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Ichnology of the Cenomanian-Turonian of the Calabar Flank, SE Nigeria

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Abstract

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Trace fossils are described for the first time from Cenomanian-Turonian rocks of the Calabar Flank, SE Nigeria. The rocks essentially consist of SW dipping shales intercalated with thin beds of calcareous mudstone. In places, marly limestone occurs as low ridges parallel to the strike of the sequence. *Thalassinoides* are common in the calcareous rocks. Another, less numerous trace fossil, is probably the borings of phoronid. Marine benthonic pelecypods and gastropods, although of low diversity, are common in the mudstone and are rare or absent in most of the shale intervals which contain planktonic and impoverished benthonic foraminifera. Ichnological analysis supported by palaeontological and sedimentologicic evidence suggest a depositional environment with fluctuating shallow, aerated and oxygen-deficient bottom conditions.

Introduction

The Calabar Flank (Fig. 1), a term first introduced by Murat (1970), refers to that part of the southern Nigeria sedimentary basin which is bounded by the Precambrian Oban massif in the north and the Tertiary-Recent Niger delta in the south respectively. It extends to the Afikpo syncline in the northwest and the Cameroun volcanic ridge in the east. It has been considered as the SE extension of the Benue trough or Benue aulacogen (Petters 1980).

The Calabar Flank is filled with Cretaceous-Recent sediments. The Cretaceous rocks range in age from ?Aptian to Maastrichtian. Trace fossils which form the major subject of this study are associated with Cenomanian-Turonian sediments that are exposed at road cuttings along the Calabar-Itu highway and in Calabar river valleys.

In the study area, microfossils have been extensively investigated for time-stratigraphic and palaeo-ecological purposes (Dessauvagie 1970; Petters 1980; Petters & Ekweozor 1982; Ramanathan & Nyong 1984). Macrofossils have, however, not been studied in detail except for the ammonites and the echinoid *Hemiaster fourneli* (Reyment 1955, 1965; Akpan & Ramanathan 1985). Trace fossils have not been investigated at all although many workers (e.g. Seilacher 1964a, 1967; Farrow 1966; Ager & Wallace 1970; Crimes 1970) have demonstrated the importance of biogenic sedimentary structures in the recontruction of palaeoenvironments as their distribution is strongly controlled by water depth, dissolved oxygen in sediments,

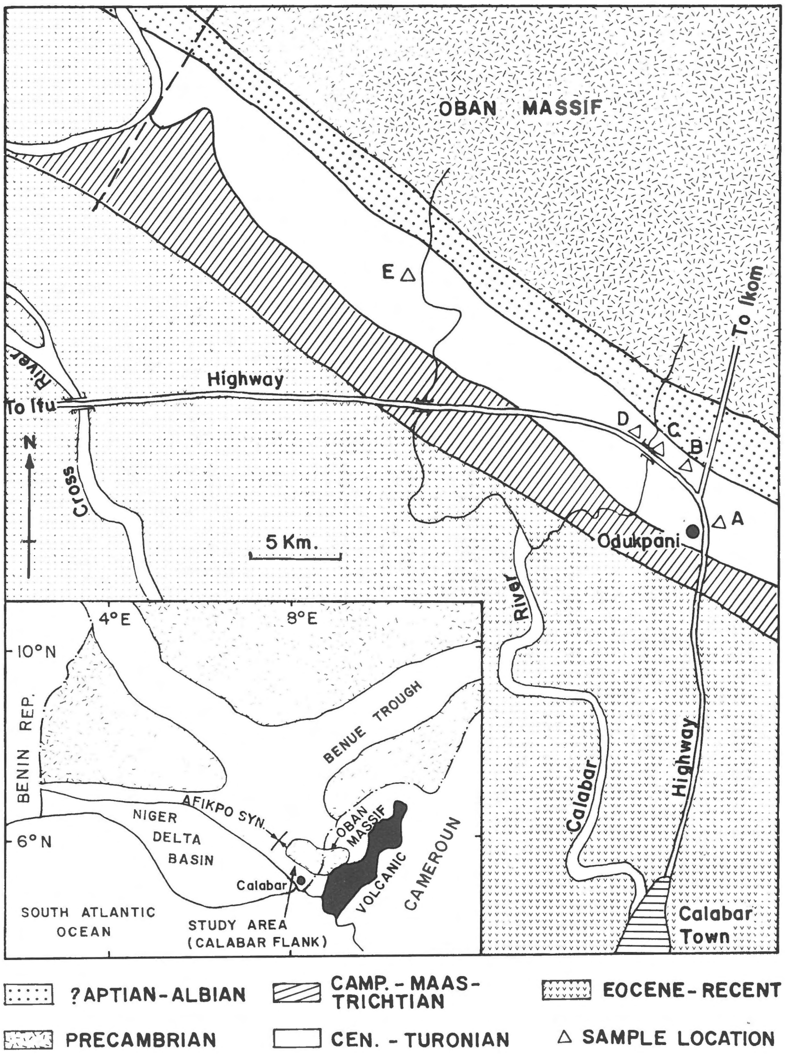

Fig. 1. Sketch geologic map of the Calabar Flank showing sample locations.

bottom stability and sedimentation rate. Furthermore, unlike body fossils, biogenic sedimentary structures are commonly destroyed by processes that rework and transport them, but when preserved, they typically remain in place (Frey 1975). In some sections, trace fossils may be the only sign of past life.

Based on foraminiferal studies, Petters (1978, 1980) argued that the Upper Cretaceous sediments of the Calabar Flank accumulated mostly under anaerobic bottom conditions. In this article, the corresponding trace fossils are described. The palaeoenvironmental interpretation of the Cenomanian-Turonian interval on the basis of the ichnofaunas is supported by the body fossil evidence. It is shown that the sediments were influenced by fluctuating bottom oxygen content and sedimentation rate.

Sample locations and geologic setting

The trace fossils studied were from five locations (Fig. 1), four from sites along the Calabar-Itu highway and one from the valley wall of a tributary of Calabar river.

Location A: About 22.5 km from Calabar where the highway cuts across a poorly bedded, narrow, marly limestone ridge which probably formed as an offshore bar. The age is Turonian on the basis of ammonites. Other macrofossils include the irregular echinoid *Hemiaster* and some deposit-feeding pelecypods. Locally, the ridge has been severely dissected by water action which cut deep gullies. Because of deep weathering, the trace fossils are only visible in fresh gullies.

Location B: The section is at the road cutting about 24.8 km from Calabar town. It is about 11 m thick; dips gently to the south and consists of organic-rich grey shales with intercalations of

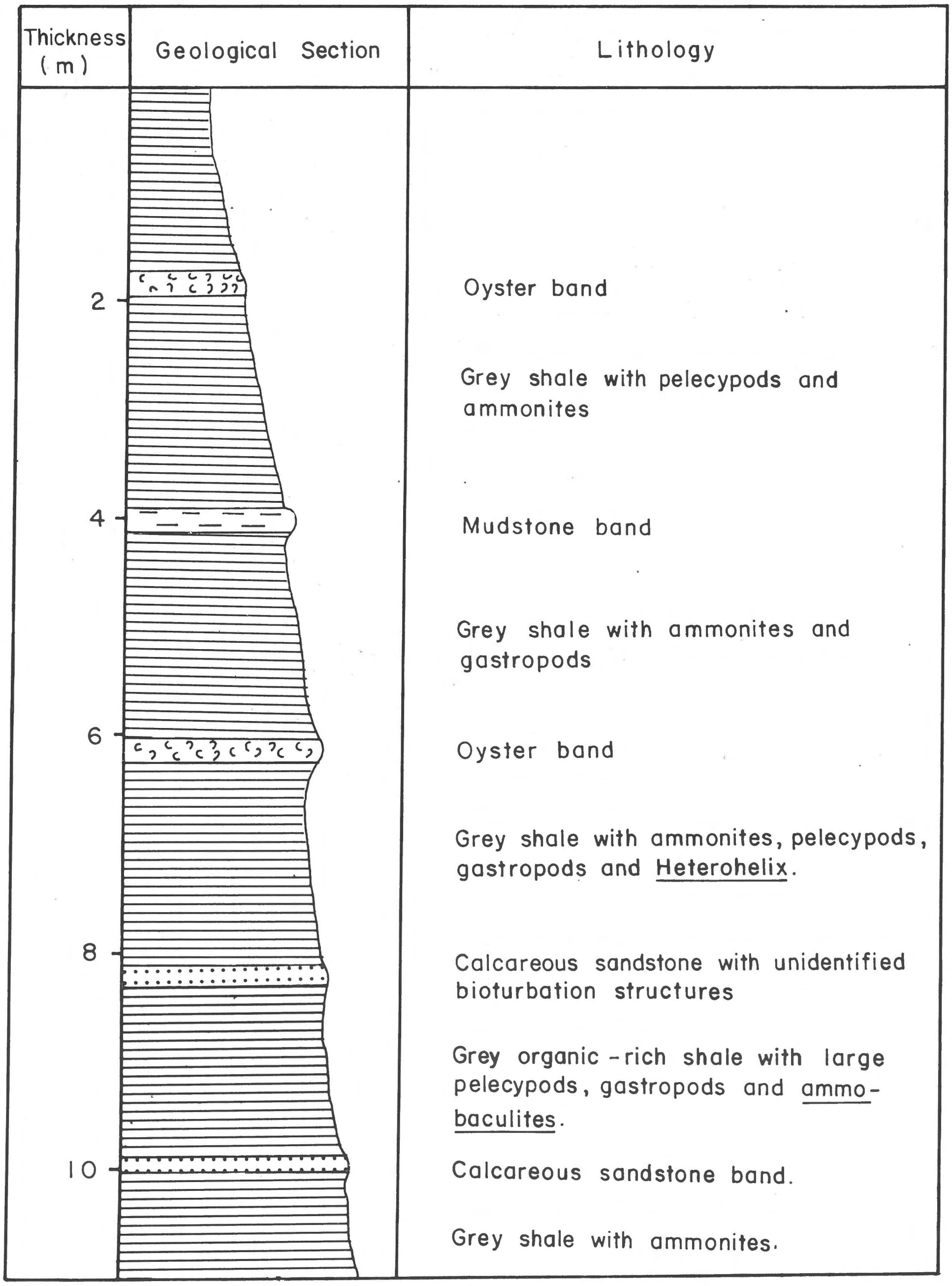

Fig. 2a. Lithologic variation and ichno/body fossil distribution in a geologic section at 24 km along the Calabar-Itu highway.

calcareous sandstone, mudstone and shelly beds (Fig. 2a). The sandstone and mudstone bands are each approximately 15 cm thick, while the thickness of the shelly beds are each about 30 cm. Gastropods, pelecypods (preserved mostly as internal moulds of articulated valves) and ammonites occur in the shales. Crab fragments have also been recorded. The shelly beds consist of oyster shells and fragments. The microfauna in the shales include the benthonic *Ammobaculites* (which is significant at one interval) and planktonic *Heterohelix* (Petters 1980). Based on the ammonites, the lower part of this sequence is dated as Cenomanian while the upper part is Turonian (Reyment 1965).

Locations C & D: These exposures are at road

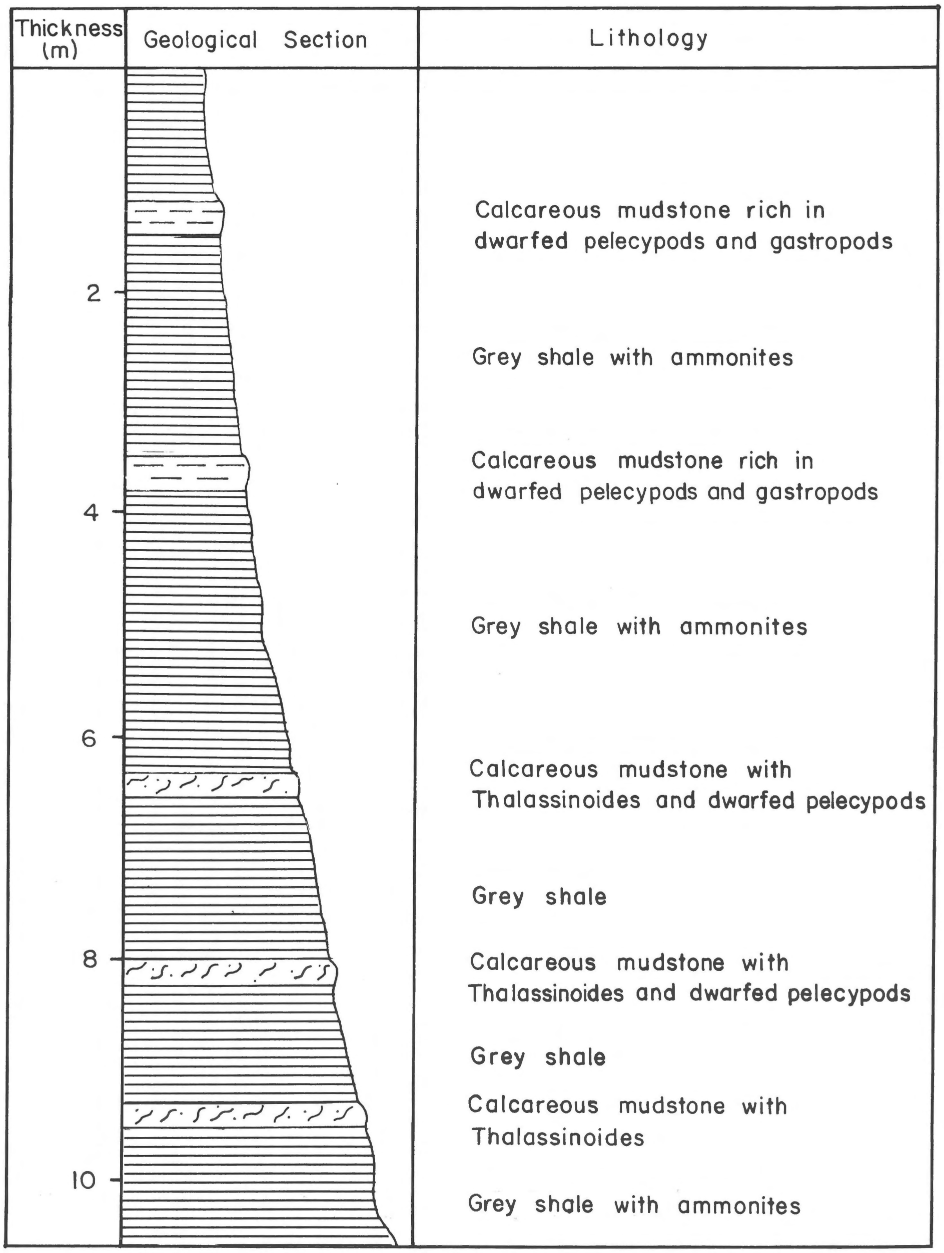

Fig. 2b. Lithologic variation and ichno/body fossil distribution in a geologic section at 28 km along the Calabar-Itu highway.

cuttings 26 and 28 kms respectively along the Calabar-Itu highway. The lithology is basically grey organic-rich shale, more than 10 m thick, with intercalations of thin calcareous mudstone beds, dipping gently in a SW direction (Fig. 2b). Besides ammonites, other macrofaunal elements and benthonic foraminifera are rare in the shale intervals. The mudstone beds, however, contain dwarfed pelecypod and gastropod internal moulds. Most of the pelecypods are preserved as articulated valves which indicate in situ preservation.

Location E: This section is exposed at a valley wall of a tributary of the Calabar river. The lithology is similar to that of locations C & D although the shale is highly weathered. The calcareous mudstone contains plenty of dwarfed pelecypods and gastropods, preserved similarly as in the previous locations.

Trace fossils

The most important trace fossils in the study area are bioturbation structures of the ichnogenus *Thalassinoides*. They are fairly common and well preserved. Hard substrate trace fossils are rare. Understandably they are excavated in shells which have subsequently been dissolved in most cases.

Systematic description of traces

Ichnogenus *Thallasinoides* Ehrenberg 1944.
These traces consists essentially of horizontally branched networks of burrows and tunnels. The tunnels vary from 1.5-2.5 cm in diameter and are slightly enlarged at the points of branching. Typically they display Y-shaped branching patterns which in most cases end blindly (Fig. 3). Branching does not occur at regular intervals but may vary between 5 and 15 cm. Although specific ornamentation is not known for *Thalassinoides* tunnels, there could be tiny scratches and pits caused by appendages of the causative organisms. Hence, while some *Thalassinoides* casts of the tunnel system have relatively smooth surface, others are rather rough.

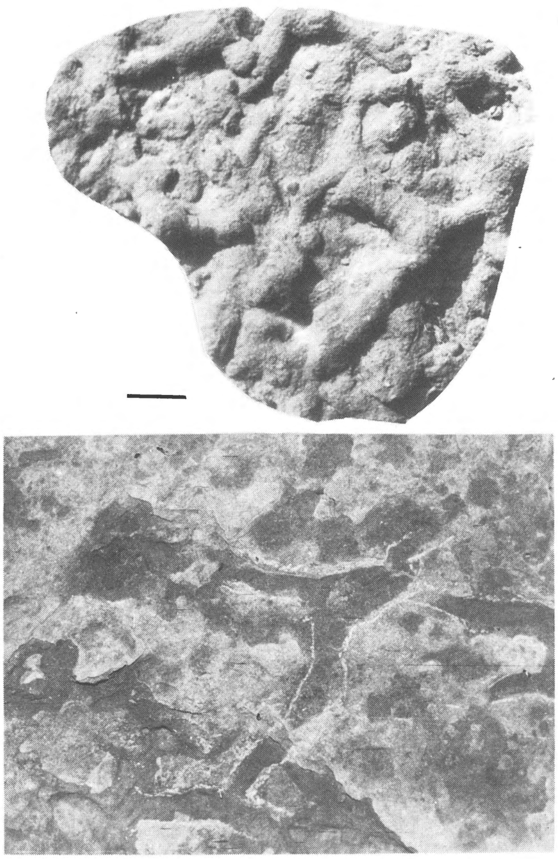

Fig. 3a. Crowded *Thalassinoides* at 28 km along the Calabar-Itu highway. Concex hyporelief. Bar length = 2.5 cm.

Fig. 3b. Horizontal view of *Thalassinoides* in the roof of a tunnel excavated on a marly limestone ridge; 22,5 km along the Calabar-Itu highway. The *Thalassinoides* is stained with iron material. Bar length = 2.5 cm.

Toponomy: It has been observed that bioturbation structures are mostly visible where the organism's activity took place at the interface between beds of contrasting lithology like shale and sandstone (Hallam 1975). In the Calabar Flank most of the Thalassinoides are recorded at interfaces between the mudstone beds and shales. The bioturbated traces are preserved as casts of the tunnels and appear as ridges on the undersurface of the mudstone which act as the casting medium (Fig. 4). The implication is that the tunnels or burrows were created in the shale at the close of its depositional cycle which was succeeded by a shorter period of mudstone sedimentation. The trace are preserved as the semi-hyporelief or the hypichnial bioturbation structures of Seilacher (1964a, b)

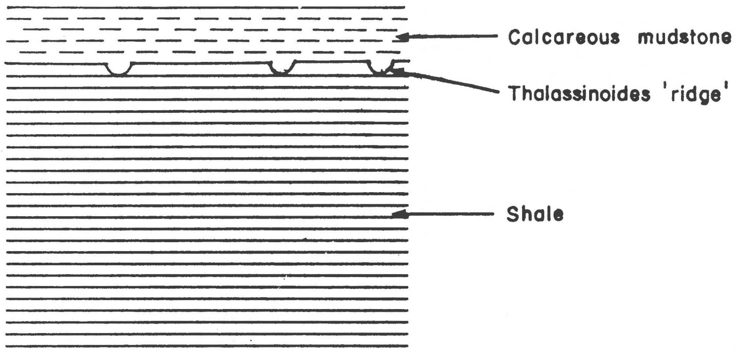

Fig. 4. Schematic representation of mode of preservation and occurrence of *Thalassinoides* at most of the studied sites.

and Martinsson (1970), respectively. Some of the *Thalassinoides* at location A occur as normal bed-junctions preserved between thin (< 6 cm) shale beds and marly limestone. Others occur within the marl strata and are preserved as full reliefs. The *Thalassinoides* at location A differ from others in the study area because their casts consist of limestone with iron staining around the walls.

Borings: These are insignificant in number. The type of borings examined represent a network of tunnels about 300 μm in diameter cut a little beneath the surface of an *Inoceramus* shell. The branching is generally at acute angles. The boring tunnels were filled with materials more resistant than the calcareous shell so that subsequent partial etching of the shell by solution leaves the boring traces preserved as branching 'ridges' on the surface of substrate. The borings were probably produced by *Phoronis*. Possible fossil phoronid borings have been documented from the Cretaceous by Joysey (1959, p. 398) and Akpan et al. (1982. pl. 37). The borings in the shell of *Pecten maximus* (Bromley, 1970, Fig. 1 & 3) are those of a phoronid labelled, however, in error as a bryozoan.

Distribution of traces

Thalassinoides are present in locations A, C, D and E. In location A, they are found at most levels of the gully walls and roofs although they are sparsely distributed. In locations C, D and E, *Thalassinoides* are found in association with the three lower beds of the calcareous mudstone (Fig. 2b). In these locations, the traces are in most cases crowded and continous. Macro-fossils are not common in the trace fossils bands. The upper mudstone beds without the *Thalassinoides* are very rich in low diversity dwarfed pelecypods and gastropods (Table2). In location B, the traces are the unidentified bioturbations associated with a sandstone band at the lower level of the succession. The phoronid borings were found in the shelly band.

Palaeoecology

In the Calabar Flank, trace fossils occur only in specific intervals of the Cenomanian-Turonian sequence. The significant traces, *Thalassinoides*, recorded at the mudstone and shale interfaces as well as the marly limestone ridge belong to the *Cruziana* ichnofacies of Seilacher (1967). These traces indicate that the associated sediments were formed in shallow, oxygenated environments with a medium to slow rate of deposition. The traces are attributed to shrimps like *Callianassa* and *Upogebia* which in Recent times burrow in fine and coarse-grained well aerated sediments within the sublittoral zone (Campbell 1976). The upper mudstone beds at locations C & D (Table 2) with layers of low deversity, dwarfed in situ pelecypods and-gastropods, apparently in absence of biogenic structures, are thought to have formed also under fairly aerobic conditions because the deposit-feeding molluscs which constitute a reasonable percentage of the fauna depended on oxygen for survival. The lack of *Thalassinoides* in these horizons may be due to absence of causative organisms at the time of sediment deposition.

The phoronid borings have no direct palaeoecological significance. They are found at a variety of depths in the present day marine environment (cf. Akpan 1981).

Most of the shale intervals are poor in benthonic foraminifera and molluscs, but the latter constitute the bulk of body fossils in the mudstone beds (Table 1 & 2). The presence of a few large articulated pelecypods and gastropods in most, as well as benthonic foraminifera in some of the shale intervals at location B (Table 1) suggest that the seabed was not oxygen deficient. The absence or paucity of benthonic foraminifera, pelecypods and gastropods in the shales at locations C, D and E is indicative of a different palaeoenvironment.

The sequence at location B would represent deposition at a depth shallower and closer to the shore than at sites C, D, E. In the study area as a whole, the oxygen concentration at the bottom varied vertically through the sequence and from one place to another. The marly limestone at location A which contains benthonic pelecypods, irregular echinoids and *Thalassinoides*, probably formed as an off-shore bar under well aerated bottom conditions.

Conclusion

Geologic factors were not uniform in the Calabar Flank during the mid-Cretaceous which coincides with a major global marine transgression. The bottom instability is manifest in the lithologic

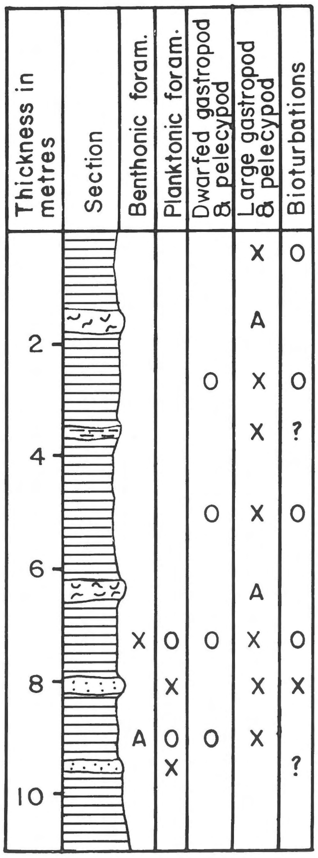

Table 1. Distribution and relative abundance of fossils in the section at location B (24,8 km).
A = Abundant C = Common X = Rare O = Absent

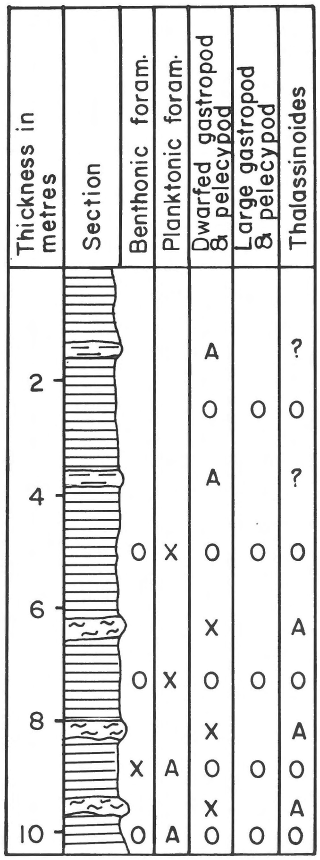

Table 2. Distribution and relative abundance of fossils in the section at locations C & D (26 & 28 kms).
A = Abundant C = Common X = Rare O = Absent

setting as well as in the ichnofaunal and body faunal associations. Within the sedimentary sequence, some intervals which formed under oxic bottom conditions are represented by thin mudstone beds within thick organic-rich shales (Petters & Ekwe-ozor 1982). Most of the latter formed under oxygen deficient conditions. Bioturbated structures and benthonic invertebrates which are common within the oxic intervals are rare or absent in the shales. Widespread oxygen deficient deposits have already been reported from the mid-Cretaceous of the world's oceanic plateaux, basins and continental margins (Schlanger & Jenkyns 1976).

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