

## FORAMINIFERAL EVIDENCE TO CLIMATIC CHANGES WITH SPECIAL REFERENCE TO WEST COAST OF INDIA

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### ABSTRACT

The planktonic foraminiferal assemblages show effects of climatic control on water masses. The southward migration of Red Sea Water and Persian Gulf Water is indicated by the dominant presence of *Globorotalia cultrata* and *Globigerinoides* starting respectively in the assemblages. However, *Globigerinoides succulifer* and *Globigerinella siphonifera* are dominant in waters of the Central and Southern Arabian Sea that is not influenced by high salinity from the north. *Globoquadrina dutertrei* and *Globorotalia menardii* though relate to tropical warm waters indicate cool upwelled waters. *Globigerina bulloides* and dextrally coiled *Neogloboquadrina pachyderma typica* are known cold water species but their very occurrence off Kerala, Mangalore and Goa coasts indicate upwelling in the region. *Globorotalia menardii* and *G. menardii neoflexuosa* are tropical but live in deep or intermediate water masses hence irregular in upwelling areas.

### INTRODUCTION

The ecological study of living planktonic foraminifera provides a baseline information which can be used for comparison and reconstruction of the paleo-oceanographic environments of the fossil preserved in the older sediments of the ocean. Therefore, stratigraphic and geographic distribution of fossilised faunal remains and their distributional pattern with emphasis on the ecological conditions (seasonal, spatial, bathymetric and latitudinal) of the living foraminifera are studied. This gives a perspective evidence to climatic changes through space and time. Further, such a study reflects the effects of climatic control on water bodies of different oceans.

Phillippi (1910) first interpreted the occurrence of globigerina ooze overlying the red clays in the Indian Ocean as post-glacial and attributed the change as due to climatic variation. Similarly, other observations relating to cause-effect relationships were made by Stubbings (1939), Zobel (1971; 1973), Setty (1973, 1977, 1983) on the Arabian Sea; Phleger (1951) on northwest Gulf of Mexico; Cushman (1931) and Ericson and Wollin (1956) on Atlantic; Parker (1956) on the Mediterranean; Bradshah (1959) on the Pacific and several others.

## OCEANOGRAPHIC CONDITIONS

Arabian Sea is the northwestern part of the Indian Ocean. Oceanographic conditions here vary during monsoon and post monsoon periods. During the southwest monsoon the current pattern which was north to south (April and May) suddenly changes in June and July, becoming northeast to southwest in August and September. The North Equatorial current flows from east to west. The wind direction which was from the north in April becomes seaward in July. Along the Indian west coast the salinity changes from  $> 36\%$  in April to 31.6 to 34%. Thus, it gradually decreases from the northern region in its southern direction. The high salinity is due to high evaporation, and high influx of highly saline water masses from the Red Sea and the Persian Gulf, migrating into the Arabian Sea. Upwelling is reported along the coastal waters off Sri Lanka, Cape Kanyakumari, Cochin and extending to southern part of Goa through the entire southwest monsoon (Zobel 1971; Setty 1983).

The sea water temperature range from  $24^{\circ}\text{C}$  to  $27^{\circ}\text{C}$  and increases further towards the equator. The sea surface temperatures are lowered by  $4-5^{\circ}\text{C}$  from a maximum at  $29^{\circ}\text{C}$  in April and May to  $25^{\circ}\text{C}$  in July and August. Its reversal to  $29-30^{\circ}\text{C}$  in October-November thus indicates that upwelling is strongest during July and August and it lasts until October (George 1953, Setty 1983). The low oxygen but high nutrient concentrations of the cool upwelled waters in the shelf region augments phytoplankton productivity; however, during the post-monsoon period, oxygen concentrations increase and the phosphate concentrations of the surface waters varies inversely with the amount of diatoms present. The short term massive organic productivity in the surface waters accounts for high organic carbon content in the underlying sediments, sometimes resulting in anoxic conditions, promoting generation of hydrogen sulphide and deposition of pyrite as infilling in tests of foraminifers as observed in samples off Mangalore (Setty 1979).

## FORAMINIFERAL COMPOSITION

Planktonic foraminiferal composition observed from regions along the west coast of India, on the whole is very similar, but their character of abundance differs in different regions. The planktonic foraminifers reported are: *Globigerina bulloides*, *G. fulconensis*, *G. rubescens*, *G. calida*, *Globigerinoides ruber*, *G. conglobatus*, *G. succulifer*, *Pulleniatina obliqueloculata*, *Orbulina universa*, *Globigerinella siphonifera*, *G. aequilateralis*, *Globoquadrina conglomerata*, *G. hexagona*, *Globigerinita glutinata*, dextrally coiled *Neogloboquadrina pachyderma typica* s.s., *Globorotalia menardii*, *G. tumida* and *G. menardii neoslexuosa*, *G. cultrata* and *G. hirsuta*.

## DISTRIBUTION

All the foraminiferal species listed here were present in the upper 100 m of water but their number decreased with depth. The populations of those preserved in the shelf sediments showed varying degrees of proportion : their percentage was high in the southern region, low in the northern region and transitional in the central region. The unusual high salinity of the water may be the causative factor for the paucity of foraminifera in the northern part.

The distribution of planktonic foraminifera is not only controlled by temperature ( Cifelli 1971 ) but also by factors like, salinity, upwelling and movement of water masses ( Zobel 1971, Setty 1972, 1973, 1977, 1979 ). However, changes in temperature may be regarded as being expressed in the irregularities of the faunal composition ( Rögl and Bolli 1973 ).

Hutson ( 1977 ) observed that some species in the Indian Ocean may show changes in the relative abundance and also species ranges between seasons. Thus the geographical range of *Globigerinoides conglobatus* decreases and that of *Globigerina rubescens* increases from May-June to August-September. Similarly the region of maximum abundance of *Globorotalia menardii* shifts northward between May-June and August-September while that of *Globoquadrina dutertrei* shifts southwards.

The cold and cooler water indicator planktonic foraminifera are *Globigerina bulloides* s.l., and dextrally coiled *Neogloboquadrina pachyderma typica* s.s., but those indicative of warm water are *Globigerinoides ruber*, *G. succulifer*, *Globorotalia menardii*, *G. menardii neoflexuosa* and *G. tumida*. But *G. rubescens* and *Orbulina universa* are indicators of the Central subtropical region of the Indian Ocean where the waters are consistently low in phosphates, very high in salinity and intermediate in temperature and oxygen values ( Be 1977 ).

From the post-southwest monsoonal productivity, tows yielded *Globigerina bulloides*, *Globigerinoides ruber* most abundantly while *Globigerinoides quadrilobatus succulifer*, *Globigerinella aequilateralis* and *Globorotalia menardii* decreased ( Setty 1972 ). The occurrence of *Globigerina bulloides* in coastal sediments of western India is indicative of upwelling in that region ( Zobel 1973, Be and Hutson 1977 ). Distribution of *G. bulloides* dextrally coiled *Neogloboquadrina pachyderma typica* s.s., and *Globoquadrina dutertrei* as well as *Globorotalia menardii*, *G. menardii neoflexuosa* relate to tropical warm waters and to the areas of cool upwelled waters ( Setty 1983 ). Dextrally coiled *Neogloboquadrina pachyderma typica* s.s. a cold to cool water species which appears in sediments off Kerala, Mangalore and Goa coasts and upto 23° N along western Indian shelf, is considered to originate in upwelled waters, immigrated and deposited in these

sediments (Setty 1977). Its record in the sediment explains the presence of such a water exchange and water movement (Setty 1979; 1983).

*Globorotalia menardii* and *G. menardii neoflexuosa* are tropical but live in deep or intermediate water masses hence irregular in upwelling areas (Setty 1983). Therefore, they are totally absent in the surface sediments near the upwelling zone off Cochin where tropical waters are known to exist.

*Globoquadrina dutertrei* and *Globigerinella aequilateralis* are present in boundary currents, areas of upwelling and near continental margins, hence they occur in higher frequencies in the assemblages of the shelf deposits of the southern region. *Globoquadrina hexagona* and *G. conglomerata* prefer regions of high temperature, and low salinity, hence they occur along Kerala Coast. *Globigerinoides conglobatus* which is a subtropical species and inhabits the central water mass and being resistant to solution, it is well preserved and encountered in the southern region only.

*Pulleniatina obliqueloculata* is quite abundant in the northern region of the sea but its distribution is quite ubiquitous. As its highest abundance is between 10°N–10°S in the Equatorial Current it is not present in the Central region.

*Globigerinoides ruber* and *G. succulifer* occur in the entire region but their percentage varies at each station. The inverse relationship between the two indicates that salinity rather than temperature has greater influence on their relative abundance. Thus *G. succulifer* which is relatively abundant in the southern region decreases towards the north while this pattern is reversed in the case of *G. ruber*. Therefore it may be stated that *G. ruber* occurs dominantly in subtropical waters whose salinity is higher than 36‰ while *G. succulifer* is predominant in tropical waters where salinity is less than 36‰. (Bé and Hutson 1977). *Globigerinella siphonifera* becomes abundant in the region where *G. succulifer* and *G. ruber* are not dominant (Zobel 1971). So it is observed that *G. succulifer* and *G. siphonifera* are dominant in the waters of the central and southern Arabian sea that is not influenced by high salinity from the north.

The distribution of the foraminiferal populations thus indicate the southward migration of high salinity Red Sea water mass and the Persian Gulf water mass into the Arabian Sea during the monsoon period. According to Düing and Schwill (1967) and Setty (1983) the dominant presence of *Globorotalia cultrata* and *Globigerinoides ruber* respectively in the faunal assemblages is a clear signature of the spreading pattern of these water masses. The distribution of foraminifera and the oceanographic parameters thus compliment the relative abundance, upwelling, water masses, mixing and water movement. Thus planktonic foraminiferal assemblages show effects of climatic control on water masses.

## ACKNOWLEDGEMENT

The author is thankful to the Director, National Institute of Oceanography for permission to publish this report paper.

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