Stratigraphy of the Keana-Awe area of the middle Benue region of Nigeria

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The region described covers mainly topographical sheet 231 and part of sheet 232 (scale 1:100 000) of the middle Benue area of Nigeria. It is of particular scientific interest owing to its strategic location at the supposed RRR junction in the Benue trough. The sedimentary sequence comprises Middle to Late Albian marine sediments, Cenomano-Turonian marine sediments, Coniacian paralic deposits with important coal horizons, and Late Cretaceous (Maastrichtian?) non-marine beds. The sedimentary cycles derive from three major transgressions. Several phases of folding can be identified. The dating has been made on ammonites and ostracods. The earliest ammonite associations are characterized by *Oxytropidoceras* s.l. The next in age is dominated by vascoceratids and species of *Bauchioceras*, all of which occur in the upper Benue area. This transgression introduced *Kanabiceras septemseriatum.* The mode of occurrence of the ammonites, notably in quantity, locally, lies at the base of a "catastrophic" interpretation of the epicontinental environment in terms of salinity crises. The Coniacian deposits contain foraminifers and ostracods in beds between coal seams. The ostracods are mainly species of *Ovocytheridea,* known from the upper Benue area and elsewhere on the west coast of Africa.

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Introduction

The region under study covers most of the topographical quarter degree sheet 231 and extends slightly westwards to encompass the Awe part of sheet 232 (scale 1:100 000) of the middle Benue area of Nigeria. It underlies the northern and southern parts, respectively, of the Benue and Plateau States. The location of the area mapped is given in Fig. 1 and the details of the administrative centres and major roads in Fig. 2. The area is about 3 800 square kilometres and it is bounded approximately by latitudes 8° to 8°30′ N and longitudes 8°30′ to 9°10′ E.

The topography (Fig. 3) commences with a relatively high gradient of about 1:7 in the northern area, immediately south of Akwanga, below the Jos Plateau. Thereafter, towards the River Benue, a more gentle slope of approximately 1:800 occurs on the average. Despite the regional slope towards the river, the land is generally undulating, with ridges running roughly parallel to the course of the Benue. The drainage in mostly of a dendritic character. The main drainage systems (Fig. 3) are the Guma, Ma, Asuku and Ankwe. The Guma, Ma and Asuku rise from the central

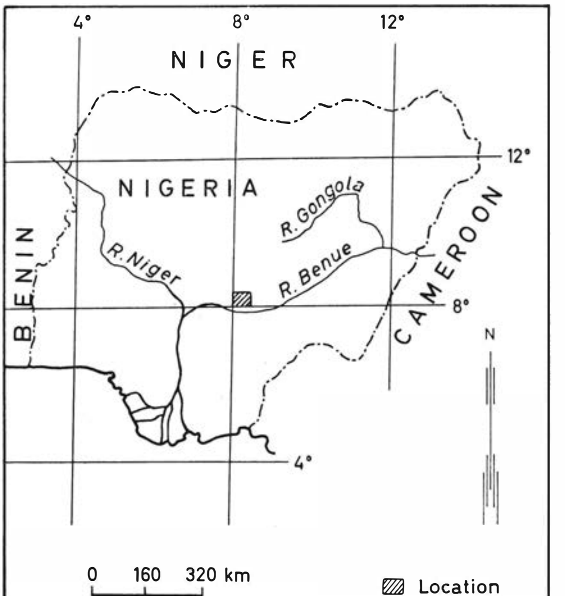

Fig. 1. Location of the area mapped and discussed in this report.

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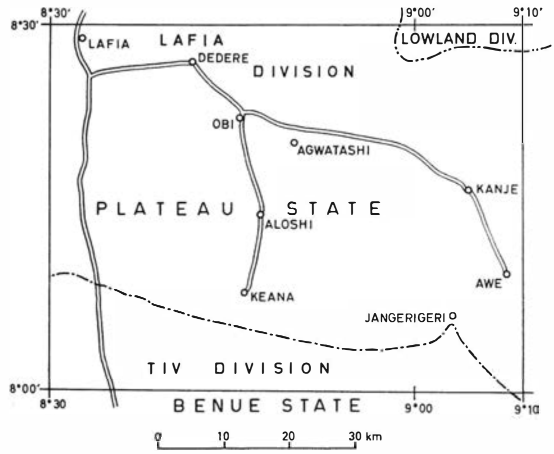

Fig. 2. Locations of administrative centres and main roads in the Keana-Awe area.

Lafia watershed, while the River Ankwe (= River Dep) rises from the more northerly Akwanga Hills. All of the rivers are roughly parallel to each other and they empty separately into the River Benue to the south.

Only limited geological work has been done in the middle Benue area. Apart from short-term mineral investigation and some reconnaissance surveys, little systematic study has been carried out. The first mention of this area was made by Falconer (1911, pp. 147—154). This was followed by sketchy accounts, in relation to lead-zinc exploration, by McConnel (1949), Farrington (1952) and Bogue, in unpublished reports (1011 and 1015) of the Geological Survey of Nigeria. A more detailed study was later made by Cratchley & Jones (1965). Reyment (1965) summarized stratigraphical information for the area, using mainly results obtained from a field programme in 1950 and published partly in a palaeontological monograph (Reyment 1955a). Esso West Africa Inc. (1967) published a set of their geological maps covering the whole Benue Valley, including the area under review. This work was more of a photogeological interpretation with some ground follow-up. However, because of the regional nature of the project and the short time put into it, detailed interpretations could not be gone into.

In 1974, under the auspices of the Geological Survey of Nigeria, Offodile carried out a detailed mapping programme of quarter degree sheet 231 (Lafia) and a reconnaissance survey of part of sheet 232 (Akiri) on a scale of 1:100 000. This area can be justly claimed to provide the key to the geology of the Benue Valley. Some of the results of the investigation are outlined in this paper.

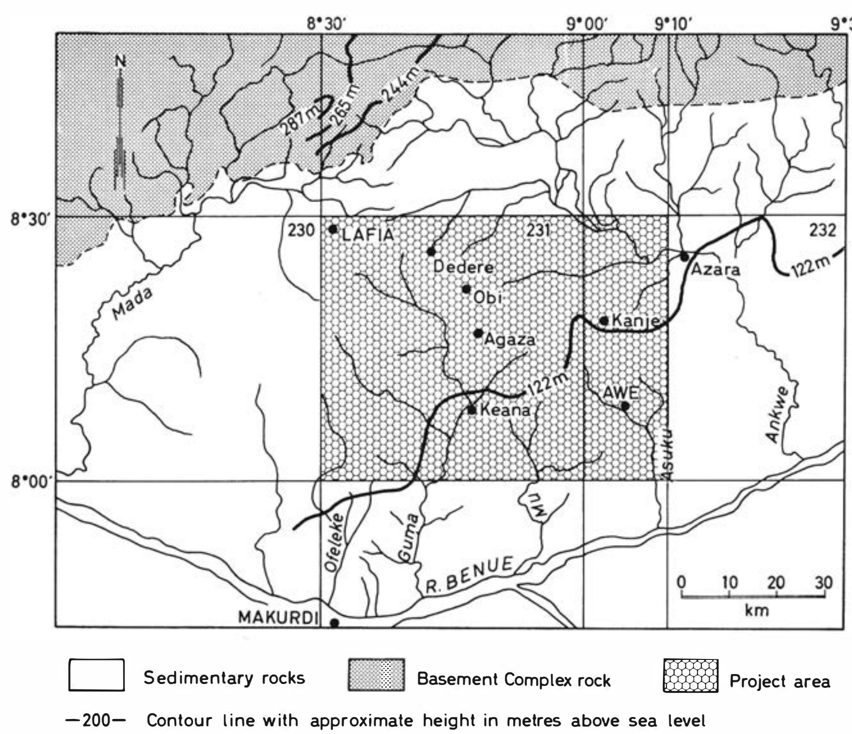

Fig. 3. Topography of the Keana-Awe area.

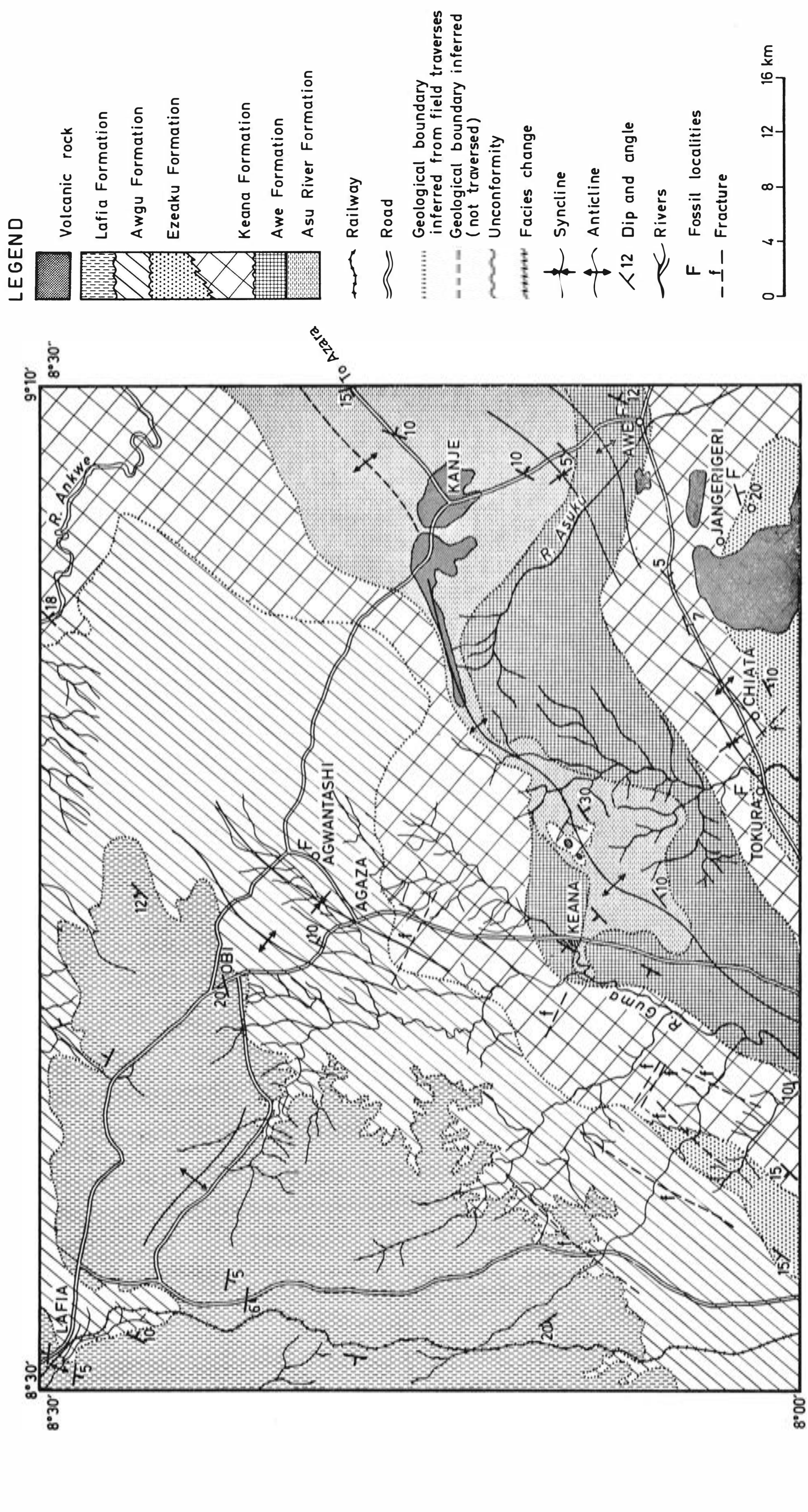

Fig. 4. Geological sketch map of the Keana-Awe area.

Stratigraphy

A geological sketch map of the area treated in this paper is shown in Fig. 4. A general summary of the stratigraphical succession is given in Table 1.

Asu River Formation

This formation ranges in age from Middle to Late Albian and it contains the oldest known sedimentary rocks of the area. Its outcrops are seen to occupy the Keana anticline, to the east of the town of Keana. This anticline trends northeast-southwest. The type section of the Asu River Formation was described for outcrops in the River Asu in the Abakaliki area of the Anambra State of Nigeria. The history of the study of the formation is given in Reyment (1965). In the middle Benue, the best exposures are to be seen in river beds and road excavations; it comprises essentially grey, dark to pink, micaceous siltstones, fissile shales, mudstones and subordinate clays. The exposure on the Keana anticline is roughly elliptical. To the northeast therefrom, it is exposed firstly in a narrow belt, after which it broadens, then to underlie most areas immediately south of Azara.

About six km south of Keana, on the Keana-Makurdi road, the sequence was traced downstream, along the Ugir River, from its source, east of the bridge, and found to consist of alternating shales, siltstones, mudstones and clays. This sequence is immediately overlain, in the vicinity of the bridge, by the more arenaceous, younger Awe Formation, discussed below. Elsewhere in the outcrop areas (e.g., along the River Baa, the source streams of the River Okpalaga and the area between kilometres 6—12, on the Akanje-Azara road), the lithological characteristics are well displayed. Along the core of the anticline, where in contact with intrusive rocks, the mudstones and shales display baking with some "mudcrack" features. An exposure of the mudstones in a source stream of the River Okpalaga is shown in Fig. 5.

Fig. 5. Exposure of the Asu River Formation in a source stream of the River Okpalaga. Photograph taken in March, 1976.

Table 1. Summary of the stratigraphy of the Keana-Awe area

POST-CRETACEOUS		VOLCANICS
LATE CRETACEOUS	MAASTRICHTIAN	LAFIA FORMATION ?
	SANTONIAN-CAMPANIAN	VOLCANICS
	CONIACIAN	AWGU FORMATION
	LATE TURONIAN	hiatus
	EARLY TURONIAN	EZEAKU FORMATION
	LATE CENOMANIAN	KEANA FORMATION
	EARLY CENOMANIAN	hiatus
		AWE FORMATON
EARLY CRETACEOUS	MIDDLE-LATE ALBIAN	ASU RIVER FORMATION

The Asu River Formation contains *inflatum* and *dispar* zone ammonites in southeastern Nigeria. In the Keana-Awe area, the formation has yielded only somewhat older ammonites belonging to the genus *Oxytropidoceras.* During the present field programme, oxytropidoceratids were obtained from a locality 12 km east of Akiri. These have been identified as *Oxytropidoceras* (*Oxytropidoceras*) sp., *O.* (*Manuaniceras*) sp. and *O.* (*Oxytropidoceras*) aff. *mirapelianum* (d'Orbigny).

An earlier collection, studied by Reyment (1955a, 1957), came from a locality nearer Keana and contained *O.* (*Oxytropidoceras*) *hausa* (Reyment), *O.* (*Manuaniceras*) and *O.* (*Adkinsites*). The sediments of the two localities are of the same age.

Owen (1971) has studied the Middle Albian of the Anglo-Paris Basin, but has not taken up the question of the true status of *O. mirapelianum*, the exact identity of which is in some doubt.

Some of the oxytropidoceratid material obtained is figured in the palaeontological section.

Awe Formation

The Awe Formation, here proposed formally as a lithostratigraphical unit, was first recognized by Falconer (1911) as a mappable entity under the

Fig. 6. Brines issuing from the Awe Formation at Keana. Photograph taken in March, 1976.

name of the "Passage Beds". He noted the formation to comprise white sandstones and carbonaceous shales at Awe. He placed it too high, however, in the stratigraphical sequence. Cratchley & Jones (1965) followed Falconer's usage exactly and thus made the same slip. This mistake was inevitable in the absence of a detailed, systematic survey of the area. The present study leaves no doubt whatsoever about the stratigraphical position of the formation. At the type locality, around the town of Awe, the so-called "passage beds" can be seen to lie between the older Asu River Formation and the younger Keana Formation. Here, the formation consists of flaggy, whitish medium to coarse-grained sandstones, on the average about 30 cm in thickness, and interbedded with carbonaceous shales or clays, from which brines issue copiously. Towards the base, the sandstones become finer grained and successively more micaceous. This formation began to build up during

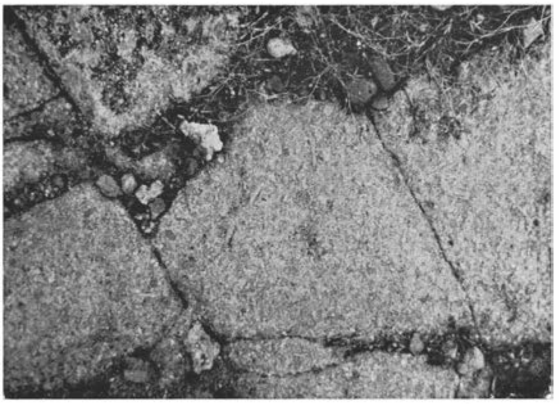

Fig. 7. Gritty sandstone in the Awe Formation; exposure north of the town of Awe. The ring gives the scale.

Fig. 8. Tracks in exposure of the Awe Formation, north of Awe town.

the Late Albian regression and probably ranges into earliest Cenomanian. The thickness of the formation at Awe is estimated to be 1 000 m.

Towards the southeast, the Awe Formation is directly overlain by the more arenaceous and more massive Keana Sandstone. Exposures of the formation can be seen along the River Ugir, where a section of 800 m can be followed, west of the Keana- Makurdi road, to the Keana Sandstone. At Keana, the brines are seen to issue from these transitional strata (Fig. 6). In Fig. 7, an exposure of gritty sandstone is illustrated and in Fig. 8, finer sandstone showing tracks and burrows is shown.

Although fossils are rare in the Awe Formation, a few gastropods and pelecypods occur. Woods, in Falconer (1911), recorded several specimens of *Trigonarca, Modiola, Lima, Pseudomelania,* etc. from outcrops around Awe town. Two new species were also described. *Astarte awensis* Woods is now also known from the Lower Turonian of Niger Republic and southeastern Nigeria. The gastropod, *Semifusus africanus* Woods, has about the same distribution. Reyment (1955b) discussed briefly later collections from Awe.

Keana Sandstone

The Keana Sandstone is a lateral equivalent of the Makurdi Formation in the present area. As far as can be ascertained on the existing evidence,

Fig. 9. Massive outcrop of Keana Sandstone near Takura, on the road to Awe. Note the conglomeratic band.

the one appears to grade into the other. The Keana Sandstone consists mainly of massive, highly indurated, current-bedded, fine to very coarse, sometimes conglomeratic, gritty, arkosic sandstones. The formation is clearly fluviatile in origin. It grades downwards into the Awe Formation and laterally, in part, into the marine Ezeaku Formation in the south. Massive outcrops occur at various localities, around Keana, at Chikinye, Jangerigeri, Azara, Daudo. These locations flank the east and west sides of the Keana anticline. The pebbles and boulders range in size from about 2,5 cm to 15 cm in diameter. The sandstone is relatively competent but, because of the high stress deriving from the folding, the formation is intermittently marked by an exaggerated relief. Where fractured, it becomes readily reduced to a mass of rubble and screes. An outcrop of massive sandstone with conglomeratic bands near Takura is shown in Fig. 9.

Ezeaku Formation

This formation, first formally described by Reyment (1965), consists essentially of calcareous shales, micaceous fine to medium grained friable sandstones and occasional beds of limestone, locally shelly. In the Keana-Awe area, this formation can be seen to overlie the Keana Sandstone in places and, locally, to interfinger with it in areas of transitional environment. Its basal beds can be studied at Ortesh, some 4 km east of the village of Jangerigeri. They consist of shelly limestone composed almost entirely of shells of *Exogyra olisiponensis* (Sharpe). In a marly horizon, the highly diagnostic ammonite *Kanabiceras septemseriatum* (Cragin) has been found, which indicates the highest zone of Cenomanian to be represented (zone of *Sciponoceras gracile*). About 10 km south east of Jangerigeri, an extensive limestone sequence, with marly levels, is exposed. The ammonites occurring in these beds are all known from the Upper Benue (Barber 1957) and in places they occur in great profusion; they represent a slightly higher level than that marked by the *Kanabiceras* and are already of earliest Turonian age.

On the western flank of the anticline, the Ezeaku Formation is represented by limestones and friable micaceous sandstones. Here, it is not easily separable from the Awgu Formation, owing to the lack of good exposures.

A typical section of the Ezeaku Formation, as seen in the area under consideration, can be observed in the bank of the River Tokura, some 20 km southeast of Keana, where the following sequence of beds occurs:

Laterite	0,7 m
Brownish white clay	10 m
Brownish white sandstone (fine, loose to coarsely feldspathic)	1,7 m
Grey shale with intercalations of clay	3,3 m
Grey to black shale	70 m

Fig. 10. Allocrioceras annulatum (Shumard)? Fragment from the Western Aboine River, Anambra State. This specimen is close in appearance to material figured by Cobban & Scott (1972). Af 400. × 3.

Table 2. Correlation of the Benue-Awe sequence with some nearby areas

		SOUTHWESTERN NIGERIA	MIDDLE BENUE (KEANA-AWE)	GOMBE AREA	UPPER BENUE
PALEOCENE		IMO FORMATION	VOLCANICS	?—?—?—?	
DANIAN		NSUKKA FORMATION		GOMBE FORMATION	
MAASTRICHTIAN	LATE	AJALI FORMATION	?—?—?—? LAFIA FORMATION		?—?—?—?
	EARLY	MAMU FORMATION	UNCONFORMITY	UNCONFORMITY	LAMJA SANDSTONE
CAMPANIAN	LATE	NKPORO FORMATION	VOLCANICS	UNNAMED FORMATION	hiatus
	EARLY	hiatus	?—?—?—? hiatus	hiatus	hiatus
SANTONIAN		hiatus	hiatus	hiatus	hiatus
CONIACIAN		AWGU FORMATION	AWGU FORMATION	UNNAMED FORMATION	NUMANHA SHALE SEKULE FORMATION
TURONIAN	LATE	hiatus	hiatus	hiatus	hiatus
	MIDDLE	hiatus	hiatus	hiatus	hiatus
	EARLY	EZEAKU FORMATION	EZEAKU FORMATION in part = KEANA+MAKURDI FS	PINDIGA FORMATION YOLDE FORMATION	JESSU FORMATION DUKUL FORMATION YOLDE FORMATION
CENOMANIAN	LATE	hiatus	hiatus		
	EARLY	hiatus	hiatus	? hiatus ?	? hiatus ?
MIDDLE TO LATE ALBIAN		ASU RIVER FORMATION	AWE FORMATION ASU RIVER FORMATION	BIMA SANDSTONE ?—?—?—?	BIMA SANDSTONE ?—?—?—?

(hatched) = hiatus

Grey, shelly limestone with *Exogyra* 1,0 m
Grey to black shale 7 m
Grey, shelly limestone with *Exogyra* 1,0 m
White to grey clay - - -
——top of the Keana Formation——
White, fine to very coarse feldspathic sandstone

The interesting fact arising out of the present work is the recognition of the basal part of the Ezeaku sequence as being latest Cenomanian in age. This is new for Nigeria and it was therefore thought necessary to attempt to identify beds of the same age in southeastern Nigeria, where the sequence should be more complete. Although truly diagnostic material was not found, evidence of latest Cenomanian seems to have been forthcoming. In an outcropping sequence, just off the Western Aboine River, a specimen of *Allocrioceras annulatum* (Shumard)? was found immediately above a limestone composed almost entirerly of *Exogyra olisiponensis* Sharpe. The specimen (Fig. 10), although fragmentary, agrees well with material figured from the latest Cenomanian of the Western Interior of the USA (Cobban & Scott 1972).

As regards the fossils found in the Ezeaku Formation of the Awe area, the exposures near the village of Jangerigeri have yielded the following.

In beds immediately overlying the limestone with a multitude of *Exogyra olisiponensis*, a specimen of *Kanabiceras septemseriatum* (Fig. 11a—b) has been obtained. Probably from the same clayey marl, although found loose, the largest specimen yet seen of *Ezilloella ezilloensis* Reyment (Fig. 12) was collected, together with a number of gastropods and pelecypods.

The earliest Turonian ammonites found at Akahana comprise numerous species, all of which have been found in the Gongila area of northeastern Nigeria (Barber 1957). Because of the difficulty of recognizing the complicated vascoceratids in orthodox illustrations, we have published stereographic photographs of these ammonites. The species identified are:

Vascoceras depressum Barber?
V. globosum (Reyment)
V. nigeriense Wood
Paravascoceras costatum (Reyment)
Gombeoceras gongilense (Woods)
G. compressum Barber
Bauchioceras tabulatum (Barber)
B. nigeriense (Woods)
B. planum (Barber)
Wrightoceras wallsi Reyment
Neoptychites telingaeformis Solger

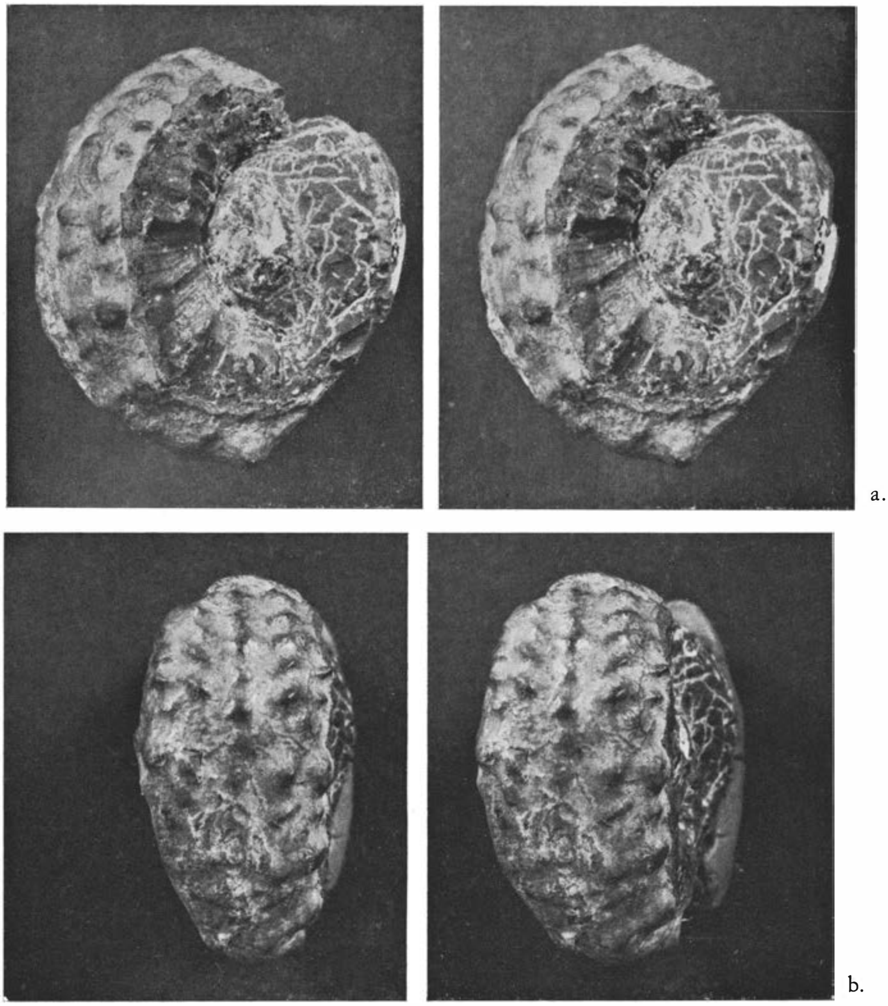

Fig. 11a—b. Kanabiceras septemseriatum (Cragin). Stereophotographs of (a) the lateral view of the fragment, (b) the ventral view. Latest Cenomanian, Ortesh, near Jangerigeri, Benue State. Af 401. Maximum diameter = 57 mm.

The collection also contains several well preserved specimens of *Choffaticeras spathi* Reyment (Fig. 40), the exact provenance of which is unknown. The material was obtained from the flood plain of the R. Ankpe in an area in which outcrops do not occur.

Awgu Formation

The type locality of the Awgu Formation of Coniacian age lies between Awgu and Ndeaboh in Anambra State (cf. Reyment 1965). The formation is marine in origin and consists mainly of black shales, sandstones and, locally, seams of coal (coking coal), with subordinate limestones. The coal seams appear to be concentrated to the northern extension of the formation in the Benue trough. In the area of outcrop of the Asu River Formation in and around Keana, much of the younger sedimentary cover has been eroded away, leaving remnants of the Awgu, Keana and Ezeaku Formations in the hills northeast of the town.

A typical sequence through the formation is yielded by a borehole at Agwantashi, east of Lafia:

Clay	0 — 3,5 m
Shale	3,5— 4,7 m
Grey clay	4,7— 7,6 m
Black shale	7,6— 77,9 m

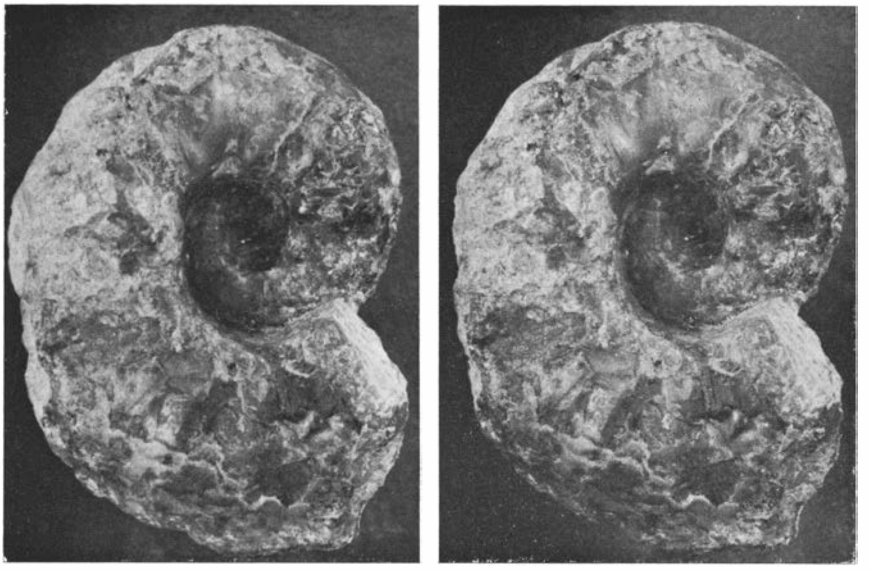

Fig. 12. Ezilloella ezilloensis Reyment. Stereophotograph of the lateral view of the largest specimen known of the species. Latest Cenomanian, Ortesh, near Jangerigeri, Benue State. Af 402. Maximum diameter = 80 mm.

Black shale with coal seams, containing marine ostracods and foraminifers	77,9— 99,0 m
Black shale with thin limestones containing marine ostracods	99,0—103,8 m

The following section has been observed in the bank of the River Dep to the northeast of the foregoing locality (Fig. 13).

Laterite	1,0 m
Clay	30,0 m
Brown clay-shale	3,0 m
Coal	0,07 m
Brown to grey shaly clay	0,30 m
Coal	0,15 m
Shaly clay, brown to grey	0,60 m
Coal	0,14 m
Brown to grey clay-shale	0,60 m
Coal	0,14 m
Grey to brown shale	0,90 m
Coal	0,30 m
Decomposed shale	0,90 m
Coal	0,60 m
Shaly coal	1,50 m
Brown shale with shelly bands	1,5 m
Grey to black shale	3,0 m
Grey calcareous clay	9,0 m
Sandstone, grey, fine-grained, micaceous, current bedded with intercalated shale	1,5 m
Brown to grey shale	1,8 m
Coal	0,75 m
Clay-shale with sandstone intercalation	3,0 m
Sandstone, brown, fine-grained, micaceous	1,5 m

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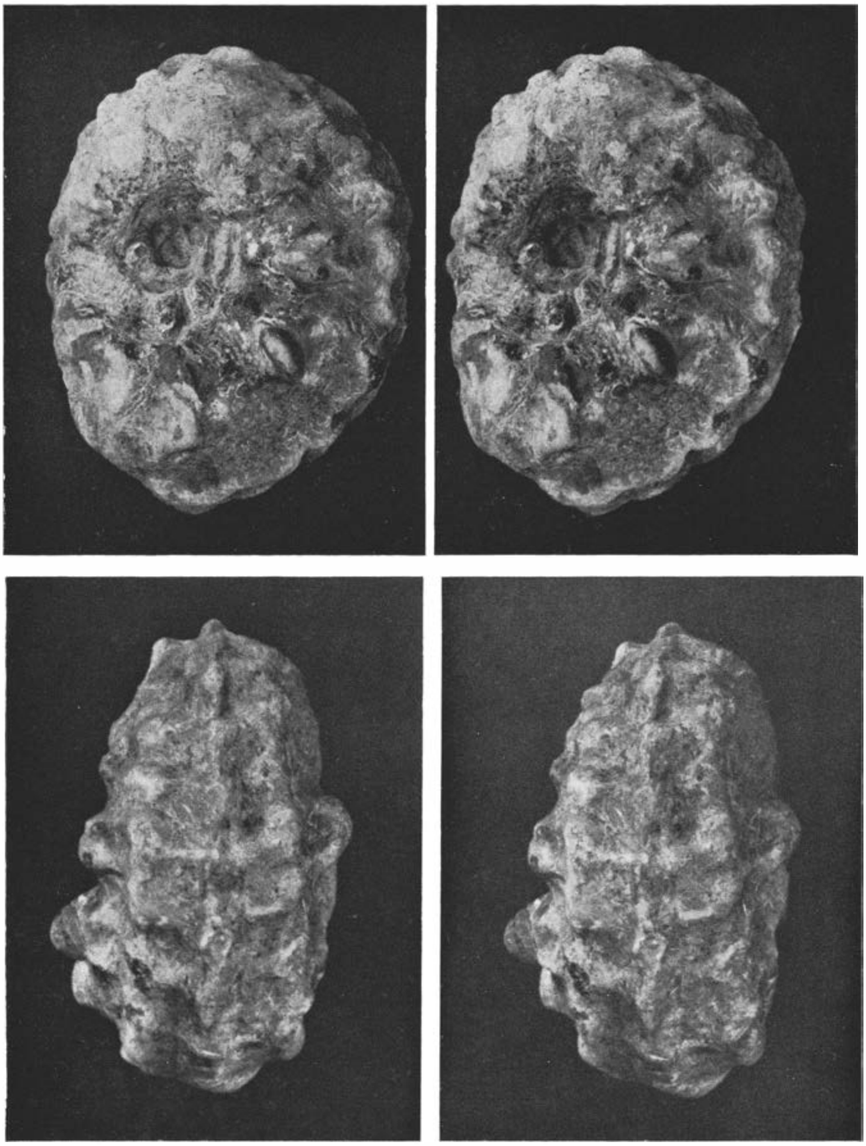
In the area under consideration, it is difficult to separate the Awgu Formation from the Ezeaku Formation and, owing to the lack of a recognizable

Fig. 13. Sequence in Coniacian coals in the southern bank of the River Dep. It is this coal occurrence that has been extensively drilled further south at Obi by the Nigerian Steel Development Authority.



a.

b.

Fig. 14a—b. Barroisiceras nwalii sp. nov. Holotype. A specimen from marl immediately above bed B/20 in the Nigercem quarry, Nkalagu, Anambra State, collected by Mr. G. C. Nwali, Quarry Manager. Early Coniacian. Stereopairs showing (a) the lateral aspect with the umbilical tubercles passing up onto the flanks and there forming the point of bifurcation of the irregular ribs and, (b) the ventral aspect showing particularly the strong, crenulated keel which does not diminish in strength. Af 403. Maximum diameter = 120 mm.

unconformity between the two formations, it could be possible that there is a continuous passage from the one to the other. However, recent observations we have been able to make in the quarries of Nigercem at Nkalagu definitely prove that the Ezeaku Formation terminates in Middle Turonian, being unconformably, though not discordantly, overlain by Awgu Formation with *Barroisiceras nwalii* sp. nov. (Fig. 14a—b). The uppermost beds of the Ezeaku Formation at Nkalagu are rich in inoceramids, among them the species *Mytiloides hercynicus* (Petrascheck), *M.* aff. *subhercynicus* (Seitz) and *Sergipia* aff. *posidonomyaformis* Maury (Fig. 15). In the same shale beds, there are

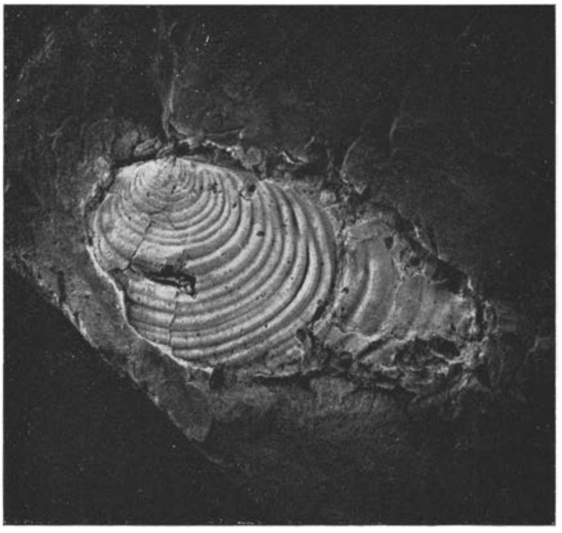


Fig. 15. Sergipia aff. *posidonomyaformis* Maury. Early Middle Turonian. Upper part of Bed 20, Nigercem Quarry, Nkalagu, Anambra State. Af 404. × 1.

crushed *Collignoniceras* sp. indet. We thank Dr. Erle Kauffman for assisting us with the identifications of the inoceramids.

Lafia Formation

The Lafia Formation is the youngest formation of the area. It has been described differently by different workers and, unfortunately, it has been the object of much confusion. Falconer (1911) called it the "Upper Grits and Sandstones", while Farrington (1952, p. 591) referred to it as the "Sandstones of Lafia/Makurdi". Later, Cratchley & Jones (1965, pp. 3, 5) termed it the Lafia Sandstone. The published reports of Esso West Africa Inc. (1967) considered it to be the northerly extension of the "Enugu Formation". Dessauvagie (1972) used the name Lafia Sandstone.

The Lafia Formation, as understood by us, covers thinly the Awgu Formation and occupies most areas to the west and northwest of the area described in this paper. It continues southwestwards into adjoining areas and it is thought to be a time equivalent of the Nkporo Formation, although there is no direct evidence for this. Esso West Africa Inc. put its thickness at 500—1500 m. In the Lafia-Awe area, the formation seems to be wedging out and its maximum thickness hardly exceeds 50 m.

Lithologically, the formation consists essentially of continental ferruginized sandstones, red, loose sands, flaggy mudstones and clays. The type locality is in and around the town of Lafia.

A gorge at a bridge on the road to the Emir's palace in Lafia town exposes the following sequence:

Bright-red, loose sands, clayey sands, medium- to fine-grained (Fig. 16)	7 m
White to brown clay	10 m
Medium- to fine-grained current-bedded sands, white to grey in colour	base of exposure

What appears to be a more complete sequence was observed in the bank of the River Amba, in the vicinity of the above-mentioned gorge. Here, the section is

Laterite	1 m
Ferruginized sandstone	7 m
Bright-red, loose sands and clays	7 m
White to brown clay	10 m
Current-bedded sandstone, fine- to medium-grained, coloured white to grey	base of sequence

The following sequence was observed on the hill to the north of Shara village, southwest of Lafia town:

Laterite and ferruginized, current-bedded, gritty sandstone	? m
Brownish lateritic clays with plates of red mudstone and indurated red shales	7 m

Fig. 16. View of the erosion gully in the Lafia Formation near the palace of the Emir of Lafia.

Bright-red sandstone, loose and gritty	5 m
Sandy clay, whitish at the base, becoming grey to brown upwards	base of sequence

At a point 1,5 km south of Lafia on the road to Makurdi, a palaeosoil is exposed in a road cutting. This consists predominantly of red, sandy clay, with an irregular band of angular fragments of ferruginized sandstone, the average thickness of which is about 30 cm. This horizon may possibly derive from the ironstone capping of the Lafia Formation.

Identifiable fossils have not yet been obtained from the formation, although carbonized plant remains occur.

Igneous Rocks

Intrusive and extrusive rocks occur within the area. Extrusive rocks are confined to the southeastern parts of the sheet where extensive lava flows once emanated from the numerous volcanic hills. In the Awe area, the lava flows cover outcrops of the Asu River Formation, thereby baking the shales and mudstones at the contact.

About 15 km south of Lafia, Nigerian Steel Development Authority borehole No. 1 pierced a doleritic rock at a depth of 12,6 m. This dolerite, 8,7 m in thickness, appears to lie as a sill within the Lafia Formation.

Salt

Brine springs issue at several points within a narrow belt in the Benue valley, continuing southeastwards into the Abakaliki area, and northeastwards into the Gongola valley. The origin of the brines is a subject of controversy. It seems as though the lead-zinc and barytes mineralization is correlated with the occurrences of brines. This mineralization has been variously interpreted as occurring towards the close of Turonian time and to be hydrothermal in origin (Farrington 1952; McConnel 1949), although a somewhat later date is more likely, to wit, Santonian or Early Campanian (Reyment 1965). The brines have been thought by some to derive from the hydrothermal source. Other possibilities include connate water, salt beds. So far, no conclusive evidence for any of the hypotheses has been forthcoming and work is currently in progress to try to resolve the problem.

In the Keana-Awe area, the brines have been found to issue from the Awe Formation which, as already indicated, lies between the marine Asu River Formation and the predominantly fluviatile Keana Formation. The kind of environment pertaining (see below) would have been conducive to the deposition of salt beds, alternating with shales and sandstones. Fig. 17 shows brine works at dipping beds of the Awe Formation 2 km from Keana.

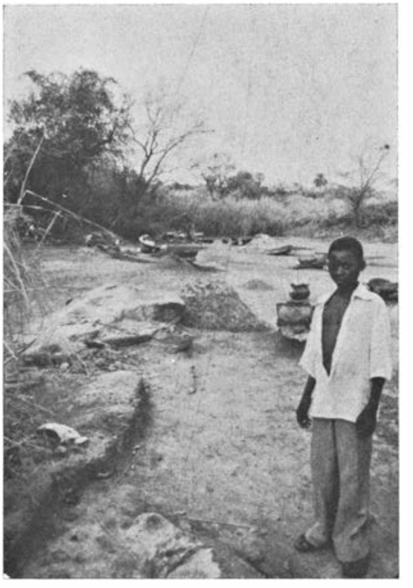


Fig. 17. Brine works in shallowly dipping strata of the Awe Formation, 2 km from Keana.

In this connexion, it is of interest to consider the geological conditions of the beds of the same age in Niger Republic, the deposition of which is genetically directly related to the sediments of the Benue valley and northeastern Nigeria. Greigert & Pougnet (1967) report numerous occurrences of gypsum in the "lagoonal" sediments corresponding in age to the Awe Formation. There are also occurrences of gypsum in the marine equivalents of the Ezeaku and Awgu Formations, as well as in younger sediments, although most of the latter seem to be a result of secondary formation. In addition, gypsiferous and saliferous shales occur widely in the Cenomanian to Coniacian deposits. One of the gypsums, namely that at In Arial in the Coniacian, appears to be sizeable. There are brines analogous to those of Nigeria and they form the base of local industries. Busson (1970) has reported in detail on numerous occurrences of Cretaceous evaporites and precipitates in Algeria and Tunisia in sequences which have a certain genetic correlation with analogues in Nigeria and Niger Republic.

Structure

The Cretaceous rocks of the area have been subjected to several folding episodes and, as a result, dips tend to be variable. In the Asu River Formation, dips vary from 0°, on the crest of the Keana anticline, to 25° on the flanks of this fold. The Asu River and Ezeaku Formations are more intensely folded than the younger sediments and they are characterized by drag folds. The dip in the Lafia Formation is low and its southwesterly orientation is unconformable with the regional dip.

The folding is characteristically parallel to subparallel, running approximately northeast-southwest. There is evidence for three folding episodes. Nwachukwu (1972) suggested the existence of a post-Albian and pre-Turonian folding phase, basing his inference on inter alia the "greater intensity of folding of the Albian sediments". This greater intensity of folding of the Asu River, Ezeaku, and Keana Formations has already been remarked upon. It is also generally accepted that there was a folding episode in Santonian or Early Campanian time and the effects of this can be identified in all the formations of the area with the exception of the Lafia Formation. The resultant uplift and subsequent erosion has left remnants of the Makurdi and Awgu Formations dotting the volcanic hills around Keana. Finally, there is the post-Maastrichtian folding episode (Wright 1975) which appears to have acted at right angles to the trends of the two older phases. The Maastrichtian episode touched all formations, including the Lafia Formation. In Fig. 18, the superimposed post-Maastrichtian effect at right angles to the earlier folding direction is shown in strata north of Awe town. In this connexion, it is significant that the Lafia Formation is gently folded in a northwestern-southeasterly direction and there is a small flat anticline passing through Lafia Town. Finally, we note that the post-Maastrichtian folding episode appears to have distorted the regional fold axes, giving them their sinusoidal flexures (for example, as shown in Fig. 19, a scene on the south side of Awe).

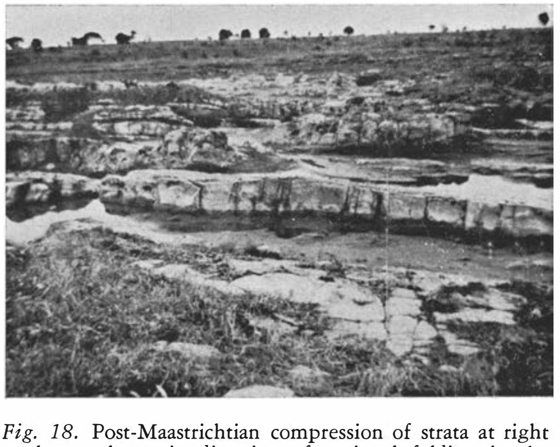


Fig. 18. Post-Maastrichtian compression of strata at right angles to the main direction of regional folding in the Middle Benue. Awe Formation, immediately north of Awe town.

Fig. 19. Distortion of the regional fold axis shown in a large exposure immediately south of Awe town.

Two fracture trends conform with the two main folding directions, the northeasterly-southwestern and the approximately northwesterly-southeasterly, or west-east, trends. The later fractures are generally mineralized and account for most of the veins of barytes in the area. This could be taken to suggest a post-Maastrichtian age for the mineralization.

Palaeoecology

The key to understanding the complicated geology of the Benue valley lies with a correct interpretation of the palaeoenvironment. The transgressions and regressions of the Nigerian coastal basin cannot be held separate from the extensive changes that took place on a mondial scale during the middle part of the Cretaceous Period .

The transgressive surges can be readily correlated with epicontinental inundations of the sea in many parts of the world and it now stands clear that the late Middle Albian, latest Cenomanian and the Coniacian were three times of major eustatic shifts in sealevel. The main force causing these rises of sealevel derived from episodic changes in the volumes of the oceanic basins,

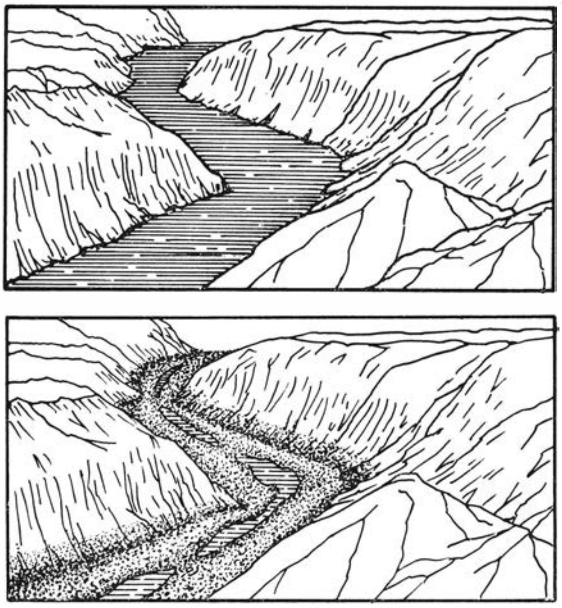


Fig. 20. Idealized representation of the effects of continental climatic variations on the epicontinental sea of western Africa. The upper drawing represents the low salinity environmental extreme and the lower picture, the high salinity variant, with the formation of great salt lakes.

resulting from spreading of the seafloor and the growth of mid-oceanic ridges. During the periods of quiescence, regressive phases took place which, for the South Atlantic, would have been governed by geoidal eustasy (cf. Mörner 1976). During the latest Cenomanian to Early Turonian epicontinental transgression, the narrow sea spread across the Sahara for a short time, uniting the South Atlantic and the Tethys. The Albian and Coniacian transgressions did not stretch as far, the latter being the more extensive of the two.

The exceptional marine environment that existed in the long (several thousand km) narrow inland sea merits attention. This sea, partly channelled through tectonically controlled basins and partly spilled out over the craton, was mostly very shallow. Normal marine meteorological conditions did not apply and the epicontinental sea was influenced by continental climatic factors over most of its extent. The implications of this are summarized in Table 3 and illustrated schematically in Fig. 20.

It is to be expected that switches from normal salinity to either environmental extremes could take place rapidly, in the geological sense, and there was an oscillatory pattern of climatic variations. The fact that ammonites occur in great numbers at only certain levels in the Early Turonian of Niger Republic and Nigeria can be taken as an indicator of episodes of mass mortality brought on by shifts in salinity. The frequent occurrence of primary salt and gypsum in shales in the Cenomano-Turonian of particularly Niger Republic is further evidence of salinity crises.

There is reason to suspect that accumulations of salts could have occurred during periods of aridity, during which the always tenuous marine connexion inland was broken, with the formation of a chain of elongated hypersaline lakes. This is more likely in the Benue valley, and has been proven in the Algerian part of the epicontinental sea, than in the Saharan stretch, owing to the greater time interval occupied by the transgression in the outer reaches.

Acknowledgements. — We are grateful to the Director of the Geological Survey of Nigeria, Mr. C. N. Okezie, who initiated and directed the mapping programme

Table 3. Influence of continental climate on the northwest African epicontinental seas

Climatic conditions	Oceanographical effects	Biological effects
Periods marked by heavy rains average effect of higher rainfall)	Lower salinities, particularly in shallow marginal areas of seas, increase in lateral extent	Stenohaline life banished from large areas, mass mortality episodes, e.g. of ammonites; local abundance of euryhaline organisms
Pronouncedly dry periods (average effect of long droughts)	High salinities, break-up of sea into chain of hypersaline lakes, formation of evaporites, precipitates, decrease in lateral extent of sea and shallowing	Stenohaline organisms banished, mass mortality episodes, impoverished fauna of hypersaline organisms, locally; azoic conditions, stagnation environments
Periods of normal salinity	"Normal" conditions of sedimentation	Stenohaline organisms appear

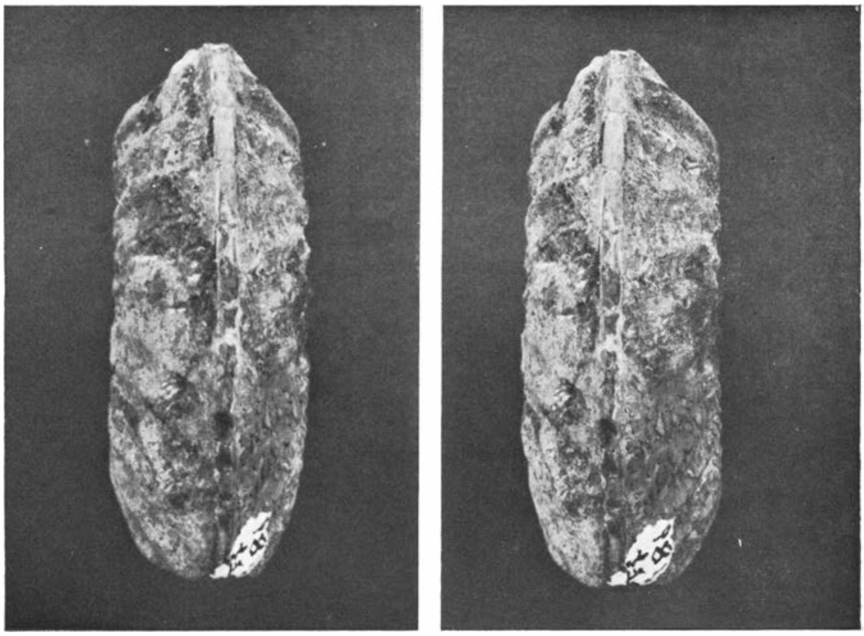


Fig. 21. Oxytropidoceras aff. *mirapelianum* (d'Orbigny). Stereopair showing the lateral aspect. From the floodplain of the River Ankwe, Benue State. This resembles *O. mirapelianum* with respect to the ornament (as originally figured), but differs from that species in that it has a strongly cardioid whorl section. Af 405. Maximum dimension = 120 mm. Latest Middle Albian.

at its inception. We are also thankful to the General Manager of the Nigerian Mining Corporation, Alhaji R. Lukman, who made this follow-up possible. We should also like to thank Mr. Kenneth Diebel, Exploration Manager, Esso Exploration Inc., for making a set of reconnaissance geological maps of the Benue area available to us. Our gratitude also goes to the officials of the Nigerian Steel Development Authority for their co-operation, the Chief of Keana for his hospitality and all the field assistents, drivers and villagers without whose support this work would not have been possible. The photographs were made by Mr. Gustav Andersson and the drawings by Mrs. Dagmar Engström. The fine job of developing the fossil material was done by Mrs. Suzana Bengtson. A publication grant from the Shell-B.P. Petroleum Development Co. of Nigeria Ltd is gratefully acknowledged.

Palaeontological appendix

R. A. REYMENT

The collections from the Keana-Awe area are of considerable interest as they contain irrefutable evidence of the latest Cenomanian age of the earliest part of one of the major transgressions in western and northern Africa as well as new information on the palaeontology of the West African Early Turonian. The collections also throw light on the relationships between the Turonian ammonoid associations of Nigeria and Sergipe (Brazil), pointed out by Reyment & Tait (1972), and further strengthened by the present work. The figured fossils have been incorporated in the type collection of the University of Uppsala.

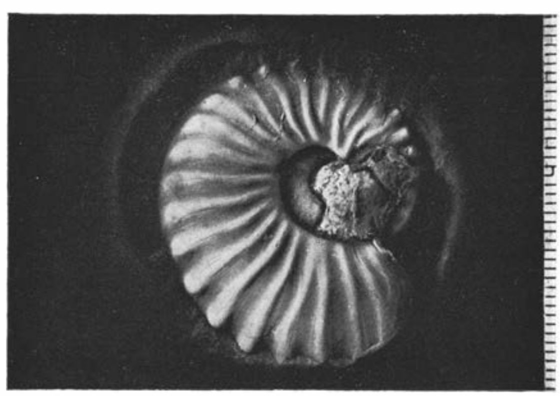
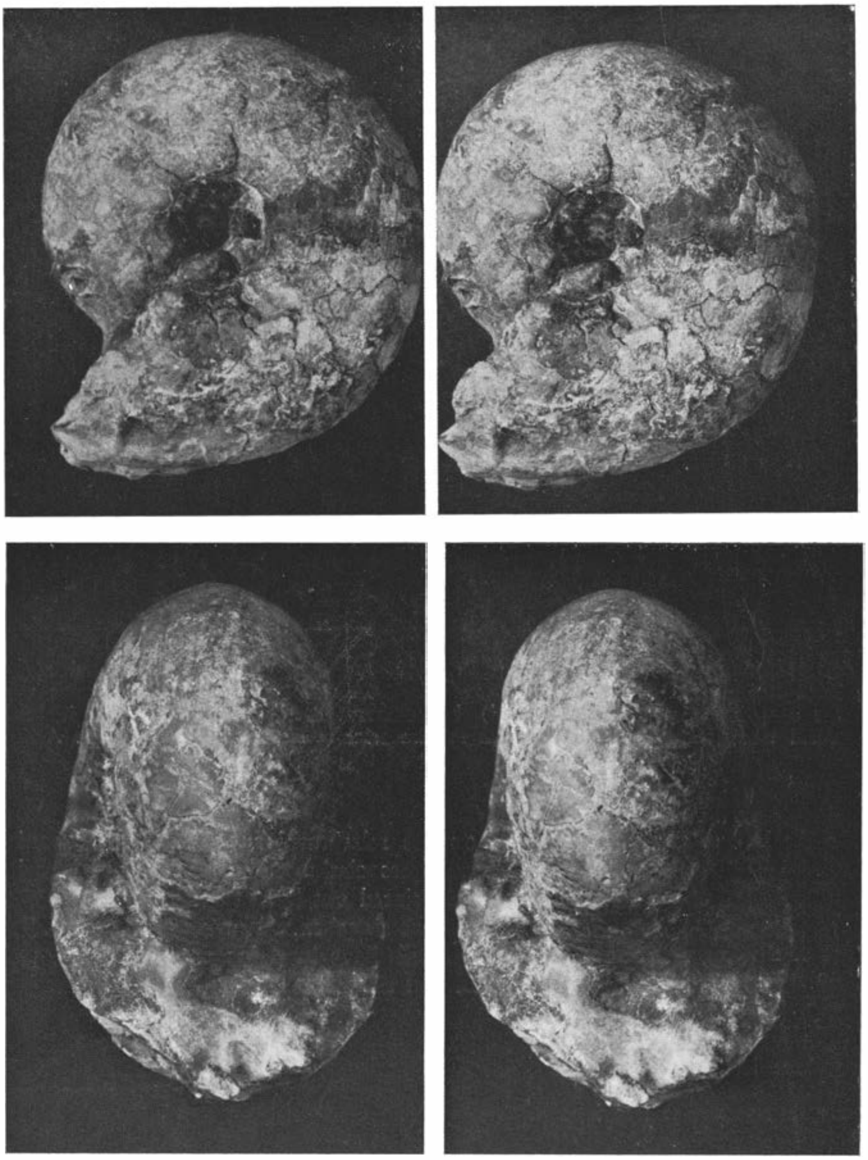


Fig. 22. Venezoliceras clavicostatum Renz? Impression of a juvenile individual showing strong, clavate ventrolateral tubercles. Floodplain of the River Ankwe, Benue State. Af 406. Maximum diameter = 39 mm. Latest Middle Albian.



a.

b.

Fig. 23a—b. Vascoceras robustum Barber. Stereophotographs showing (a) the lateral aspect of a small specimen and (b) the ventral aspect. Akahana, Benue State. Early Turonian, Af. 407. Maximum diameter = 95 mm.

Middle Albian

The collections contain numerous fragmentary oxytropidoceratids. None of this material was found in situ, having been collected from the floodplain of the River Ankwe by M. E. Offodile and coworkers in 1974. Most of the fragments belong to *Oxytropidoceras* aff. *mirapelianum* (d'Orbigny), a specimen of which is shown in Fig. 21. Although the ornament of the Nigerian fragments is undoubtedly similar to that of *mirapelianum*, the whorl shapes differ significantly in that the Nigerian individuals are pronouncedly cardioid. *Oxytropidoceras hausa* (Reyment), also from the Keana-Awe area, is generally similar to the fragments treated here, but it is more sigmoidally ribbed and there are other differences.

The collection also contains impressions of what seems to be a *Venezoliceras*, rather close to *V. clavicostatum* Renz (1968) (Fig. 22). This

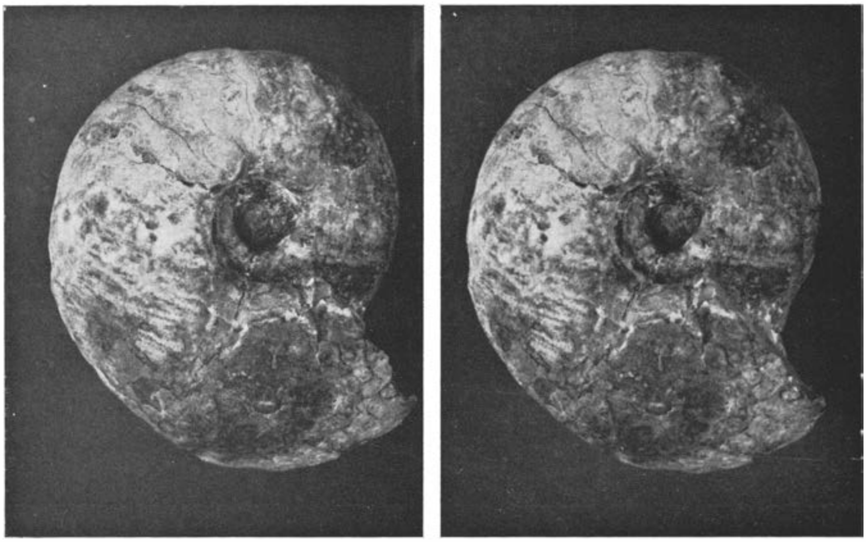


Fig. 24. Vascoceras sp. juv. Stereophotographs of the lateral aspect of the inner whorls of a vascoceratid possibly allied to *V. robustum.* Akahana, Benue State. Af 408. Maximum diameter = 65 mm. Early Turonian.

species was said to lack lateral nodes on earlier whorls, but to develop strong ventrolateral tubercles at an earlier growth stage. The typical lateral nodulation of *Venezoliceras* appears first at an advanced developmental stage in this species. The Nigerian material is insufficient to permit a definite identification but the features available for study indicate that it differs from any true *Oxytropidoceras* hitherto recorded and that, apart from the lack of lateral nodes, falls well within the range of variation of *Venezoliceras.*

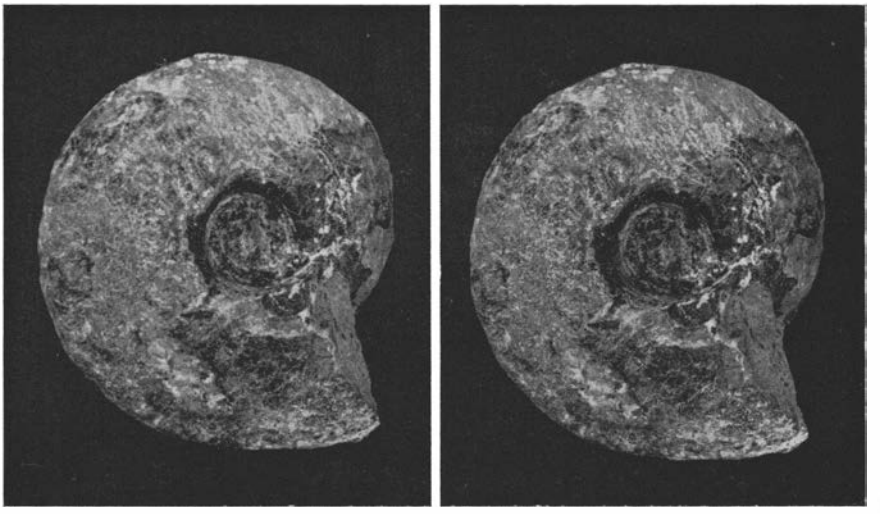
Reyment & Tait (1972) used the distribution of *Venezoliceras* as one of their criteria for dating transgressions in the South Atlantic. *Venezoliceras* (as *Lophoceras* van Hoepen) occurs in South Africa, for example, and is not really useful in establishing diagnostic differences in palaeobiogeographical associations.

Although there are some minor differences of opinion on the stratigraphical location of oxytropidoceratids of the kind here considered, it seems that a latest Middle Albian age probably lies close to the truth.

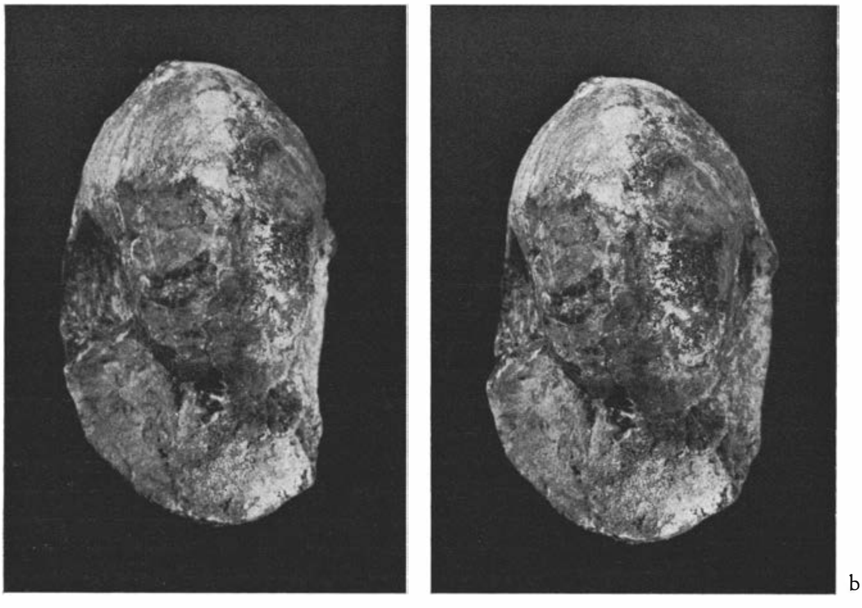
Late Cenomanian to Early Turonian

The collection contains a few, though very important, Late Cenomanian fossils from Ortesh, near Jangerigeri, Benue State. *Kanabiceras septemseriatum* (Cragin), shown in Figs. 11a—b, is an excellent marker for latest Cenomanian in many parts of the world, including the Western Interior of the United States. Its location, immediately below a typical lowermost Turonian association, provides good evidence for the time at which the Cenomano-Turonian transgression was initiated in the Benue trough. The same beds yielded a large specimen of *Ezilloella ezilloensis* Reyment (Fig. 12), previously known from the lowermost Turonian deposits of coastal Nigeria.

The locality of Akahana, some 15 km from Jangerigeri, and stratigraphically immediately above Ortesh, yielded a large number of Lower Turonian ammonoids, all of which are known from the monograph of Barber (1957). Barber (op. cit.), faced by a bewildering profusion of forms, was seduced into separating out a large number of morphotypes he called subspecies. This is clearly an incorrect usage of the concept inasmuch as these categories occur together in the same bed, as shown, for example, at the Akahana locality. There is, in my opinion, a genuine need to recognize several morphotypes in the Lower Turonian vascoceratid associations and I have therefore employed Barber's names in the sense of species. As regards the zonational scheme proposed for northeastern Nigeria (Carter et al. 1963, p. 50), I find it to be of dubious value as the supposed zonal indices are not clearly separated in time, as at Akahana, and it seems likely that the three zones erected are not applicable outside of the area for which they were proposed.



a.



b.

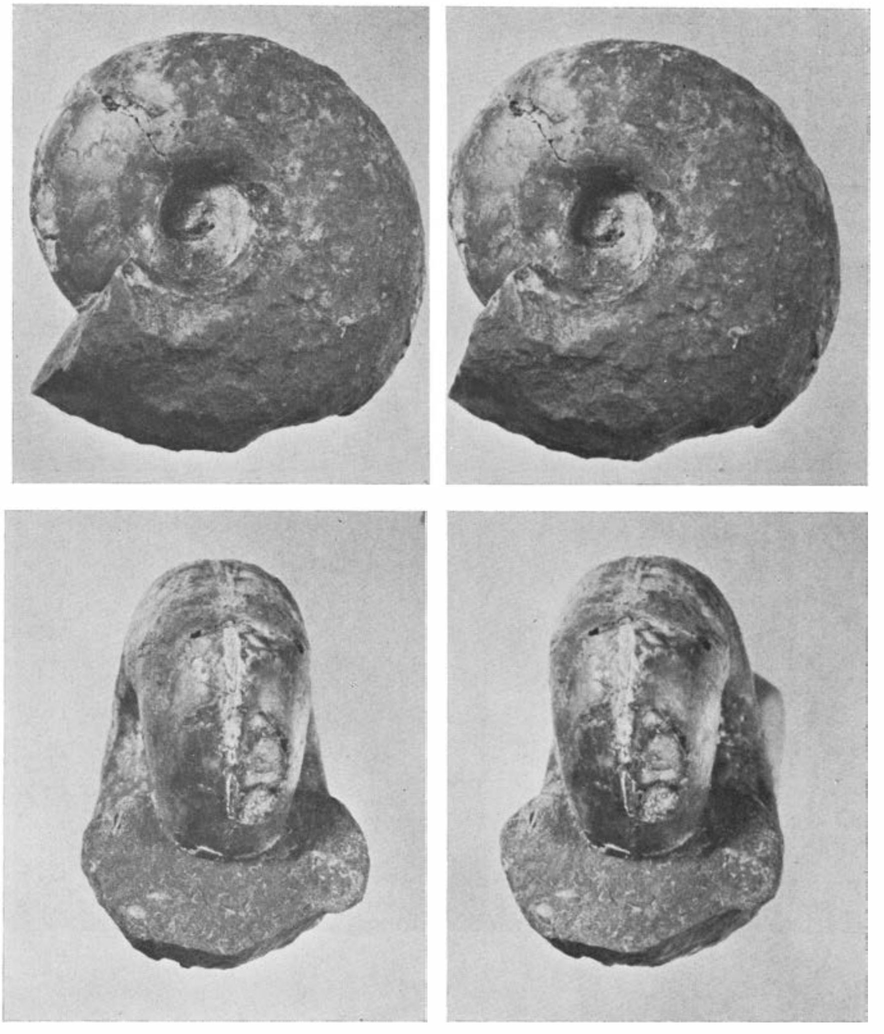
Fig. 25a—b. Vascoceras ellipticum Barber. Stereophotographs showing (a) the lateral aspect and (b) the ventral appearance with the elliptiform whorl section. Akahana, Benue State. Af 409. Maximum diameter = 79 mm. Early Turonian.

Species of Vascoceras. — *Vascoceras robustum* Barber (Figs. 23a—b) could possibly be a variant of *Vascoceras nigeriense* (Woods); the degree of evolution is about the same in both and not more involute, as was stated in the original description (Barber 1957, p. 17). The collection contains several ammonoids referred here, the largest of which is figured.

Vascoceras ellipticum Barber. This specimen (Fig. 25a—b) agrees fairly well with the original description as regards the trianguloid whorl shape, but the umbilicus appears to be more open. Barber (op. cit., p. 17) considered the diameter of the umbilicus to be a variable feature.

There are also some specimens of *Vascoceras* sp. juv. (Fig. 24) and these agree with some of the ammonoids figured by Barber (op. cit., p. 27) as juvenile *Vascoceras.*

It is perhaps remarkable that no true *Vascoceras*



a.

b.

Fig. 26a—b. Paravascoceras costatum (Reyment). Stereophotographs showing (a) the lateral aspect and (b) the venter. Akahana, Benue State. Af 410. Maximum diameter = 66 mm. Early Turonian.

nigeriense were obtained at Akahana, nor did Barber have many in his collection. It seems as though the first described Nigerian *Vascoceras* is rare.

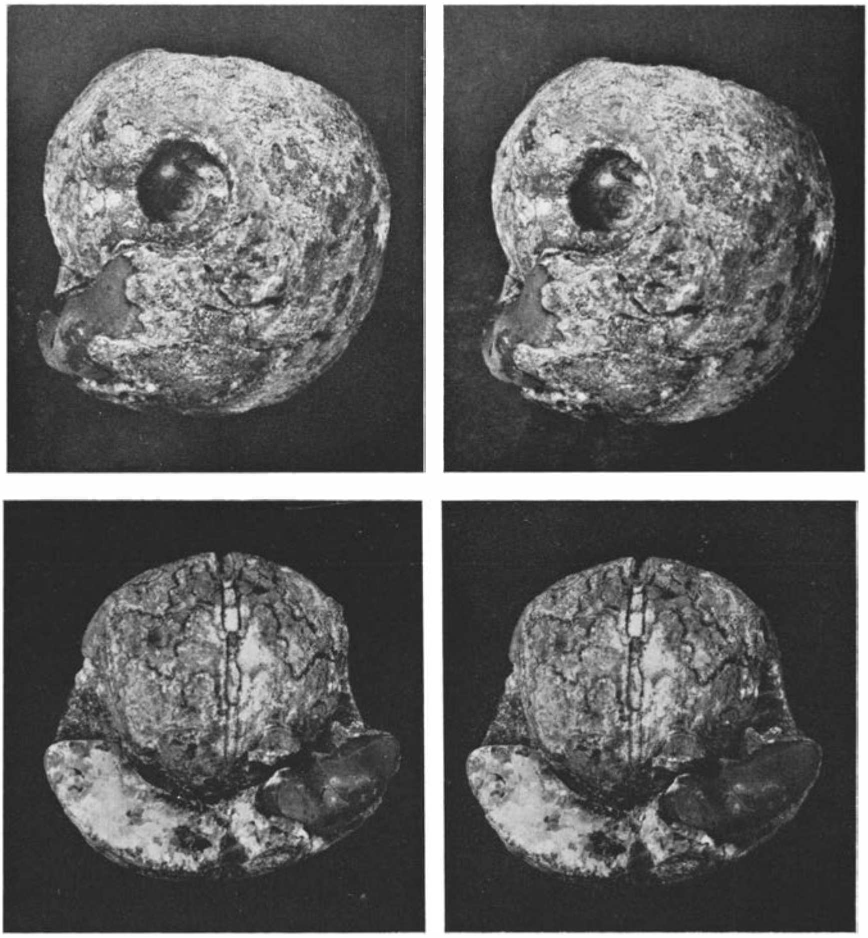
Species of Paravascoceras. — The revision of Schöbel (1975) is used here in defining *Paravascoceras.* Briefly, the major difference between *Vascoceras* and *Paravascoceras* is that the latter has umbilical tubercles at early growth stages at least, whereas *Paravasoceras* always has an untuberculated umbilical margin.

Paravascoceras costatum (Reyment) is a relatively common species at Akahana. One of the specimens is shown in Figs. 26a—b.

Paravascoceras carteri (Barber). This species was originally assigned to *Vascoceras* by Barber (op. cit.) but, owing to the absence of umbilical tubercles (Fig. 28), it is more logically placed with *Paravascoceras.* A large, typical specimen is shown in Figs. 27a—b. Identical material occurs in the Brazilian collection at Uppsala, found by Dr. P. K. Bengtson.

Paravascoceras tectiforme Barber is similar in shape to *Vascoceras ellipticum* but differs from that species in lacking umbilical tubercles (Figs. 29a—b).

The collection also contains a single specimen of *Neoptychites telingaeformis* Solger (Fig. 30). This is the first record of a *Neoptychites* from



a.

b.

Fig. 27a—b. Paravascoceras carteri (Barber). Stereographs showing (a) the lateral aspect and (b) the strongly depressed venter. Akahana, Benue State. Af 411. Maximum diameter = 105 mm. Early Turonian.

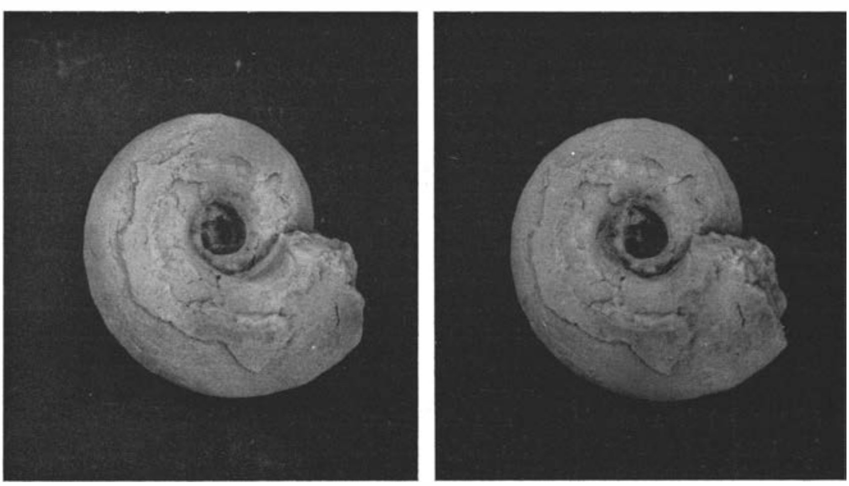


Fig. 28. Paravascoceras carteri (Barber). Lateral aspect of inner whorls showing the smooth umbilical margin. Akahana, Benue State. Af 412. Maximum diameter = 39 mm. This specimen has faint ventral bulges. Early Turonian.

a.

b.

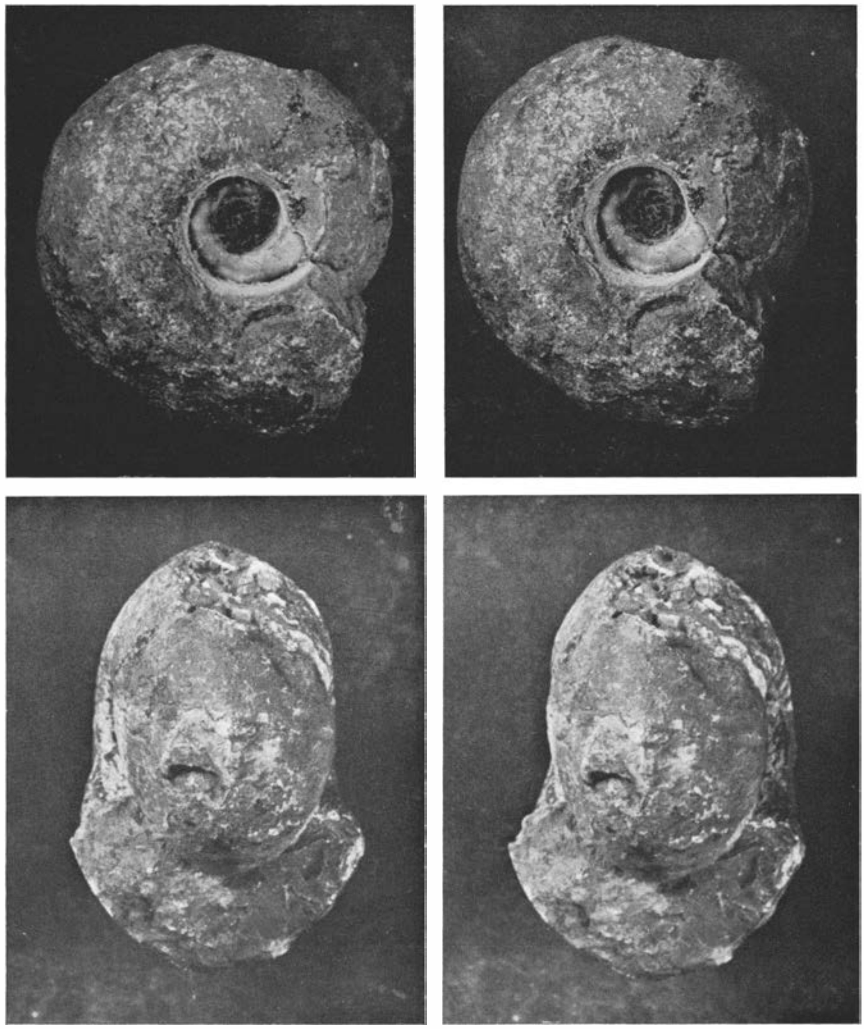


Fig. 29a—b. Paravascoceras tectiforme Barber. Stereophotographs showing (a) the non-tuberculate umbilicus and (b) the sharply angular venter. Akahana, Benue State. Af 413. Maximum diameter =89 mm. Early Turonian.

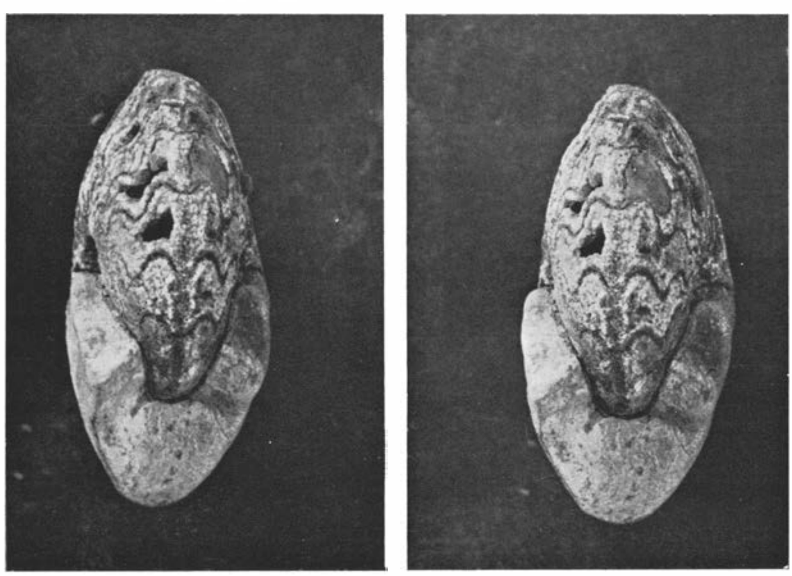
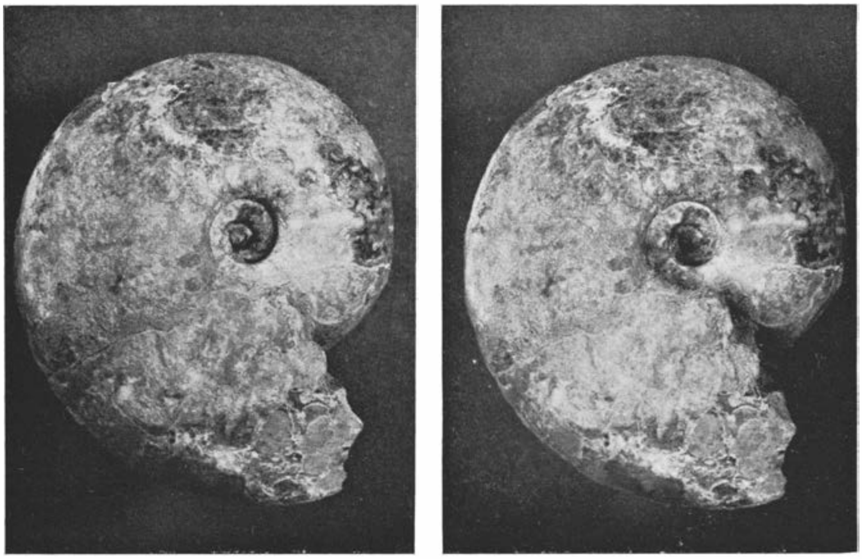
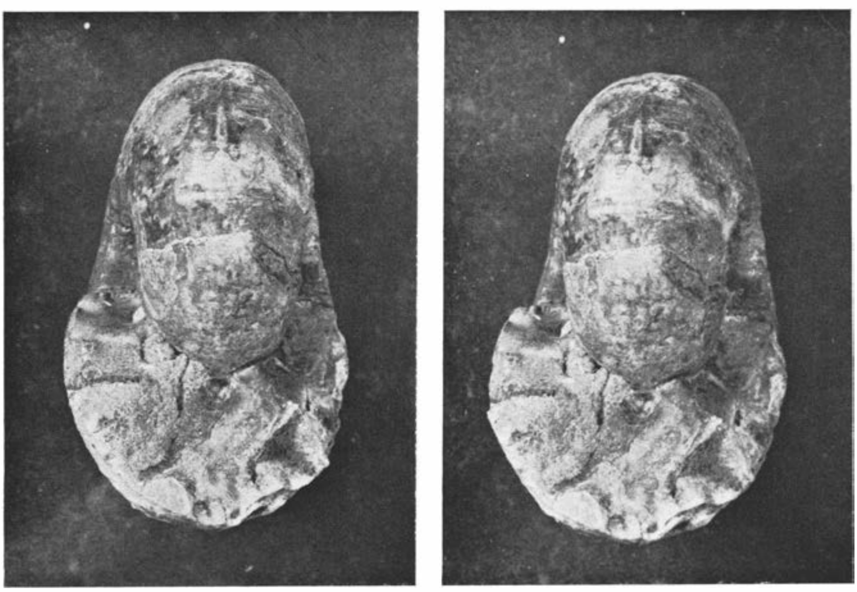


Fig. 30. Neoptychites telingaeformis Solger. Ventral view. Akahana, Benue State. Af 414. Maximum diameter = 74 mm. Early Turonian.



a.

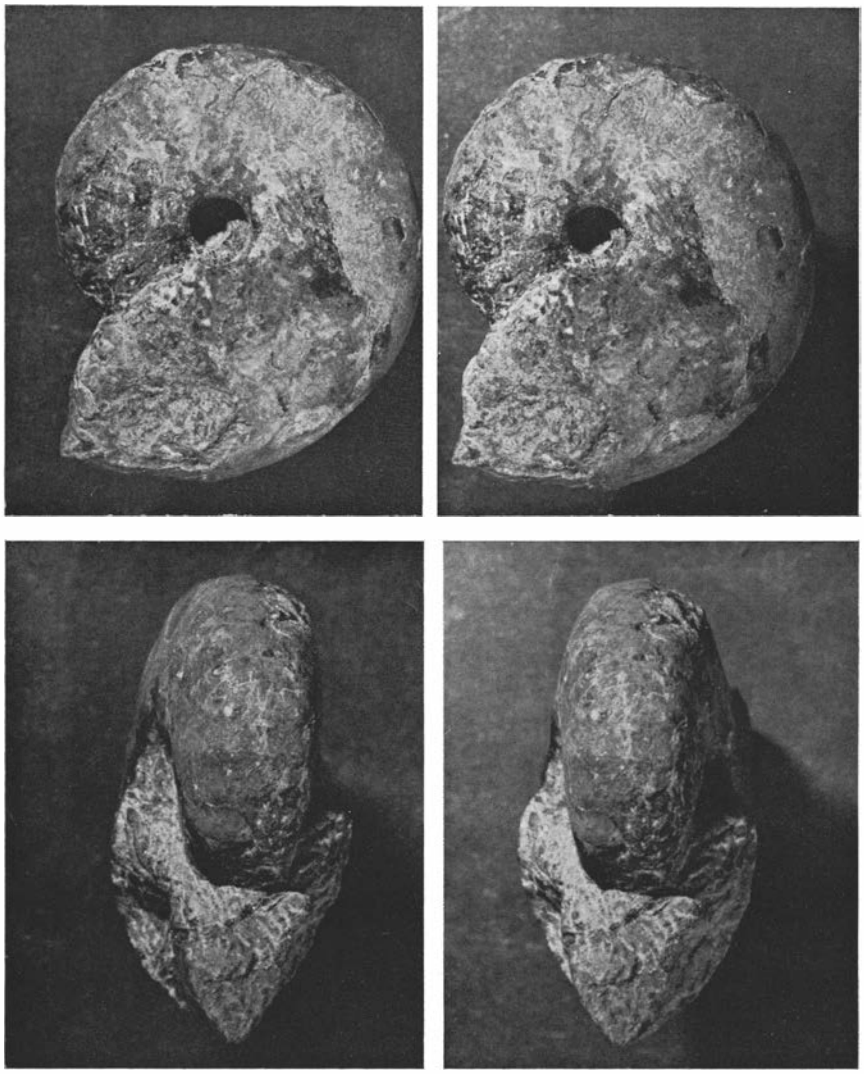


b.

Fig. 31a—b. Gombeoceras gongilense (Woods). Stereophotographs showing (a) the tuberculate umbilicus and (b) the weakly keeled venter. Akahana, Benue State. Af 415. Maximum diameter = 135 mm. Early Turonian.

northeastern Nigeria and Niger Republic, although it occurs in comparable associations in North Africa.

Species of Gombeoceras. — *Gombeoceras gongilense* (Woods) is quite common at Akahana. Two variants are figured here. The one (Figs. 31a—b) is a large specimen (diameter = 135 mm) with stout umbilical tubercles disclosed in the umbilicus (Fig. 31a) and in which the central and ventrolateral ornament has degenerated into lateral and siphonal keel-like ridges. The second specimen (diameter = 75 mm) has very feeble umbilical tubercles (Fig. 32a) but displays the typical lateral and ventral ornament of the genus. The siphonal tubercles form a weak siphonal (Fig. 32b) ridge on the last preserved part of the specimen. An interesting feature of this individual is a comprehensive shell damage, which could have been the cause of death (Fig. 32a).



a.

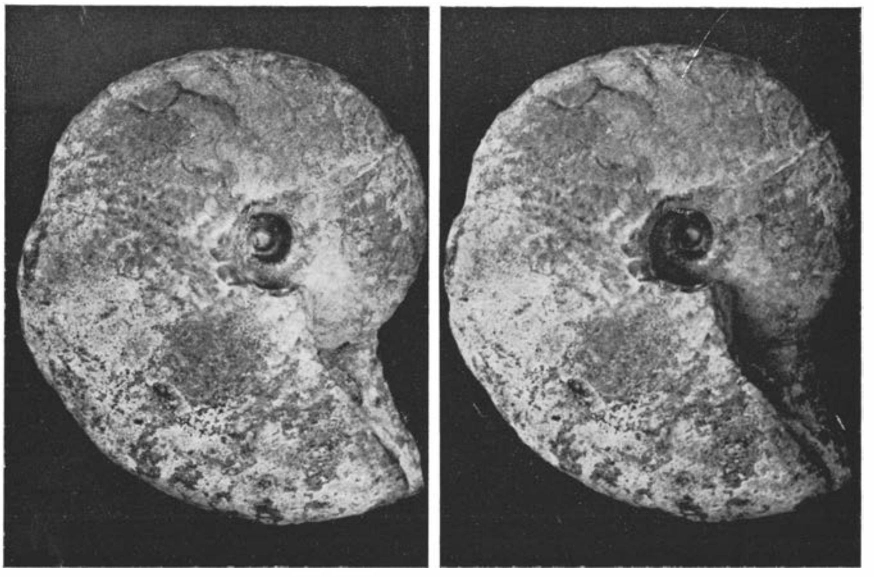
b.

Fig. 32a—b. Gombeoceras gongilense (Woods). Stereophotographs illustrating (a) the lateral aspect and (b) the venter. This specimen shows the typical ventral and ventrolateral ornament of the species but the umbilical tubercles are very weakly developed. Akahana, Benue State. Af 416. Maximum diameter = 75 mm. Early Turonian.

Gombeoceras compressum Barber. A compressed variant of *G. gongilense* which shows the typical ornamental features of the genus (Figs. 33a—b) and interesting because of the morphological similarity it possesses with some *Bauchioceras*. Barber's taxa *tectiforme* and *lautum* should probably be grouped together with *G. compressum*. These latter two categories also resemble some *Bauchioceras*.

Species of Bauchioceras. — Barber (op. cit., p. 45) pointed out the close relationship between the morphology of some *Gombeoceras* and certain *Bauchioceras* and concluded that the latter evolved from the former. I have already indicated certain species of *Gombeoceras* that have a *Bauchioceras*-kind of appearance. Species of *Bauchioceras* that bear a striking resemblance to *Gombeoceras* are Barber's subspecies *macrocarinatum* and *bicarinatum*. Immature species of both genera display sutures that are similar and it is only in large individuals of *Bauchioceras* that the characteristic saddles and first lateral lobe are developed.

The Akahana locality is particularly rich in


a.

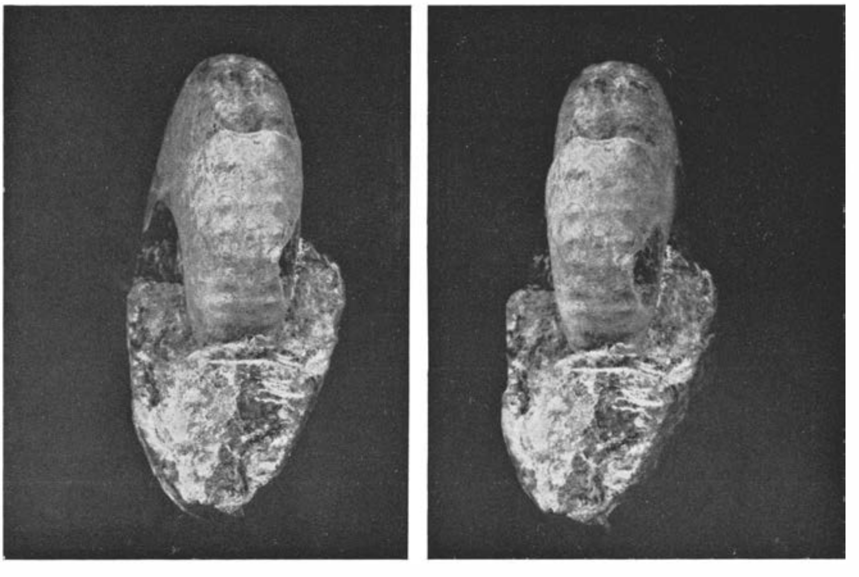
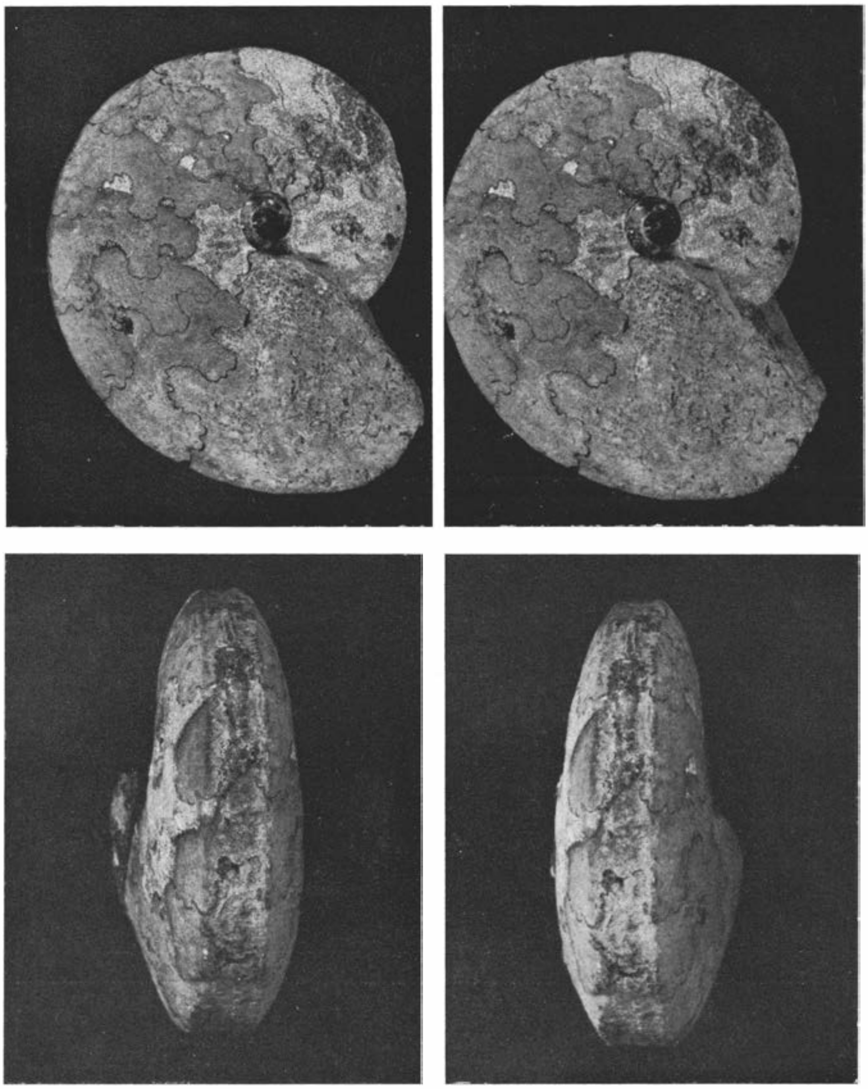

b.

Fig. 33a—b. Gombeoceras compressum Barber. Stereopairs showing (a) the lateral aspect and (b) the ventral aspect. Akahana, Benue State. Af 417. Maximum diameter = 79 mm. Early Turonian.

Bauchioceras and the study of this material, together with Barber's observations, have inclined me to regard *Bauchioceras* as a specialized vascoceratid, linked to the less specialized *Gombeoceras*, rather than as a subgenus of *Pseudotissotia*. This latter genus differs not only in the details of its sutural pattern, but also in the morphology of its ornamental development. The relationships between the two Nigerian genera had been noted when I erected them (Reyment 1954, p. 158) but not as forcefully as now.

Bauchioceras nigeriense (Woods). A typical specimen is figured in Fig. 34a—b. This specimen, the diameter of which is 95 mm, shows the details of several suture lines.

Bauchioceras tabulatum Barber (Figs. 35). The specimen shown in Fig. 35 is close to the original illustrations in that the venter is quite flat. *Bauchio-*



a.

b.

Fig. 34a—b. Bauchioceras nigeriense (Woods). Stereopairs illustrating (a) the lateral aspect with several well preserved sutures and (b) the tricarinate venter with the median keel weaker than the ventrolateral keels. The sutures can be seen to be of the vascoceratid kind. A portion of the body chamber is preserved. Akahana, Benue State. Af 418. Maximum diameter = 95 mm. Early Turonian.

ceras planum Barber (Figs. 36a—b) was stated to be like *B. tabulatum*, but to be more strongly ornamented. Compressed, tabulate *Bauchioceras* are common at Akahana; they appear to form a natural variational entity.

Wrightoceras wallsi Reyment. The specimen figured as Figs. 37a—b is a rather compressed variant of the species which, as interpreted at present, shows variation from quite compressed individuals (cf. Reyment 1955, pl. 24) to rather inflated individuals (cf. Barber 1957, pl. 24).

In addition to the foregoing vascoceratids, the Lower Turonian beds of the area have yielded many specimens of *Choffaticeras spathi* Reyment (Fig. 38), particularly as float in the floodplain of the River Ankwe.

Coniacian

Description of Barroisiceras nwalii *sp. nov.* — Ammonoid with strong, irregular ornament. The umbilical tubercles climb up onto the flanks on the

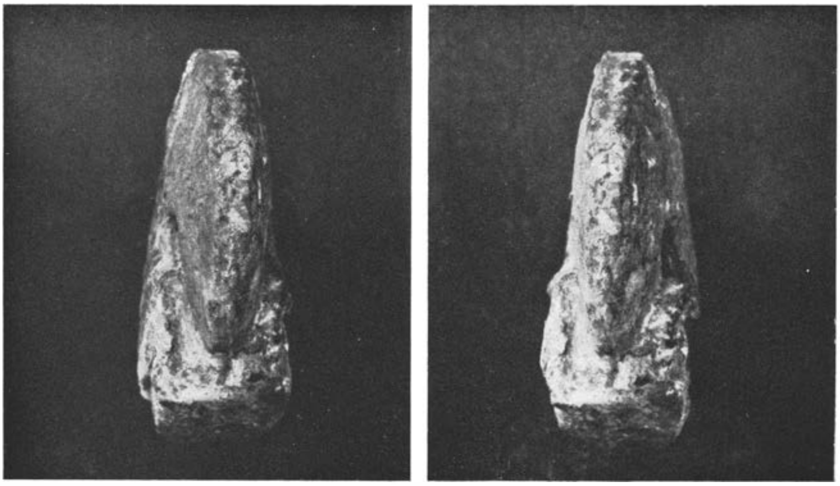
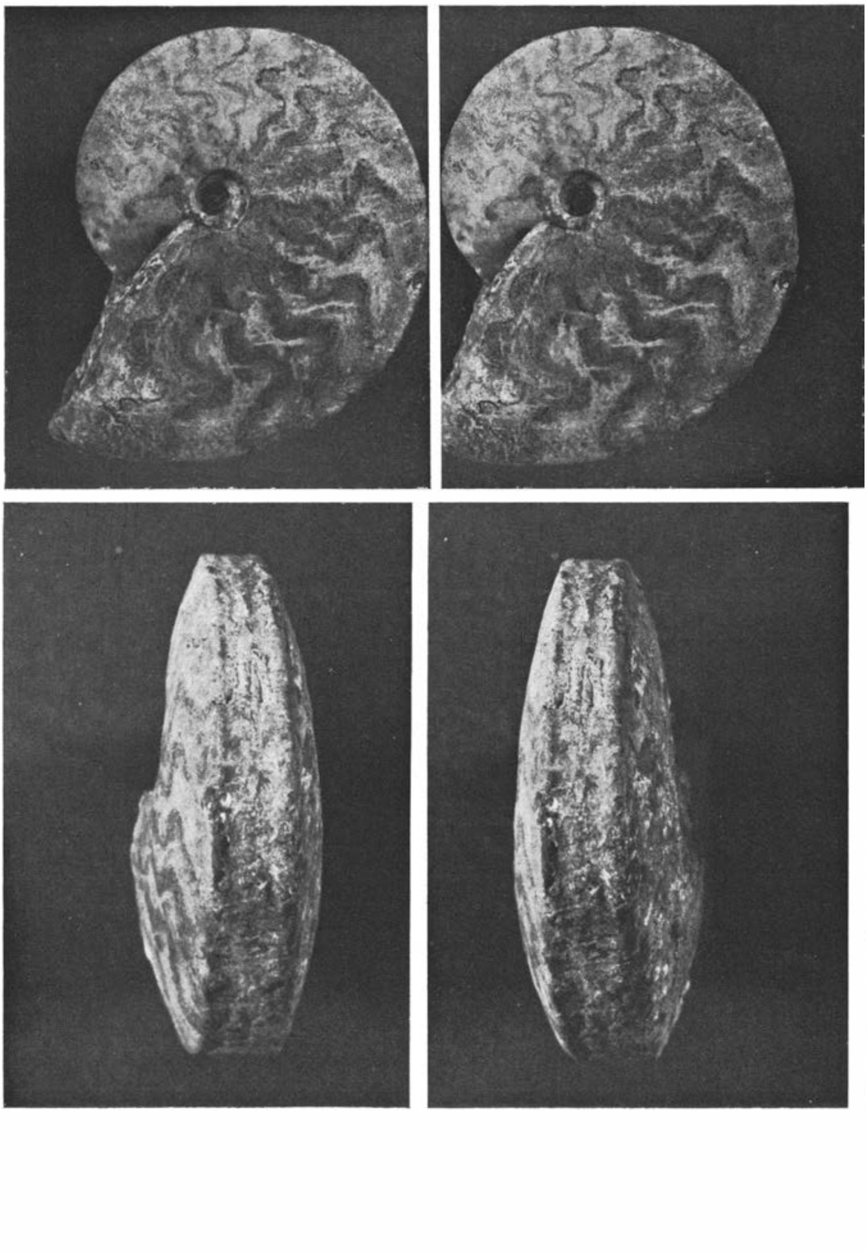


Fig. 35. Bauchioceras tabulatum Barber. Stereoview of the venter of a typical specimen showing the absence of keels and the tabulate ventral surface. Akahana, Benue State. Af 420. Maximum diameter = 60 mm. Early Turonian.



a.

b.

Fig. 36a—b. Bauchioecras planum Barber. Stereophotographs showing (a) the smooth lateral aspect, with worn sutures and (b) the tricarinate venter with ventrolateral keels much stronger than the median keel. Akahana, Benue State. Af 421. Maximum diameter = 80 mm. Early Turonian.

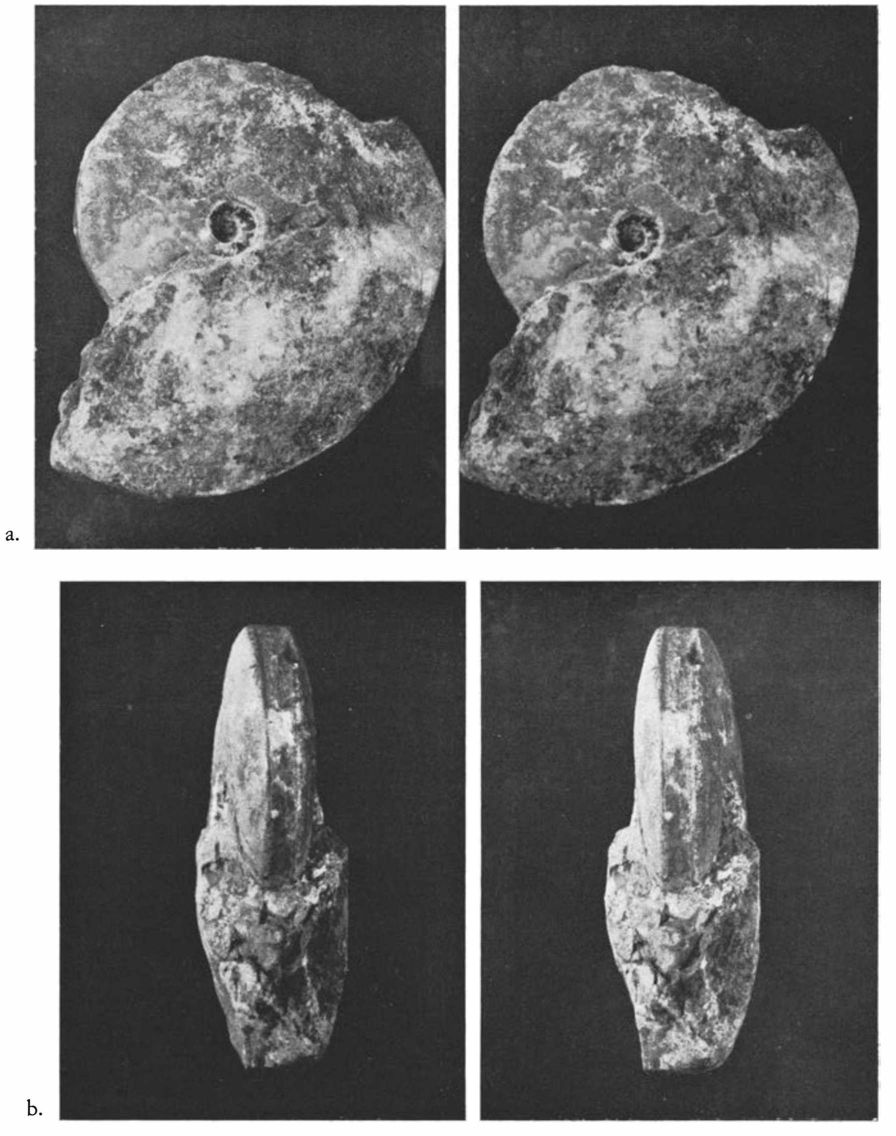


Fig. 37a—b. Wrightoceras wallsi Reyment. Stereophotographs showing (a) the smooth lateral surface and (b) the bicarinate venter. Akahana, Benue State. Af 422. Maximum diameter = 110 mm. Early Turonian.

last preserved (septate) whorl. The ventrolateral tubercles are strong, being bullate at first and becoming, finally, obliquely clavate. The ribs are stubby and irregular and some of them bifurcate. The keel is strongly crenulated and does not weaken. The specimen illustrated in Figs. 14a—b is the holotype. It comes from the top bed exposed in the Nigercem Quarry at Nkalagu, Anambra State, Nigeria.

It is not possible to fit this species into any of the categories recognized by Basse (1947). It has some characters said to be typical of *Forresteria* and others pointing to *Reesideoceras.* At first sight, it appears to resemble strongly ornamented variants of *Barroisiceras onilahyense*, as interpreted by Basse (1947), but it differs from this species in the nature of the ornament and by being quite evolute.

Ostracods. — The Coniacian marine sediments in the Obi area have yielded some poorly preserved microfossils, of which the ostracods sometimes occur in great number. In some cases, the exact

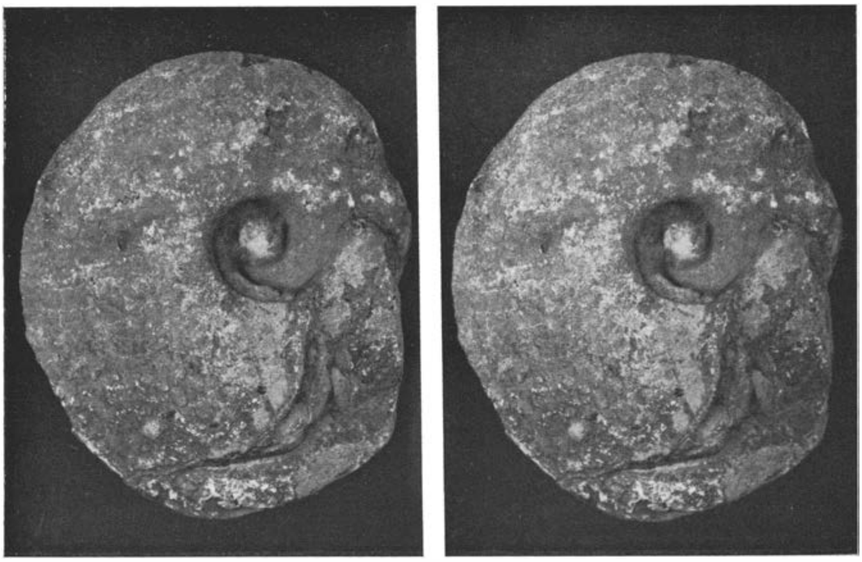


Fig. 38. Choffaticeras spathi Reyment. Lateral stereoview of a specimen from the floodplain of the River Ankwe, Benue State. Af 423. Maximum diameter = 93 mm. Early Turonian.

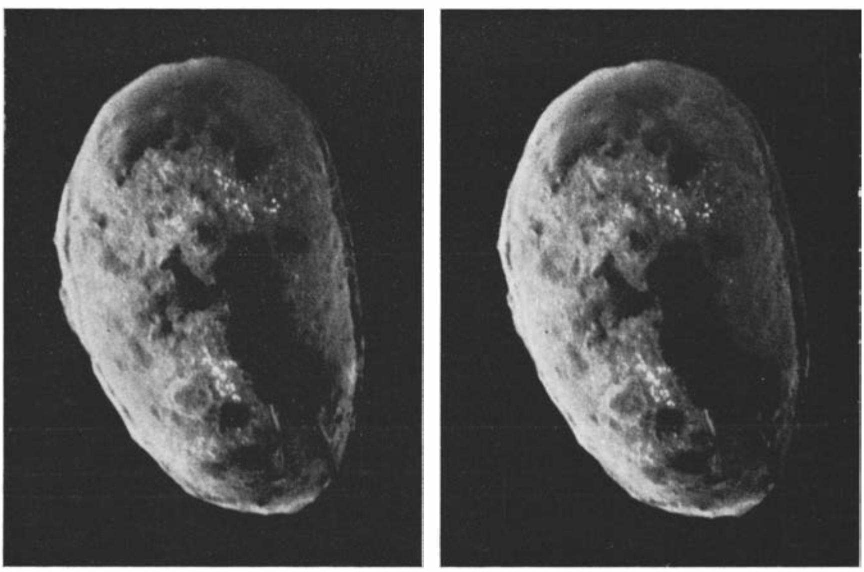


Fig. 39. Ovocytheridea symmetrica Reyment. Specimen from borehole LB 88 of the Nigerian Steel Development Authority, near Obi, Plateau State. Af 424. × 100. Coniacian.

identification of species is possible, in others, no more than a generic assignation can be attempted. The material studied comes from three of the boreholes drilled in the search for coal around Obi by the Nigerian Steel Development Authority.

Borehole LB83 encountered a non-marine level at 383 m with coalified plant fragments in sandy shale. At 383,2 m, marine beds were penetrated in which inoceramid prisms, as well as fragments of other pelecypods, are abundant. The microfauna found in this sample contains *Ovocytheridea* and arenaceous foraminifers. There are grains of glauconite and pyrite in the sediment.

Borehole LB85 disclosed a fine, sandy shale

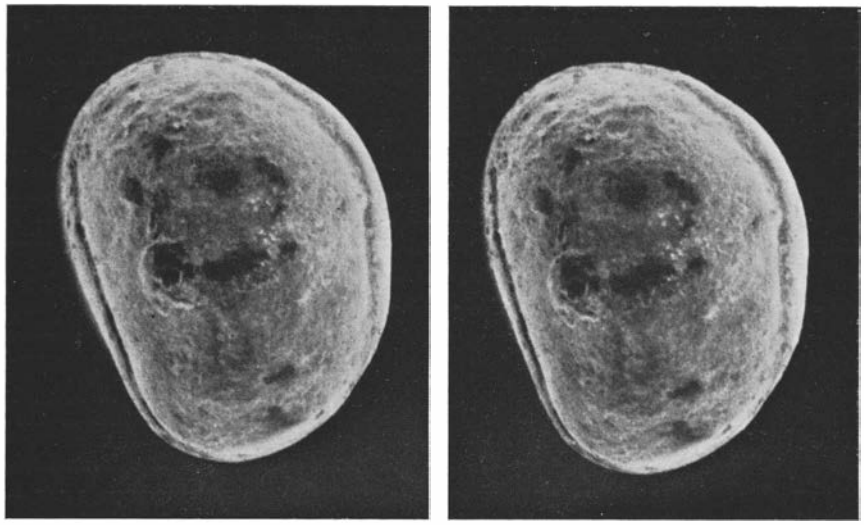


Fig. 40. Ovocytheridea nuda Grekoff. Stereopair of lateral view of specimen from borehole LB 88 of the Nigerian Steel Development Authority, near Obi, Plateau State. Af 425. × 100. Coniacian.

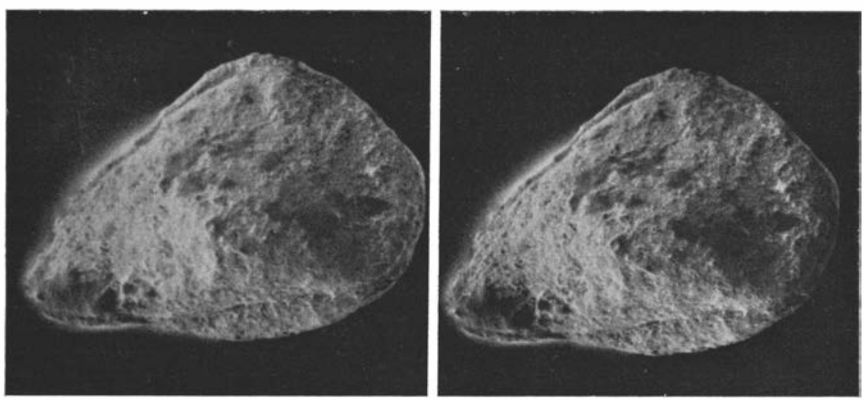


Fig. 41. Brachycythere ekpo Reyment. Stereoview of the right side of a carapace from borehole LB 88 of the Nigerian Steel Development Authority, near Obi, Plateau State. Af 426. × 100. Coniacian.

at 90,6 m in which glauconite and mica occur. *Ovocytheridea* is found occasionally. At 94 m, inoceramid prisms appear with the ostracods.

Borehole LB88. This borehole penetrated a marine, sandy shale at 323,0 m in which a few specimens of *Bairdia* were found, together with fragments of pelecypod shells. At 323,9 m, ostracods of several genera, including *Ovocytheridea*, become relatively abundant; arenaceous foraminifers also occur. From 329,4 m to 351,5 m a nonmarine sand was drilled. This contains plant fragments.

At 367,9 m, marine microfossils become abundant, there being many arenaceous foraminifers, including *Trochammina* and *Pseudotextularia. Guembelina* sp. also occurs. There are many ostracods of which species of *Ovocytheridea* are the most common. Rare *Metacytheropteron* were found. Coprolites, echinoid spines juvenile gastropods and fragments of pelecypods are frequent. At 371,6 m, *Brachycythere ekpo* Reyment and a *Protobuntonia* appear. *Cyclammina* sp. is fairly common. The fine-grained sediment of this sample contains coprolites, mica and phosphatic pellets.

The most abundant species of ostracods at all levels is *Ovocytheridea symmetrica* Reyment (Fig.

39). Slightly less common is *Ovocytheridea nuda* Grekoff, a rather stubby variant of which is shown in Fig. 40. A few specimens of *Brachycythere ekpo* Reyment were found in one sample of which a typical example is shown in Fig. 41. The assemblage of microfossils shows the Obi sediments to be Coniacian in age and to be correlatable with the sequence at Lamja, northeastern Nigeria and the Awgu Formation of the coastal sedimentary basin. There are also relationships with the subsurface Coniacian of the Senegalese basin (cf. Apostolescu 1963).

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