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Biostratigraphic Evidence of Early Cretaceous (Aptian – Albian) In Cote D'ivoire Sedimenatry Basin Based on Planktic Foraminiferal Data

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Abstract

Aptian – Albian planktonic foraminifera were studied from seven boreholes MK 1, MK 2, MK 3, MK 4, MK 5, MK 6 and MK 7 drilled in Cote d'Ivoire sedimentary basin. The latest Aptian was identified in holes by very small size planktonic assemblages represented by *Hedbergella maslakovae, Hedbergella similis Globigerinelloides duboisi* and *Globigerinelloides clavatus*. Albian planktonic assemblage was characterized by *Ticinella primula, Ticinella roberti, Ticinella*

raynaudi, Ticinella madecassiana, Biticinella breggiensis, Hedbergella rischi, Hedbergella gorbachikae, Hedbergella angolae, Costellagerina lybica, Praeglobotruncana delrioensis. The presence of latest Aptian planktonic assemblages suggest that marine conditions were already established during Late Aptian - Early Albian within Côte d'Ivoire sedimentary basin during this period.

Key Words: Aptian, Albian, Cote d'Ivoire, Planktonic, Foraminifera

Introduction

Cote d'Ivoire basin is the result of the opening of the South Atlantic during the Lower Cretaceous. The geological framework can be resumed in four steps (Digbehi, 1987, Chierici, 1996; Sombo, 2002):

a) The rifting phase (Barremian – Albian) with more than 5000 m of marginal – marine continental sands and clays accumulated during subsidence period, fracturing the basement in horsts and grabens.;

b) The initial ocean opening phase (Cenomanian to Senonian) marked by the beginning of a marine transgression and a rapid decrease in subsidence. Black shales and Oligostegenid limestone were deposited on the crest of the fault blocks, while a thick sequence of turbidites spread in half graben. During Lower Senonian the block crests were subject to subaerial or shallow marine erosion;

c) The maximum opening phase took place from Campanian to Maastrichtian. Transgressive Campanian marine shales covered the block crests and half grabens. The Lower Senonian unconformity partly separates transgressive Campanian from underlying Cenomanian series;

d) During the final opening phase (Tertiary), the Gulf of Guinea was completely open in North and South Atlantic because the equatorial fracture zones ceased acting on the topographic barrier during Lower Tertiary.

Most of recent studies on foraminiferal assemblages of Cote d'Ivoire basin are focused on Upper Cretaceous to Tertiary (KLASZ and KLASZ, 1992; GOUA, 1997; N'DA and al., 1995; KOUASSI and al., 2013). Very few publications on Lower Cretaceous from Cote d'Ivoire (SAINT MARC & N'DA, 1997; BAMBA and al., 2011) described Albian by planktonic suggesting that shallow marine incursions were developed in this period during the early rift stage of the proto South Atlantic. However, works of HOLBOURN & MOULLADE (1998) on Lower Cretaceous benthic foraminiferal assemblages realized on basal sedimentary sequences of Holes 959D, 962B, and 962D during the Ocean Drilling

Program (ODP) on the Côte d'Ivoire-Ghana Transform Margin; they revealed that marine conditions were already established by Late Aptian–Early Albian.

The main aim of this study is the comprehension of the onset marine sedimentation in Cote d'Ivoire basin by the analyses of Early Cretaceous sediments from seven wells drilled from eastern to western parts (Fig. 1).

Methodology

A total of two hundred fifty-nine cuttings samples from the basal lithologic units of holes MK 1, MK 2, MK 3, MK 4, MK 5, MK 6 and MK 7 were analyzed. Samples were carefully cleaned of drilling mud and then oven-dried. The dried residues were treated with a buffered 10 % hydrogen peroxide solution to help break them up before sieving. The samples were washed through 250, 100, and 63-µm mesh sieves under running water and then dried. The residues of each sieved fraction were spread on a picking tray and all microfossils were picked and deposited into a slide for analysis. The biostratigraphic interpretation resulting from the composition of the planktonic assemblages follows the zonal scheme of Caron (1985), which is partly based on the schemes proposed by Robaszynski et al (1979, 1995).

Results

Biostratigraphy

No benthic foraminifera were recorded within all samples analyzed.

Hole MK 1

- Interval 2600 m – 2615 m: Latest Albian

The last occurrences (LO) of index taxa Hedbergella gorbachikae, Hedbergella angolae, Globigerinelloides cf. texomaensis and Costellagerina libyca defined the top of this interval. This index assemblage was associated with Clavihedbergella subcretacea, Praeglobotruncana cf. stephani, Heterohelix moremani, Globigerinelloides bentonensis and Globigerinelloides caseyi (Fig. 2).

- Interval 2615 m – 3100 m: Aptian? – Lower Albian

Foraminifers are absent. Based on unpublished palynological data of Petroci, this interval devoid of Elaterosporites, may suggest an age no younger than Early Albian (Jardine & Magloire, 1965, Mahmoud and al., 2007).

Hole MK 2

Most of badly preserved foraminifers have presented calcite-filled and recrystallized tests.

- Interval 4460 m – 4520 m: Late Albian

The characteristic association is represented by Costellagerina libyca, Hedbergella gorbachikae, Biticinella breggiensis, Hedbergella trocoidea, Hedbergella planispira, Clavihedbergella subcretacea, Globigerinelloides bentonensis, Ticinella roberti, Ticinella primula and Ticinella madecassiana (Fig. 3).

- Interval 4520 m – 4556 m: Middle Albian

The planktonic microfauna is dominated by Hedbergella specimens. The rare Ticinellids species are represented by Ticinella primula and Ticinella roberti. Hedbergella gorbachikae is present in this interval.

Hole MK 3

- Interval 2128 m – 2137 m: Middle (upper part) to Late Albian

The preservation is mostly good and planktonic assemblages are abundant and moderately diversified. Ticinella primula and Globigerinelloides bentonensis are abundant. Also occurred in this interval, the species Globigerinelloides caseyi, Biticinella breggiensis, Costellagerina libyca, Hedbergella rischi, Hedbergella gorbachikae and Globigerinelloides texomaensis (Fig. 4).

- Interval 2137 m – 2192 m: Middle Albian

Samples analyzed yielded rare Ticinella specimens. The planktonic population is dominated by Hedbergella genera. The presence of Hedbergella gorbachikae, Hedbergella aff. trocoidea, Ticinella primula and Globigerinelloides bentonensis is indicative of Middle Albian age.

- Interval 2192 m – 2518 m: Lower to Middle Albian

No foraminifers have been recorded within this interval.

Hole MK 4

- Interval 2600 m – 2646 m: Latest Albian

The planktonic foraminifera are abundant, well preserved, but few diversified with medium size. They are dominated by Costellagerina libyca (Plate 1, figs. 4 – 6). Hedbergella gorbachikae, Hedbergella rischi (Plate 5, figs. 4 – 6), Hedbergella delrioensis (Plate 1, figs. 7 – 9), Clavihedbergella subcretacea, Globigerinelloides bentonensis (Plate 3, figs. 1 – 2) and Globigerinelloides caseyi (Plate 3, figs. 3 – 4) occurred in this interval (fig. 5).

- Interval 2646 m – 2765 m: Middle (upper part) to Late Albian

Planktonic species are abundant with mostly good preservation. This assemblage is characterized by a bloom of Ticinella species such as Ticinella primula (Plate 4, figs. 4 – 6), Ticinella roberti (Plate 4, figs. 10 – 12) and Ticinella raynaudi (Plate 4, figs. 7 – 9). Biticinella breggiensis (Plate 3, figs. 5 – 6), Ticinella madecassiana (Plate 4, figs. 1 – 3), Hedbergella rischi, Globigerinelloides bentonensis and Favusella washitensis

- Interval 2765 m – 3072 m: (Mid - Albian)

The rare microfauna is common. However, the presence of Hedbergella rischi, Ticinella primula, Ticinella roberti and Favusella washitensis suggests a Mid-Albian age.

Hole MK 5

- Interval 2137 m – 2390 m: Late Albian

The characteristic planktonic assemblage is represented by *Hedbergella gorbachikae*, *Clavihedbergella subcretacea*, *Ticinella primula*, *Ticinella raynaudi*, *Globigerinelloides bentonensis*, *Globigerinelloides caseyi*, *Ticinella madecassiana*, *Biticinella breggiensis*, *Praeglobotruncana delrioensis*, *Ticinella roberti*, *Heterohelix moremani* and *Guembelitria cenomana* (Fig. 6).

- Interval 2390 m – 2448 m: Mid-Albian

The samples analyzed contain poor microfauna. The sporadic presence of *Ticinella primula*, *Ticinella roberti* and *Hedbergella angolae* is indicative of Mid-Albian age.

Hole MK 6

- Interval 2542 m – 2591 m: Late Albian

The identified species include *Praeglobotruncana delrioensis*, *Hedbergella gorbachikae* (Plate 5, figs. 1 – 3), *Hedbergella rischi*, *Hedbergella infracretacea*, *Costellagerina libyca*, *Hedbergella angolae* (Plate 1, figs. 1 – 3), *Clavihedbergella simplicissima*, *Ticinella* cf. *madecassiana*, *Globigerinelloides bentonensis* and *Globigerinelloides caseyi* of Late Albian age (Fig. 7).

- Interval 2591 m – 2615 m: Mid-Albian (Upper part) to Late Albian

This interval contains well preserved and abundant planktonic foraminifera dominated by *Ticinella primula* and *Ticinella roberti*. Species *Biticinella breggiensis*, *Ticinella raynaudi*, *Ticinella madecassiana*, *Hedbergella rischi*, *Globigerinelloides blowi*, *Globigerinelloides bentonensis* and *Globigerinelloides gottisi* (Plate 2, figs. 4 – 5) have been recorded.

- Interval 2615 m – 2646 m: Mid-Albian

The common occurrences of *Ticinella primula* and *Ticinella roberti* associated with *Favusella washitensis* suggest a Mid-Albian age.

- Interval 2646 m – 2688 m: Lower to Mid-Albian (Lower part)

This interval is characterized by very small size and less diversified planktonic microfauna represented by genera *Hedbergella*, *Favusella*, *Globigerinelloides* and *Ticinella*. *Hedbergella planispira* and *Favusella washitensis* are abundant. The species *Ticinella primula* and *Hedbergella infracretacea* (Plate 5, figs. 7 – 9) are sporadic. This assemblage suggests Lower Albian to early part of Mid-Albian age.

- Interval 2688 m – 3764 m: Aptian?

The samples from the upper part of this interval (2688 m – 2908 m) displayed scarce to common assemblage of poorly preserved and very small size planktonic foraminifera. The presence of *Hedbergella maslakovae* (Plate 5, figs. 10 – 12) in the sample 2688 m and *Hedbergella similis*, *Hedbergella trocoidea*, *Hedbergella gorbachikae*, *Favusella washitensis*, *Hedbergella sigali*, *Globigerinelloides clavatus* (Plate 2, figs. 1 – 3), *Globigerinelloides duboisi* (Plate 2, figs. 6 – 7) and *Globigerinelloides aptiensis* (Plate 2, figs. 8 – 9) point to Latest Aptian?

The samples from the basal part (2908 m – 3764 m) are barren of foraminifera, indicative of an age no younger than Aptian.

Hole MK 7

Taxa identifications of microfauna was difficult due to their very small size and bad preservation. All morphotyps were picked in residues of ***63-µm mesh*** sieve.

- ***Interval 4002 m – 4056 m: Lower to Mid- (Lower part) Albian***

Species *Favusella washitensis* (Plate 1, figs. 10 – 11) and *Hedbergella planispira* are predominant while taxa belonging to *Ticinella* genera are absent in this interval. The characteristic planktonic association consists mainly of *Hedbergella planispira*, *Favusella washitensis*, *Favusella pessagnoi*, *Gubkinella graysonensis* (Plate 1, figs. 12 – 13) and *Globigerinelloides aptiensis* (Fig. 8).

- ***Interval 4056 m – 4132 m: Aptian?***

The samples analyzed in this interval displayed very rare and badly preserved foraminifera. So, the occurrences of *Favusella washitensis* and *Hedbergella* cf. *sigali* probably point to Latest Aptian?

Discussions

The planktonic assemblage analyzed is mostly known through Phanerozoic basins bordering Atlantic coast, particularly in the Cretaceous sediments of Morocco (Krashenikov, 1978, Leckie, 1984), Côte d'Ivoire (Digbehi et al., 1997; Saint-Marc & N'da, 1997; Bellier, 1998; Bamba et al. 2011), Gabon (DupponT, 1996), Angola (Caron, 1978, Kochhann et al., 2013), but also those of Brazil (Koutsoukos, 1992,

Koutsoukos & Bengtson, 1993) and Europe (Moullade, 1966, Breheret 1995, Reichelt 1995).

The small size of planktonic foraminifers in Latest Aptian-Lower Albian sediments, the low diversity of planktonic population dominated by *Hedbergella* in our study, were also reported in works of Breheret (1995) in vocontian basin of Paris, Koutsoukos (1992) in Brazil, CARON (1978) and KOCHHANN et al. (2013) in the Angolan basin. According to Leckie (1989) and Breheret (1995) this event should be probably linked to the Late Aptian - Early Albian Anoxic Oceanic Event 1b (OAE 1b). Breheret (1995) revealed a major breakthrough on Aptian-Albian boundary, during which the normal-sized *Ticinella* and *Hedbergella* disappear and where only tiny *Hedbergella* survive. This disappearance was also recorded on a global scale (Leckie, 1989). In the present work, sediments of the Upper Albian have revealed an absence of the keeled form *Rotalipora* which are well known worldwide in the Upper Albian deposits. Sediments have indeed delivered a microfaunistic assemblage only represented by globular morphotypes *Hedbergella gorbachikae*, *Hedbergella angolae*, *Hedbergella rischi*, *Costellagerina libyca*, *Globigerinelloides texomaensis*, *Globigerinelloides bentonensis*, *Globigerinelloides caseyi*, *Ticinella primula*, *Ticinella raynaudi*, *Ticinella madecassiana*, *Praeglobotruncana delrioensis* and *Clavihedbergella subcretacea*. According to other authors (Bellier, 1998; Premoli Silva & Boersma, 1977; Caron, 1978), this absence of *Rotalipora* may be related to a cool environmental condition prevailing during the Albian time in the southeastern Atlantic. However, in the present work, blooms of *Ticinella* and *Costellagerina* during Late Albian (holes MK – 3, MK – 4 and MK – 6) point to upwelling effects.

Conclusion

So, absence of benthic foraminifera could be explained by a restricted basin with probably anoxic bottom water conditions prevailing. Thus, according to our results, upwelling effects and a restricted basin with probably anoxic bottom water conditions could explain the absence of the rotaliporids.

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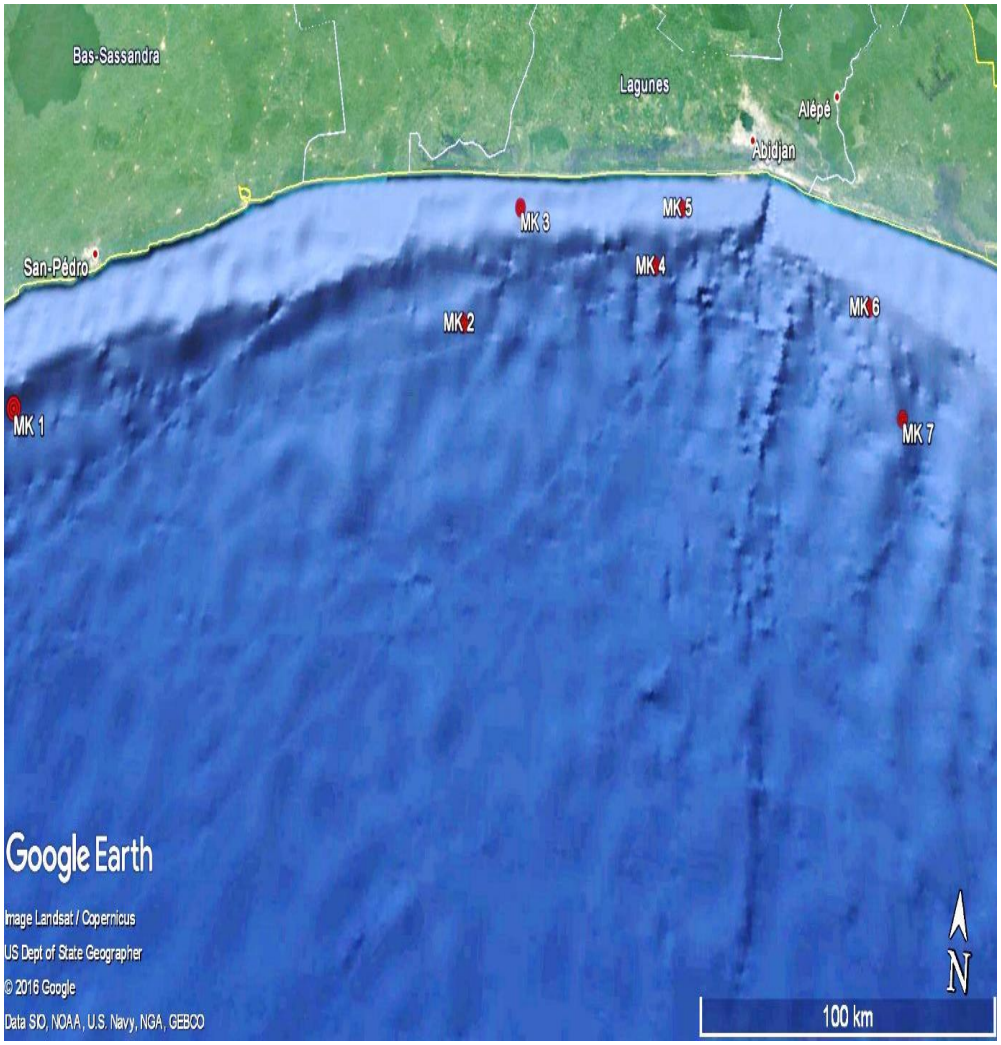
APPENDIX: List of Figures and Tables

Figure 1: Location of drilling Sites



ECHANTILLONS	ETAGES	*Hedbergella delrioensis*	*Hedbergella* spp.	*Hedbergella planispira*	*Hedbergella* cf. *simplex*	*Costellagerina lybica*	*Globigerinelloides bentonensis*	*Globigerinelloides* cf. *bentonensis*	*Globigerinelloides caseyi*	*Globigerinelloides* cf. *texamaens*	*Hedbergella angolae*	*Hedbergella gorbachikae*	*Hedbergella* cf. *subcretacea*	*Praeglobotruncana delrioensis*	*Praeglobotruncana* cf. *stephani*	*Heterohelix moremani*
2600 m		▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	
2605 m	LATEST													▮		
2610 m	ALBIAN	▮	▮	▮		▮					▮					▮
2615 m																
2620 m																
2630 m																
2640 m																
2650 m																
2660 m																
2670 m																
2680 m																
2690 m																
2700 m																
2710 m																
2720 m	APTIAN ?															
2730 m																
2740 m																
2750 m																
2760 m																
2770 m	TO															
2780 m																
2790 m																
2800 m	LOWER															
2810 m																
2820 m	ALBIAN															
2830 m																
2840 m																
2850 m																
2860 m																
2870 m																
2880 m																
2890 m																
2900 m																
2910 m																
2920 m																
2930 m																
2940 m																
2950 m																
2960 m																
2970 m																
2980 m																
2990 m																
3000 m																
3010 m																
3020 m																
3030 m																
3040 m																
3050 m																
3060 m																
3070 m																
3080 m																
3090 m																
3100 m																

Figure 3: Stratigraphic range of planktonic foraminifers, Hole MK 2

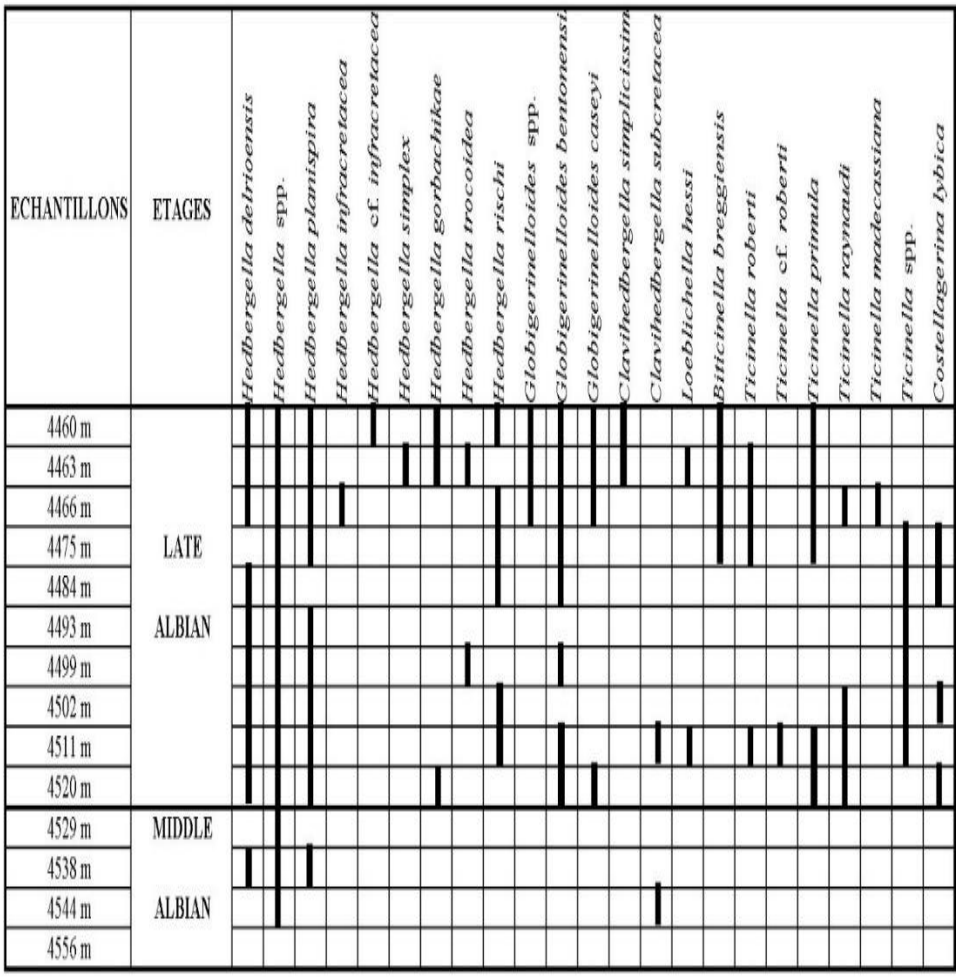


Figure 4: Stratigraphic range of planktonic foraminifers, Hole MK 3

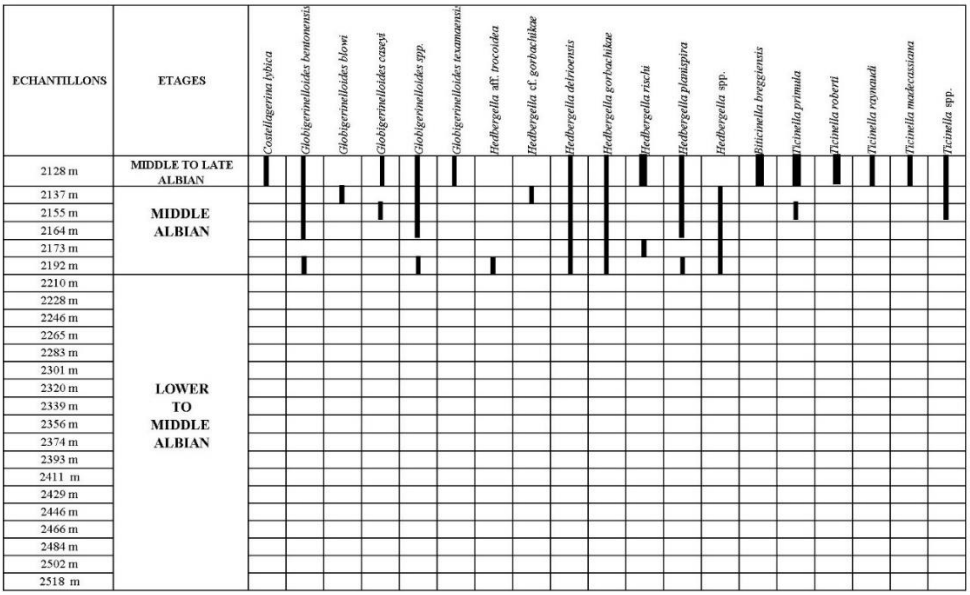


Figure 5: Stratigraphic range of planktonic foraminifers, Hole MK 4

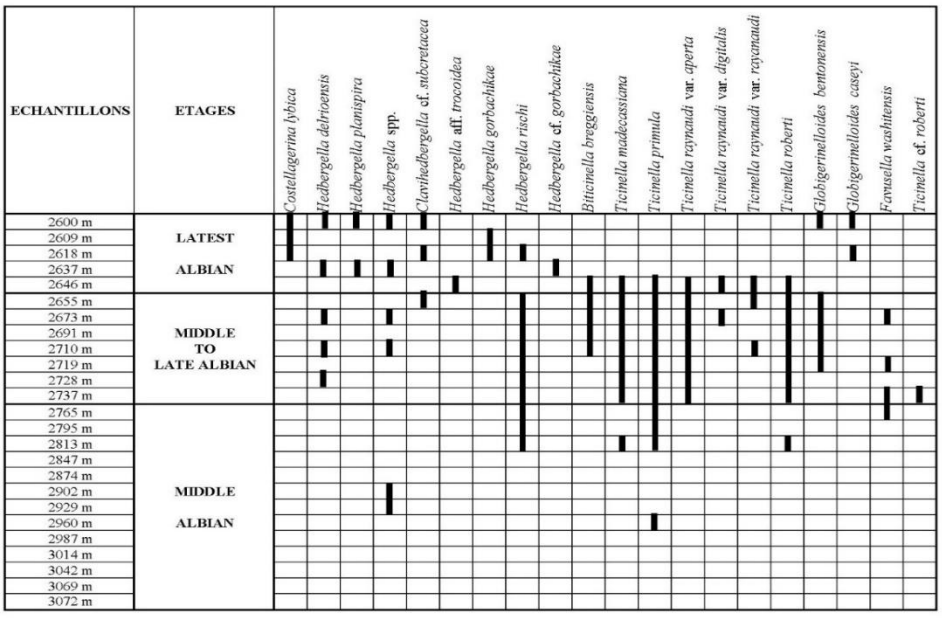


Figure 6: Stratigraphic range of planktonic foraminifers, Hole MK 5

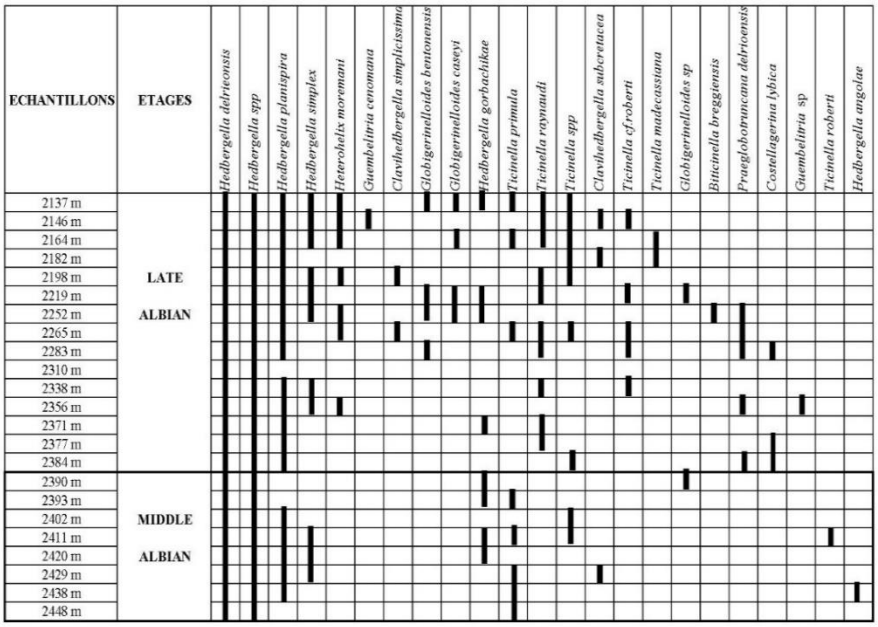


Figure 7: Stratigraphic range of planktonic foraminifers, Hole MK 6

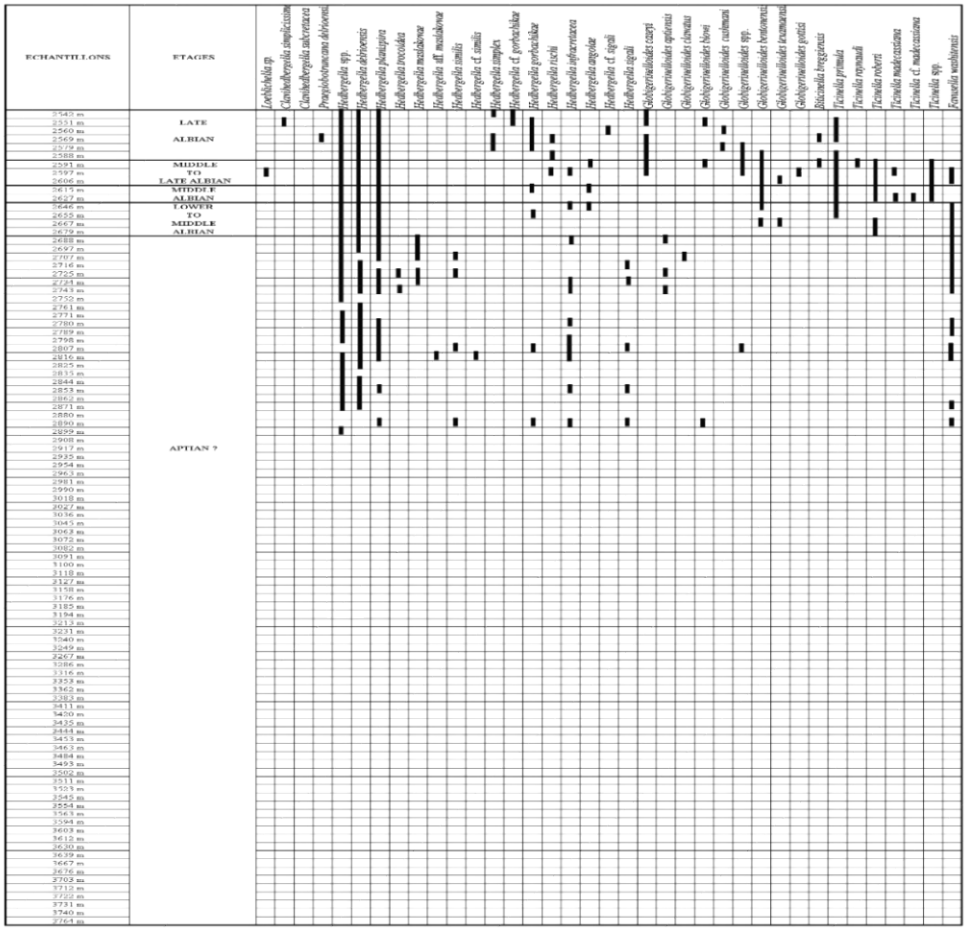


Figure 8: Stratigraphic range of planktonic foraminifers, Hole MK 7

ECHANTILLONS	ETAGES	*Favusella pessagnoi*	*Favusella washitensis*	*Globigerinelloides aptiensis*	*Gubkinella graysonensis*	*Hedbergella cf. sigali*	*Hedbergella planispira*	*Hedbergella spp.*
4002 m	LOWER TO MIDDLE ALBIAN							
4008 m								
4014 m								
4020 m								
4026 m								
4032 m								
4038 m								
4044 m								
4050 m								
4056 m	APTIAN ?							
4062 m								
4068 m								
4074 m								
4080 m								
4086 m								
4092 m								
4098 m								
4104 m								
4110 m								
4116 m								
4122 m								
4128 m								
4132 m								

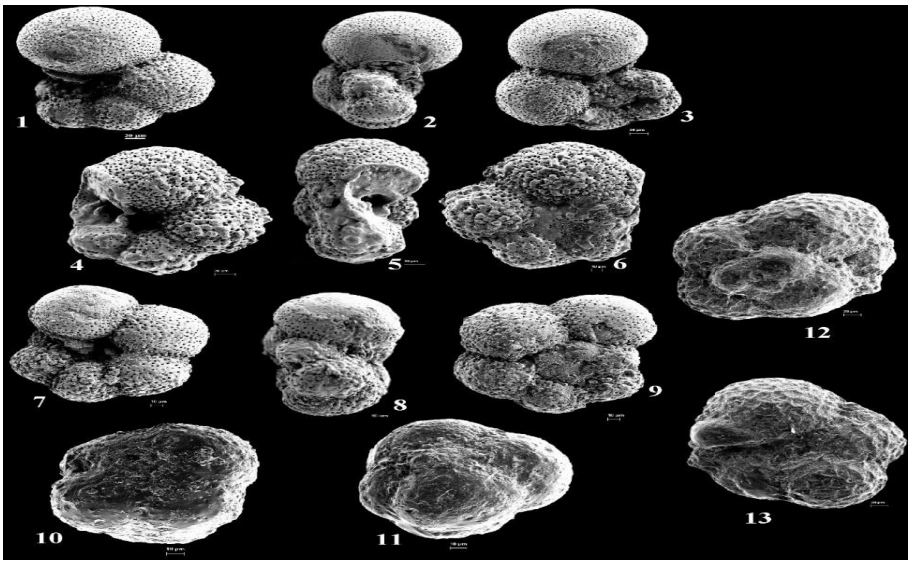


Plate 1: 1 – 3. *Hedbergella angolae* (CARON, 1978), Hole MK 6, Sample 2591 m, × 250.
4 – 6 *Costellagerina libyca* (BARR, 1972), Hole MK 4, Sample 2618 m, × 200.
7 – 9. *Hedbergella delrioensis* (CARSEY, 1926), Hole MK 4, Sample 2637 m, × 250.
10 – 11. *Gubkinella graysonensis* (TAPPAN, 1940), Hole MK 7, Sample 4002 m, × 400.

12 – 13. *Favusella washitensis* (CARSEY, 1926), Hole MK 7, Sample 4002 m, × 250.

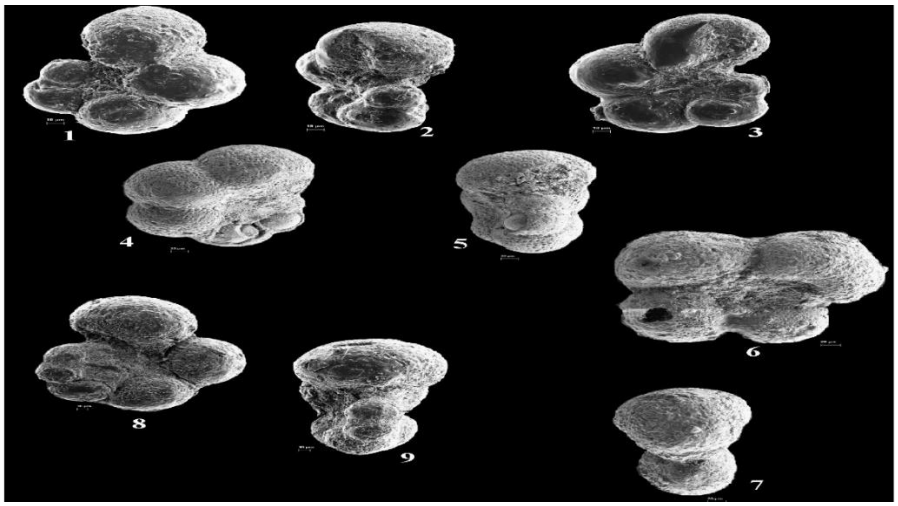


Plate 2: 1 – 3. *Globigerinelloides clavatus* (VERGA et PREMOLI SILVA, 2005), Hole MK 6, Sample 2697 m, × 400.
4 – 5 *Globigerinelloides gottisi* (CHEVALER, 1961), MK 6, Sample 2597 m, × 350.
6 – 7. *Globigerinelloides duboisi* (CHEVALER, 1961), Hole MK 6, Sample 2707 m, × 400.
8 – 9. *Globigerinelloides aptiensis* (LONGORIA, 1974), Hole MK 6, Sample 2688 m, × 400.

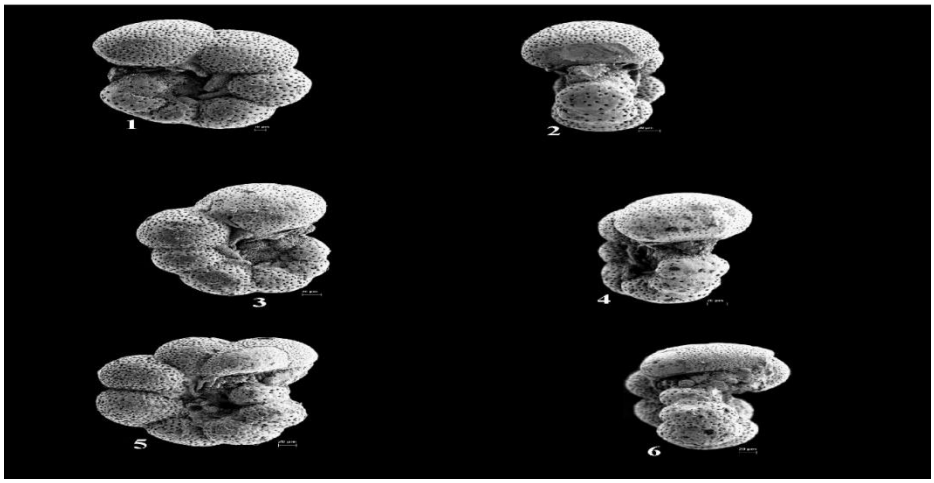


Plate 3: **1 – 2**. *Globigerinelloides bentonensis* (MORROW, 1934), Hole MK 4, Sample 2600 m, × 200.
3 – 4 *Globigerinelloides caseyi* (BOLLI, LOEBLICH and TAPPAN, 1957), MK 4, Sample 2600 m, × 200.
5 – 6. *Biticinella breggiensis* (GANDOLFI, 1942), Hole MK 4, Sample 2646 m, × 200.

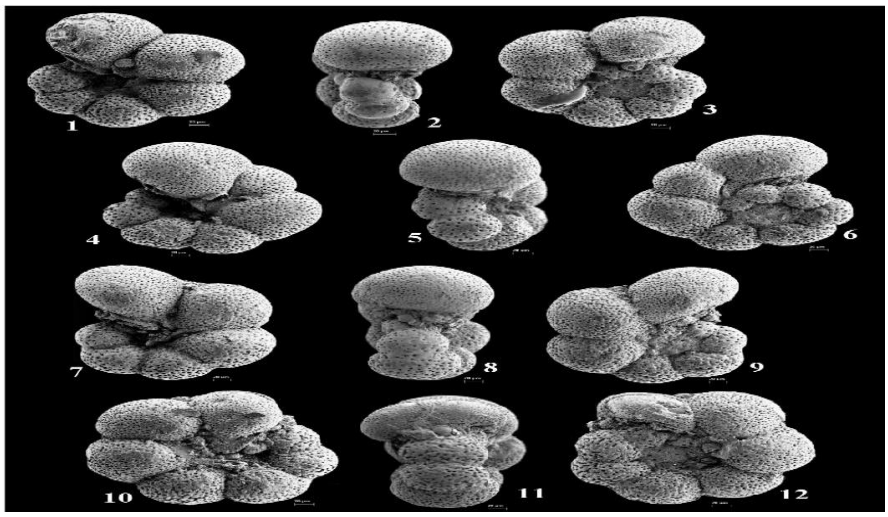


Plate 4: **1 – 3**. *Ticinella madecassiana* (SIGAL, 1966), Hole MK 4, Sample 2710 m, × 200.
4 – 6 *Ticinella primula* (LUTERBACHER, 1963), Hole MK 4, Sample 2710 m, × 200.
7 – 9. *Ticinella raynaudi* (SIGAL, 1966), Hole MK 4, Sample 2646 m, × 200.
10 – 13. *Ticinella roberti* (GANDOLFI, 1942), Hole MK 4, Sample 2646 m, × 200.

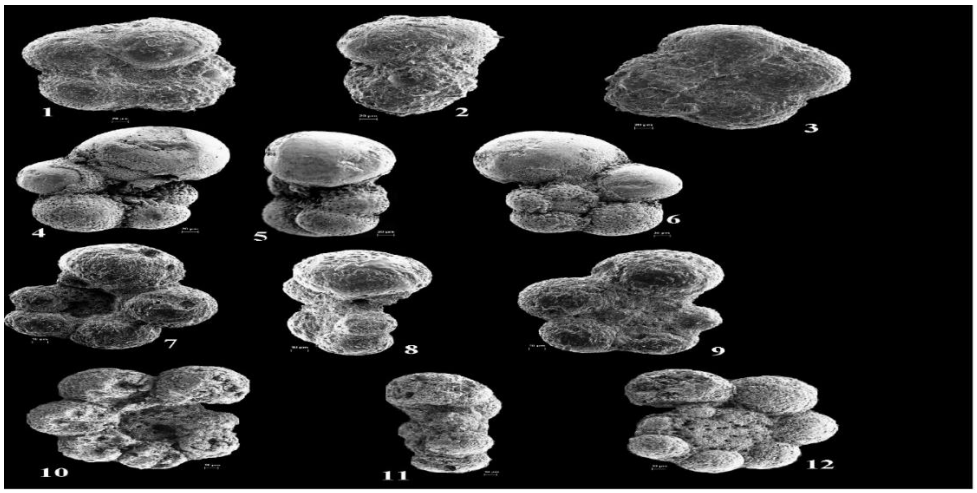


Plate 5: **1 – 3**. *Hedbergella gorbachikae* (LONGORIA, 1974), Hole MK 6, Sample 2542 m, × 200.
4 – 6 *Hedbergella rischi* (MOULLADE, 1974), Hole MK 4, Sample 2618 m, × 300.
7 – 9. *Hedbergella infracretacea* (GLAESSNER, 1937), Hole MK 6, Sample 2688 m, × 400.
10 – 13. *Hedbergella maslakovae* (LONGORIA, 1974), Hole MK 6, Sample 2688 m, × 400.