they represent primary magmatic water related to cooling history of the granite or resulted from late-stage interaction between the solid rock and deep circulating meteoric water. On the basis of the random orientation of these inclusions and their temperature of homogenization and high salinity, we suggest that they are remnants of magmatic fluids. Inclusions with low salinity associated with quartz veins represent a more evolved stage of fluid entrapment.

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Fluctuating sea levels off Bombay (India) between 14,500 and 10,000 years before present

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A 26.5-metre-long core collected from the outer-shelf area off Bombay at 75 m water depth showed ooids and shallow-water benthic foraminifera all along the core. The presence of these well-known indicators of shallow-water environment of deposition shows that sea level had transgressed considerably prior to 10,000 years before present (^{14}C age of the surface sediment). By comparison with global events, we infer that the sea level was at 101.5 m below the present level at about 14,500 years BP. We further observe that this rise occurred with two minor pauses (or minor reversals) at 13,000 and 11,500 years BP.

GLOBAL variations of sea level are viewed in the light of their behaviour in the recent past and possible consequences of a future rise that may be accelerated by the greenhouse effect. There are evidences of sea level changes in the past few thousand years not only globally but also along the west coast of India. It is important to analyse the changes that took place over this region after the last glacial maximum[1] to understand the present and to anticipate the future.

It is known that sea level between 22,000 and 15,000 years before present (BP) was characterized by relatively stable conditions[1]. A number of studies[2–5] have been made on sea level at 10,000 years BP and the variations thereafter along the western continental shelf of India. However, the period before 10,000 years BP has not received adequate attention. Our objective in this study is to fill this gap.

We studied down-core variations of depth indicators like ooids and foraminifera in a bore-hole sample collected from the outer-shelf area off Bombay (19° 02′ 10.44″ N, 71° 30′ 36.36″ E) in the northern Arabian Sea (Figure 1). Depth of water at the bore-hole site is 75 m and the length of the core was 26.5 m.

The bore-hole sample was subsampled at one-metre intervals from 2 to 26.5 m. Approximately 200 g of subsamples from each level was brought to the laboratory and dried at 60°C. These samples were washed through a 230-mesh sieve (63 μm). The +63 μm fraction showed presence of ooids and shallow-water benthic foraminifera. Study of ooids in a core is important because they are indicators of low stands of sea level. They have earlier been reported from the surficial sediments of the western continental margin of India and their spatial distribution is well known[6–8]. The radiocarbon age has been reported to be between 9,000 and 11,000 years BP[8].

It was also recently observed that the zone on the shelf between 60 and 90 m, which has abundant ooids, also contains foraminiferal species like *Amphistegina*, *Operculina*, etc. These relict foraminiferal tests also showed the presence of the fouling barnacle species *Tetraclita squamosa*[11], which indicates prevalence of a high-salinity intertidal environment of deposition. This species is absent in the modern environment of the west coast of India, and therefore provides further conclusive evidence that the surficial sediment in the 60-to-90-m zone was deposited under shallow-water conditions.

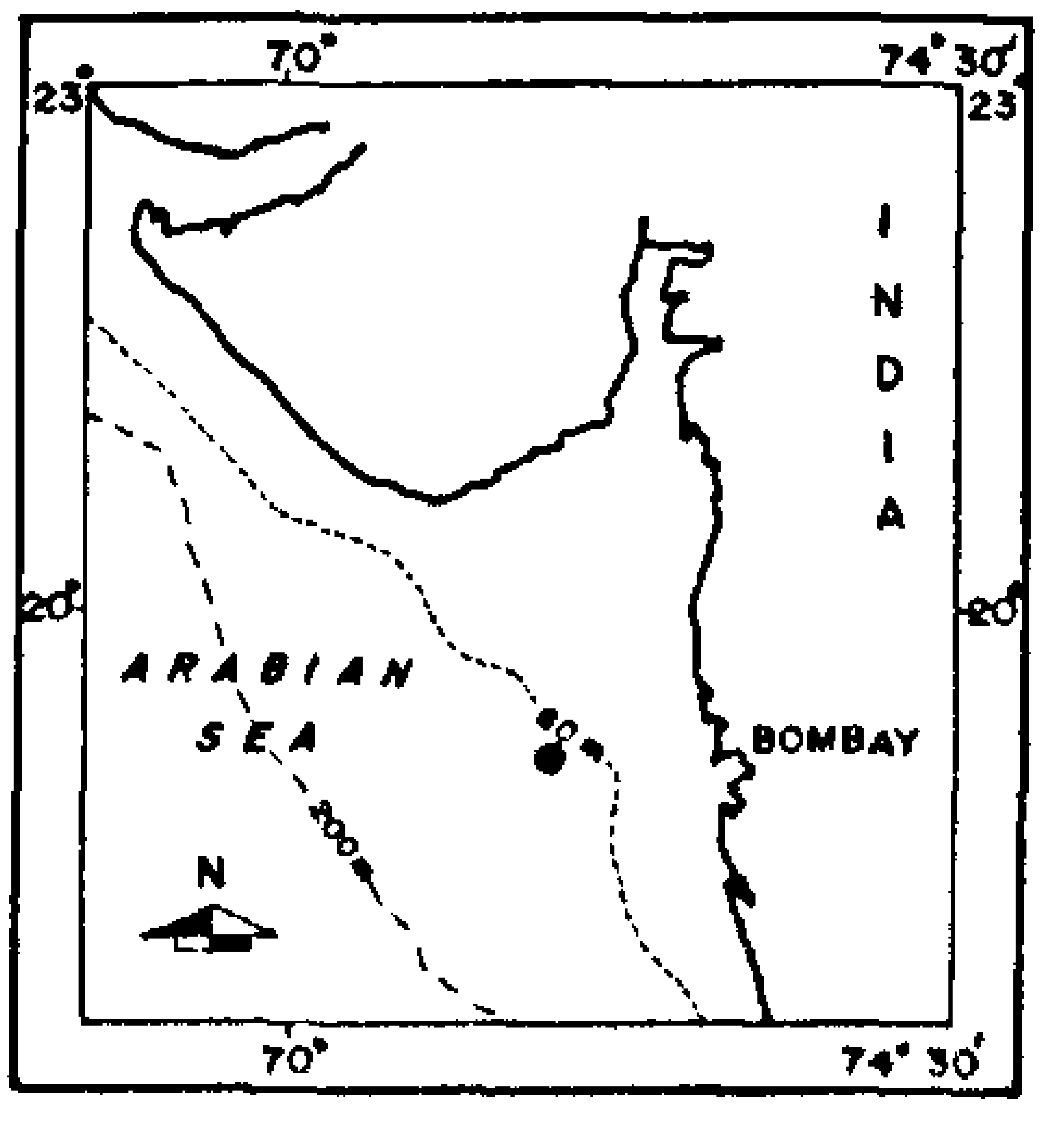

Figure 1. Location of bore-hole

The present study revealed shallow-water benthic foraminiferal species (Table 1) and ooids in the 26.5-m-long core collected off Bombay. The size of ooids ranges between 0.27 and 0.52 mm throughout the bore hole. The variation in size is indicative of variation in water depth and, therefore, of sea level. For example, Bathurst[12] states that the more rapid their accumulation the quicker the burial and the smaller the grain size. Furthermore, in these samples we found that the smaller the size of ooids fewer were specimens of associated foraminifera, to a maximum of 7%. Since the average age of the surface sediments is around 10,000 years[8], the subsurface sediments must have deposited prior to 10,000 years BP. The presence of ooids and shallow-water foraminifera in subsurface sediments indicates that the general optimum depth for ooid formation remained unchanged.

Table 2 shows down-core variations in mean size of the ooids. We propose three zones A_1, A_2 and A_3 on the basis of relative percentage of occurrence and mean size of ooids, which, as mentioned earlier, can serve as indicators of episodic changes in depositional environment. These represent stable sea-level episodes in an otherwise rising trend of sea level after the last glacial maximum at 18,000 years BP[1].

In the absence of specific data regarding sea-level fluctuation along the western continental shelf of India for the period before 10,000 years BP, we compare the above results with the global picture of sea-level fluctuation derived from the behaviour of the west Antarctic ice sheet[13], in respect of which it was suggested that gradual shrinkage after 18,000 years BP was followed by a minor readvance at 14,000 years BP and that another readvance may have occurred at about 12,500 years BP.

Table 1. A checklist of shallow-water foraminiferal species present in the bore-hole sample

Triloculina sp.
Triloculina tricarinata
Triloculina trigonula
Triloculina terquemiana
Quinqueloculina sp
Quinqueloculina lamarckiana
Quinqueloculina seminulum
Quinqueloculina kerimbatica
Spiroloculina excavata
Spiroloculina communis
Spiroloculina planissima
Spiroloculina sp.
Cibicides lobatulus
Cibicides refulgens
Elphidium discoidale
Elphidium advenum
Elphidium crispum
Nonion elongatum
Glabratella sp.
Ammonia tepida
Ammonia papillosus
Cavarotalia annectens
Textularia sp.
Pararotalia calcar

Table 2. Distribution and average size of ooids at different levels in the core

Sample depth (*m*)	Age (years BP)	Ooids in coarse fraction (%)	Average size (mm)	Zone
0 (Surface)	10,000*	15	0.34	
B-2 m		41	0.37	
B-3 m		23	0.37	
B-4 m	11,500†	23	0.41	A_3
B-5 m		13	0.32	
B-6 m		3	0.44	
B-7 m		7	0.27	
B-10 m		17	0.31	
B-11 m		18	0.31	
B-12 m		21	0.37	
B-13 m		32	0.42	
B-14 m		8	0.40	
B-15 m		10	0.41	
B-16 m		10	0.28	
B-17 m	13,000†	25	0.52	A_2
B-18 m		17	0.43	
B-19 m		3	0.31	
B-21 m		< 1	0.36	
B-22 m		2	0.37	
B-23 m		< 1	0.34	
B-24 m		3	0.33	
B-26.5 m	14,500†	9	0.45	A_1

*Average age taken from Nair and Hashimi[8].
†Age inferred from Fairbridge[14].

Earlier Fairbridge[14] assembled data on sea-level rise and showed still-stand or reversals in trends at approximately 14,500, 13,000, 11,500 and 10,500 years BP. Therefore, by comparison, our zones A_1, A_2 and A_3 may be assigned the approximate ages of 14,500, 13,000 and 11,500 years BP respectively (Table 2). The French two-step deglaciation model[15], with maximum melting rate from 14,000 to 12,000 years BP and from 10,000 to 7,000 years BP separated by a mid-glacial pause with little or no ice volume loss, is also helpful in supporting our data. The low (< 3%) occurrence and small size of ooids in subsurface sediments (19 to 24 m in our subsamples) may correspond to the first step of the two steps of deglaciation[15].

With the handicap of not having the absolute ages of these sediments we propose that the bottom of the core (26.5 m) may be assigned an age of 14,500 years BP, when sea level was lower by 101.5 m (75 m water depth + 26.5 m sediment thickness). This estimate is very close to the estimate of 110 m at 14,500 years BP of Fairbanks[16].

In conclusion, our studies indicate that past changes in sea level are characterized by episodic still-stand and were not a continuous rise. Detailed work involving radiometric dating and distribution of faunal components are in progress.

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'Foraminiferal linings' from Late Cretaceous–Palaeocene sediments of Ohafia-Ozu Abam area, Nigeria

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Foraminiferal linings are chitinous remains representing the inner tests of certain foraminifera and are frequent occurrences in palaeo-palynological preparations. Their presence in sediments confirms marine influences. They have not been studied in as great detail as other microfossils and thus have remained a neglected and non-conventional fossil group. Since dispersed organic matter has been given a lot of importance in recent years, it has become imperative to consider the significance of these linings in biostratigraphic and palynofacies studies of a sedimentary basin during exploration for hydrocarbon resources. Here we report the foraminiferal linings encountered in the Nsukka Formation of Ohafia-Ozu Abam area in Nigeria and discuss their use in stratigraphical and palaeoecological interpretation.

WHILE studying the microfossil assemblages (fauna and flora) of outcrops belonging to the Nsukka Formation occurring in the Ohafia-Ozu Abam area of Imo state in Nigeria (Figure 1), we observed a large number of diversified foraminiferal linings in palynological preparations of shale samples collected from exposed sections between Ozu-Abam and New Nkwebi Road.

Foraminiferal linings are acid-resistant organic remains and have been referred to in many palynological communications as microforaminifera, a term coined by Wilson and Hoffmeister[1]. Although these forms have been reported earlier, only recently have their taxonomy and application in biostratigraphy and palaeoecology been highlighted by Stancliffe[2], with particular reference to British Oxfordian sediments. Since foraminiferal linings contribute to the organic component and 'palynodebris' of a microfossil assemblage, their occurrence and diversity could be used along with other conventional microfossil groups to study the palynofacies; it would also facilitate interpretation of the depositional environment. Although mention of microforaminifera is common in palynological reports of West Africa[3] and India[4-6], no attempt has been made to study them in such detail as to enable researchers to exploit fully the organic component of the sediments in which they are found for palaeoenvironmental analysis and proper evaluation of the hydrocarbon potential of a sedimentary basin. Our aim is therefore to report the occurrence of foraminiferal linings and highlight their importance in the Late Cretaceous–Palaeocene sediments of south-eastern Nigeria. The other objective of this communication is to generate interest among micropalaeontologists and palynologists to tap the resources contributed by foraminiferal linings in sedimentary rocks for a synergistic approach, as suggested by Venkatachala[7], in dealing with hydrocarbon potential of source rocks in petroliferous basins. Study of foraminiferal linings must be carried out on a systematic basis for an understanding of the total sedimentological picture of a basin for hydrocarbon exploitation.

The foraminiferal linings reported here were obtained in palynological preparations of strew mounts of three samples collected from Ozu-Abam black shale (source 1, Figure 1,*b*), Nkwebi/Ozu-Abam road section (source 2) and a section exposed at the 'stopping point' along *Ozu-Abam Road (source 3). Of the six samples of shales* belonging to Nsukka Formation, only three showed foraminiferal linings and other palynomorphs. However, sample number 6 of clay shale showed rare occurrence of peridinoid dinoflagellates.

As stated earlier, there is neither a classification nor a formal descriptive scheme to assign and refer foraminiferal linings. Therefore they cannot be referred to a generic or specific level. However, *Trochilasca* Deak is the only genus known, but this too has been cited under genera of uncertain status by Loeblich and Tappan[8]. Foraminiferal linings referable to *Ammonia*