

Can Bathymetry be a Discriminatory Factor for the Distribution of Benthic Foraminiferal Morpho-Groups in Modern Marine Sediments ?

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ABSTRACT

The foraminiferal content of one hundred eight modern marine sediment samples off Vengurla-Cochin sector (ranging in water depth from 30 to 1330 m), West Coast of India were studied. A total of two hundred four foraminiferal species (comprised of one hundred eighty benthic and twenty four planktonic species) were recorded. Based on the external morphology, the benthic foraminiferal population was clubbed into two coarser morpho-groups namely, angular-asymmetrical and rounded-symmetrical. The distribution profiles of these morpho-groups in the surface sediments apparently showed that angular-asymmetrical morpho-group is more or less abundant in deeper regions while, rounded-symmetrical morpho-group tends to flourish in relatively shallower regions. Such characteristic pattern indicates depth control over the external morphology of benthic foraminifera. Therefore, if these morpho-groups are studied in the subsurface, sediments may show great potential in generating proxy data for paleodepth.

INTRODUCTION

There has been a great deal of interest towards global sea level changes occurred in the

geological past. Foraminifera (an exclusively marine organism and sensitive to environmental changes) provide a good data set for evaluating such changes. However, their probable use in the paleobathymetric studies necessitates the need to record their response in the modern marine realm related to the depth. In view of this, benthic foraminiferal content has been studied off Vengurla-Cochin sector, West Coast of India to evaluate their depth linked modifications, utilizing the external test morphological features.

The significance of morpho-groups is initially recognised by Chamny (1976); Severin (1983); Jones and Charnock (1985) and, Bernhard (1986). Corliss and his co-workers studied the morphological differences between epifaunal and infaunal foraminiferal assemblages in deep sea sediments and use them to study paleoproductivity (Corliss, 1985 ; Corliss and Chen, 1988 and Corliss and Emerson, 1990). This is further confirmed by Widmark and Malmgren (1992). However, depth linked variations in the morpho-groups have been considered in the present study. For the present purpose, we studied the morphological groups (morpho-groups) of benthic foraminifera which are classified based on the external morphological features of the test, irrespective of the taxonomic status.

THE STUDY AREA

The continental shelf, off Vengurla-Cochin sector (West Coast of India) is bordered by the coastal mountain range of Western Ghats (Krishnan, 1968), which play a prominent role in the southwest monsoon of this tropical belt. The seasonal heavy precipitation is carried into the Arabian Sea through

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numerous streams and rivers in addition to the land run off. The rivers in the study area are Narmada, Tapi, Kali, Gangavali, Mandovi, Sharavati, Venkatapur, Yedamavina, Kollar, Chakra, Haladi, Sita Nadi, Madisal, Swarna Nadi, Shirva, Mulki, Gurpur, Netravati, Uppala, Chandragiri, Ariakuduva, Kavvayi puzha, Talipparamba, Valapattanam, Ponnani and Periyar. The shelf width is variable, being widest in the north (~350 km) off Bombay and narrower (~60 km off Cochin) to the south. In between these ranges, the shelf is around 80 km wide. The topography of the innershelf is smooth with a gentle slope, while the outershelf is characterized by numerous small prominences and undulations.

MATERIALS AND METHODS

One hundred eight surficial sediment samples were collected from the inner and outer shelf region off Vengurla-Cochin sector of West Coast of India (Fig. 1) onboard *R V Gaveshni* from water depth ranging from 30 to 1330 m using La Fond Dietz snapper and modified Peterson Grab Sampler. All samples were washed through a 63 μm sieve and oven dried. About 300-500 foraminifera were picked from weighed sample which includes benthic as well as planktonic foraminifera. Within benthic community, the population is further classified into two morpho-groups namely, rounded - symmetrical morpho-groups and angular - asymmetrical morpho-groups, which were based on external test morphologies, irrespective of the taxonomic level. Nigam and Khare (1994) have provided the details of the criterion for such classification.

RESULTS AND DISCUSSION

The foraminiferal study of the surface sediment samples off Vengurla-Cochin sector revealed the presence of two hundred four foraminiferal species belonging to 95 genera. Out of the total two hundred four species, one hundred eighty belong to the benthic foraminifera while twenty four belong to planktonic community.

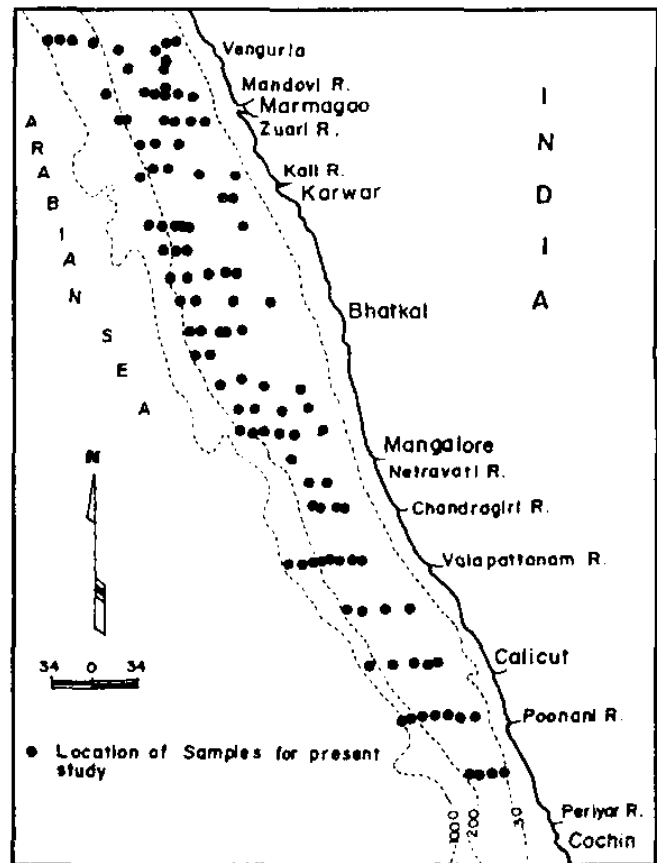


Fig. 1 : Location map of the study area.

Morphological variability in foraminifera has been related to various environmental properties (Bandy, 1959; Lutze, 1962; Hermelin, 1983; Nigam and Rao, 1987; Wetmore, 1987; Spencer, 1987 and Nigam, 1988). Pronounced intraspecific morphological variability can lead to erroneous taxonomy and misleading ecologic and evolutionary interpretations (Collins, 1989). Therefore, it was suggested that reliance should not be placed only on a single species but, efforts should be made to recognize an indexing assemblage (Sahni *in* Nigam, 1989).

In view of this, attention was paid to the coarser morphogroups. As discussed earlier, all one hundred eighty benthic foraminiferal species were clubbed into two morphological groups. The distribution of these morpho-groups in the surface sediments off Vengurla-Cochin sector revealed that angular-asymmetrical forms varied from 11.46 to 87.72 %, whereas rounded-symmetrical forms fluctuated between 12.25 and 84.14 %. In general,

the distribution profiles apparently showed that angular-asymmetrical morpho-group is more or less abundant in deeper regions (Fig. 2) while, rounded-symmetrical morpho-group tend to flourish in relatively shallow regions (Fig. 3).

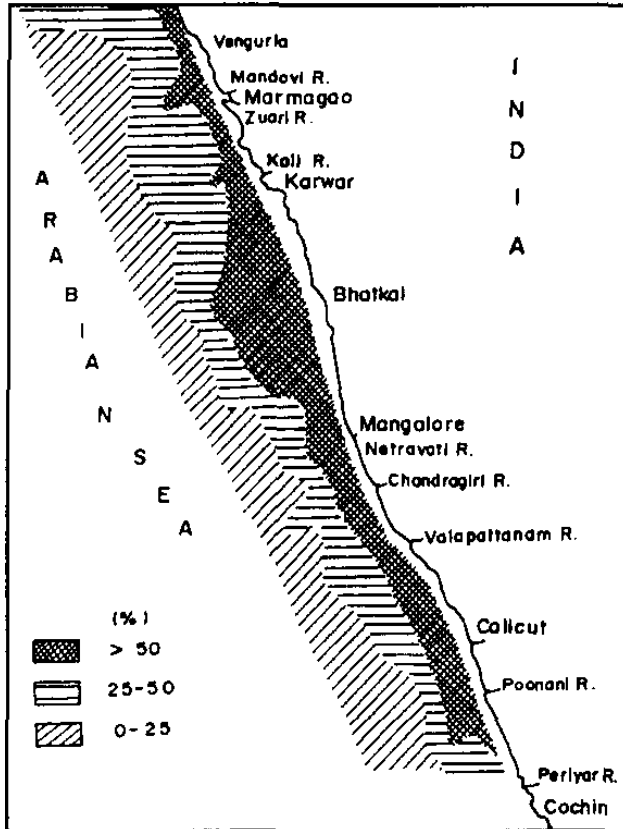


Fig. 3. Distribution of rounded-symmetrical morpho-groups in surface sediments off Vengurla-Cochin sector.

BATHYMETRY : A DISCRIMINATORY FACTOR FOR THE BENTHIC FORAMINIFERAL MORPHOGROUPS

The water depth not only influences different species of benthic foraminifera (Bandy and Arnal, 1960; Hermelin and Malmgren, 1980 ; Drooger, 1983; Spencer, 1987 and Naidu et al., 1989), but also controls the external test morphology, resulting in distinct morpho-groups.

Therefore, such characteristic distributions (Figs. 2 and 3) intuitively suggest that water depth played an important role in the test morphology of

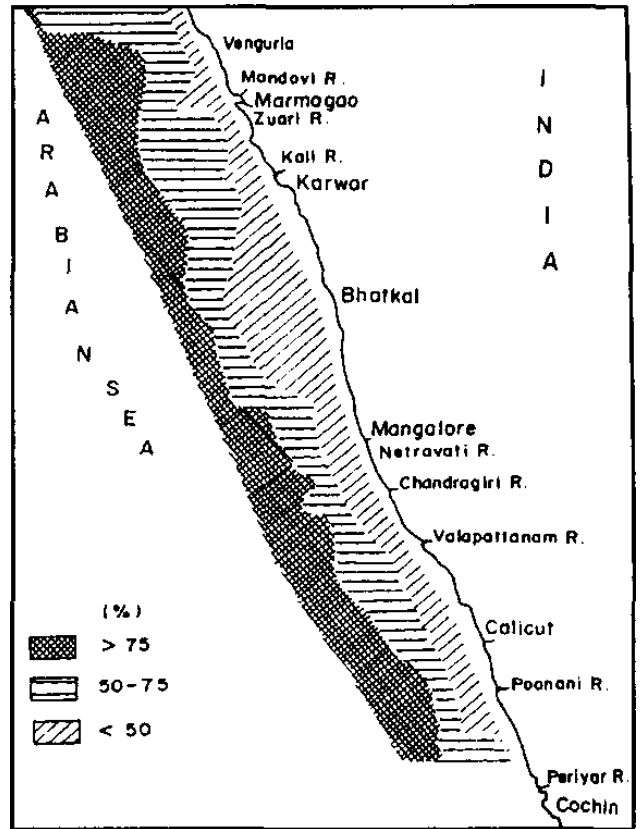


Fig. 2. Distribution of angular-asymmetrical morpho-groups in surface sediments off Vengurla-Cochin sector.

the benthic foraminifera. This could be attributed to the sediment turbulence because an increase in test asymmetry in deeper water is generally related to abiotic sediment turbulence. In turbulent conditions, the position and the orientation of foraminifera would be controlled largely by the motion of the sediments. Foraminifera with symmetrical tests are able to move more easily through the sediments and hence, are able to regain their preferred micro-habitat following the disturbance of the sediments by turbulence (Severin, 1983). Such turbulence shows a gradient from greater in shallow water to lesser in deep water. Therefore, an increase in the abundance of angular-asymmetrical forms in the deeper region is perhaps due to low turbulence in the ambient water. A reverse explanation holds good for rounded-symmetrical forms. The role of turbulence is also suggested by Nigam and Khare (1994) who observed less abundance of angular - asymmetrical forms in the

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regions affected by the river discharge and explained it to be due to the influence of river borne turbulence over these morpho-groups (Nigam et al., 1992).

The inferences of this paper are in agreement with Severin (1983) who suggested that sediment turbulence controls the distribution of various morpho-groups of foraminifera in modern sediments and found that overall angular and asymmetrical forms tend to occur in deeper water while round and symmetrical forms favour shallow water conditions.

CONCLUSIONS AND IMPLICATIONS

In view of the above, it may be concluded that the tendency of developing symmetry decreases with depth. Therefore, angular-asymmetrical morpho-group could be considered as an indicator of deeper environmental conditions while rounded-symmetrical forms suggest relatively shallow environmental conditions. Hence, if these morpho-groups are studied in subsurface sediments will show great potential in generating proxy data for paleodepth.

REFERENCES CITED

- Bandy, O.L., 1959, Geologic significance of coiling ratios in foraminifer *Globigerina pachyderma* (Ehrenberg) : Journal of Paleontology, v. 34, p. 671-681.
- Bandy, O. L. and R. Arnal, 1960, Concept in foraminiferal paleoecology : American Association of Petroleum Geology Bulletin, v. 41, p. 2037-2053.
- Bernhard, J. M., 1986, Characteristic assemblages and morphologies of benthic foraminifera from anoxic, organic rich deposits : Jurassic through Holocene : Journal of Foraminiferal Research, v. 16, p. 207-215.
- Chamny, T.P., 1976, Foraminiferal morphogroup symbol for paleoenvironmental interpretation of drilling cutting samples : Arctic America Albian Continental Margins : Maritime Sediments Special Publications, p. 585-624.
- Collins, L.S., 1989, Relationship of environmental gradients to morphologic variation within *Bulimina aculeata* and *B. marginata* Gulf of Maine : Journal of Foraminiferal Research, v. 9, p. 222-234.
- Corliss, B.H., 1985, Microhabitats of benthic foraminifera within deep sea sediments : Nature, v.314, p. 435-438.
- Corliss, B.H. and C. Chen, 1988, Morphotype pattern of Norwegian Sea, deep sea benthic foraminifera and ecological implications : Geology, v. 16, p. 716-719.
- Corliss, B.H. and S. Emerson, 1990, Distribution of Rose Bengal stained deep sea benthic foraminifera from the Nova Scotian continental margin and Gulf of Maine: Deep Sea Research, v. 37, p. 381-400.
- Drooger, C.W., 1983, Environmental gradients and evolutionary events in some larger foraminifera, in Meulenkamp, J.E., ed., Reconstruction of Marine Paleoenvironments Utrecht Micropaleontology Bulletin, p. 298.
- Hermelin, J.O.R., 1983, Biogeographic patterns of modern *Reophax dentaliniformis* and Brady (arenaceous benthic foraminifera) from the Baltic Sea : Journal of foraminiferal Research, v.13, p. 155-162.
- Hermelin, J.O.R. and B. Malmgren, 1980, Multivariate analysis of environmentally controlled variation in *Lagena* : Maastrichtian Sweden : Cretaceous Research, v. 1, p. 193-206.
- Jones, R. W. and M. A. Charnock, 1985, "Morphogroups" of agglutinated foraminifera, their life positions and feeding habits and potential applicability in paleoecological studies : Revue de Paleobiologie, v. 4, p. 311 -320.
- Krishnan, M.S., 1968, Geology of India and Burma : Higginbotham, p. 536.
- Lutze, G. F., 1962, Variationsstatistik and ökologie bei rezenten foraminiferen : Palaentologisches Zeitschrift, v.36, p. 252-265.

- Naidu, T. Y., Kamalakaram, S., and M.S. Rao, 1989, Benthic foraminifera as bathymetric indicators : Current Science, v. 12, p. 680-681.
- Nigam, R., 1988, Reproductive behaviour of benthic foraminifera: A key to paleoclimate: Proceedings of the Indian National Science Academy, v. 54, p. 585-594.
- Nigam, R., 1989, Geoscientific investigations of the sea bed for paleoclimatic inferences : Thrust area for priority research in the nineties : Memoirs Geological Society of India, v. 18, p. 113-117.
- Nigam, R. and A. S. Rao, 1987, Proloculus Size Variation in Recent Benthic Foraminifera : Implications for paleoclimatic studies: Estuarine, Coastal and Shelf Science, v.24, p. 649-655.
- Nigam, R. and N. Ichare, 1994, Effects of river discharge on the morphology of benthic foraminiferal test: Journal of Geological Society of India, v. 43, no. 4, p. 457-463.
- Nigam, R., Khare, N., and D.V. Borole, 1992, Can benthic foraminiferal morphogroups be used as an indicator of paleomonsoonal precipitation : Estuarine, Coastal and Shelf Science, v.34, p. 533-542.
- Severin, K .P., 1983, Test morphology of benthic foraminifera as a discriminator of biofacies : Marine Micropaleontology, v. 8, p. 65-76.
- Spencer, R.S ., 1987, Canonical variate analysis of selected benthic foraminifera : A preliminary study of a potential paleobathymetric tool : Palaios, v. 2, p. 91-100.
- Wetmore, K.L., 1987, Correlations between test strength, morphology and habitat in some benthic foraminifera from the coast of Washington : Journal of Foraminiferal Research, v. 17, p. 1-13.
- Widmark , J.G.V. and B. Malmgren, 1992, Benthic foraminiferal changes across the Cretaceous - Tertiary boundary in the deep sea ; DSDP sites 525, 527 and 465 : Journal Foraminiferal Research, v. 28, p. 81-113.