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Foraminiferal Biostartigraphy and Paleocology in the Late Palocene-Eocene Sequence of the Oshosun Formation Exposed Around Sagamu, Southwestern Nigeria.

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Abstract

Planktonic foraminiferal biostratigraphical and paleoecological studies were carried out on the Paleocene-Eocene successions exposed at the Sagamu quarry of the West African Portland Cement Company (WAPCO) southwestern Nigeria. The exposed section from the base to the top includes the Ewekoro Formation (Paleocene) which is essentially limestones and the Oshosun Formation (Late Paleocene – Early Eocene) mainly of shales. Biostratigraphy and paleoecology of foraminifera species was carried out. Twenty species of planktic and sixteen species of benthic forms were identified from the Oshosun shale interval of the section. In general, benthic species of infaunal and epifaunal habitat dominate the population. Based on the abundance and stratigraphical distribution of the planktonic foraminiferal species, two planktonic foraminiferal biostratigraphic zones were recognized, within the Oshosun Formation: a *Globanomalina pseudomenardii* Zone of Late Paleocene and *Morosovella subbotinae* Zone of Early Eocene age. Benthonic foraminifers are generally shallow marine (mostly muddy bottom dwellers). The estimated paleo-depth ranges between 50m and 150m. The environment of deposition was relatively stable during the Late Paleocene – Early Eocene times.

Keywords: Foraminifera, Biostratigraphy, Paleoecology, Oshosun, Planktonic, Ewekoro

1. Introduction

Previous works on the eastern Dahomey basin, southwestern Nigeria have focused on the lithostratigraphy and tectonic framework of the basin and recently on its hydrocarbon potential. Adegoke (1969, 1972, 1977); Adegoke *et al.* (1970); Petters and Olsson (1979); Adegoke *et al.* (1980); Petters (1982); Nwachukwu *et al.* (1992) and Adekeye (2005) discussed general occurrence and taxonomy of the foraminiferal species in the basin. The present study was carried out at the Sagamu quarry of the West African Portland Cement Company (WAPCO) southwestern Nigeria (Fig. 1). The study is based primarily on the exposed sedimentary sections in the quarry with emphasis on the Oshosun Formation (shales).

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The aim and objective of this research is to measure, sample, describe the exposed sediments in the quarry benches and investigate their lithological characteristics and discuss foraminiferal biostratigraphy and paleoecology. The present work defines the biostratigraphy and paleoecology of foraminiferal for the first time in the study area. The sections were compiled to yield one composite section representing the time interval spanning the Paleocene-Eocene. The detailed description of the lithofacies exposed at the Sagamu quarry (Fig. 2) have been published by Okosun (1990), Adekeye (2005), Adekeye *et al.* (2007) and Gebhardt *et al.* (2010).

2. Materials and Methods

This study was carried out at the Sagamu quarry of WAPCO during a field session that lasted for one week. During this period, sedimentary rocks were studied, logged and several rock samples including limestones, sandstones and shales were collected for different laboratory examinations and investigations. Seventeen shale samples were collected from the Oshosun Formation at the quarry. About 100g of each sample was gently crushed and soaked in water with a solution of 10-20% hydrogen peroxide to accelerate the process of disintegration. The samples were then washed several times through a set of sieves ranging between 63 and 126µm, using a gently running current of water.

The washed sediment residues were dried in an oven at 60^{o}C. The planktonic and benthonic foraminifera were then picked out of the sediment residues and were identified and classified using a binocular microscope (GRIFFIN model) and relevant literatures in the paleontology laboratories of the Department of Geology and Mineral Sciences, University of Ilorin and Technical University Berlin, Germany. The photographs of the identified species were produced at the "Zentraleinrichtung Elektonenmikroscopie" (ZELMI), Technical University Berlin, Germany.

3. Results and Discussion

3.1 Planktonic Foraminiferal Biostratigraphy

Several authors have proposed planktonic foraminiferal biostratigraphic zonations from the Cretaceous-Paleogene for example Bolli (1957); Fayose (1970); Luterbacher and Premoli Silva (1964); Nwachukwu *et al.* (1992), Pardo *et al.* (1996); Berggren and Norris (1997); Arenillas *et al.* (2000); Imam (2001) and Adekeye (2005). The planktonic foraminiferal content of seventeen samples covering the stratigraphic interval of the Late Paleocene-Early Eocene, were examined from the studied sections (Table 1). The sections were sampled bed by bed to ensure good zonal boundaries. Twenty cosmopolitan planktonic foraminiferal species were identified from the Oshosun Formation (Fig. 3) and two zones were recognized.

The schemes used for zonation are those proposed by Bolli (1966); Stainforth *et al.* (1975) and the more recent work of Berggren and Norris (1997). Distributions of these planktonic foraminifers were plotted according to their range zones (Fig. 4). The different diagnostic species were photographed using scanning electron microscope (SEM). The recorded planktonic foraminiferal zones are described from base to top (of the Oshosun Formation interval) as presented below.

Globanomalina pseudomenardii zone

The *Globanomalina pseudomenardii* zone of Bolli (1957) named as Planorotalites pseudomenardii Zone has been defined by the total range of *Globanomalina pseudomenardii* (Bolli). The lower boundary was not defined in the Oshosun Formation but in the underlying Ewekoro Formation (Petter and Olsson, 1979). The upper boundary was defined on the basis of the first occurrence of *Morozovella subbotinae*. This zone comprises the lower part of the Oshosun Formation, from sample SH16-SH26 and is 8m thick (Fig.4). It was assigned a Late Paleocene (Thanetian) age. This zone is characterized by the presence of the following planktonic foraminifera: *Igorina albeari, Acarinnina soldadoensis, A. nitida, A. coalingensis, Morozovella apanthesma, M. acutispira and M. aequa*. There is absence of *Morozovella velascoensis*. This zone could be correlated with the *Globanomalina pseudomenardii* zone (P4) of Berggren *et al.* (1995), Salis *et al.* (1998), Aref and Yousef (2000) and Imam (2001).

Morozovella subbotinae zone

This zone was defined by the total stratigraphical range of the zonal marker, *Morozovella subbotinae* (Bolli). It conformably overlies the *Globanomalina pseudomenardii* zone. The zone represents the youngest planktonic foraminiferal zone recorded in the studied section. It has been recorded in the Oshosun Formation from sample SH28-SH29 (about 10m thick), Fig. 4, and has been assigned Early Eocene (Ypresian) age. The most diagonistic planktonic foraminifers recorded in this zone were: *Morozovella subbotinae, M. aequa, M. apanthesma, Acarinina soldadoensis* (Bronnimann), *A. nitida* (Martin) *and A. coalingensis*. This zone could be correlated with the *Morozovella formosa formosa* zone (P5) of Berggren and Norris (1997) as well as the *Globorotalia iostra/M. lensiformis* zone of Blow (1979).

3.2 Foraminiferal Paleoecology

Many benthonic species of foraminifers (agglutinated and calcareous) were recovered from the Oshosun shale interval of the section (Table 2). Sixteen species of benthics were identified (Fig. 5). In general, the benthic species of infaunal and epifaunal dominate the populations. Paleoecologic interpretation of past environments with regards to paleobathymetry, paleosalinity or paleo-oxygenation can be made on the basis of comparisons with distribution patterns of recent faunas and morphogroups (Bernhard, 1986; Murray, 1991; Gebhardt *et al.*, 2010) or by general comparison with paleoenvironments as far back as the Cretaceous (Sliter and Baker, 1972; Murray, 1991; Gebhardt *et al.*, 2004). Such interpretations must be based on comparisons with modern environments and their faunas, although some taxa may have changed their environmental preferences through time. Fig. 6 shows the benthic foraminiferal paleoecological interpretation for this work.

Deeply infaunal detritivore, low oxygen tolerant, *Bulimina* (tapered morphogroup; Bernhard, 1986) show the high proportion during the lower Paleocence. This genus dwells in muds to fine sands of shallow marine shelf to bathyal depths. It indicates mostly phytodetritus flux and oxic or mildly dysaerobic bottom waters. The infaunal, oxygen depletion tolerant *Nonionella* (flattened planispiral morphogroup; Bernhard 1986) is rare in the lower part of the section but becomes more frequent in the upper part together with marked increase in *Bulimina* and productivity related *Gavelinella*. The latter genus is also rather rare in the lower part of the section but becomes dominant over the late Paleocene/Eocene boundary. Small *Gavelinellas* followed an opportunistic life strategy and exploited increased food availability during the Paleocene/Eocene (Speijer *et al.*, 1996).

Gavelinella is an epifaunal genus, dysoxic environment dweller. It is an active deposit feeder that tolerates low oxygen level (Koutsoukos *et al.*, 1990). Occurrence with Lenticulina is an indicative of high phytodetritus influx and severely dysaerobic bottom water. It is regarded as a typical assemblage of high productivity zone. *Textularia* is a species that inhabit normal marine environments ranging from lagoon to bathyal. They live epifaunally on hard substrates, muddy silts and sands (Murray, 1991a). Some Cenomanian to Turonian textulariids seem to resist reduced salinities (Koutsoukos *et al.*, 1990). It indicates normal (low) phytoplankton flux and possibly oxygen deficient bottom waters (Adekeye, 2003). *Lenticulina* is epifauna, oxic genera (planoconvex or lenticular morphogroup, Bernhard, 1986). The frequent occurrences indicate oxic bottom water condition. High oxygen levels in the bottom water were interpreted for the intervals where they occurred.

Haplophragmoides is a probable infaunal detritivore that is commonly found in muddy to sandy substrates in environments ranging from marsh to bathyal. It is primarily a marine genus but has also been reported from hypersaline lagoons and estuaries (Murray, 1991b; Brönnimann *et al.*, 1992, Adekeye, 2003). *Ammobaculites* is an infaunal deposit feeder that lives in muddy sediments with brackish to normal marine salinities (marsh to bathyal environments). It also tolerates low oxygen levels. This genus is present in all niches of modern seas (Culver and Buzas, 1981; Koutsoukos *et al.*, 1990; Murray, 1991a, Adekeye, 2003).

In general, paleoenvironments for the Oshosun Formation deduced from the benthic foraminifera assemblage indicated a generally shallow marine with an estimated paleowater-depth ranging between 50m and 150m (Fig. 7). There was dominance of productivity indicators (*Gavelinella*) and increased foraminiferal abundance just before the P/E boundary.

4. Conclusion

Many planktonic and benthonic species of foraminifera (agglutinated and calcareous) were recovered from the Oshosun shale interval of the section under study. Twenty species of planktics and sixteen species of benthics were identified. In general, benthic species of infauna and epifauna dominate the population. Based on the abundance and stratigraphical distribution of the planktonic foraminiferal species, two planktonic foraminiferal zones were recognized, from the base to the top of the Oshosun Formation: *Globanomalina pseudomenardii* of Late Paleocene and *Morosovella subbotinae* zone of Early Eocene. Benthic foraminiferal paleoecology deduced from the assemblage indicated generally shallow marine (mostly muddy bottom) paleoenvironments with an estimated paleowater-depth ranging between 50m and 150m. The litho- and biostratigraphical results show that the presence of *Morozovella aequa* and *Morozovella subbotinae* indicate stability of the study area during Late Paleocene – Early Eocene times.

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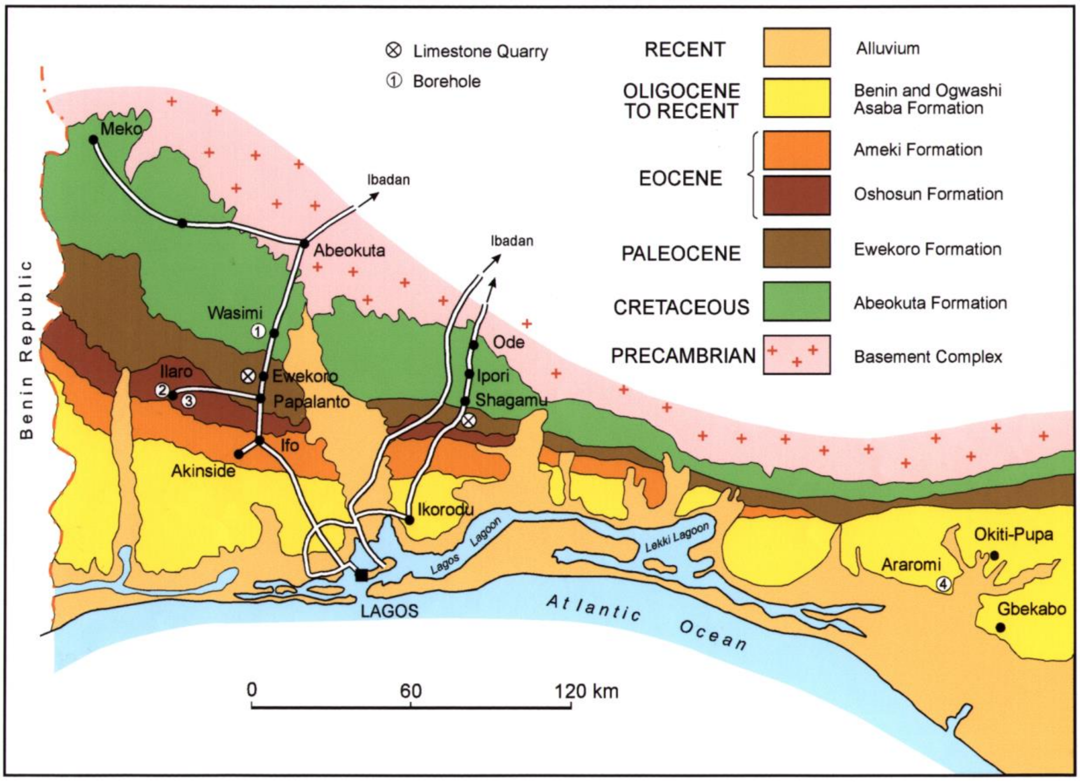

Fig. 1: Geological map of the Dahomey embayment (Nigerian part) and location of Sagamu

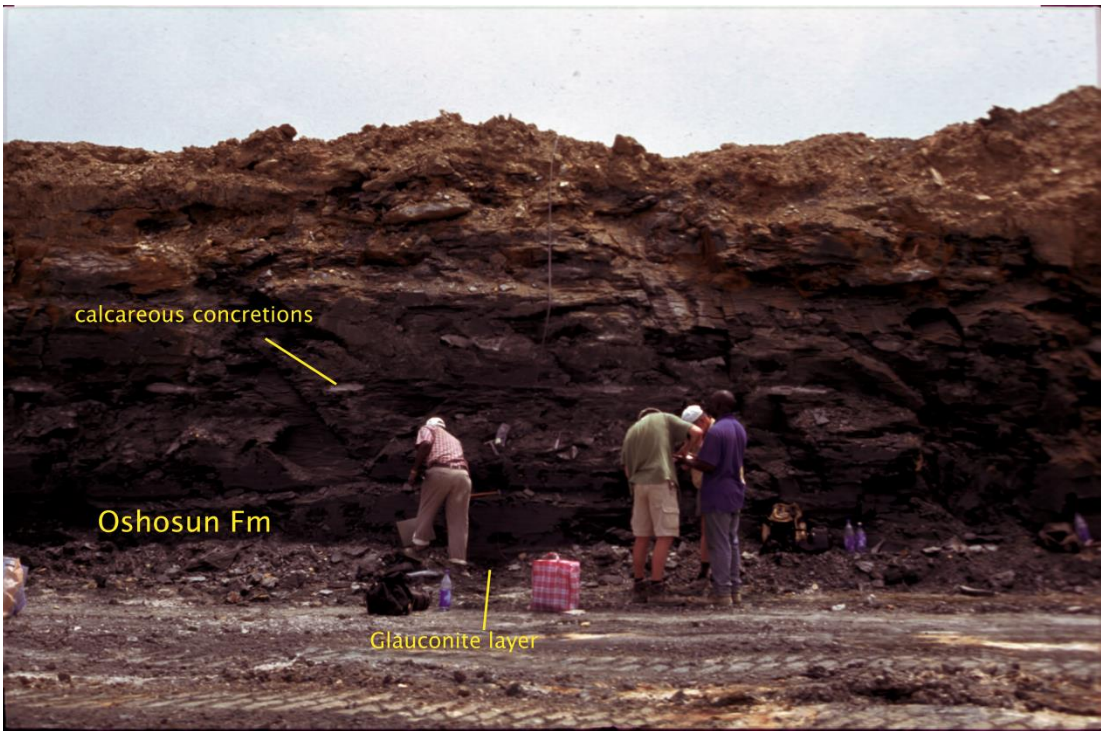

Fig. 2: Field photograph showing the lower part of the Oshosun Formation in the Sagamu limestone quarry.

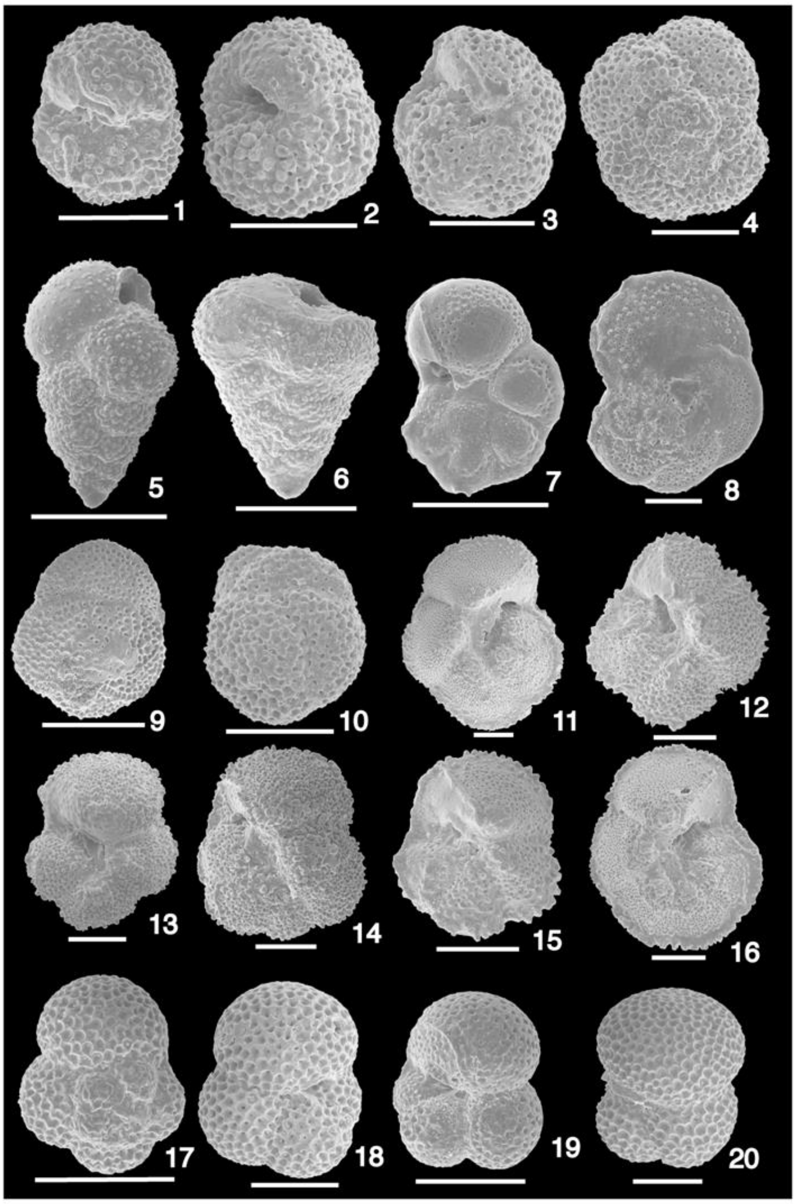

Fig. 3: Planktonic foraminifera species recovered from the selected samples

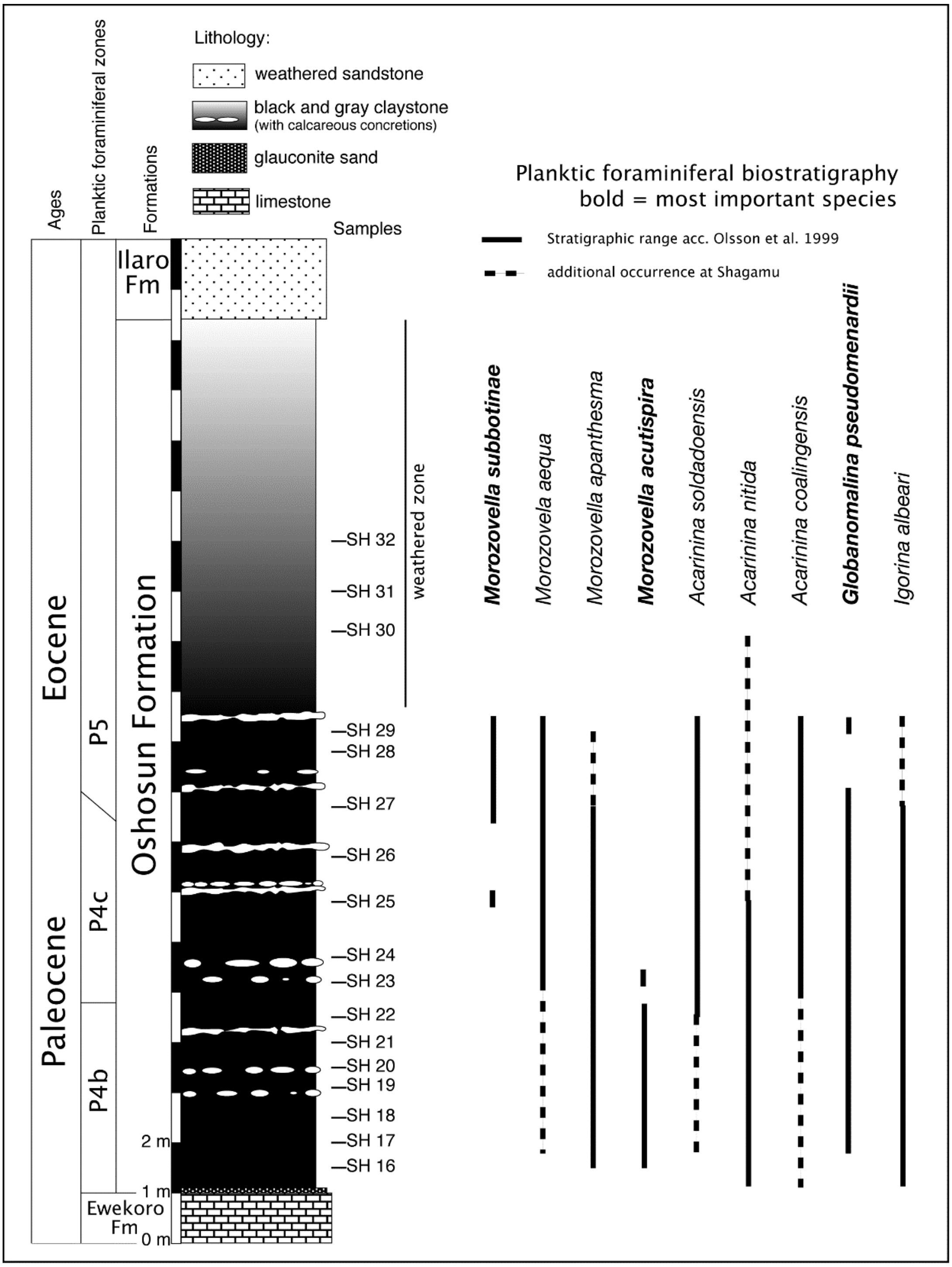

Fig. 4: Planktonic foraminiferal biostratigraphic zonation of the Oshosun Formation exposed at WAPCO Quarry

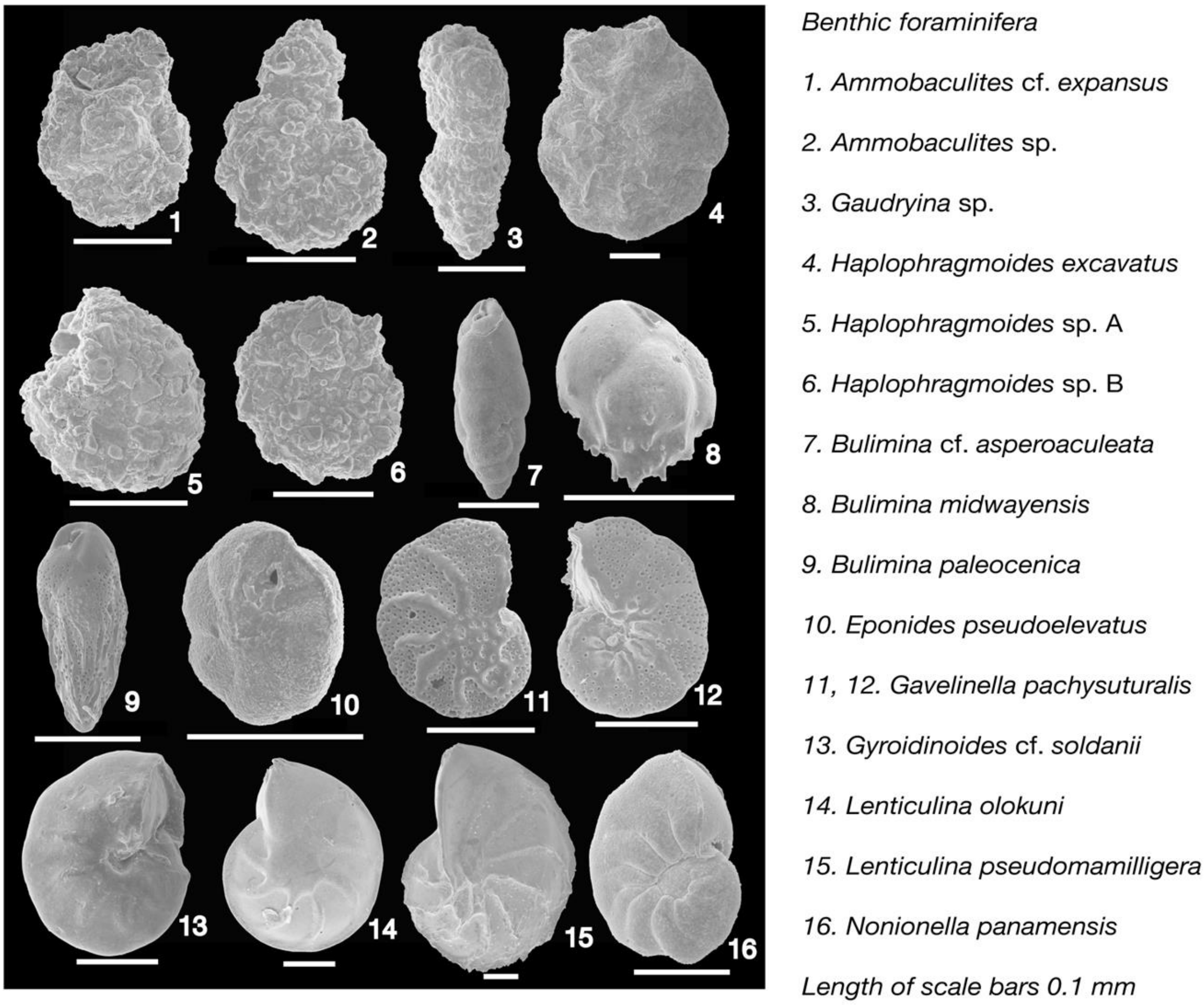

Fig. 5: Benthonic foraminiferal species recovered from the selected samples

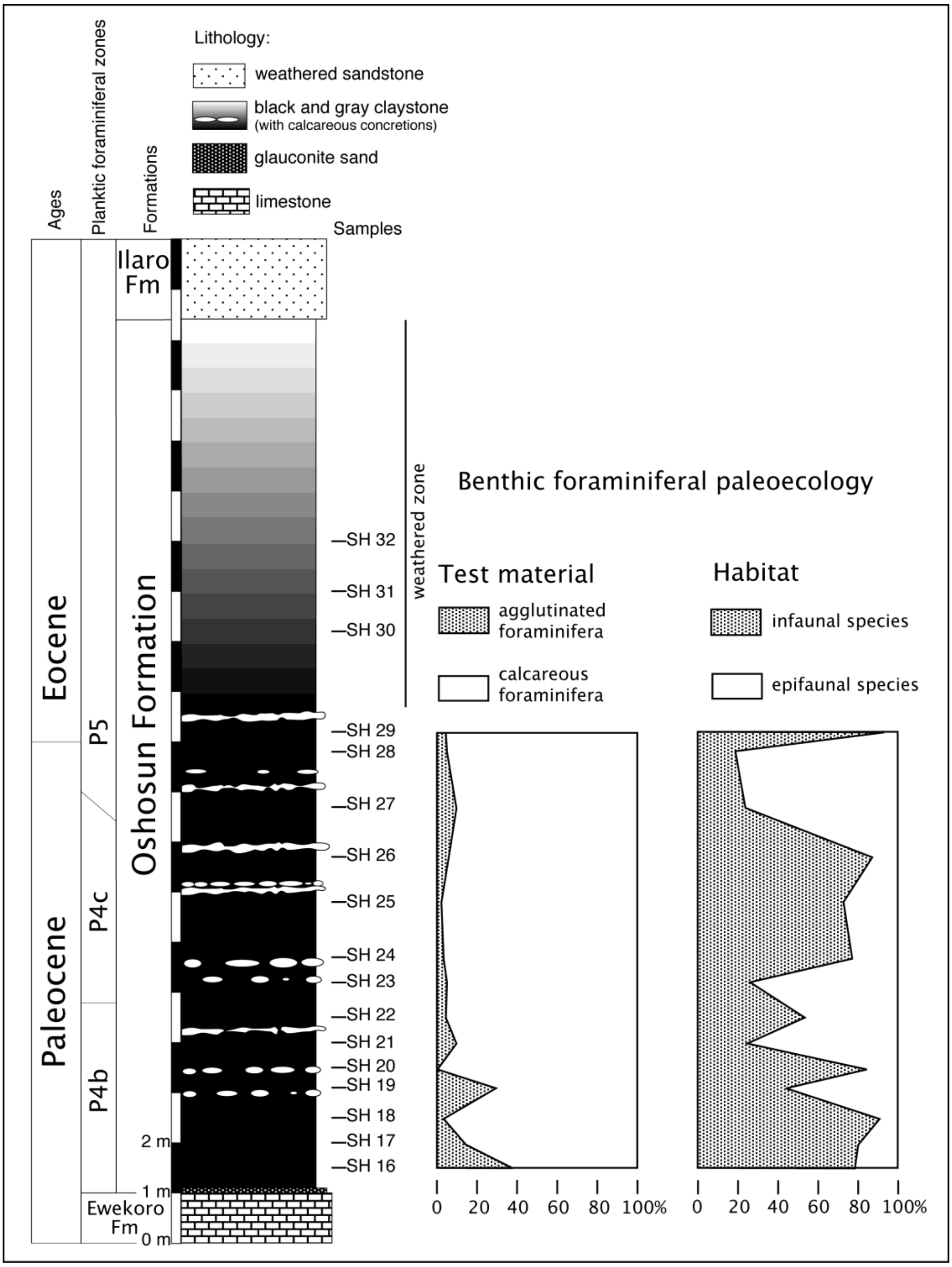

Fig. 6: Stratigraphical interpretation of the benthonic foraminiferal species.

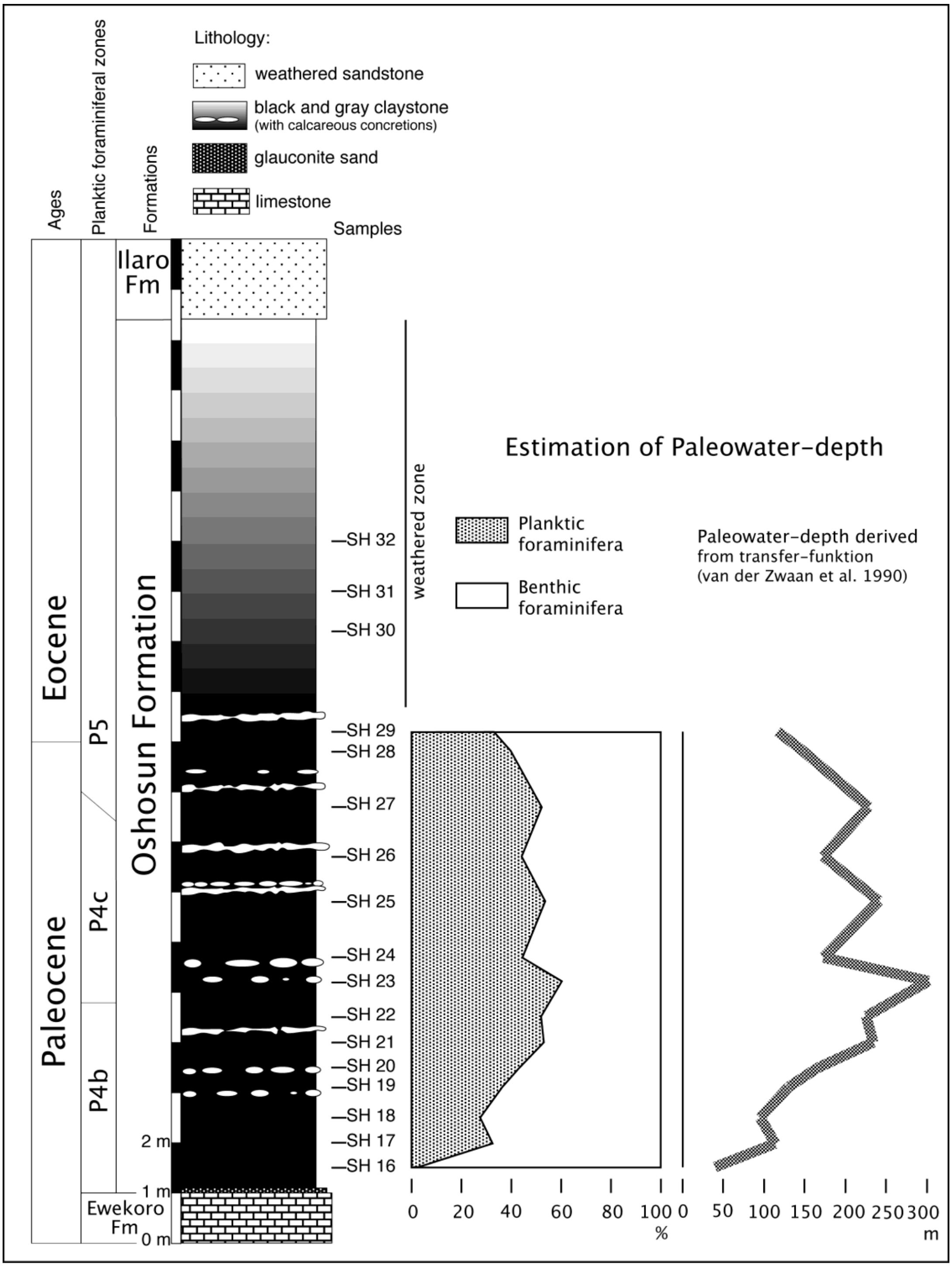

Fig. 7: Stratigraphical occurrence of the infauna and epifauna benthonic foraminiferal species showing the estimation of paleowater depth.

Table 1: Distribution of planktonic foraminifera

Samples	Acarinina cf. coalingensis	**Acarinina cf. mckannai**	Acarinina nitida	Acarinina soldadoensis	Chiloguembelina ctinita	Chiloguembelina midwayensis	Globanomalina chapmani	Globanomalina pseudomenardii	Igorina albeari	Igorina tadjikistanensis	Morozovella acuta	Morozovella acutispira	Morozovella aequa	Morozovella apanthesma	Morozovella subbotinae	Morozovella velascoensis	Parasubbotina varianta	Subbotinae cancellata	Subbotina triangularis	Subbotina velascoensis
32													1							
32													1							
30			1		1															
29				22	3		15		83	31	39		27	38	16				13	
28			8	12	4	3	19	2	75	35	43		135	3	20		16		27	3
27									2				6	3					1	
26			16	16	5	5	9	9	68	32	18		85	12			5		28	5
25			81	3	21		15	21	109	45	23		180	21			21		29	7
24			7	9	1	4	26	10	34	9	8		113	16			20		12	11
23			33	8	1	4	27	11	99	38	36	6	129	30			13		5	7
22	2		82	9	4	3	14	11	52	35	22	3	74	6			18		26	5
21	3		102	12	1		14	4	100	13	35	11	82	9		3	2		14	5
20	10		94	11	9	17	37	7	146	82	20	12	56	3			63		25	2
19	9		40	7			9		55	10	51	24	105	12		4			5	2
18	6		20	7	8		27	16	75	6	19	26	66	5			11		17	
17		22					6	7	94	34	19	40	55	3				2	9	
16	1		18				1		5	5										

Table 2: Distribution of benthonic foraminifera

Samples	Ammobaculities cf. expansus	Ammobaculite sp.	Bulimina midwayensis	Bulimina paleocenica	Bulimina thanetensis	Cibicidoides succedens	?Cibicidoides sp.	?Dentalina sp	Epistominella minuta	Eponides pseudoelevatus	?Eponides sp.	Gaudryina sp.	Gavelinella pachysuturalis	Gyroidinoides cf. soldanii	Haplophragmoides excavatus	Haplophragmoides glabra	Haplophragmoides sp. A	Haplophragmoides sp. B	Lenticulina olokuni
32										3					31		176		
32				2	1										36		9		
30					2					1					60		115		1
29				148	46								30		9		14		3
28				31	5				1				390		22		10		31
27				7									2		7				2
26				206	24					5	2		4		16		5		27
25				197	26					2			52	2	7		4		53
24			1	107	53					6	5		29		8		2		32
23				16	13					2			10	2	17		6		153
22				88	36								11		12		3		118
21				12	15	4				1	1		5	9	28		3		191
20			2	439	57		1			4	2		16	27	2		2		38
19			1	7	2	1								44	121				230
18			7	495	86	5		1		2	5		6	21	22				18
17		7	20	210	43	3					1	7		36	27		6	5	41
16	70	32	56	91	34	27		1	2	1	1	362	8	64	103	9	9	24	54

Table 2: Distribution of benthonic foraminifera (cont'd)

Samples	Lenticulina pseudomamilligenus	Lenticulina sp.	Nonionina panamensis	Osangularia plummerae	?Recurvoides sp.	Saccammina sp.	Siphogenrinoides eleganta	Stilostomella cf. midwayensis	Stilostomella cf. pulmmerae	Tappanina selmensis	Textularia cf. midwayana	Trochammina globigeriniformis
32			1									
32												
30												2
29	1		203									1
28	1		28									
27			2									
26	2		40									
25	1		57	1								
24			53			3						
23	3		4									
22	3		4	2								
21	6											
20	5		7	1								
19	9				2							
18	2		1		1				1		1	
17		1	1	3	4		1	1				
16	2			12	8				2	1		