

# Foraminifera as Climatic Indicators in the Sediments of Western Indian Continental Shelf

By

M. G. Anantha Padmanabha Setty,  
*National Institute of Oceanography, Panaji, Goa*

## Introduction

Foraminifera are the single celled microscopic organisms found abundantly in the seas and oceans. The tests of these organisms are preserved in the present sediments of the ocean as in the past, sometimes constituting extensive deposits as oozes; however they form one of the major constituents of almost all types of sediments. They are not only considered to be the major source of oil and gas but some of the species are also considered as delineators or markers of oil bearing horizons and geological time factors. Thus, they are indicative of various parameters like the environmental conditions of deposition, latitudinal zonation, type of the geosynclinal structure, distance from the shore, rate of sedimentation etc. In fact, they have a story to tell, which can be unravelled by careful analysis and interpretation.

Foraminifera are primarily of two kinds—planktonic and benthonic—each having a significant role to play. Therefore, in the study of a sample, the planktonic and benthonic populations should be considered separately. It is so suggested because these two assemblages represent different habitats and environmental conditions.

Planktonic foraminifera are distinctly a few in number compared to several

thousand benthonic species present. These are about 50 in all but the most characteristic ones are about 30–35 only, however, there are only 8–10 living genera, most of the species of which occur in an extreme abundance of individuals. Individual species are widely distributed by ocean currents and occur in marine water masses at different depths; thus they are not only pelagic but occur, survive, propagate and characterise the distinct parameters of depth distribution, water density, salinity variation, oceanic circulation, temperature gradient or a vertical thermal structure and latitudinal zonation of the seas and the oceans.

## Distribution

Based upon detailed investigations of the several cores and surface sediment samples and also the overlying water masses of the shelves and the open ocean, certain broad conclusions have been drawn and accordingly the foraminifera, particularly the planktonic foraminifera are broadly classified into five distinct faunas having discrete distributions. According to Phlegar (1960) and with a few modifications by the author, they are, (1) Polar (arctic and antarctic) fauna, (2) Subpolar (subarctic and subantarctic) fauna, (3) Transitional fauna, (4) Central fauna, and (5) Equatorial fauna.

These faunas are characteristic of

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surface water masses which are distinguished by temperature and salinity parameters. The largest population occurs in subarctic and subantarctic regions, and at certain areas of the equatorial region while the smallest populations are in the central region. The region of abundant populations of foraminifera are also areas of high phosphate concentration. (Bradshaw 1959). Also the specimens are most abundant in the upper 100 m of water as also the highest concentration of tests being in the deeper waters. The distribution of these forms is minimum at regions nearer the shore but it increases towards the slope and open ocean subject to latitudinal range and the species abundance of the region. Emiliani (1954) studied the oxygen isotope composition of a few species of planktonic foraminifera and based on an estimation of the average relationship between depth and temperature, concluded that, it "—enhances the possibility of using pelagic foraminifera from cores for paleoclimatological studies". Thus a study of the distribution of planktonic foraminifera in sediment samples by various workers (Schott, 1935; Ovey (in Wiseman and Ovey) 1950; Phlegar *et al.* 1953; Bradshaw 1959; Be' 1959, Parker 1962), resulted in the distribution of the species in terms of their "temperature distribution", giving rise to arctic, temperate, and warm water species. Thus, five generalised distribution zones are established, which often, cannot be strictly demarcated. Phlegar *et al.* (1953) studied the surface sediment samples from approx. 0° lat. to 50°N lat. in the North Atlantic and recognised the five zones. However, the author believes

that these five zones can be applied to other regions also. Thus, they are: (1) species of high latitudes, (2) species of midlatitudes, (3) species of low latitudes, (4) Transitional species and (5) universal or cosmopolitan species.

However, mixing besides overlapping, of these faunal zones occurs resulting quite often in the mixing of different types of waters and their contained fauna *e.g.*, (1) *Globorotalia menardii* (d'Orbigny) and *Globigerinoides succulifer* which are typically low latitude warm water species are transported to mid-latitudes by the Gulf stream. Thus by the very fact of the positioning of the Gulf stream in the north Atlantic from low latitudes connecting the mid and high latitudes the warm water species are transported and sometimes invade far beyond from the normal path of the current also.

(2) *Globigerina bulloides* (d'Orbigny) considered to be a typical mid-latitude species is present in low latitude and even warm equatorial waters (Phlegar *et al.* 1953; Setty, 1972.)

(3) Rare, but undoubted specimens of *Globigerina pachyderma* (Ehrenberg) a cooler water, bipolar species found in the nearshore as well as offshore and open sea between 27°–34°N along the path of the Gulf Stream (Wilcoxon 1964); and between 3°S and 10°N (Cifelli, 1967) also. Similarly, *G. pachyderma* is found to occur in the offshore-slope sediments off Cochin (Setty 1972) and off Mangalore (Setty and Guptha, in Press).

Today, modern planktonic foraminiferal fauna occurs at the top of the surface

sediment or the topmost part (5-10 cm) of the core. It has been observed that the fauna of the topmost part of the core differs from the lower part. This lower core fauna may be similar to the modern fauna of a higher latitude. This is considered to represent cooler water conditions than at present. This fauna may be differentiated from the top fauna by the absence of *Globorotalia menardii* (d'Orbigny). Thus "cold water faunas" are recorded from several submarine cores of the present day "warm water fauna" areas of Atlantic (Schott, 1935; Phlegar *et al.* 1953); from the Gulf of Mexico (Phlegar 1951 b), Caribbean Sea (Phlegar 1948); from the Mediterranean Sea (Arrhenius 1952, Parker 1958, Todd 1958); Arabian Sea (Stubbings 1935, Setty 1972). Stubbings (1935) reported as many as four "colder water" faunas separated by "warm water" faunal assemblages. These colder water fauna are correlated with the glacial stage/stages of the Pleistocene. Thus they are paleoclimatic indicators.

### Discussion

The shelf sediments of the western Indian continental shelf, collected at various positions during the Indian Programme of the International Indian Ocean Expedition and again later from the shore to the slope off Cochin and upto Saurashtra coast are processed. The results of the analyses done revealed that the planktonic assemblages of these sediments indicate a mixed assemblage consisting of species which are typically referable to warm water, cold temperate and also undoubted cooler water forms in a sediment which is greenish grey,

medium to fine textured, and the composition varying from sands to clay to calcareous muds occurring mostly towards the slope (Setty 1972, Setty and Gupta in Press).

Of the 22 species of planktonic foraminifera identified in the Cochin Sector, 14 are warm water, 5 cold temperate, 2 cosmopolitan and one cold water high latitude form (Setty 1972). Similarly of the 15 species noticed from Mangalore and Karwar regions, further north, include 8 warm water, 4 cold temperate, 2 cosmopolitan and one cooler water form, however, this cooler water form (*Globigerina puchyderma*) is found in the slope sediments of Mangalore sector only but not in the Karwar sector (Setty and Gupta in press).

In the Karwar and Mangalore sector the analyses further showed that there is a consistency in the distribution of these species by their number and populations thus indicating favourable conditions for their growth and development and comparatively a stable shelf being present with a regulated sedimentation rate in the region. The total population of planktonic and benthonic assemblages is in equilibrium with the sediment which indicates favourable conditions for development and a steady rate of sedimentation.

The foraminiferal number in the planktonic assemblages and their abundance indicate the environments of the overlying water masses as well as the range in terms of depth, density, salinity and temperature tolerance of the individual species.

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The concurrence of *Globigerina pachyderma* (Ehrenberg) in the offshore and slope sediments of Cochin and Mangalore sector is very significant because this is a bipolar dextrally coiled, cooler water species which occurs in an area which is outside its normal habitat. Its value as paleoclimatic indicator is greatest and particularly so when its occurrence is noticed in sediments of areas which are known today as typical tropical regions of the world. While it is admitted that occasional specimens are observed even at the equator (Parker 1962), its occurrence north of the equator is of significance. The species that is encountered in these sediments is typically dextrally coiled, thin walled with square outline, having pitted appearance and terminated with a small aperture in the final chamber. Since *G.*

*pachyderma* also has a vertical distribution in addition to lateral range, it is observed after careful consideration that (1) it signifies a lowering of the temperature resulting in Pleistocene glaciation causing climatic changes, (2) a shift in the mid-latitude fauna further to lower latitudes, and (3) it being transported to these regions by sub-polar intermediate current and also possibly the Antarctic Bottom Drift.

Thus, it is found that the foraminifera act as paleoenvironmental and/or climatic indicators.

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