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Characterization of Bentic Microfauna of the Maastrichtian Deposits of EB-1 Well, Ivory Coast Onshore Basin

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Abstract

This study focuses on the characterization of the benthic microfauna from 19 drill cuttings samples from the EB-1 oil well, located in the onshore part of the Ivory Coast basin. The main objective is to reconstruct the depositional environment and establish the lithostratigraphy of the Maastrichtian sediments. The studied lithological profile (between 201 m and 120.5 m in the direction of sedimentation) is divided into three main units: Unit A (Base) is essentially composed of fossiliferous limestone. Unit B (Middle) is an alternation of clays and fine to coarse sands, and finally, Unit C (Top) is an alternation of sand and kaolinite. Biostratigraphic and microfaunal analysis revealed a rich (3241 individuals) but not very diverse microfauna, dominated at 84.49% by benthic foraminifera. The genera *Praebulimina*, *Orthokarstenia*, and *Afrobolivina* predominate. However, there is a low presence of planktonic foraminifera (*Planoheterohelix*, *Rugoglobigerina*). The combined analysis of lithological data and the pelagism index allows for the reconstruction of the depositional environment. This is a medium-depth, internal platform environment (estimated depth between 10 and 100 meters) which suggests ecological conditions characterized by a high proliferation of *Bolivinidae* and *Buliminidae*, associated with low species diversity, indicating anoxic conditions (oxygen-poor environment) and an abundance of organic matter. This work confirms the Maastrichtian age of the EB-1 well deposits and highlights a shallow marine environment, marked by sea-level fluctuations and episodes of oxygen deficiency.

Keywords

Foraminifera, Lithology, Paleoenvironment, Maastrichtian, Ivory Coast Basin

1. Introduction

Following the discovery of bitumen at Eboinda in Ivory Coast in 1896, exploration and exploitation permits were granted to oil companies in order to increase discoveries and increase hydrocarbon production.

It is in this context that PETROCI conducted studies to determine the overall structure of the Ivorian basin as well as the main biostratigraphic features (microfauna), both offshore and onshore. Indeed, the environment of the Ivorian basin was highlighted by the existence of fossiliferous species living over a geological time interval (from the Cretaceous to the current one). These research studies on the basin conducted by geologist researchers Zahoui (2003), Ouffoue (2005), Djeya et al. (2010), Bamba et al. (2011), Kouassi et al. (2013), Koffi (2017), Ahoure (2021) and many others have provided details on microfauna (foraminifera, ostracods) and the microflora of the Cretaceous in offshore, from biostratigraphic data that led to the identification of various species, in different stages. However, there is a scarcity of information on the lithology, biostratigraphy and deposition environment of the Cretaceous (onshore) as well as its valorization. This work is part of this framework and aims to provide clarification on the species of the Maastricht Chtian. This study is based on the spoil of deposits traversed by the EB-1 drill located on the onshore part (Figure 1). Its coordinates are 5˚18'42.35"N and 3˚58'15.64"W.

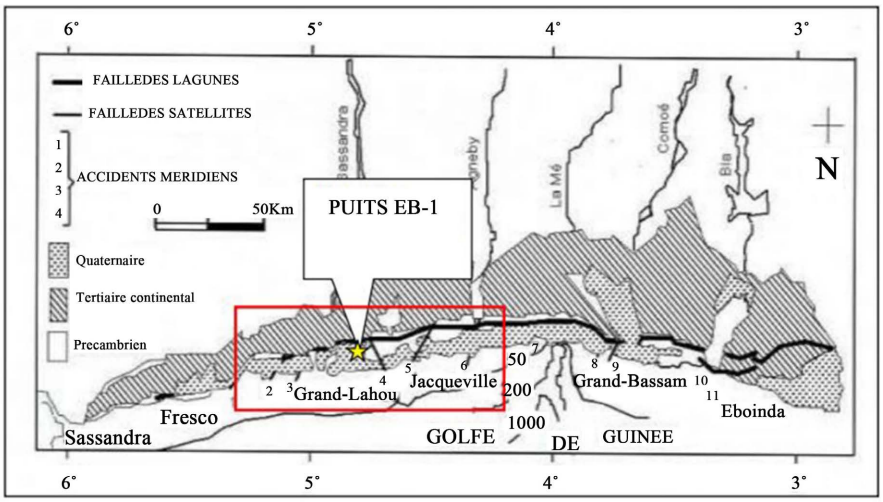

Figure 1. The sedimentary basin of Côte d'Ivoire and location of the EB-1 well.

2. Material and Methods

Nineteen samples of spoil from the interval 120.5 m to 201 m of the EB-1 oil drilling were used as support for this study. Each sample, processed using a conventional method starting from about 20 grams, was the subject of lithological and micropaleontological analyses. The analytical protocol includes a washing with soapy water, followed by a wet sieving using a decreasing mesh sieve column (250 µm, 100 µm, 63 µm). The residues are then dried at 90˚C in the oven, then sorted

under a binocular lens. The taxonomic identification of extracted microfaunas is based on specialized literature and internal technical reports from PETROCI. The interpretation of deposition environments is based on the model of Elf-Aquitaine Boussens Pau (1977), based on the pelagic index, defined by the ratio between the number of planktonic foraminifera and the total planctonic and benthic foraminifera.

3. Results

3.1. Lithostratigraphy

Figure 2 presents the lithostratigraphic synthesis of the studied interval, detecting three main units arranged from base to top. This organization reflects a vertical evolution of facies, reflecting variations in deposition conditions over time:

Unit A: is essentially composed of limestone. This unit is fossiliferous between 201 m and 194.5 m.

Unit B: consists of clays and sands in alternation, between 195.5 m and 155.5 m.

Unit C: Consists essentially of an alternation of sand and kaolinite. This unit is between 132 m and 120.5 m.

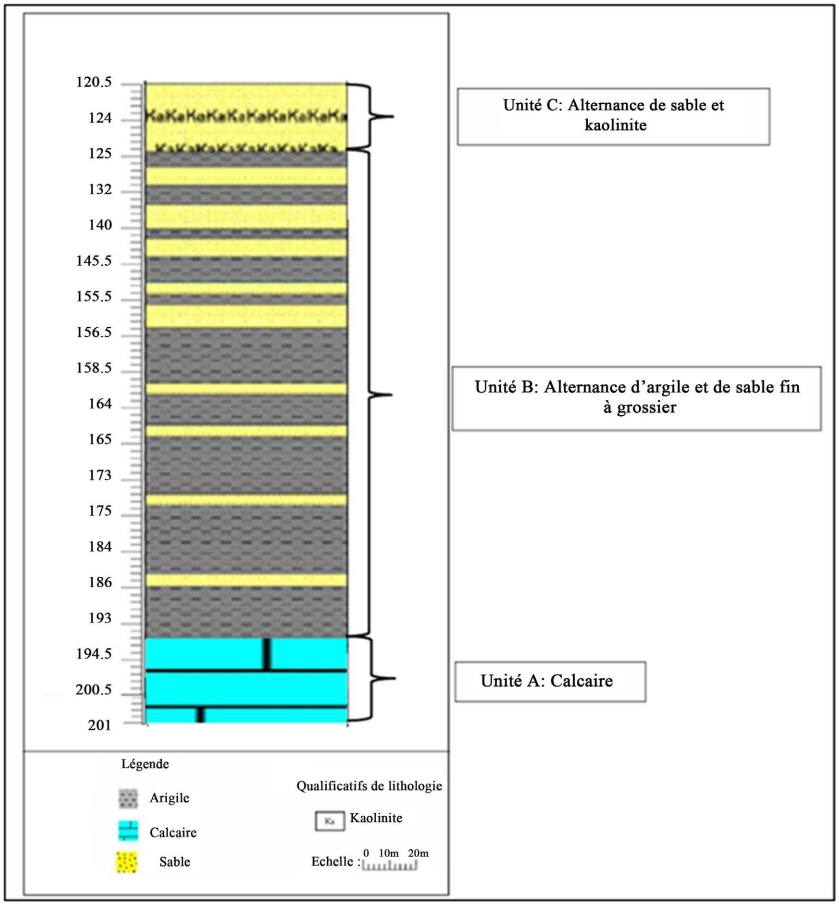

Figure 2. Lithological synthesis of the studied interval in the EB-1 well.

The lithological synthesis of the interval studied in the EB-1 well revealed that this well is essentially composed of limestone, alternating clay and fine coarse sand and alternating sand and kaolinite.

3.2. Biostratigraphic

Quantitative Analysis of Microfauna (Figure 3)

The sorting work carried out on all the residues of the 19 samples showed a rich microfauna composed mainly of foraminifera (3241 individuals recorded) associated with ostracods, shell debris (gastropods and bivalves), fish teeth. Figure 3 shows an abundance of microfauna in benthic forms, i.e. a rate of 84.49% of the total population divided into 12 genera and 14 species, and a rarity of planktonic forms, i.e. 15.51% of the total population divided into 3 genera and 5 species. 19 shells of gastropods and 16 bivalves; and 23 teeth of fish also make the percentage of these.

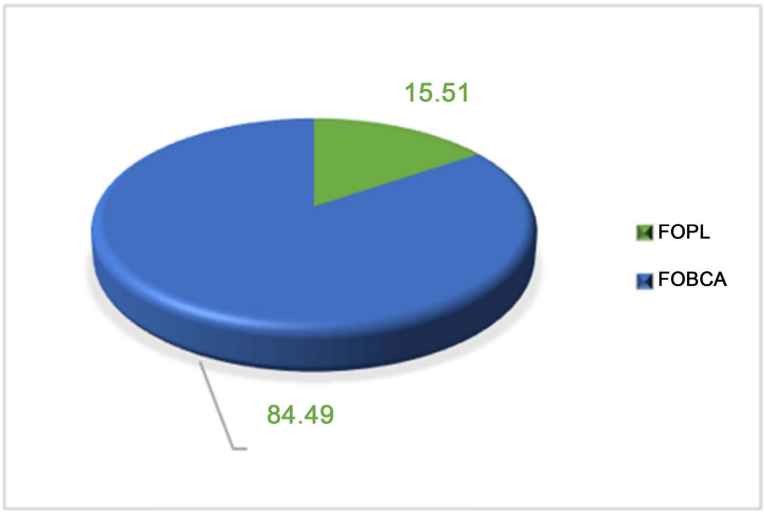

Figure 3. Sectoral distribution of foraminifer populations in the range 120.5 m - 201 m from well EB-1 (FOBCA: Limestone benthic foraminifers; FOPL: Planktonic foraminifers.).

3.3. Biostratigraphic Synthesis of the Study Interval

By the analytical method, the study carried out on this interval allowed to confirm the Maastricht stage with the presence of species at different sides that are dominated by planktonic forms throughout the interval: *planoheterohelix* and *rugoglobigerina*. These planktonic forms are associated with the endofaunal limestone benthic forms characteristic of the Maastrichtian. These are: *Praebulimina*; *Orthokarstenia*; *Afrobolivina* (Figure 4).

3.3.1. Systematics of Microfauna

1) Systematic (Plate 1)

The planktonic and benthic foraminiferal species mentioned in this thesis have been described in the micropaleontological literature. Microfauna analysis is based on the number of lodges, the test and certain morphological traits. Obser-

vation with a Nikon smz 1500 stereoscopic microscope with magnification (100 μm).

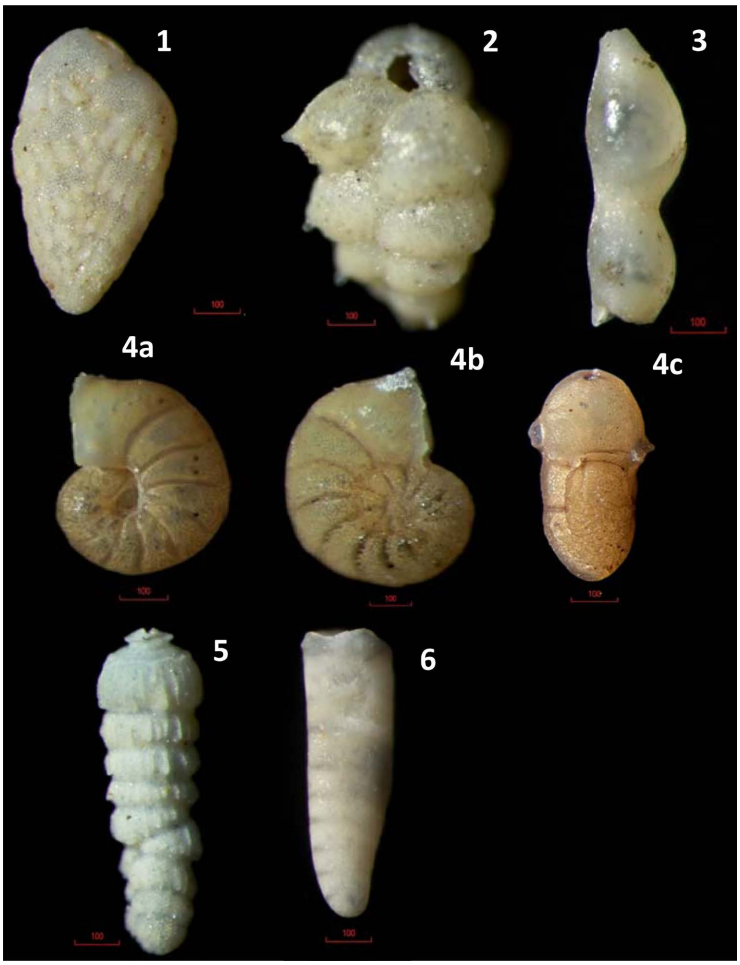

Plate 1. 1: *Afrobolivina afra* (Reyment, 1959); 2: *Praebulimina accumifera* (Hofker, 1953); 3: *Laevidentalina sp* (Loeblich & Tappan, 1986); 4: *Gavelinella nacatochensis* (Brotzen, 1942); a: Ombilical face; b: Spiral face; c: View face; 5: *Vaginulina sp* (d'Orbigny, 1826); 6: *Orthokarstenia idkyensis* (Dietrich, 1935).

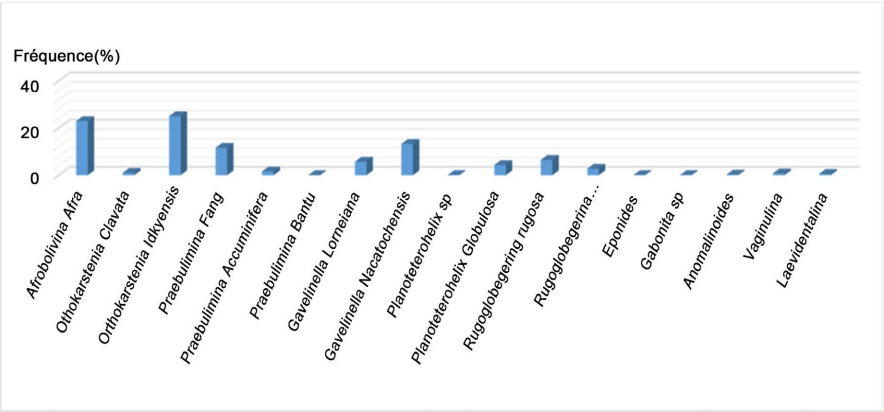

Figure 4. Frequency histogram of foraminifera from Maastrichtian.

Suborder: Rotaliina (Delage & Hérouard, 1896)

Family: Bolivinidae (Glaessner, 1937)

Gender: *Afrobolivina afra* (Reyment, 1959)

Description: Large test, elongated, biserial throughout, with angular lodges. Adorned with ribs and a terminal opening.

Family: Siphogenernoididae (Saïdova, 1981)

Genus: *Orthokarstenia idkyensis* (Dietrich, 1935)

Description: Elongated test, gradually widening from the rounded base, spherical, of a biserial stage not well visible, slightly swollen in the uniseriate, characteristic sutures, depressed; calcareous walls, striated and discontinuous surface; terminal opening.

Family: Heterolepidae (González-Donoso, 1969)

Genus: *Praebulimina accumifera* (Hofker, 1953).

Description: Test ovoid, swollen, triserial shape, depressed; limestone wall, finely perforated, appearing thick and opaque, smooth or spiny surface; opens a loop at the base of the final loge.

Suborder: Lagenina (Delage & Hérouard, 1896)

Family: Nodosariidae (Ehrenberg, 1838)

Genus: *Vaginulina sp* (d'Orbigny, 1826)

Description: Arched, compressed limestone test with a small number of ribs, composed of compartments separated by depressed inclined sutures.

Genus: *Laevidentalina sp* (Loeblich & Tappan, 1986)

Description: Limestone test, elongated and uniseriate. The sutures are depressed and a tooth opening and the number of lodges is 2.

Family: Gavelinellidae (Hofker, 1956)

Genus: *Gavelinella nacatochensis* (Brotzen, 1942)

Description: Test trochospiral, biconvex, rounded periphery; limestone wall, perforated; extraumbilical opening, bordered above by a narrow lip, the opening continue under the flaps to connect with those of the anterior chambers, depressed sutures.

3.3.2. Paleoenvironment

The study of this microfauna coupled with that of lithology, has made it possible to highlight associations that reflect different types of deposition environments.

1) Hierarchical tree of microfauna

The hierarchical ascending classification carried out here has made it possible to obtain a similarity of the abundant species in the studied stage that goes from the most abundant to the least abundant. This method made it possible to identify 5 distinct classes similar among each other.

The classes are as follows **(Figure 5)**:

- Class 1: consists of *Preabulimina fang*, *Gavelinella nacatochensis*, *Afrobolivina afra*, *Orthokarstenia idkyensis*, *Gavelinella lorneiana*.
- Class 2: consists of *Planoheterohelix globulosa*, *Rugoglobigerina rugosa*, *Rugoglobigerina macrocephala*, *Gabonita sp*.

- Class 3: also consists of *Orthokarstenia clavata*, *Vagininula*, *Preabulimina accuminifera*.
- Class 4: was divided into 2 groups consisting of *Preabulimina bantu*, *Eponides* and *Planoheterohelix sp*, *Anomalinoides*.
- Class 5: consists of *Laevidentalina sp*.

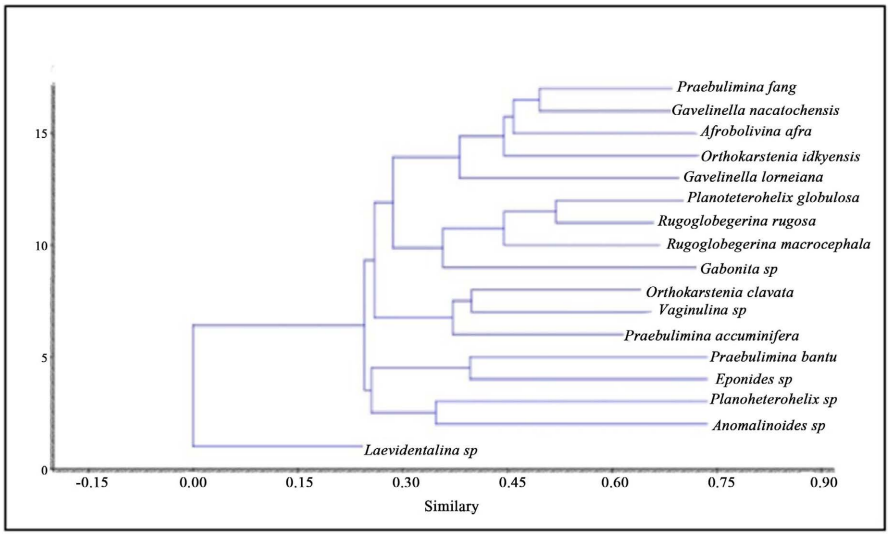

Figure 5. Hierarchical tree.

2) Pelagic index

- Between 120.5 m and 132 m, we notice the presence of water with a pelagic index ranging from 2% to 0% (Figure 6).
- Between 132 m and 140 m, we notice a slight increase in the sea level.
- Between 140 m and 145.5 m, we notice a sudden drop of up to 5% which would indicate a decrease in the sea level.
- Between 145.5 m and 158.5 m, the pelagic index from 5% to 20%; this indicates an increase in the water slice.
- Between 158.5 m and 165 m the pelagism evolves in the range of 40% and 60% with significant fluctuations.
- Between 165 m and 184 m, we notice a drop in the sea level.
- The pelagism index obtained at the level of 184 m to 186 m and from 194.5 to 200.5 m shows an increase in the sea level.

At the sedimentological level, lithology consists of sandy black argillites, then compact argillites (kaolinite), followed by limestone of which some gastropods are observed. According to Djrouko et al. (2021), the presence of these species in the basin reflects a shallow marine deposition environment.

This interval is distinguished by a rich but little diversified benthic microfauna, dominated by the families of *Bolivinidae* and *Buliminidae*. This proliferation, associated with a low specific diversity, suggests anoxic conditions, these taxa being adapted to oxygen-deficient environments. Moreover, the occasional rarity of planktonic forms and globular tests indicates an environment from internal to

medium platform (10 - 100 m).

The presence of the genus *Gabonita* confirms a shallow deposition medium, eutrophic and marked by severe dysoxia, linked to a high concentration of organic matter. Overall, the assemblage of benthic foraminifers (although quite monotonous) combines *Nodosariidae* (such as *Laevidentalina* and Vaginulina), characteristics of coastal areas, and deeper facies forms like *Eponides*. This set is typical of medium platform circalitoral environments (Brun, 1978).

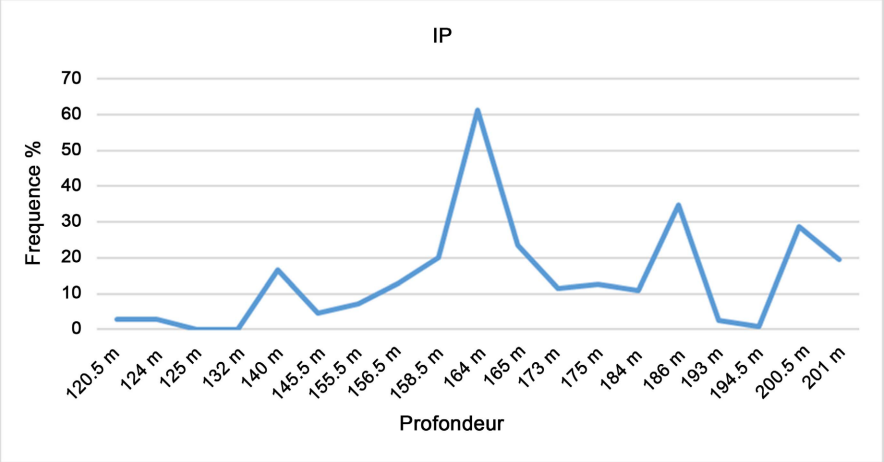

Figure 6. EB-1 pelagic well index.

4. Discussion

The different microfaunas that allowed the biostratigraphy of the studied interval to be established are known in most West African coastal basins. In our study interval the association of limestone benthic genera such as *Afrobolivina* (Reyment, 1959), *Eponides* (Montfort, 1808-1810), *Anomalinoides* (Brotzen, 1942), *Praebulimina* (Hofker, 1953), *Orthokarstenia* (Dietrich, 1935), *Laevidentalina* (Loeblich & Tappan, 1986), *Vaginulina* (d'Orbigny, 1826), *Gabonita* (Dieni, 1974), *Gavelinella* (Brotzen, 1942) and rare planktonic forms, notably Planoheterohelix (Georgescu & Huber, 2009), *Rugoglobigerina* (Brönnimann, 1952) have made it possible to affirm the Maastrichtchtian. The work of Koutsoukos & Hart (1990) indicates that this association of bolivinidae and buliminidae is typical of the Maastrichtian in the Sergipe basin (Brazil), (M'Bani, 2008) in the Congo Basin. As noted, the microfauna in our sediments is dominated by the Buliminidae (*Praebulimina fang*, *Parabolizing acuminifera*) and the Bolivinidae (*Afrobolivina afra*, *Anomalinoides*, *Orthokarstenia*…) and the observations obtained on the hierarchical tree confirm the abundance of these species in the treated samples. These results corroborate those of Goua (1997) which stipulate that these endofaunas (*Buliminidae* et *Bolivinidae*) large sizes abound in hostile habitats related to facies deposited under a layer of water with minimum oxygen, where they proliferate without any competition and also as an example in Congo (Massala, 1993) and in Senegal (Ly & Kuhnt, 1994). Moreover, this association above is also encountered in the surveys of Fresco,

Yao (2012) and even mentioned in Congo by M'Bani (2008), according to the work of (Goua, 1997) indicates a slice of oxygenated water and the indices of pelagics ranging from 20% to 60% indicate the presence of water and reoxygenation of the environment which corresponds to the average platform Vail et al. (1987). One can deduce that these associations suggest a medium platform deposition environment. The lithological data (kaolinite, sandy clay and limestone) mentioned in the work of Douzo et al. (2019) and Yao (2012) and stratigraphy were highlighted at the Maastricht-Chtian and allowed the determination of the environment of deposits starting from the internal to medium platform.

5. Conclusion

The characterization of the microfauna of the Maastricht-aged deposits of the EB-1 shaft in the onshore part of the basin allowed for an inventory of microfaunas (foraminifera, ostracods and other mollusc debris). It resulted in the establishment of lithology as well as its fossiliferous content and subsequently deduced its depositional environment.

From a lithological point of view, the analyzed drill cuttings deposits consist of 3 units dominated by the alternation of clay and fine to coarse sand between 195.5 m and 155.5 m and an alternation of sand and kaolinite between 132 m and 120.5 m.

At the biostratigraphic level, micropaleontological data revealed a microfauna rich in calcareous benthic foraminifers with a high abundance of *bolivinida*e and *buliminidae* which, despite the rarity of planktonic forms, served to confirm the Maastricht period. The hierarchical tree highlighted a similarity of abundant species in the basin. The environment of Maastrichtian-aged deposits is of the internal to medium platform type.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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