonites. – Bull. geol. Soc. Denmark *33*, 147–161.

Kogbe, C. A. (1975): Paleogeographic history of Nigeria from Albian times. In: Kogbe, C. A. (Ed.): Geology of Nigeria (p. 237–252). – Geol. Dept. Univ. Ife.

— (1981): Attempts to correlate the stratigraphic sequence in the Middle Benue basin with those the Anambra and Upper Benue Basins. – Earth. Evol. Sci. *2*, 139–143.

Lawal, O. (1980): Contribution de la palynologie à la connaissance des paléoenvironnements des séries du Crétacé supérieur dans la haute vallée de la Bénoué (Nigéria Nord-Oriental). – 8e Réunion annu. Sci. Terre, Marseille, p. 213.

— (1982): Biostratigraphie palynologique et paléoenvironnements des formations crétacées de la Haute-Bénoué, Nigéria nord-oriental. – Thèse Univ. Nice.

Lewy, Z. (1975): The geological history of Southern Israel and Sinai during the Coniacian. – Israel J. Earth-Sci. *24*, 19–43.

Lewy, Z., Kennedy, W. J., & Chancellor, G. (1984): Co-occurrence of *Metoicoceras geslinianum* (d'Orbigny) and *Vascoceras cauvini* Chudeau (Cretaceous Ammonoidea) in the southern Negev (Israel) and its stratigraphic implications. – Newsl. Stratigr. *13*, 67–76.

Lewy, Z., & Raab, M. (1978): Mid-Cretaceous stratigraphy of the Middle East. – Ann. Mus. Hist. nat. Nice *4*, 32, 1–20.

Moullade, M., et al. (1980): Problèmes de corrélation des formations crétacées dans la partie nord-est du Bassin de la Bénoué (Nigéria). – 8e Réunion annu. Sci. Terre, Marseille, p. 254.

Offodile, M. E. (1976): The geology of the Middle Benue, Nigeria. – Publ. palaeont. Instn. Univ. Uppsala, spec. vol. *4*.

Parnes, A. (1965): Coniacian ammonites from the Negev (Southern Israel). – Bull. geol. Surv. Israel *39*.

Pervinquière, L. (1907): Etudes de Paléontologie Tunisienne. I. Céphalopodes des terrains secondaires. – Direction Gén. Trav. Publics, Carte Géol. Tunisie, Paris.

Petters, S. W. (1978): Paleogeography of West Africa. – J. Geol. *86*, 311–322.

Popoff, M., Kampunzu, A. B., Coulon, C., & Esquevin, J. (1982): Découverte d'un volcanisme mésozoïque dans le NE du Nigéria: datations absolues, caractères magmatiques et signification dans l'évolution du rift de la Bénoué. In: Popoff, M. & Tiercelin, J. J. (Ed.): Rifts et Fossés anciens (p. 47–49). – Rés. Commun. Trav. Lab. Sci. Terre St-Jérôme, Marseille (B) *19*.

Quaas, A. (1902): Beitrag zur Kenntnis der obersten Kreidebildungen der libyschen Wüste (*Overwegi*-Schichten und Blättertone). – Palaeontographica *30*/2, 153–336.

Raeburn, C., & Jones, B. (1934): The Chad Basin: Geology and water supply. – Bull. geol. Surv. Nigeria *15*.

Reyment, R. A. (1954a): New Turionian (Cretaceous) ammonite genera from Nigeria. – Colon. Geol. miner. Resour. (London) *4*/2, 149–164.

— (1954b): Some new Upper Cretaceous ammonites from Nigeria. – Colon. Geol. miner. Resour. (London) *4*/3, 248–270.

— (1955): The Cretaceous Ammonoidea of southern Nigeria and the southern Cameroons. – Bull. geol. Surv. Nigeria *25*.

— (1956): On the stratigraphy and paleontology of the Cretaceous of Nigeria and the Cameroons, British West Africa. – Geol. Fören. Stockholm Förh. *78*, 17–96.

— (1957): Über einige wirbellose Fossilien aus Nigerien und Kamerun, Westafrika. – Palaeontographica (A) *109*, 41–70.

REYMENT, R. A. (1965): Aspects of the geology of Nigeria. – Univ. Press, Ibadan.
— (1980): Biogeography of the Saharan Cretaceous and Paleocene epicontinental transgressions. – Cretaceous Res. *1*, 299–327.
REYMENT, R. A., & REYMENT, E. R. (1981): The Paleocene Trans-Saharan transgression and its ostracod fauna. In: SALEM, M. J., & BUSREWIL, M. T. (Ed.): Geology of Libya *2*(p. 245–254). – Academic Press, London.
REYMENT, R. A., & TAIT, E. A. (1972): Biostratigraphical dating of the early history of the South Atlantic ocean. – Phil. Trans. r. Soc. London *258*, 55–95.
ROBASZYNSKI, F., & CARON, M. (Ed.) (1979): Atlas de foraminifères planctoniques du Crétacé Moyen (Mer Boréal et Téthys). – Cah. Micropaléontol. *1979*/1.
WIEDMANN, J. (1960): Le Crétacé supérieur de l'Espagne et du Portugal et ses Céphalopodes. – C. R. 84e Congr. Soc. Savantes Paris et Dépt., Dijon 1959, Sect. Sciences, Sous-sect. Géol., p. 709–764.
— (1964): Le Crétacé supérieur de l'Espagne et du Portugal et ses Céphalopodes. – Estud. geol. *20*, 107–148.
— (1978): Eine paläogeographisch interessante Ammonitenfaunula aus der alpinen Gosau (Santon, Becken von Gosau, Oberösterreich). – Eclogae geol. Helv. *71*, 663–671.
— (1980): Itinéraire géologique à travers le Crétacé moyen des Chaînes Vascogotiques et Celtibériques (Espagne du Nord). – Cuad. Geol. (ibérica) *5*, 125–240.
WIEDMANN, J., & KAUFFMAN, E. G. (1978): Mid-Cretaceous Biostratigraphy of Northern Spain. – Ann. Mus. Hist. nat. Nice *4*, 3: 1–22.
WIEDMANN, J., & NEUGEBAUER, J. (1978): Lower Cretaceous Ammonites from the South Atlantic Leg 40 (DSDP), their stratigraphic value and sedimentologic properties. In: BOLLI, H. M., RYAN, W. B. F., et al.: Init. Rep. Deep Sea Drill. Proj., Suppl. vol. *38–41*, 709–721. – US Government Printing Office, Washington.
WOZNY, E., & KOGBE, C. A. (1983): Further evidence of marine Cenomanian, Lower Turonian and Maastrichtian in the Upper Benue Basin of Nigeria (West Africa). – Cretaceous Res. *4*, 95–99.
WRIGHT, C. W. (1957): Mesozoic Ammonoidea (pars). In: ARKELL, W. J., KUMMEL, B., & WRIGHT, C. W. (Ed.): Mesozoic Ammonoidea, Treatise Invertebrate Paleontology *L* (p. L 80ff.). – Geol. Soc. Amer., New York – Lawrence.
WRIGHT, C. W., & KENNEDY, W. J. (1981): The Ammonoidea of the *Plenus* Marls and the Middle Chalk. – Monogr. palaeontogr. Soc. (London) *560*.

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