

## NANNOPLANKTON FROM RC9-156 IN THE SOUTHEASTERN ARABIAN SEA

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### Abstract

A deep sea core RC9-156 collected in the Arabian Sea at a water depth of 4583 m was analysed for calcareous nannoplankton and dissolution studies. Twelve species of nannoplankton were identified and based on the assemblage, it is suggested that the age of the sediment is late Quaternary. The alternate fossiliferous and unfossiliferous bands encountered in the core is attributed to the fluctuations in the rate of sedimentation by the river Indus during glacial and interglacial periods.

### INTRODUCTION

A deep sea piston core RC9-156 collected by the Lamont Doherty Geological Observatory's *RV Conrad* in the year 1965 was chosen to study the distribution of nannoplankton flora and its dissolution. The core was collected at 06°04'N latitude and 69°48.2'E longitude from a water depth of 4583 m in the equatorial Indian Ocean (Fig. 1). The length of the core recovered is about 11.74 m.

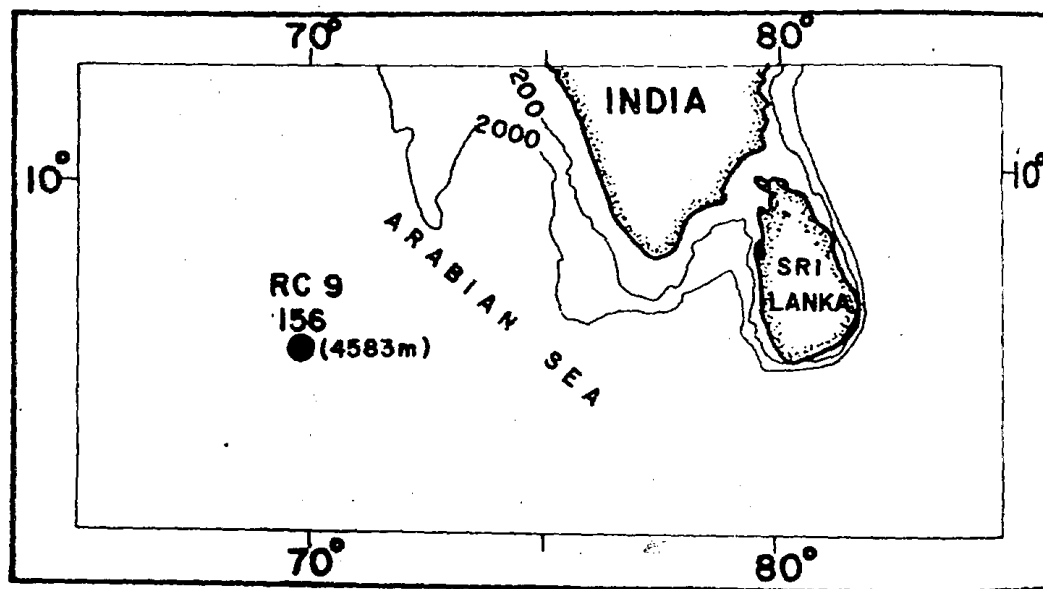


Figure 1. Showing the location of Core RC 9-156.

### CORE DESCRIPTION

The core consists of moderate yellowish brown lutite (10YR 5/4) interbedded with a very light gray (N8) lutite and a dark gray (N3) mottled lutite which is due to burrowing. The moderate yellowish brown lutite which forms the predominant portion of the core is characterised by carbonate and a low coarse fraction content consisting of broken foraminiferal tests. The dark gray lutite bands contain micro-manganese nodules, have a low carbonate and coarse fraction content and consist mainly of planktonic foraminiferal tests. The colour change between

adjacent bands is gradational. The light gray lutite bands have a high carbonate content. The coarse fraction consists mainly of broken foraminiferal tests. The top and bottom contacts are relatively sharp and less gradational in nature. From 985 cm to the bottom of the core the lutite appears to have a flow-in type structure and between 1114-1117 cm a light gray lutite band is present. Although the sedimentation rate has not been determined for this core, the sedimentation rate of 7 m/m.y. estimated for the nearby DSDP site 220 may apply to the present core also. But, because the core under investigation was retrieved from a depth 500 m greater than the DSDP site 220 in which dissolution has been encountered, it is possible that sedimentation rate in core RC9-156 may be less than 7 m/m.y.

### RESULTS AND DISCUSSION

*Age of the sediment*: Based on the nanoplankton floral assemblage, two biostratigraphic zones have been identified i.e, *Gephyrocapsa oceanica* Zone and *Pseudoemiliania lacunosa* Zone. The absence of discoasters, except for a few re-worked ones, indicates that the age of the core is late Quaternary. The last occurrence of *P. lacunosa* was encountered at 160 cm.

Calcium carbonate percentage has been determined for the entire core length, which shows a range of 18-35%. From top to bottom  $\text{CaCO}_3$  progressively decreases, except in a short interval between 240-340 cm, where it is slightly higher than in the rest of the core. There is clearly a minimum concentration at about 580-620 cm and then  $\text{CaCO}_3$  percentage increases towards the bottom, to a secondary maximum at about 960 cm.

From visual observation of core sample (Fig. 2) at intervals of 20 cm throughout the core length, it was observed that from top to 200 cm down was represented by sparsely distributed planktonic foraminiferal keels and tests which progressively increase in number to a maximum at the 500 cm level and abruptly diminishes in quantity from 500-800 cm down core. Between 800 and 1000 cm they are sporadically distributed along with a few tests of benthic foraminifera. From 1000-1100 cm they are absent, while below 1100 cm they occur only in traces (Fig. 2a). The nannofossil distribution down core is similar to that of the foraminifera (Fig. 2b). In general, the distribution of nanoplankton is very poor.

Micro-manganese nodules were encountered in association with the gray lutite band with a low  $\text{CaCO}_3$  content and low coarse fraction consisting mainly of broken foraminiferal tests. The low coarse fraction content may be due to the high fragility of foraminiferal tests caused by dissolution. It is seen that there exists a good correlation between the faunal content in the core with the percentage of  $\text{CaCO}_3$  (Fig. 2).

Among planktonic foraminifera, *Globorotalia*, *Globigerina*, *Pulleniatina* and *Sphaeroidinella* were the chief microfossils commonly encountered. *Globorotalia*, *Sphaeroidinella* and *Pulleniatina* were invariably noticed in the lower levels of the core. Nanoplankton diversity and concentration are very low throughout the core (Table I). This may be attributed to the dissolution effects seen throughout the core rather than to productivity in the overlying waters. Presumably the concentration of coccoliths in sediment above the compensation depth is proportional to the productivity in the overlying surface waters as the current transport in the open ocean is insignificant (McIntyre and Bé, 1967).

Table I shows that twelve species of coccoliths are encountered in addition to some re-worked species of discoasters such as *Discoaster brouveri*, *D. calcaris* and coccoliths such as *Watzneura barnesae*, *Reticulofenestra pseudumbilica* and *Sphenolithus* spp.

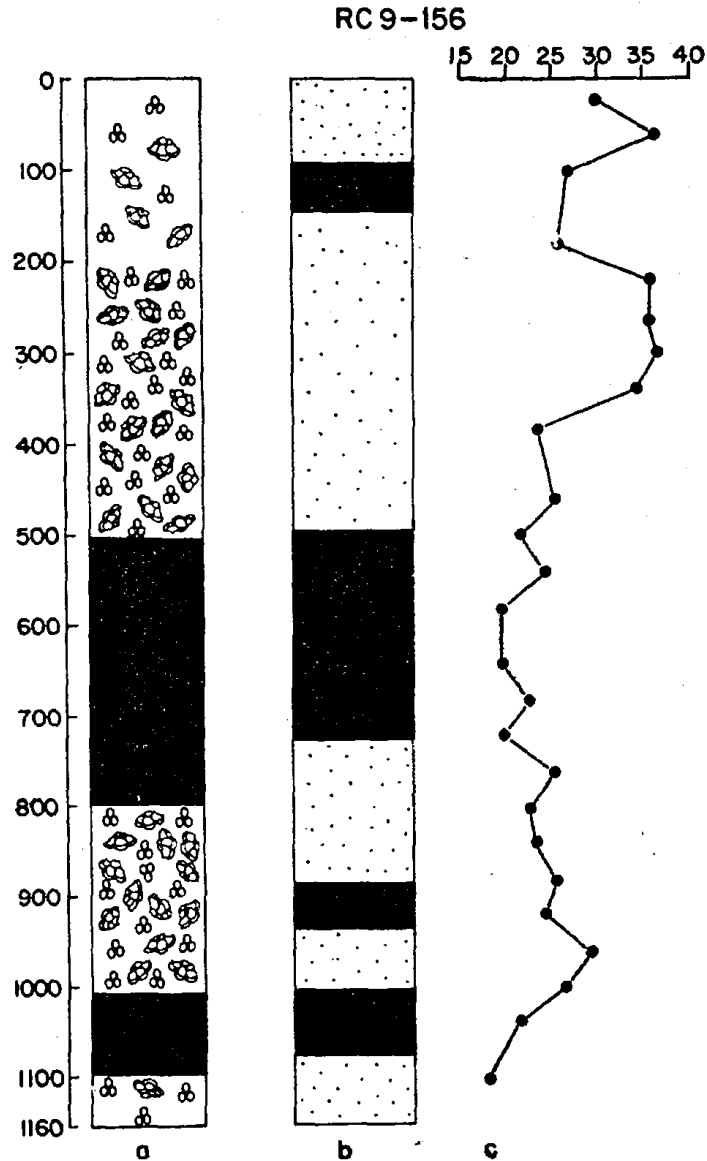


Figure 2. Showing the distribution of planktonic foraminifera (a) and calcareous nannoplankton (b), along with CaCO<sub>3</sub> (c).

From 320 cm and downward, it is noted that the smaller *Gephyrocapsids* occur frequently which may be due to unfavourable conditions prevailed in the area. According to Gartner (1977), throughout the Pleistocene small specimens of various species of *Gephyrocapsa* generally indicate a marginal or stress environment, as for example a shallow shelf. It is observed that *Cyclococcolithina leptopora* and *Gephyrocapsa* sp. represent constant abundance followed by *Pseudoemilliana lacunosa*, which is fairly well distributed. The other species identified in the order of less abundance include, *Helicosphaera carteri*, *Ceratolithus cristatus*, *Gephyrocapsa doricoides*, *Coccolithus pelagicus*, *Umbilicosphaera sibogae*, *Seyphosphaera* sp. and *Coccolithus gelidus* (?).

TABLE I. Showing the distribution of nannoplankton.

X=Abundant; ⊙=Common and △=Rare.

DEPTH IN CORE (CM)	<i>Pseudoemiliana lacunosa</i>	<i>Gephyrocapsa</i> sps	<i>Cyclacoccolithus leptoporus</i>	<i>Helicopontosphaera kampferi</i>	<i>Gephyrocapsa dorenicoides</i>	<i>Ceratolithus cristatus</i>	<i>Coccolithus pelagicus</i>	<i>Scyphosphaera</i> sp.	<i>Syracosphaera</i> sp.	<i>Umbilicosphaera mirabilis</i>	<i>Tharacosphaera</i> sp.	<i>Coccolithus gelidus</i>	REMARKS
TOP		X	⊙			△							
20		X	⊙			△							
40		X	X			△	△						<i>Watzneura barnesae, Discoaster</i> sp.
60		X	⊙	△		△	△			△			
80		X	⊙	△	⊙	△	△	△	△				
100-140			B	A	R	R	E	N					
160	X	X	⊙	△		△	△			△			
180	X	X	⊙	△		△	△			△			
200	X	X	X	△	⊙	⊙	△			△			<i>Discoaster brouweri</i>
220	X	X	X	△		⊙							
240	X	X	X	△		⊙							
260	⊙	⊙	⊙	△		△				△			
280	△	△	△			△							
300	⊙	⊙	△	△									
320	⊙	X	X	⊙		△							<i>Smaller Gephyrocapsiids</i>
340	X	X	X	⊙									
360	X	X	X	X	⊙	⊙				△			
380	X	X	X	X		⊙							
400	X	X	X	X	⊙	⊙	⊙			⊙	△	△	<i>Sphenolithus abies</i>
420			B	A	R	R	E	N					
440	⊙	X	X	△		△	△			△			
460	△	△					△						
480	X	X	X	△			△	△		△			<i>S. abies, D. brouweri, D. calcaris, Reticulotriaster pseudoumbilica</i>
500-740			B	A	R	R	E	N					
760	△	△	△			△	△						
780	△	△			△		△						<i>Smaller Gephyrocapsiids</i>
800			B	A	R	R	E	N					
820	⊙	⊙	△			△	△						
840	△	△	△			△							
860	△	△	△		△	△	△		△				
880	△	△	△		△					△			
900-940			B	A	R	R	E	N					
960	X	X	⊙	⊙	⊙	△							<i>Smaller Gephyrocapsiids</i>
980	X	X	X		⊙	△				△	△		<i>Smaller Gephyrocapsiids, R. pseudoumbilica</i>
1000	⊙	⊙	⊙		△		△						<i>R. pseudoumbilica</i>
1020-1080			B	A	R	R	E	N					
1100	⊙	△	⊙										
1120	⊙	△	⊙										
1140	X	X	X	X	⊙	△	△	△	⊙	⊙			<i>H. kampferi (Large size)</i>
1180	X	⊙	X	⊙	X					⊙			<i>Small Gephyrocapsiids, H. Selli</i>

The differential dissolution of coccoliths has been studied by various workers (Bramlette and Sullivan, 1961; Hay, 1970; Hsu and Andrews, 1970; Cita, 1971; McIntyre, 1971; Bukry, 1971, 1973; Roth and Thierstein, 1972; Schneidermann, 1973; Berger, 1973 and Honjo, 1975). From the above studies it has been established that species like *Emiliania huxleyi* and *C. leptopora* are the more resistant among coccoliths. The placoliths show the greatest resistance to dissolution. The heavy U-shaped elements are strongly interlocked to form two oval to circular shield connected by a circular tube (McIntyre and McIntyre, 1971). In the present study, dissolution of coccoliths agree well with the established fact that the *C. leptopora*, *G. oceanica* and *U. sibigae* have more resistant placoliths. With increasing dissolution on the structure of coccolith it becomes difficult to identify even the more resistant forms (Pl. I)

In the present investigation, dissolution has been noted at a water depth of 4583 m in the Arabian Sea. Bezrukov (1961) noted the replacement of carbonate sediment by red clays between 4200-5000 m depth at various stations in the Indian Ocean. According to Weser (1974), except for a few small silled basins on the lower flanks of the Carlsberg Ridge, water depth does not exceed 4700 m in the Arabian Sea. Complete solution of calcium carbonate, therefore, does not occur in this area. Recently, Kolla *et al* (1976) stated that dissolution in the Indian Ocean starts at 4500 m depth.

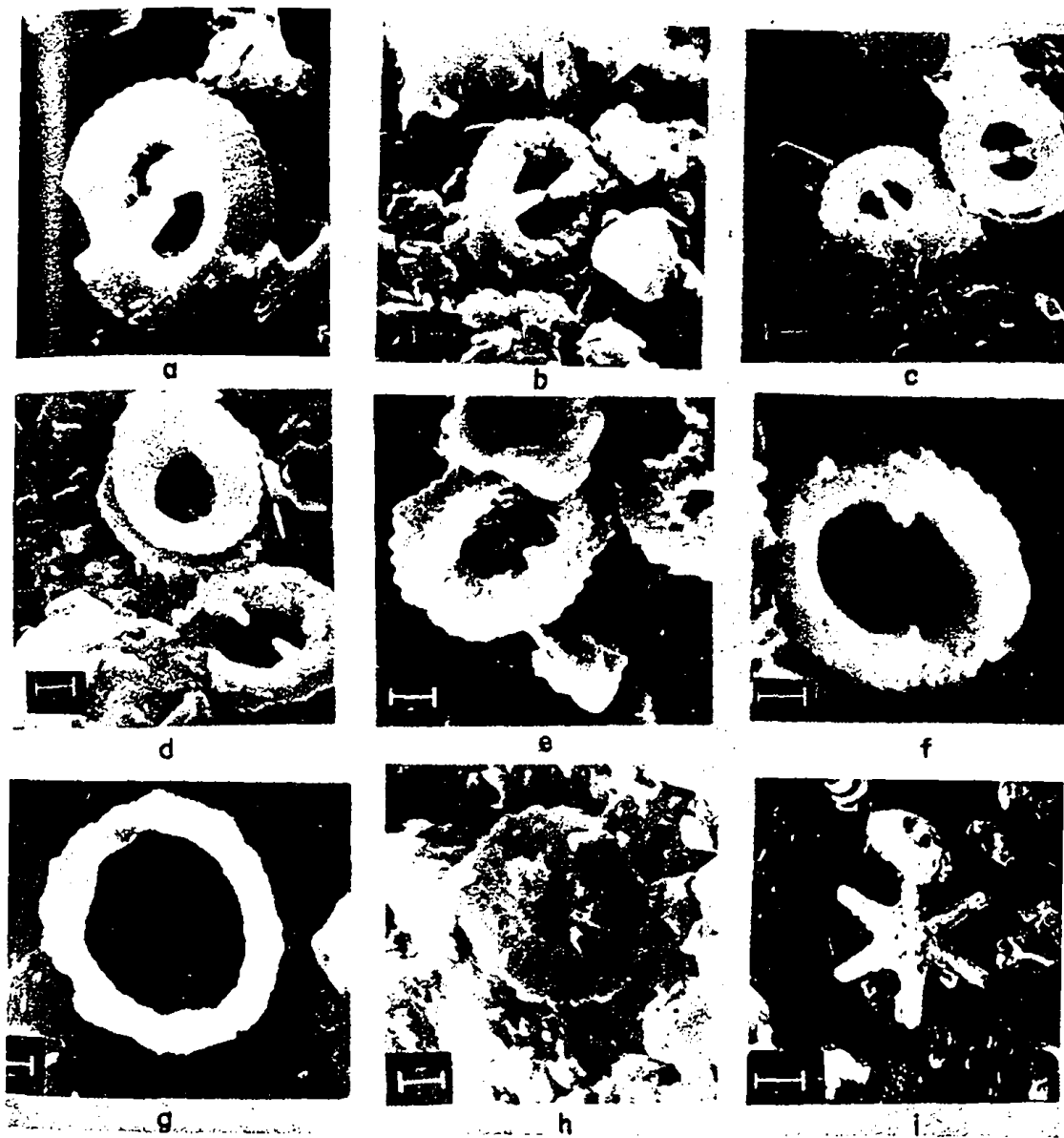
The cyclic variation in calcium carbonate and microfossil content, as evidenced by the presence of alternate fossiliferous and unfossiliferous bands throughout the core length, may be attributed to the following reasons.

*Fluctuation in the rate of Productivity:* Although variation in abundance of  $\text{CaCO}_3$  could be due to changes in the rate of production of calcareous plankton (Prell and Hays, 1976), the role of productivity in the present instance, if any, cannot be discussed as the core under investigation lies in the zone of lysocline. Hence, it is assumed that the productivity and the rate of production of carbonate remains constant. Consequently, the presence of alternate layers of fossiliferous and unfossiliferous zones may not be due to productivity changes.

*Dissolution:* Dissolution in the ocean is accomplished by many ways, as for example, by the incursion of Antarctic Bottom Water (ABW) which is highly corrosive to carbonate material and in the zone of lysocline which occurs at depths where greatest rate of change in carbonate dissolution takes place owing to the prevailing physico-chemical conditions.

In view of the fact that the ABW while spreading northward gradually becomes warmer and more saline due to admixture of varying proportions of circum-polar and other deep waters, the possibility of carbonate dissolution encountered may not be due to ABW only. Apparently, the conspicuous dissolution as evidenced by the presence of warm water planktonic foraminifera like *Pulleniatina obliquiloculata*, *Globorotalia menardii* and *G. tumida* may be attributed to the lysocline depths from which this core was retrieved. It is a well established fact that dissolution affects planktonic foraminiferal tests in deep sea sediment resulting in fragmentation (Berger, 1968, 1970; Ruddiman and Heezen, 1967). Besides, there may be some other mechanism responsible in bringing out this cyclic event.

*Dilution:* The influx of terrigenous material or non-carbonate material into the ocean may also be responsible for the presence of clay bands which are unfossiliferous. The dilution by non-carbonate material could be effected in three ways i.e., river discharge, under water currents and wind borne material.



a-g: *Gephyrocapsa oceanica*, showing various stages of dissolution.

h: *Cyclococcolithina leptopora*, affected by dissolution.

i: *G. oceanica* resting on a *Discoaster* sp.

Terrigenous sedimentation from the western continental shelf is ruled out because of the Laccadive Ridge which acts as a barrier. It is, however, envisaged that the terrigenous sediment was transported from the river Indus, a fact substantiated by the studies of Weser (1974) and Siddiquie *et al* (1976).

Fossiliferous bands may be attributed to increased sedimentation rates, mostly by yellowish brown clays during interglacial (?) periods which prevented rapid dissolution. Fluctuation in rate of sediment influx into the deep basin may cause dilution by non-carbonate material by the river discharge. Further, it is conceived that the slow rate of sediment discharge might result in intense dissolution during glacial (?) periods, owing to long exposure to corrosive waters undersaturated with carbonates in the zone of lysocline. Conversely, high sedimentation rate results in higher carbonate content as the dissolution could be prevented by continuous blanketing of terrigenous material.

*Winnowing and turbulence*: If it is assumed that the cyclic events are the result of winnowing, there should have been an increase in the number of fragments by selectively removing the smaller particles. As indicated in the core description, the coarse fraction content is low suggesting that winnowing effect was absent.

Edmond (1974) has suggested that hydrodynamic rather than chemical character of water is the dominating influence in calcite dissolution, where high turbulence makes ocean water well stirred, preventing formation of protective coating in calcite and facilitating rapid dissolution.

Of the various mechanisms discussed in the foregoing paragraphs, it seems likely that the fluctuation in sedimentation rates during glacial and interglacial periods from the river Indus was responsible for the presence of alternate fossiliferous and unfossiliferous bands in the core. Precise dating of the periods of fluctuation in sedimentation, however, is not possible for want of data.

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