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Upper Cretaceous Planktonic Forminiferal with Complex Range Fauna at Mitia- Ambilany, Morondava Basin- Madagascar

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A B S T R A C T

Sediments collected and treated at the Mitia-Ambilany site in Sakaraha District delivered fossil microfauna and macrofauna such as benthic foraminifera and planktonic Foraminifera, as well as Bivalves, Echinoderms and Gastropods. The method of dating by the complex range faunal gave the age of the geological section taken in this area which is estimated from the middle and upper Cretaceous from the Aptien to the Maestrichtian. Using foraminifera, as an paleoenvironment indicator and the determination of facies, allows to reconstruct the paleobiotope, which is a deep sea, subtidal, more than 200m. The living environment has a low to medium and calm hydrodynamic energy. As for the paleoclimate, the site was characterised by a warm tropical climate. Abundance of planktonic forminifera species with a high proportion of 86.3% with fine- grained sediments at the site is a typical of a calm, in a deep sea in a warm overall temperature. The similarity of the fossil fauns encountered in Madagascar and that of India and some regions of Africa affirms a biostratigraphic correlation between these formations in the Cretaceous.

Keywords: Age; Complexe Range Faunal; Mitia-Ambilany; Paleoenvironment

1. Introduction

Madagascar is in the South-East of Africa, and has completely detached from Gondwana in the Late Cretaceous. The island has three types of sedimentary basins. The Morondava basin, chosen as the axis of study, with its different stratigraphic layers, offers palaeontological and palaeoenvironmental potentialities. It is the largest sedimentary basin of Madagascar, is located in the South-West of the Island, making 1000 km of length between Cap Saint André in the North and Cap Saint Marie in the South (8).

The MitiaAmbilany/Analavelona study site of the Sakaraha District is part of this basin. The problem is that the stratigraphic subdivision of this formation is not yet well defined. The purpose of the study is to conduct a paleontological inventory of sediment collected during the field descent. This present work is a part of contribution to the inventory of fossils, such as microfauns (foraminiferous), and macrofauns (bivalves, echinodermes and gastropods), in order to understand the relationships between different organisms and the evolution of a marine environment. Planktonic Foraminifera are an important source of palaeoceano graphic information (36). Their long palaeontological record, good preservation in sediments and easy collection make them perfect indicators for studies on changes in sea-surface temperature, salinity, and nutrient content(39)

This study is to process sediments for the identification of microfossils and faunistic associations, to know the stratigraphic subdivisions of the Middle and Upper Cretaceous, ranging from the Aptian to the Maestrichtian and to have more information on the living environment of the fauna encountered.

2. Geological Setting

The study site belongs to a formation characterized by Cretaceous volcanism (8). The Cretaceous is a geological period that lasted 65 million years from 145.5Ma to 65.5Ma. It is the last period of the Mesozoic. The events were numerous all this time. A major volcanic episode with cracking basalt effusion

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affected the Middle and Upper Cretaceous, and a fairly intense marine regression and transgression (31). The sedimentary complex of the site is formed by basalts, labradorites and sakalavites (9). It presents a marine face by the presence of sandstone-marl-limestone and the fossil faunas typical of this face. It is part of the limestone-basaltic domain whose outcrops correspond to interbedded marine and lava series (40).

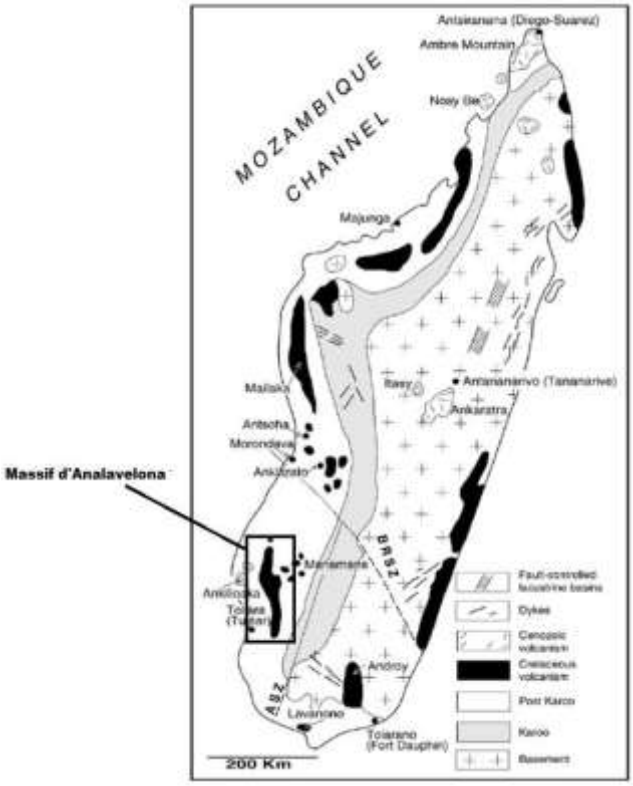


Figure 1: Volcanic Units of Madagascar (Rasamimanana et al, 1998, modified)

3. Materials and Methods

A lithological study was done on the outcrop in the study site in order to know the lithological nature and paleontological contents by strata. The purpose of this study is to monitor the paleo-environmental evolution of sedimentary deposits in the basin.

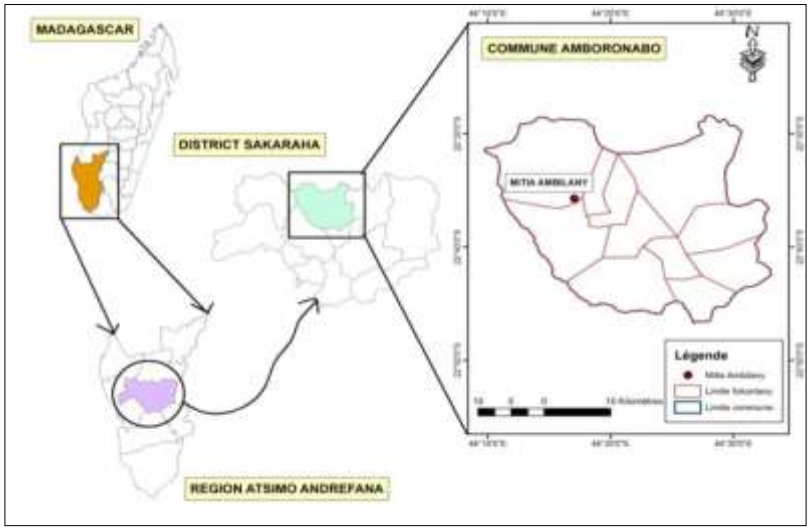


Figure 2. Location of the Mitia-Ambilany site, Morondava Basin

4. Results and Interpretations

4.1 Lithostratigraphic description

The succession is composed of sandstone and clay contained of fossils with discontinuous levels. Figure 2 below shows the lithological section of Mitia-Ambilany, respectively. It is usually formed by alternating sandstone and clay.

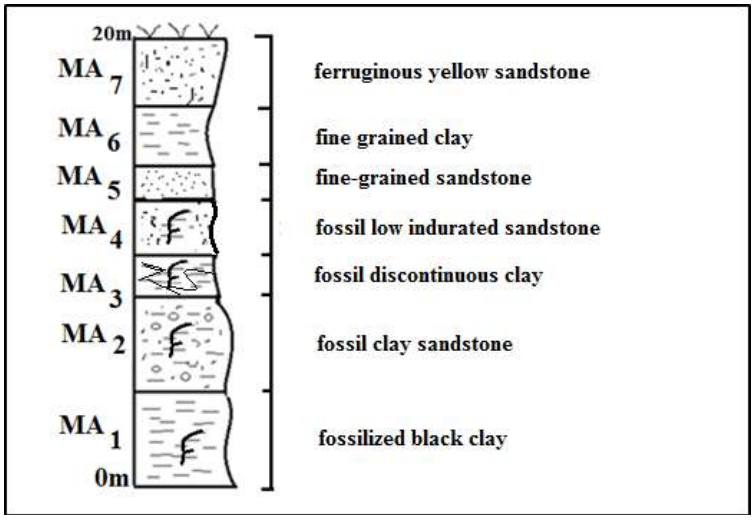


Figure 2. The section sampled Mitia-Ambilany (MA), Morondava Basin.

MA_7: ferruginous yellow sandstone with small concretions;

MA_6: highly oxidized wafer clay;

MA_5: fine-grained yellow sandstone, characterized by the absence of mica, formed by subangular quartzs.

MA_4: low-indurated sandstone with shell;

MA_3: discontinuous clay with fossils

MA_2: clay sandstone. The layer is formed by subangular to subarrondiquartzs; with fossils

MA_1: black clay, plate formed by white fossils

MitiaAmbilany's sedimentary series contains a very rich macrofauna and microfauna. Invertebrate fossils are the most abundant. The microfossils are represented by the benthic and plankton foraminifers and the macrofossils consist of the classes of Gastropods (42) in figure 3, Bivalves (figure 4A), Cephalopods, Echinoderms (figure 4B).

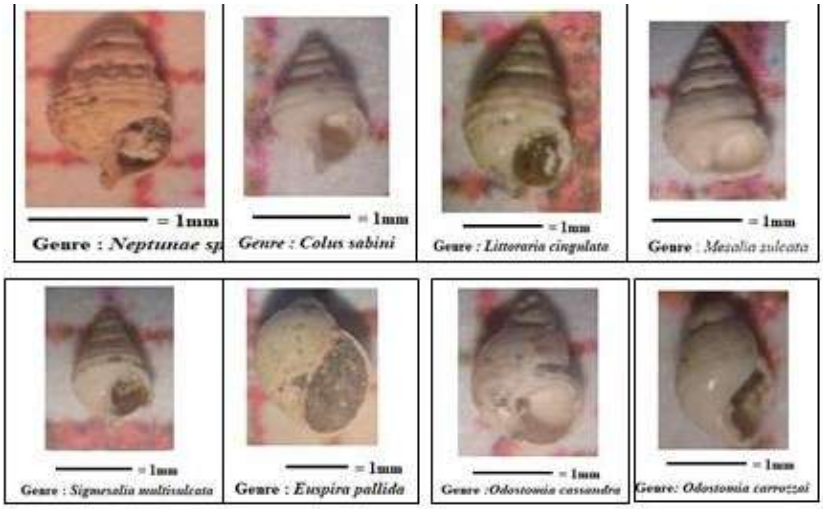


Figure 3: Gastropods samples

Figure 4A: Bivalvessample

Figure 4B: Echinodermsample

4.2 Quantitative studies

According to laboratory studies, plankton foraminifers are more abundant than benthic foraminifers in figure 5, and with a very remarkable difference. Among the planktonic forms, the GLOBOTRUNCANIDAE family is the most dominant, and the EPISTOMINIDAE family, the rarest benthic forms (39).

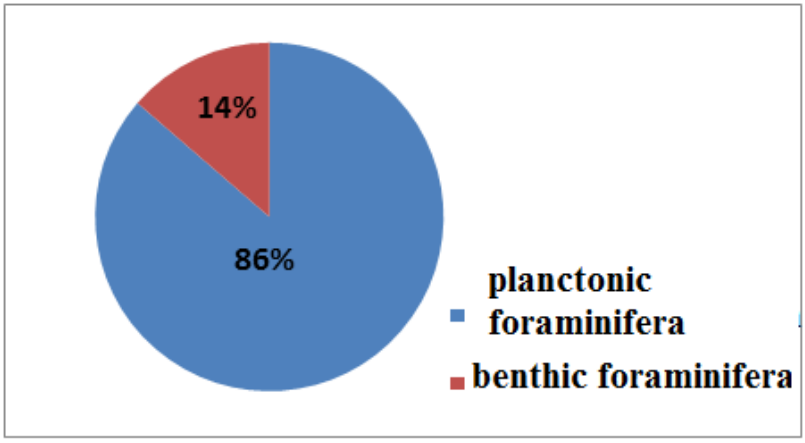


Figure 5: Abundance of foraminifera group

5. Discussion

5.1 Palaeoecological discussion

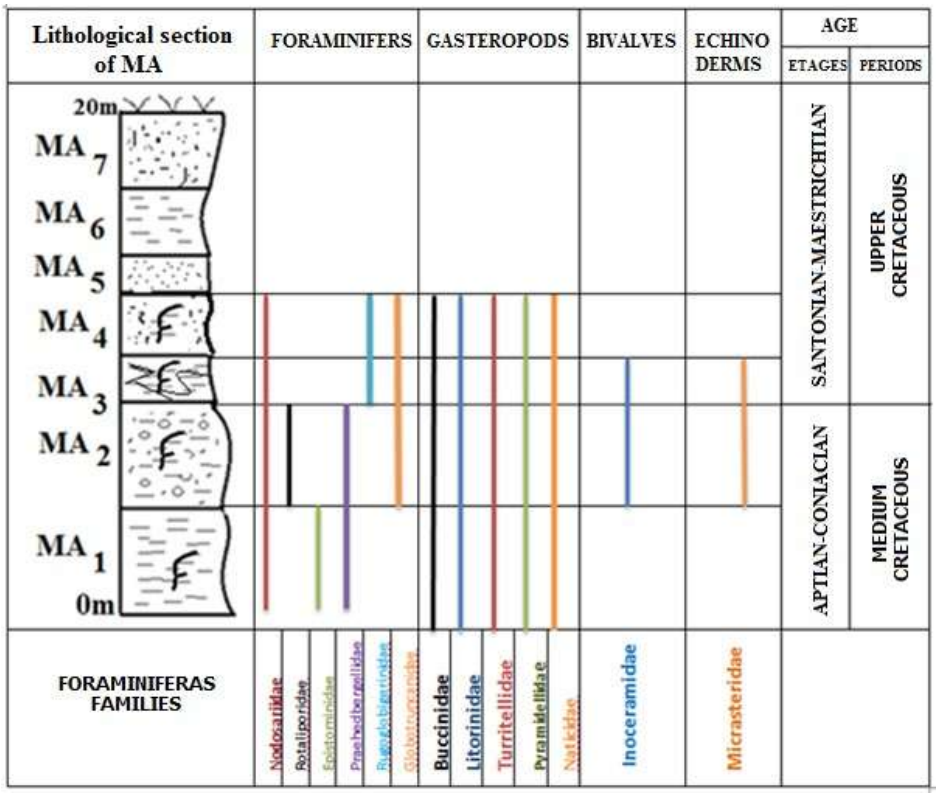
Sediments are formed by alternating sandstone and clay. At MA_1 (black clay) to MA_2 (clay sandstone), the clear sandstone of globular planktonic foraminifers in sediments indicates a fairly deep deposition medium. From MA_3 (discontinuous clay) to MA_4 (low-indurated sandstone), the globular form decreases, planktonic foraminifers (table1) that have complex forms with double hulls begin to proliferate and diversify, they are characteristic of a deep sea. This fact allows us to assume that sea levels rise in the Upper Cretaceous.The results obtained in the following table explained with the life of the foraminifera (28),(34).

Table 1: Benthic and Plankton Foraminiferous Habitats Encountered

FORAMINIFERES	**FAMILIES**	
	Benthics	- NODOSARIIDAE(*Lenticulina,Nodosaria*), - EPISTOMINIDAE
	Planctonics	- GLOBOTRUNCANIDAE,ROTALIPORIDAE -PRAEHEDBERGELLIDA - RUGOGLOBIGERINIDAE

Based on these planktonic foraminifers, this formation can be divided into 3 periods: the time of Hedbergellidae and Rotalipores, that of Dicarinelles and Marginotruncana then that of Globotruncana and Rugoglobigérines (table 2).

Table 2: Complex range faunal, age and depositional environments



According to this table:

- The MA_2 level is the co-occurring biozone, that is, several taxa coexist at thislevel.
- MA_5 to MA_7 does not contain any fossils that could be caused by the extinction crisis at the end of theCretaceous.

The Globotruncanidae family appeared at MA_2 and disappeared at MA_4, and the Micrasteridae and Inoceramidae family appeared at MA_2 and disappeared at MA_3. These 3 families are characteristic Upper Cretaceous stratigraphic fossils.

The stratigraphic distribution of the microfaunas encountered in this formation, obtained by the study of fossil associations is limited in the interval of the Aptian stage to the Maestrichtian.

5.2 Planktonic foraminifera

They are foraminifers requiring stable physico-chemical conditions. They do not support salinity variation, turbidity, etc… (6). Its thin (often globular) tests, fatty protoplasmic inclusions, and its gas capsules allow them to adapt well to flotation (28). They are indicators of the physico- chemical characteristics of the ocean: temperature, salinity, etc. (13)

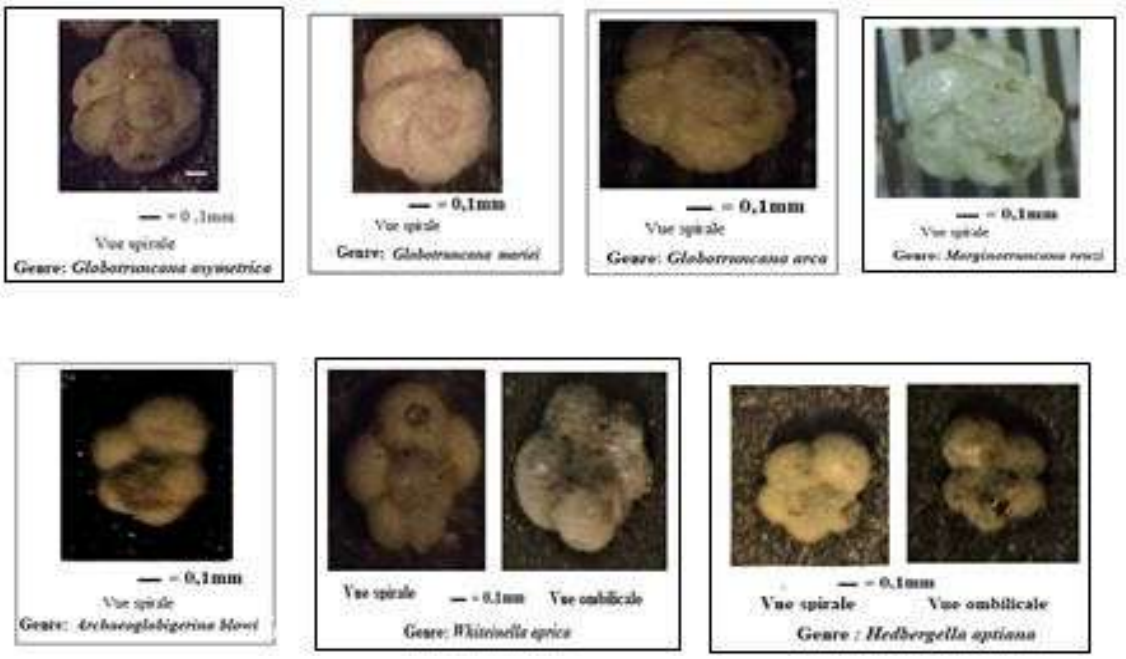


Fig 6. Planktonic foraminifera

The study is based on a detailed analysis of seven volcanic rocks samples prepared in thin section. The stratigraphic section from which the samples have been taken is about 20 m thick and has been measured on the dirt track that begins at Mitia village and that leads to the 22°35'18.4'. latitude-South and 44°19' 33.9' longitude-East with an altitude of 794m, belongs to the massif of Analavelona in the valley of Ilona, of the rural commune of Amboronabo, District of Sakaraha (figure 1).

5.3 Benthic foraminifers

Benthic foraminifers are what live in shallow seas, inside or on the surface of sediments. They can sometimes adapt to a planktonic lifestyle. The depth they support depends on the temperature, oxygenation, and illumination of the water. But the largest of them are found in tropical environments where the water has a temperature between 18 and 20 degrees and a depth of more than 200m.

Foraminifera species are very abundant and distributed according to ecological preferences (24). Warm waters are the richest in microfossils, large and diverse in tropical places (13). The determination of the direction of the winding of the test (shell) of a foraminifer allows to make this reconstruction of its environment. The majority (31) of these determined microfossils have a dextrous winding (i.e., to the right) that characterizes the water surface as hot.

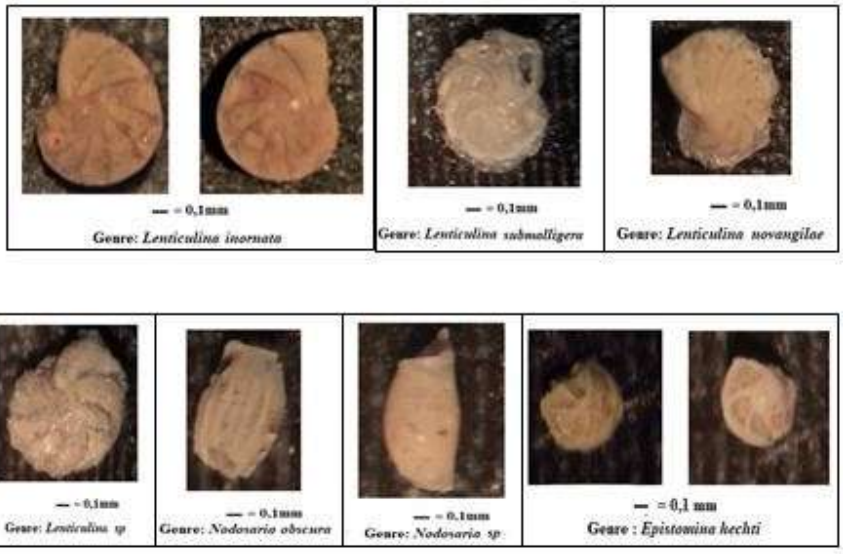


Fig 7 Benthic foraminifers

6. Conclusion

Since the end of the Paleozoic and throughout Mesozoic, Madagascar and the large Indies (Sri Lanka, India and Seychelles) have separated from the African continent. The separation of Madagascar and the Great Indies took place at the end of the Cretaceous period (~90Ma) during the opening of the Indian Ocean, which was due to the start of operation of the Marion hot spot in southern Madagascar (41). This event is marked in Madagascar by the installation of volcanic rocks (basalts and rhyolites) and plutonic rocks (gabbros) dated 92Ma (41).

The dominance of planktonic foraminifers of hyaline nature or elongated tests testify to the deep and calm sea. These straight and elongated forms are good diggers that occupy deep endofaunal habitats. Rotaliporidae, Globotruncanidae, Nodosariidae, Epistominidae are typical of the bathyal stage (5). This study suggests that some Upper Cretaceous foraminiferal taxa were adapted to tolerate moments of extreme high temperature and salinity Consorti L

In short, by examining the related fossil forms, determining the living environment of a given group, by studying Foraminiferous fossils and the rocks that contain them, it is possible to use them as facial indicators and to use them for the relative dating of a given stratum (14). In the case of the Foraminifers, the Foraminifers have a chronostratigraphic extension going from the lower Cambrian to the present time. The first forms appeared organic tests or simple agglutinated tubes. Species are rare until the Devonian. Microgranular calcitic tests culminate in Carboniferous and Permian with the development of Fusulinids that disappear at the end of the Paleozoic. The Carboniferous tests appear with Cornuspirids. They are followed during the Mesozoic by the multiplication of agglutinated tests (Lituolidae in the Jurassic and Orbitolinidae in the Cretaceous) and by the radiation of hyaline tests (including that of Nodosariidae in the Jurassic). The first forms are all benthic, planktonic forms do not exist before the Jurassic (24), but they developed well and very diversified in the Cretaceous as the case of the site of Mitia-Ambilany These different forms of fossils then provide a first support for the stratigraphic delimitation of the study site in the interval of time from the Aptian to theMaestrichtian.

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