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PARALIC ARENACEOUS FORAMINIFERA FROM THE UPPER CRETACEOUS OF THE BENUE TROUGH, NIGERIA

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The spectrum of depositional environments represented in the Benue Trough ranges from fluviatile to paralic and shallow epicontinental marine. The Upper Cretaceous paralic sequence contains diverse and well preserved arenaceous foraminifera. Nineteen new species are described, namely; *Glomospirella ivensis* sp.n., *Reophax guineana* sp.n., *Miliammina onyeamensis* sp.n., *M. pindigensis* sp.n., *Haplophragmoides bauchensis* sp.n., *H. pindigensis* sp.n., *Ammoastuta nigeriana* sp.n., *Ammobaculites amabensis* sp.n., *A. bauchensis* sp.n., *A. benuensis* sp.n., *A. gombensis* sp.n., *A. jessensis* sp.n., *A. numanhensis* sp.n., *A. pindigensis* sp.n., *Ammomarginulina emir* sp.n., *Spiroplectammina hausorum* sp.n., *Textularia biafrae* sp.n., *Trochammina afikpensis* sp.n., and *T. imensis* sp.n.

K e y w o r d s : Arenaceous foraminifera, Upper Cretaceous, Nigeria.

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INTRODUCTION

The Benue Trough is a Mesozoic rift basin that starts from the coast of the Gulf of Guinea and extends transversely as a deep "furrow" within the Nigerian shield (fig. 1). It forms part of the central West African Mesozoic bifurcating rift system which connects with other continental rifts in the interior West African republics of Chad and Niger (Machena 1973; Burke and Dewey 1974). The Benue Trough, together with the Niger Delta constitute the southern segment of the "trans-African lineament" which is a deep-seated zone of crustal weakness that trends SW-NE from Nigeria through Niger, into Libya and Egypt (Nagy *et al.* 1976).

With a length of about 1000 km and a maximum width of about 300 km, the origin, structure, and stratigraphy of the Benue Trough has been some of the most engaging and hence better understood geologic topics in West Africa. Since it forms a major re-entrant on the continental margin of West Africa and continues into the African continental pla-

ta, the Benue Trough has been considered part of the three-armed rift system which controlled the break-up of Gondwana (Burke *et al.* 1971, 1972; Burke and Whiteman 1973; Hoffman *et al.* 1974). The Gulf of Guinea and the South Atlantic were the active arms of this triple junction along which spreading occurred and Africa separated from South America. In the absence of crustal separation, the Benue Trough remained an abandoned rift with over 6000 m of sediments. Because of its tectonic setting, rift origin, and thick sedimentary pile, the Benue Trough has been considered an aulacogen (Hoffman *et al.* 1974; Olade 1975; Petters 1978*a*).

The stratigraphic succession in the Benue Trough comprises essentially thick continental and deltaic sandstones, paralics sandstones, shales, and coal measures, and shallow epicontinental shales and limestones (Murat 1972; Petters 1978*a*). The age of the sedimentary rocks in the Benue Trough ranges from Albian to Paleocene. The thicker (over 10 km) and younger deposits of the southern part of the Benue Trough belong to the Tertiary Niger aulacogen delta. Magmatic rocks ranging from the initial rift-generated alkaline basalts (Olade 1978) to a wide variety of intrusive and extrusive suites (Wright 1976), together with lead-zinc mineralization, are familiar features of the Benue Trough. The initial eastern axis Albian-Santonian deposition underwent inversional movements in the Santonian as a result of regional compressive forces (Burke *et al.* 1972; Freeth 1978). Consequently, an anticlinorial structure formed in the eastern part of the trough which became emergent, whereas the axis of deposition migrated westward so that limited marine sedimentation occurred in the west. The tectonic and stratigraphic evolution of the Benue aulacogen from the graben stage through the downward and compressional stages were discussed by Petters (1978*a*).

The above tectonic background and salient features of the Benue Trough underscore the overemphasis on the general and often speculative aspects of the geology of the trough. Few detailed local stratigraphic descriptions have been published (Carter *et al.* 1963; Reyment 1965; Offodila 1976), and paleontological investigations are limited to ammonites (e.g. Reymont 1955; Barber 1957). Few species of foraminifera from the Turonian of the southeastern part of the trough were reported in short articles by Dessauvagie (1972), and Fayose and De Klasz (1976). As recently shown by Petters (1978*a*, *b*) the foraminiferal microfaunas of the Benue Trough offer an important means of refining the biostratigraphy and unravelling the stratigraphic relationships in the basin, and also offer means of understanding the paleoenvironmental and paleocirculation patterns that prevailed during much of the basin history.

Preliminary paleoecological interpretation based on the foraminiferal population structure was presented for the Cenomanian-Coniacian peak marine phase in the Benue Trough (Petters 1978*a*, *b*). An important as-

pect of the stratigraphy of the Benue Trough which has not been sufficiently emphasized in previous studies is the extensive development of marsh lithologies in the basin. This article draws attention to this fact by describing some marsh foraminifera from the deposits of the pre- and post-Santonian phases of sedimentation in the basin. A proper knowledge of the paralic phase in the Benue Trough will aid the prospection for economic deposits such as coal and salts.

This article presents the first description of forminifera from the Pindiga Formation, Jessu Formation, Numanha Shale, Nkporo Shale, and Enugu Shale (fig. 2).

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STRATIGRAPHY AND SAMPLE LOCALITIES

The present article deals with the arenaceous foraminifera from the shallow and marginal marine lithofacies in the Benue Trough. In the northeastern part of the basin the stratigraphic units under consideration are the upper part of the Pindiga Formation near Pindiga village, and its stratigraphic equivalents, the Jessu Formation and the Numanha Shale. The Pindiga Formation in its upper part is a sequence of mostly blue-black shale and greenish-gray shale with occasional thin gypsum beds. In a valley section near Pindiga village, the upper Pindiga grades through a thin bed of white micaceous silty clay into the overlying cross-bedded, massive, fine- and medium-grained Gulani Sandstones. The greenish-gray shale and white micaceous siltstone at the top of the Pindiga Formation yielded abundant and completely arenaceous foraminifera which are here described. The Jessu Formation and the Numanha Shale are the equivalents of the Pindiga Formation in the Jessu-Numanha area (fig. 1). Carter *et al.* (1963) who mapped the upper Benue Trough, erected separate lithostratigraphic units for the Pindiga area (Zambuk Ridge), and what they termed the Benue Basin is the eastern (Jessu-Numanha) area (fig. 1). The Jessu Formation and Numanha Shale were also sampled at their type localities. Near the village of Jessu the Jessu Formation outcrops in thin, weathered and discontinuous sections, and consists of gray and brown mudstones and sandy mudstones. The foraminiferal assemblage is predominantly arenaceous, although few calcareous forms occur. The Numanha Shale at the type locality also outcrops in thin discontinuous and weathered sections and comprises brownish gray fissile and gypsiferous shales with a monospecific arenaceous foraminiferal microfauna. Detailed lithologic and paleontologic descriptions of the upper Benue Trough were presented by Carter *et al.* (1963). The ages of the Pin-

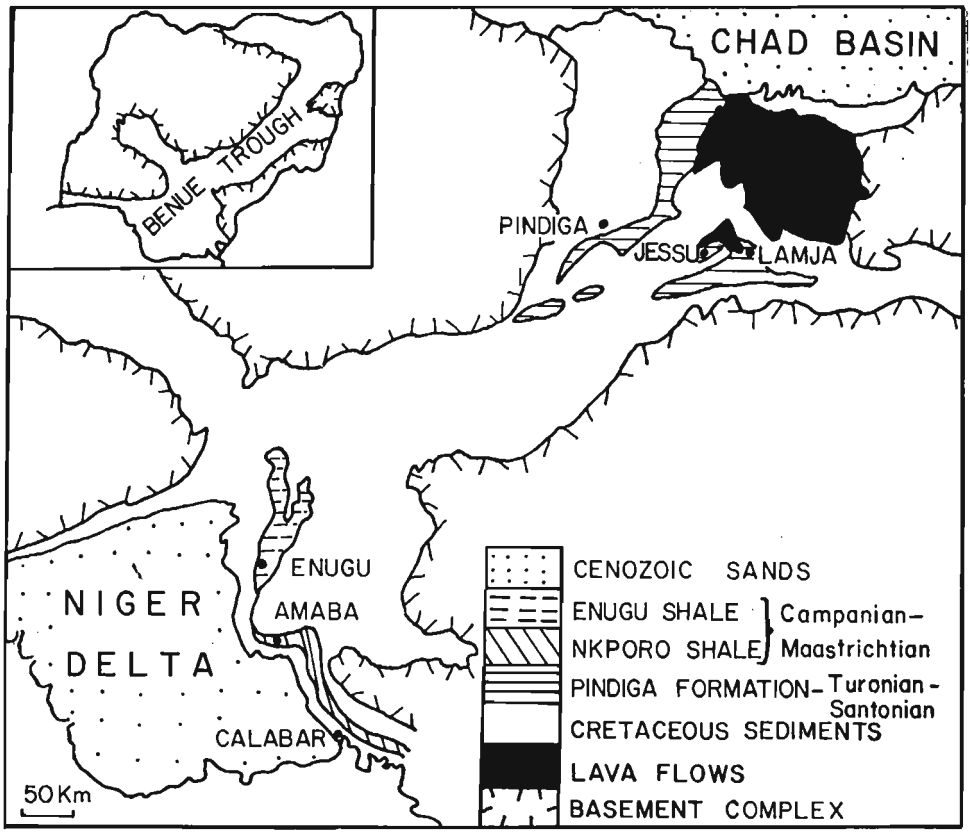

Fig. 1. Location of samples in Upper Cretaceous sections in the Benue Trough.

diga, Jessu, and Numanha Formations range from Late Turonian to Santonian on molluscan evidence, and on the basis of stratigraphic relationships (Petters 1978*b*).

In the southern Benue Trough the Campanian-Maastrichtian Nkporo Shale and Enugu Shale were sampled. The Nkporo Shale which is distributed in the southeastern part of the Benue Trough is a fissile, blue-black, highly carbonaceous and occasionally gypsiferous shale with thin marl beds. The Enugu Shale occurs northward (fig. 1), and consists of gray-blue or black carbonaceous mudstones with occasional beds of sandstone and bands of impure shale. The Enugu Shale is the paralic equivalent of the shallow marine Nkporo Shale (Dessauvagie 1975). This facies interpretation is supported by foraminiferal evidence. Whereas calcareous and arenaceous benthonic foraminifera coexist in the Nkporo Shale, the microfauna of the Enugu Shale is completely arenaceous. The upper parts of both formations were sampled at Amaba where about 2 m of the Nkporo Shale is exposed in a new road-cut, and in Enugu town where thin sections of the Enugu Shale outcrop.

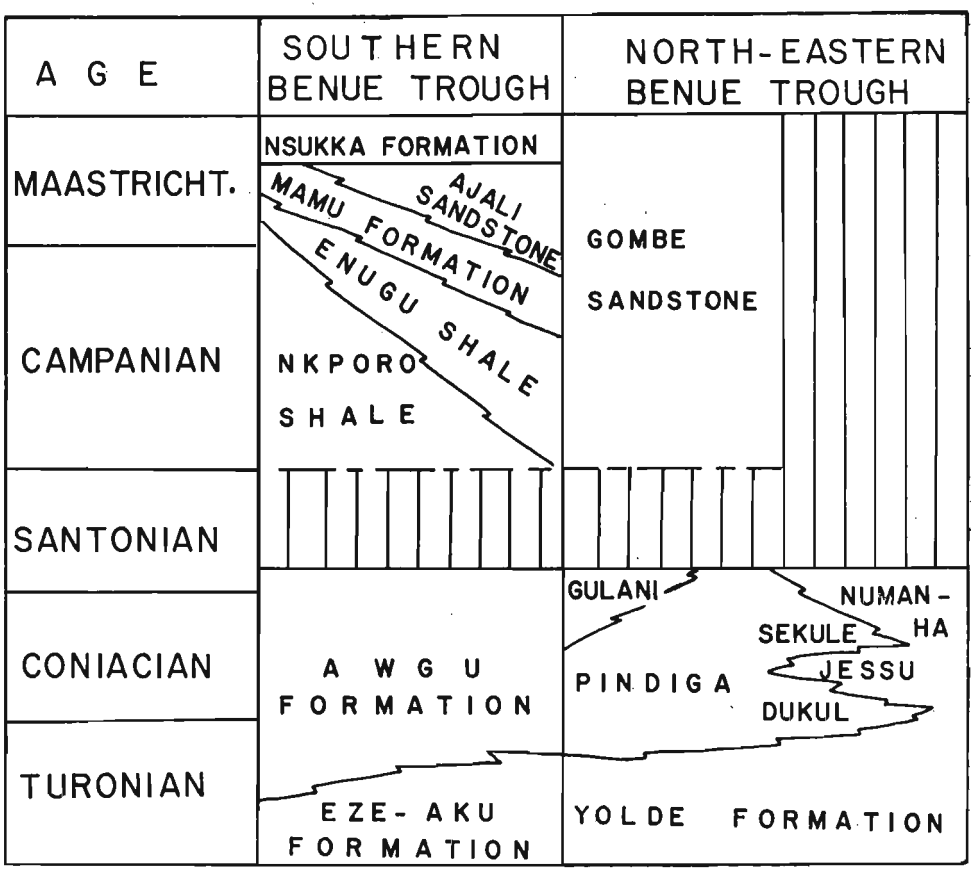

Fig. 2. Stratigraphic table showing correlation of sampled lithostratigraphic units.

One of the problems encountered in this study was the scarcity of thick and unweathered exposures of the various formations. Thus, although their composite thicknesses are considerable (about 200 m for the Pindiga Formation, 300 m for the Jessu Formation, 240 m for the Numanha Shale, according to Carter *et al.* 1963; up to 1000 m each for the Nkporo Shale and Enugu Shale, as given in Dessauvagie 1975) only scattered surface samples were analyzed from the top parts of the formations.

FORAMINIFERAL ASSEMBLAGES AND PALEOECOLOGY

An entirely arenaceous foraminiferal assemblage occurs in the shales and silty clays at the top of the Pindiga Formation near Pindiga village. Here two types of arenaceous foraminiferal associations are discernible. There is a lower abundant assemblage with about 50 percent *Ammoastuta*, 40 percent *Haplophragmoides*, 8 percent *Ammobaculites*, and traces of *Ammomarginulina*, *Spiroplectammina*, and *Miliammina*. The white, silty, and highly micaceous clay at the transition between the Pindiga

Formation and the Gulani Sandstone has an arenaceous microfauna with over 90 percent *Miliammina* and few *Ammobaculites*. These assemblages show low diversity and high dominance and are comparable with those of tidal marshes discussed by Murray (1971). The entirely simple-chambered arenaceous taxa and the dominance of *Miliammina* and *Ammoastuta* suggest hyposaline marshes or other nearshore environment for the upper part of the Pindiga Formation. This inference is based on analogy with Recent hyposaline marshes in some parts of North America where *Miliammina* and *Ammoastuta* are the dominant taxa (Murray 1971). Occasional desiccation and poor circulation resulted in the precipitation of the interbedded gypsum in the Pindiga Formation. The high mica content at the top of the formation, and the abundant organic debris suggest proximity to land. High run-off from adjacent land areas caused reduced salinities along the margins of the Benue Sea (Petters 1978*a*).

The foraminifera from the top part of the Jessu Formation are mostly *Ammobaculites*. Some mudstone and siltstone samples contain only a single species of *Ammobaculites*, while at lower stratigraphic levels subordinate numbers of *Heterohelix globulosa* (Ehrenberg) and *H. striata* (Ehrenberg) occur. Most of the Jessu Formation can be ascribed to a transitional depositional environment while the sparse planktonic foraminiferal content is indicative of open marine influence. The microfauna of the upper part of the Numanha Shale consists entirely of dwarfed specimens of *Ammobaculites*, and was attributed to marsh origin (Petters 1978*b*).

Although arenaceous foraminifera are preponderant at some intervals in the Nkporo Shale, calcareous forms are common in this formation. These include *Bolivina afra* (Reyment), and species of *Praebulimina*, *Orthokarstenia*, *Gabonita*, *Rugoglobigerina*, and *Heterohelix*. Often in outcrop samples the calcareous forms are too poorly preserved for specific identification. The above foraminiferal assemblage is suggestive of a shallow shelf environment for the Nkporo Shale. The common arenaceous genera in the Nkporo Shale are *Ammobaculites*, *Trochammina*, *Textularia*, *Haplophragmoides*, and *Reophax*.

The dark, carbonaceous and pyritic Enugu Shale contains and impoverished arenaceous foraminiferal assemblage with *Miliammina*, *Ammodiscus*, and *Glomospirella*. This microfauna suggests brackish marsh environments.

DESCRIPTIONS

The new species described here will be placed in the paleontological collection of the University of Ife Museum of Natural History. The holotypes and paratypes described below bear the catalogue numbers of that museum and are prefixed by UIFNM.

Superfamily **Ammodiscacea** Reuss, 1862
Family **Ammodiscidae** Reuss, 1862
Genus *Glomospirella* Plummer, 1945
Glomospirella ivensis sp.n.
(pl. 9: 10)

Holotype: UIFNM P19; pl. 9: 10.
Type horizon: Campanian-Maastrichtian, Enugu Shale.
Type locality: Outcrop in Enugu town behind Police barracks.
Derivation of name: After Iva Coal Mine in Enugu.

Diagnosis. — Test small, irregularly coiled initially, last whorl planispiral; peripheral outline subrounded; finely agglutinated wall.

Material. — Three specimens.

Dimensions of holotype (in mm):

	UIFNM P19
Maximum diameter	0.18
Minimum diameter	0.14

Description. — Test small, initial coiling irregular as in *Glomospira*, later planispirally evolute in the last whorl, last part of chamber may be erect. Peripheral outline subrounded; narrow peripheral margin. Single, long, tubular chamber variously coiled. Sutures depressed. Aperture a narrow terminal opening, may be rounded. Wall finely arenaceous; noncalcareous cement.

Occurrence. — This species is rare in the Enugu Shale of Campanian-Maastrichtian age.

Superfamily **Lituolacea** de Blainville, 1825
Family **Hormosinidae** Haeckel, 1894
Genus *Reophax* Montfort, 1808
Reophax guineana sp.n.
(pl. 10: 2)

Holotype: UIFNM P20; pl. 10: 2.
Type horizon: Campanian-Maastrichtian, Nkporo Shale.
Type locality: Road-cut in Amaba village, near Ovim.
Derivation of name: After the Gulf of Guinea.

Diagnosis. — Test slender and elongate, gradually tapering, uniserial; subglobular chambers; sutures depressed; aperture small, rounded, terminal, without a neck.

Material. — Five specimens, well preserved.

Dimensions of holotype (in mm):

	UIFNM P20
Length	0.43
Maximum width	0.08

Description. — Test small, uniserial, slender, elongate, subarcuate to nearly straight, pointed initial end. Peripheral outline strongly lobulate, rounded cross-section; up to 10 moderately inflated chambers increasing gradually in size. Sutures depressed especially in last part of test, indistinct in early part, horizontal. Aperture terminal, rounded, without a neck. Wall finely arenaceous; noncalcareous cement.

Remarks. — *Reophax guineana* sp.n. differs from the various species of *Reophax* described from the Upper Cretaceous of the U.S. Gulf Coastal Plain (Cushman 1946), and from the Western Interior of North America (Eicher 1967; Stelck 1975) in its slender and gradually tapering test and finely arenaceous wall texture. It differs from the finaly agglutinated and elongate form *Rheophax minuta* Tappan figured by Stelck (1975) in having subglobular chambers and strongly depressed sutures.

Occurrence. — *Reophax guineana* sp.n. occurs in the Campanian-Maastrichtian Nkporo Shale. It is rare.

Family **Rzehakinidae** Cushman, 1933

Genus *Miliammina* Heron-Allen and Earland, 1930

Miliammina onyeamensis sp.n.

(pl. 9: 2, 3)

Holotype: UIFNM P21; pl. 9: 3.
Paratype: UIFNM P22; pl. 9: 2.
Type horizon: Campanian-Maastrichtian, Enugu Shale.
Type locality: Outcrop in Enugu town, behind Police barracks.
Derivation of name: After Onyeama Coal Mine in Enugu.

Diagnosis. — Test very small, elliptical; quinqueloculine coiling; chambers narrow; wide sutures; aperture wide and rounded; wall polished when unweathered.

Material. — Six well preserved specimens.

Dimensions of two specimens (in mm):

	UIFNM P21	UIFNM P22
Length	0.16	0.17
Width	0.08	0.09

Description. — Test very small, elliptical, quinqueloculine; peripheral margin narrow; chambers elongate, narrow, slightly bulging. Sutures wide, depressed. Aperture wide and round. Wall arenaceous with abundant noncalcareous cement, may incorporate pyrite grains; smoothly finished.

Remarks. — *Miliammina onyeamensis* sp.n. differs from the stratigraphically older form *M. pindigensis* sp.n. in its small, smooth test, more inflated chambers, narrower peripheral margin, and wider sutures. Variation among *M. onyeamensis* sp.n. concerns the width of the test.

Occurrence. — This species is fairly common in the Campanian-Maastrichtian Enugu Shale.

Miliammina pindigensis sp.n.

(pl. 10: 7, 8)

Holotype: UIFNM P23; pl. 10: 7.
Paratype: UIFNM P24; pl. 10: 8.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Pindiga village.

Diagnosis. — Test small, elongate, often broad; coiling quinqueloculine; chambers wide and elongate; sutures narrow and depressed; aperture wide and rounded; wall coarsely arenaceous with abundant grains; rough wall texture.

Material. — Fifty specimens, well preserved.

Dimensions of two specimens (in mm):

	UIFNM P23	UIFNM P24
Length	0.21	0.24
Width	0.10	0.14

Description. — Test small, elongate, narrow to broad; quinqueloculine; peripheral margin wide; chambers broad and elongate. Sutures narrow, depressed, distinct. Aperture wide and rounded; wall coarsely arenaceous, abundant grains and noncalcareous cement; rough wall texture.

Remarks. — Variation among *Miliammina pindigensis* sp.n. affects the width of the test. Forms with wide and compressed tests resemble *Miliammina ischnia* Tappan figured by Eicher (1966) from the Upper Cretaceous of the Western Interior. However, *M. ischnia* Tappan is finely arenaceous and smooth.

Occurrence. — This species is very abundant at the top of the Pindiga Formation where it may constitute over 90 percent of the microfauna. Its stratigraphic range is tentatively given as Turonian-Santonian based on the known age of the Pindiga Formation.

Family **Lituolidae** de Blainville, 1825

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides bauchensis sp.n.

(pl. 10: 11, 12)

Holotype: UIFNM P25; pl. 10: 12.
Paratype: UIFNM P26; pl. 10: 11.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Bauchi State of Nigeria.

Diagnosis. — Test small, subcircular, slightly compressed, planispiral; chambers numerous, narrow and elongate; umbilicus small; sutures straight, radial, faintly depressed.

Material. — One hundred well preserved specimens.

Dimensions of two specimens (in mm):

	UIFNM P25	UIFNM P26
Maximum diameter	0.21	0.25
Minimum diameter	0.20	0.20

Description. — Test small, planispirally involute, slightly compressed. Peripheral outline subcircular; slightly narrow and rounded peripheral margin. Eight to 10 narrow elongate chambers in the last whorl. Umbilicus small. Sutures straight, radially arranged, narrow and slightly depressed. Aperture wide and high, occupying most of the apertural face. Wall coarsely arenaceous with wide range of quartz grain sizes and small amount of noncalcareous cement.

Remarks. — This species does not exhibit pronounced morphologic variation. It differs from *Haplophragmoides pindigensis* sp.n. in being larger, with a lobulate peripheral outline, and a wider range of quartz grain sizes, and in having more cement in the test. The chambers in *H. bauchensis* sp.n. are more numerous and narrower than in *H. pindigensis* sp.n. *Haplophragmoides bauchensis* sp.n. is similar to *H. glabra* Cushman and Waters figured by Cushman (1946) from the Maastrichtian of the U.S. Gulf Coast. However, *H. glabra* is larger and has a smoothly finished test.

Occurrence. — This species is very abundant at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Haplophragmoides pindigensis sp.n.
(pl. 10: 13, 14)

Holotype: UIFNM P27; pl. 10: 13.
Paratype: UIFNM P28; pl. 10: 14:
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Pindiga village.

Diagnosis. — Test very small, planispirally involute; outline circular; periphery lobulate; chambers wedge-shaped; sutures depressed; wall with fairly uniform grains; glassy.

Material. — Ten specimens, well preserved.

Dimensions of two specimens (in mm):

	UIFNM P27	UIFNM P28
Maximum diameter	0.10	0.11
Minimum diameter	0.09	0.09

Description. — Test very small, planispirally involute. Peripheral outline circular, lobulate; peripheral margin rounded. Six chambers in the last whorl, broad and wedge-shaped. Umbilicus a small depression. Sutures straight, wide and depressed, radially arranged, may be obscured by coarse quartz grains. Aperture wide, occupying most of the apertural face. Wall coarsely arenaceous with fairly uniform quartz grains, little noncalcareous cement; glassy appearance.

Remarks. — Variation among *Haplophragmoides pindigensis* sp.n. affects the sutures which may be indistinct in specimens with coarse grains. The outline is not very lobulate in some forms.

Occurrence. — This species is common at the top of the Pindiga Formation of probable Turonian-Santonian age.

Genus *Ammoastuta* Cushman and Bronnimann, 1948

Ammoastuta nigeriana sp.n.
(pl. 10: 1, 6)

Holotype: UIFNM P29; pl. 10: 1.
Paratype: UIFNM P30; pl. 10: 6.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Nigeria.

Diagnosis. — Test small, flabelliform, semienrolled, compressed; peripheral margin narrow; chambers elongate and curved; sutures curved and depressed; aperture secondary cribrate.

Material. — One hundred and fifty well preserved specimens.

Dimensions of two specimens (in mm):

	UIFNM P29	UIFNM P30
Length	0.35	0.25
Maximum width	0.13	0.18

Description. — Test small, flabelliform, semienrolled, compressed. Peripheral outline strongly lobulate in one-half of the test; peripheral margin narrow. Chambers narrow, elongate, and curved, last chamber constitutes one-half of test. Sutures curved, depressed. Aperture secondary cribrate. Wall finely arenaceous with close-fitting equidimensional quartz grains; little noncalcareous cement.

Remarks. — The form here described is assigned to *Ammoastuta* because of the flabelliform, semienrolled test and cribrate aperture at the lower end of the final chamber (Loeblich and Tappan 1964). However, the primary aperture which in this genus is a slit mid-way on the last chamber is not clearly defined on the Nigerian specimens probably due to preservation.

Occurrence. — The stratigraphic range of *Ammoastuta* given in Loeblich and Tappan (1964) is Upper Eocene to Recent. However, *Ammoastuta nigeriana* sp.n. is here reported from sediments of Turonian-Santonian age (Pindiga Formation).

Genus *Ammobaculites* Cushman, 1910

Ammobaculites amabensis sp.n.

(pl. 9: 11)

Holotype: UIFNM P31; pl. 9: 11.
Type horizon: Campanian-Maastrichtian, Nkporo Shale.
Type locality: Road-cut in Amaba village, near Ovim.
Derivation of name: After Amaba village.

Diagnosis. — Test medium to large, last whorl slightly evolute; outline lobulate; chambers broad, increasing rapidly in size; umbilicus wide; sutures depressed; wall composed of very coarse, angular equidimensional quartz grains.

Material. — Ten well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P31
Maximum diameter	1.20
Minimum diameter	1.10

Description. — Test moderate to large, slightly compressed, last whorl evolute, last chamber tending to be erect. Peripheral outline subrounded, lobulate in the later part of the test; peripheral margin rounded, may be narrow. Chambers slightly compressed, broad, 6 to 7 in the last whorl. Sutures wide and depressed especially in the later part of the test; indistinct in earlier part. Aperture narrow extending high on apertural face. Wall very coarsely arenaceous with angular equidimensional quartz grains which are closely fitting with little noncalcareous cement; rough wall texture.

Remarks. — This species is easily distinguished by its medium test with very coarse grains, and rough wall texture. Some specimens are somewhat inflated. Because of the coarse grains in the test, *Ammobaculites amabensis* sp.n. is similar to *A. fragmentarius* Cushman from the Upper Cretaceous of the U.S. Gulf Coastal Plain (Cushman 1946). However, in the Nigerian specimens the uncoiled part of the test is often not developed. In test outline and coarse wall texture *A. amabensis* sp.n. somewhat resembles *Discammina* sp. figured by Scheibnerová (1976) from the Albian of the Great Australian Basin, but there are important generic differences between both forms.

Occurrence. — This species is common in the Campanian-Maastrichtian Nkporo Shale.

Ammobaculites bauchensis sp.n.

(pl. 10: 10)

Holotype: UIFNM P32; pl. 10: 10.
Type horizon: Turonian-Santonian, Pindiga Formation.

Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Bauchi State of Nigeria.

Diagnosis. — Test broad, involute in early part, well developed uniserial portion, compressed; sutures narrow and slightly depressed; wall coarsely arenaceous with little cement.

Material. — Five well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P32
Length	0.60
Maximum width	0.52

Description. — Test small to moderate, broad and compressed; involute initial part, short uncoiled and uniserial part. Peripheral outline moderately lobulate; peripheral margin narrow. Chambers narrow and numerous; umbilicus closed. Sutures narrow, depressed, obscured in early part of test. Aperture an elongate terminal opening. Wall coarsely arenaceous with uniform grains and small amount of cement.

Remarks. — This form is somewhat similar to *Ammobaculites subcretacea* Cushman and Alexander, figured by Cushman (1946), but differs in its stronger test compression, involute initial part, and horizontal sutures in the uniserial part of the test.

Occurrence. — This species is rare at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Ammobaculites benuensis sp.n.
(pl. 10: 15)

Holotype: UIFNM P33; pl. 10: 15.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After the River Benue.

Diagnosis. — Test small, elongate, long uniserial part; strongly involute initial part.

Material. — Five specimens, well preserved.

Dimensions of holotype (in mm):

	UIFNM P33
Length	0.35
Width	0.15

Description. — Test small, slender, of uniform width, long uniserial part, initial part strongly involute. Peripheral outline rounded in initial part, later moderately lobulate; peripheral margin narrow. Chambers narrow, slightly inflated and few in the initial coiled part of test, broad and somewhat compressed in uniserial part. Umbilicus closed; sutures almost flush in coiled part of the test, indistinct, depressed and clearly defined in uniserial part. Aperture a narrow opening. Wall with nearly uniform and closely packed grains; little noncalcareous cement.

Remarks. — This form is easily distinguished by its elongate and uniform test which does not exhibit strong morphologic variation. It is similar to the Albian form *Ammobaculites tyrrelli* Naus from the Canadian Western Interior (Stalck 1975), but the uniserial part of the latter form is longer and has more chambers.

Occurrence. — *Ammobaculites benuensis* sp.n. is rare at the top of the Pindiga Formation and is tentatively assigned a Turonian-Santonian age.

Ammobaculites gombensis sp.n.
(pl. 10: 3)

Holotype: UIFNM P34; pl. 10: 3.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: After Gombe, the nearest big town.

Diagnosis. — Test small, wide involute initial part, narrow uniserial part, club-shaped; outline smooth; sutures indistinct; wall coarsely arenaceous.

Material. — Three well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P34
Length	0.24
Maximum width	0.10

Description. — Test small, club-shaped, maximum width at initial part of test; narrow uniserial part. Peripheral outline even; peripheral margin narrow. Chambers indistinct, wedge-shaped in coiled part, increasing uniformly in size. Sutures indistinct except in uniseral part of test where they are broad and depressed. Umbilicus closed; aperture a small subrounded terminal opening. Wall coarsely arenaceous with uniform grain sizes and little noncalcareous cement.

Remarks. — This form is easily distinguished by its club-shaped symmetrical test. It is somewhat similar in shape to *Ammobaculites junceus* Cushman and Applin from the Cretaceous Belle Fourche Shale and equivalents in Wyoming (Eicher 1967). However *A. gombensis* sp.n. is more compressed with indistinct chambers in the coiled part.

Occurrence. — This species is rare at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Ammobaculites jessensis sp.n.
(pl. 9: 8)

Holotype: UIFNM P35; pl. 9: 8.
Type horizon: Coniacian, Jessu Formation.
Type locality: Outcrop near Jessu village.
Derivation of name: After Jessu village.

Diagnosis. — Test small, elongate, strongly involute; ultimate chamber erect; most chambers indistinct being obscured by very coarse angular quartz grains; aperture a narrow vertical opening.

Material. — Ten fairly well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P35
Maximum diameter	0.28
Minimum diameter	0.16

Description. — Test small, elongate, compressed, strongly involute, uniserial part not developed. Peripheral margin narrow. Chambers indistinct, 4 to 6 in the last whorl, ultimate chamber partially erect. Umbilicus closed; sutures obscured by coarse grains. Aperture a narrow opening, vertical on the apertural face. Wall very coarsely arenaceous with angular nearly equidimensional quartz grains and little noncalcareous cement.

Remarks. — A distinctive feature of this form is its coarse wall texture in which the grains are loosely fitting.

Occurrence. — This form is common in the Jessu Formation of probable Coniacian age.

Ammobaculites numanhensis sp.n.

(pl. 9: 4, 5, 7)

Holotype: UIFNM P36; pl. 9: 7.

Paratypes: UIFNM P37; pl. 9: 5. UIFNM P38.

Type horizon: Coniacian-Santonian Numanha Shale.

Type locality: Small shale exposure near Numanha village.

Derivation of name: After Numanha village.

Diagnosis. — Test small, circular to subcircular in outline; periphery slightly lobulate; umbilicus wide or small depression; uneven wall texture.

Material. — Fifty fairly well preserved specimens.

Dimensions of three specimens (in mm):

	UIFNM P36	UIFNM P37	UIFNM P38
Maximum diameter	0.15	0.30	0.30
Minimum diameter	0.11	0.30	0.27

Description. — Test small, circular to subcircular, planispirally involute, uniserial part poorly developed. Peripheral outline slightly lobulate or even; peripheral margin narrow but not compressed. Seven to eight chambers in the last whorl, slightly wedge-shaped and narrow. Umbilicus wide, occasionally a small depression. Sutures flush, indistinct. Aperture a moderate vertical opening. Wall coarsely arenaceous with considerable noncalcareous cement; rough wall texture.

Remarks. — This form is distinguished by its even, circular outline and rough wall texture.

Occurrence. — This is the only foraminifer species recovered from the Numanha Shale (Coniacian-Santonian), where it occurs commonly.

Ammobaculites pindigensis sp.n.

(pl. 10: 5)

Holotype: UIFNM P39; pl. 10: 5.

Type horizon: Turonian-Santonian, Pindiga Formation.

Type locality: Outcrops in valley near Pindiga village.

Derivation of name: After Pindiga village.

Diagnosis. — Test small, well developed uniserial part, compressed; outline lobulate; chambers broad and wedge-shaped; sutures raised.

Material. — Five well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P39
Length	0.68
Maximum width	0.42

Description. — Test small, compressed, involute, subcircular initial part, well developed uniserial part. Peripheral outline lobulate; peripheral margin narrow. Chambers broad, wedge-shaped, 4 chambers are visible in coiled part. Umbilicus small; sutures raised and straight. Aperture a narrow opening. Wall with uniform small quartz grains and little noncalcareous cement.

Remarks. — This species differs from *Ammobaculites bauchensis* sp.n. in having a smaller coiled part, and from *A. benuensis* sp.n. in being wider and more compressed. *Ammobaculites pindigensis* sp.n. is distinguished by its raised sutures and excavated chambers.

Occurrence. — This species is rare at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Genus *Ammomarginulina* Wiesner, 1931
Ammomarginulina emir sp.n.
(pl. 10: 9)

Holotype: UIFNM P40; pl. 10: 9.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrop in valley near Pindiga village.
Derivation of name: "Emir" meaning "ruler" in northern Nigeria.

Diagnosis. — Test small, elongate, compressed; peripheral outline lobulate; sutures oblique, depressed; aperture marginal, on short neck.

Material. — Three well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P40
Length	0.25
Width	0.09

Description. — Test small, slender and elongate, compressed, small initial part which is closely coiled and involute; peripheral outline lobulate; oval cross-section. Chambers in uniserial part axially elongate, 4 to 5 in uniserial part. Umbilicus closed. Sutures in initial part of test indistinct, oblique and depressed in uniserial part. Aperture small, narrow, eccentric, located on a short neck. Wall coarsely arenaceous with little noncalcareous cement.

Remarks. — This species is easily distinguished by its slender, elongate test, well developed uniserial portion, and oblique sutures. The uniserial part is as well developed as in *Ammomarginulina paterella* Eicher, 1967, but *A. emir* sp.n. is smaller and has a very small initial part, and also has more strongly oblique sutures.

Occurrence. — This species is rare at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Family **Textulariidae** Ehrenberg, 1838
Genus *Spiroplectammina* Cushman,
Spiroplectammina hausorum sp.n.
(pl. 10: 4)

Holotype: UIFNM P41; pl. 10: 4.
Type horizon: Turonian-Santonian, Pindiga Formation.
Type locality: Outcrops in valley near Pindiga village.
Derivation of name: After the Hausa ethnic group in northern Nigeria.

Diagnosis. — Test small to moderate in size, elongate and compressed, well developed initially coiled part; long biserial portion; periphery lobulate; chambers broad; sutures depressed and oblique; apertural face broad.

Material. — Three well preserved specimens.
Dimensions of holotype (in mm):

	UIFNM P41
Length	0.74
Width	0.18

Description. — Test small to moderate in size, elongate, biserial part well developed, small coiled initial part with few chambers, compressed. Peripheral margin moderately lobulate. Chambers broad and alternating in biserial part which has 5 rows of chambers. Umbilicus very small. Sutures indistinct in coiled part, depressed and oblique in biserial part. Aperture low arch on broad and excavated apertural face. Wall coarsely arenaceous, fairly uniform and grains, little noncalcareous cement.

Remarks. — This species exhibits little morphologic variation and is easily distinguished by the coiled initial part, and long biserial portion. It resembles other elongate species of *Spiroplectammina* such as *S. navarroana* Cushman (figured by Hanzlikovâ 1972 from the Carpathian Upper Cretaceous), and *S. lalickeri* Albritton and Phleger from the Campanian of the U.S. Gulf Coast (Cushman 1946), but *S. hausorum* sp.n. differs markedly from these forms because of its broad alternating and highly compressed chambers, strongly oblique sutures and coarsely arenaceous wall with rough texture.

Occurrence. — This species is rare at the top of the Pindiga Formation, and is tentatively assigned a Turonian-Santonian age.

Genus *Textularia* Defrance in de Blainville, 1824

Textularia biafrae sp.n.

(pl. 9: 9)

Holotype: UIFNM P42; pl. 9: 9.
Type horizon: Campanian-Maastrichtian, Nkporo Shale.
Type locality: Road-cut in Amaba village near Ovim.
Derivation of name: After the Bight of Biafra.

Diagnosis. — Test moderate to large, gradually flaring; peripheral outline slightly lobulate; sharp peripheral margin; chambers numerous and narrow; sutures horizontal and depressed.

Material. — Five specimens, fairly well preserved, initial part often broken.
Dimensions of holotype (in mm):

	UIFNM P42
Length	0.54
Width	0.35

Description. — Test moderate to large, biserial, gradually flaring, bulging along the median line. Peripheral outline slightly lobulate; peripheral margin sharp. Chambers narrow, up to 10 in each row. Sutures depressed, wide, horizontal, more distinct along peripheral margin. Aperture low opening on narrow apertural face. Wall finely arenaceous with much cement; smoothly finished.

Remarks. — This species does not exhibit much variations and is easily distinguished by its robust medially inflated but marginally compressed test.

Occurrence. — *Textularia biafrae* sp.n. is rare in the Nkporo Shale of Campanian-Maastrichtian age.

Family **Trochamminidae** Schwager, 1877

Genus *Trochammina* Parker and Jones, 1859

Trochammina afikpensis sp.n.

(figs 3a, b; pl. 9: 1)

Holotype: UIFNM P43; figs 3a, b; pl. 9: 1.
Type horizon: Campanian-Maastrichtian, Nkporo Shale.
Type locality: Road-cut in Amaba village, near Ovim.
Derivation of name: After Afikpo town.

Diagnosis. — Test small, trochospiral, low to high spiral side, depressed umbilical side; strongly compressed; peripheral outline oval, strongly lobulate; very narrow peripheral margin; chambers highly compressed and broad; umbilicus wide; sutures depressed; wall smooth when unweathered.

Material. — Fifty well preserved specimens.

Dimensions of holotype (in mm):

	UIFNM P43
Maximum diameter	0.23
Minimum diameter	0.19

Description. — Test small, low to high trochospiral coiling; concave umbilical side; highly compressed and ofted distorted. Peripheral outline oval, strongly lobulate; peripheral margin sharp due to test compression. Chambers broad, may be highly flattened, 4 to 6 in the last whorl; chambers increased rapidly in size, $2\frac{1}{2}$ to 3 whorls; all chambers visible on the spiral side. Umbilicus wide and shallow. Sutures depressed and radially arranged. Aperture low arch. Wall smooth, finely arenaceous with abundant noncalcareous cement.

Remarks. — This is the commonest species of *Trochammina* in the Nkporo Shale. It is distinguished by its strongly lobulate periphery, broad chambers and strong susceptibility to distortion in which one chamber may be pushed over the other. Morphologic variation also affects the spiral side which may be quite high.

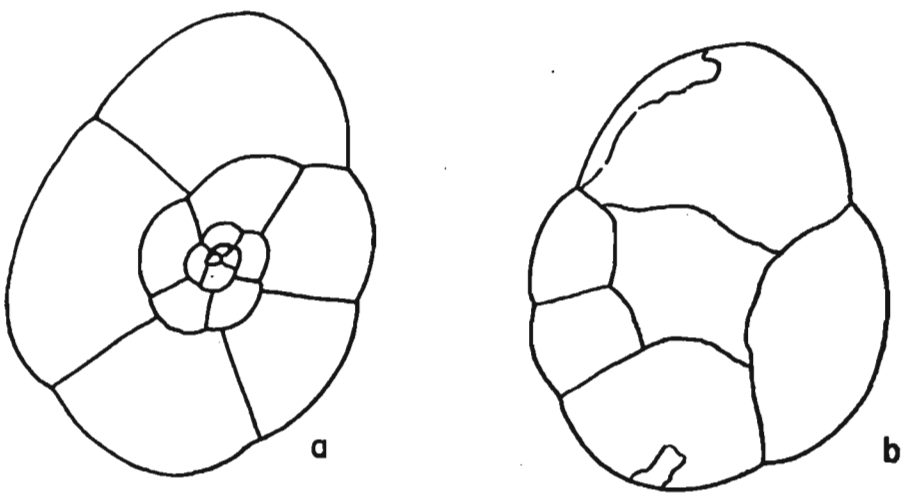

Fig. 3. Sketch line drawings of *Trochammina afikpensis* sp.n. Nkporo Shale, in Amaba, near Ovim: *a* umbilical view; *b* spiral view, both × 260; holotype (UIFNM P43).

This species is somewhat akin to *T. wetteri* Stelck and Wall from the Cretaceous of the North American Western Interior (Eicher 1967). Both forms have many whorls, 4 to 6 chambers in the last whorl, a strongly lobulate periphery, and a finely arenaceous wall texture. However, *T. wetteri* is more inflated and has oblique sutures.

Occurrence. — *Trochammina afikpensis* sp.n. is very abundant in the Nkporo Shale of Campanian-Maastrichtian age.

Trochammina imensis sp.n.

(figs 4a, b; pl. 9: 6)

Holotype: UIFNM P44; figs 4a, b; pl. 9: 6.
Type horizon: Campanian-Maastrichtian, Nkporo Shale.
Type locality: Road-cut in Amaba village, near Ovim.
Derivation of name: After the Imo State of Nigeria.

Diagnosis. — Test small, trochospiral, very flat; periphery lobulate; chambers numerous, somewhat narrow and wedge-shaped; raised sutures.

Material. — Ten specimens, fairly well preserved.

Dimensions of holotype (in mm):

	UIFNM P44
Maximum diameter	0.23
Minimum diameter	0.16

Description. — Test small, elongate, trochospiral, very compressed. Peripheral outline lobulate; peripheral margin very sharp. Chambers narrow, wedge-shaped, numerous, about 7 to 8 in the last whorl, strongly flattened. Umbilicus wide and rather indistinct due to flattening of the test. Sutures limbate and straight. Aperture indistinct. Wall finely arenaceous, smoothly finished with much noncalcareous cement.

Remarks. — This species is easily distinguished from the co-occurring form

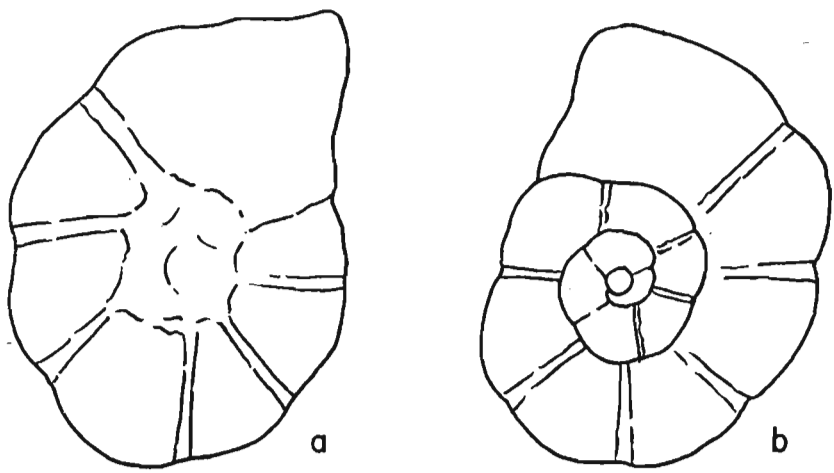

Fig. 4. Sketch line drawings of *Trochammina imensis* sp.n. Nkporo Shale, in Amaba, near Ovim: *a* umbilical view; *b* spiral view, both × 260; holotype (UIFNM P44).

Trochammina afikpensis sp.n. by its extremely flattened, somewhat elongate test, and limbate sutures.

Occurrence. — This form is fairly common in the Nkporo Shale of Campanian--Maastrichtian age. It is subordinate in numbers to *Trochammina afikpensis* sp.n.

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SUNDAY W. PETTERS

ZLEPIEŃCOWATE OTWORNICE Z GÓRNOKREDOWYCH OSADÓW TYPU PARALICZNEGO ROWU BENUE, NIGERIA

Streszczenie

Rozpiętość środowisk sedymentacji reprezentowanych przez osady w rowie Benue sięga od typu rzecznego do paralicznego i płytkomorskiego, epikontynentalnego. Sekwencja paraliczna górnej kredy zawiera zróżnicowane i dobrze zachowane zlepieńcowate otwornice. W pracy opisano 19 nowych gatunków tych otwornic.

EXPLANATION OF PLATES 9 AND 10

Plate 9

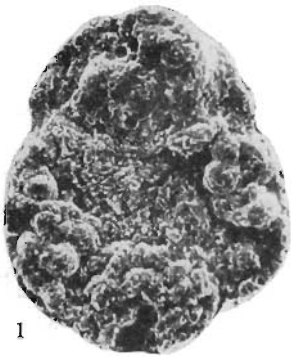
All magnifications are approximate

1. *Trochammina afikpensis* sp.n. Nkporo Shale, in Amaba, near Ovim: umbilical view, × 205, holotype (UIFNM P43).
2, 3. *Miliammina onyeamensis* sp.n. Enugu Shale, in Enugu town: side views; 2 × 270, paratype (UIFNM P22); 3 × 340, holotype (UIFNM P21).
4, 5, 7. *Ammobaculites numanhensis* sp.n. Numanha Shale, near Numanha: umbilical views; 4 × 136 (UIFNM P38); 5 × 136, paratype (UIFNM P37); 7 × 270, holotype (UIFNM P36).
6. *Trochammina imensis* sp.n. Nkporo Shale, in Amaba, near Ovim: umbilical view, × 205, holotype (UIFNM P44).
8. *Ammobaculites jessensis* sp.n. Jessu Formation, near Jessu: umbilical view, × 205, holotype (UIFNM P35).
9. *Textularia biafrae* sp.n. Nkporo Shale, in Amaba, near Ovim: side view, × 90, holotype (UIFNM P42).
10. *Glomospirella ivensis* sp.n. Enugu Shale, in Enugu town: side view, × 270, holotype (UIFNM P19).
11. *Ammobaculites amabensis* sp.n. Nkporo Shale, in Amaba near Ovim: umbilical view, × 40, holotype (UIFNM P31).

Plate 10

All magnifications are approximate

1, 6. *Ammoastuta nigeriana* sp.n. Pindiga Formation, near Pindiga: side views; 1 × 136; holotype (UIFNM P29); 6 × 205, paratype (UIFNM P30).
2. *Reophax guineana* sp.n. Nkporo Shale, in Amaba, near Ovim: side view, × 136, holotype (UIFNM P20).
3. *Ammobaculites gombensis* sp.n. Pindiga Formation, near Pindiga: side view; × 205, holotype (UIFNM P34).
4. *Spiroplectammina hausorum* sp.n. Pindiga Formation, near Pindiga, edge view; × 68, holotype (UIFNM P41).
5. *Ammobaculites pindigensis* sp.n. Pindiga Formation, near Pindiga, side view; × 68, holotype (UIFNM P39).
7, 8. *Miliammina pindigensis* sp.n. Pindiga Formation near Pindiga: side views; 7 × 205, holotype (UIFNM P23); 8 × 205, paratype (UIFNM P24).
9. *Ammomarginulina emir* sp.n. Pindiga Formation, near Pindiga: side view, × 205, holotype (UIFNM P40).
10. *Ammobaculites bauchensis* sp.n. Pindiga Formation, near Pindiga: side view, × 68, holotype (UIFNM P32).
11, 12. *Haplophragmoides bauchensis* sp.n. Pindiga Formation, near Pindiga: umbilical views; 11 × 205, paratype (UIFNM P26); 12 × 205, holotype (UIFNM P25).
13, 14. *Haplophragmoides pindigensis* sp.n. Pindiga Formation, near Pindiga: 13 umbilical view, × 480, holotype (UIFNM P27); 14 edge view, × 410, paratype (UIFNM P28).
15. *Ammobaculites benuensis* sp.n. Pindiga Formation, near Pindiga: side view, × 136, holotype (UIFNM P33).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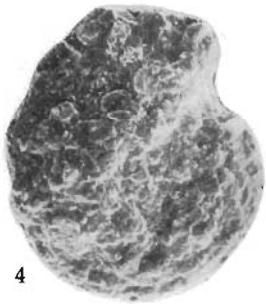
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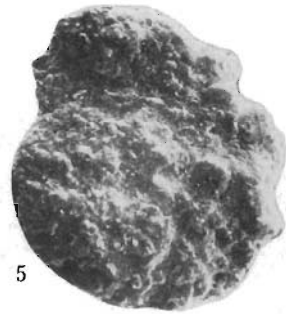
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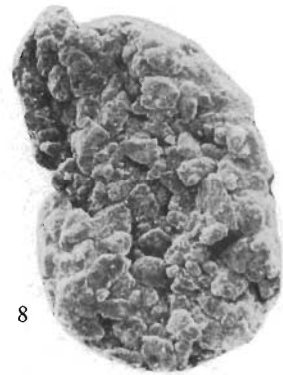
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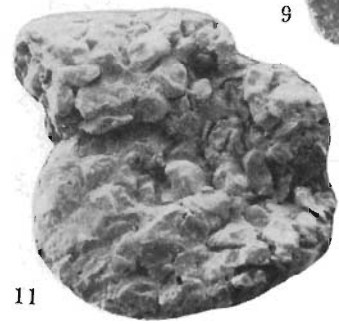
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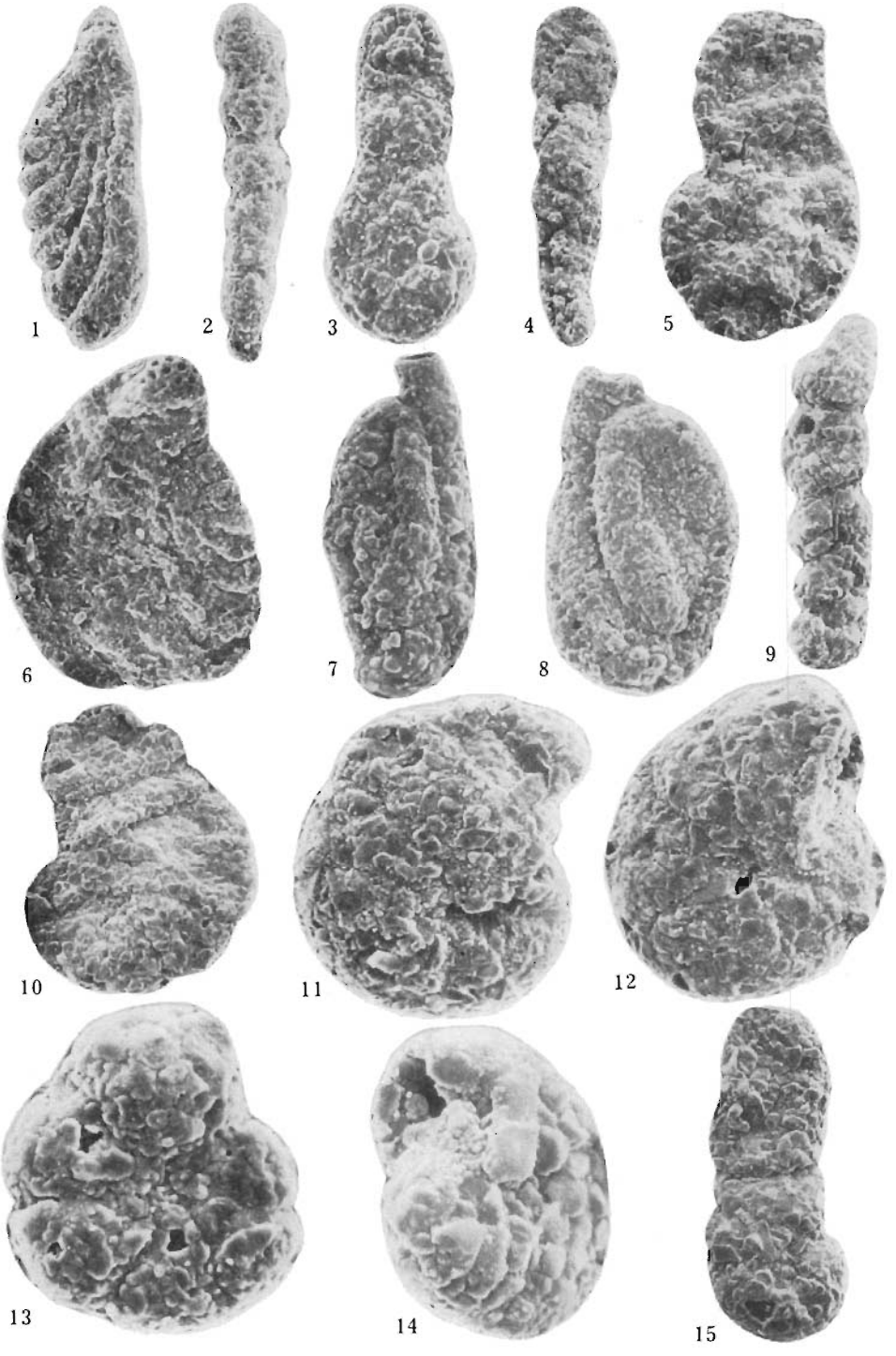
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