

Distributional pattern of benthic foraminiferal morpho-groups in the shelf region off Mangalore: Environmental implications

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The foraminiferal population in 45 surface sediment samples (20-86 m water depth) off Mangalore, was divided into benthic and planktonic assemblages. Within the benthic community based on the external test morphology, the population was further placed into two broad morpho-groups namely, angular-asymmetrical and rounded-symmetrical. The surficial distribution of these groups revealed that angular-asymmetrical forms are abundant in relatively deeper region whereas rounded-symmetrical forms flourish in nearshore regions. Such distinct distribution may be ascribed due to river borne turbulence. It further suggests that rounded-symmetrical forms favour high turbulence associated with increased fresh water river discharge in shallow regions. However, since fresh water river discharge is linked with precipitation over the catchment area, the results may show high potential in generating proxy data for the reconstruction of paleomonsoonal history through the study of morpho-groups in subsurface sediments of coastal regions. An anomaly in the distribution pattern is noticed off New Mangalore Port which is attributed to dredging for the navigational channel.

Among the numerous varieties of microorganisms, Foraminifera dominate modern ocean floor in the form of meiobenthic and macrobenthic communities. These are very sensitive to subtle changes in the ambient environment. The factors which influence their distribution and abundance on the ocean floor include bathymetry, sediment type, physico-chemical characters of bottom water masses, calcium carbonate saturation, oxygenation, salinity, temperature, organic matter input and surface productivity¹⁻⁶. Therefore, these organisms provide one of the best sources of proxy climatic information. In order to test the integrity of any parameter of Foraminifera to be used as climate proxy, it should first be studied in the present environmental conditions. In view of this, a study of foraminiferal content has been undertaken from the inner shelf region off Mangalore. The main emphasis is laid on the external morphology of benthic foraminiferal test with the aim to study their utility in the environmental studies.

Study area

The continental shelf, off Mangalore, (Fig.1) is bordered by the coastal mountain range of Western Ghats, consisting of Dharwarian metamorphosed rocks of gneisses, schists, phyllites, quartzite and chlorite schists⁷, which play a prominent role in the

southwest monsoon of this tropical belt. The seasonal heavy precipitation is carried into the Arabian Sea through numerous streams and rivers in addition to the land run off. Major river in the study area is

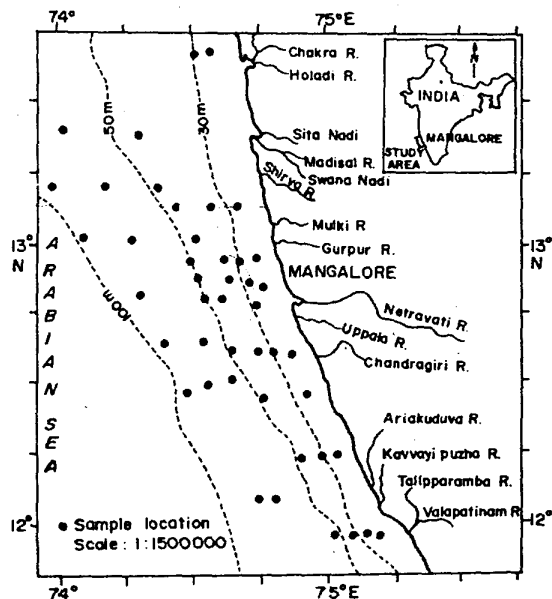


Fig. 1—Location of the surface sediment samples

Netravati which has an area of 3657 km² and annual average discharge of the order of $4615 \times 10^6/m^3$. In addition to these, other rivers are Venkatapur, Yedamavina, Kollar, Chakra, Haladi, Sita Nadi, Madisal, Swarna Nadi, Shirva, Mulki, Gurpur, Uppala, Chandragiri, Ariakuduva, Kavvayi Puzha, Talipparamba and Valapattanam for which data of annual average discharge and area are not available⁸.

The seasonal hydrographic parameters around this region are taken from Rivonkar & Reddy⁹. According to them the average temperature and salinity ranged from 28.32° to 29.17°C and between 33.66 to 34.18×10^{-3} respectively. Dissolved oxygen values ranged between 2.65 and 4.98 ml/l. The hydrogen ion concentration (pH) fluctuated between 8 and 8.6.

The important feature which is responsible for modification of the normal marine environmental setup to a certain extent is the establishment of the New Mangalore Port, since there has not been a proper channel maintenance to help open up water ways connecting the coast to the interior. Therefore, in order to make this Port navigable, a 12 m deep¹⁰ channel is created to a depth of 10 m. The sedimentary environment in and around the channel has already been studied¹¹.

Materials and Methods

Surficial sediment samples (45) from the inner shelf region off Mangalore (Fig. 1) were collected during various cruises of *RV Gaveshani* and *DSV Nand Rachit* from the water depth ranging from 20 to 86 m using Peterson grab. All the samples were washed through a 63 μ m sieve and oven dried. About 300-500 Foraminifera were picked from weighed sample. In each sample, the total foraminiferal population was divided into benthic and planktonic assemblages. The ratio between benthic and planktonic foraminifera (B/P ratio) in 1 g sediment was calculated and plotted in the surficial sediment samples. Within the benthic community, the population was further classified into two morpho-groups namely, rounded symmetrical and angular asymmetrical which was based on external test morphologies, irrespective of the taxonomic level. The details of the criteria and the working hypothesis have already been published¹². Since these two morpho-groups are complimentary to each other, the percentage distribution of only angular-asymmetrical group in the surface sediments is plotted.

Results

The ratio of benthic/planktonic Foraminifera

(B/P ratio) in surface sediment samples varied from 2.12 to 208. The profiles of B/P also showed a decreasing trend with depth with an anomaly in the general profile off New Mangalore Port (Fig. 2). It further suggested that there was a general increasing trend in the abundance of planktonic Foraminifera with depth. The inference of direct relationship of planktonic Foraminifera with water depth is in agreement with the findings of earlier studies¹³⁻¹⁷.

The entire population of benthic Foraminifera are placed into two morpho-groups, complimentary to each other. The distribution patterns of these morpho-groups revealed that in general angular-asymmetrical group varied from 10.40 to 76.51% (Fig. 3). In general, the distribution profiles apparently show that angular-asymmetrical morpho-group is relatively abundant in deeper regions, except an anomaly just off Mangalore (Fig. 3). A reverse trend holds good for rounded-symmetrical morpho-group.

Discussion

The significance of the morpho-groups in the environmental assessment has already been identified by various workers¹⁸⁻²¹. The results of the present study have shown that angular-

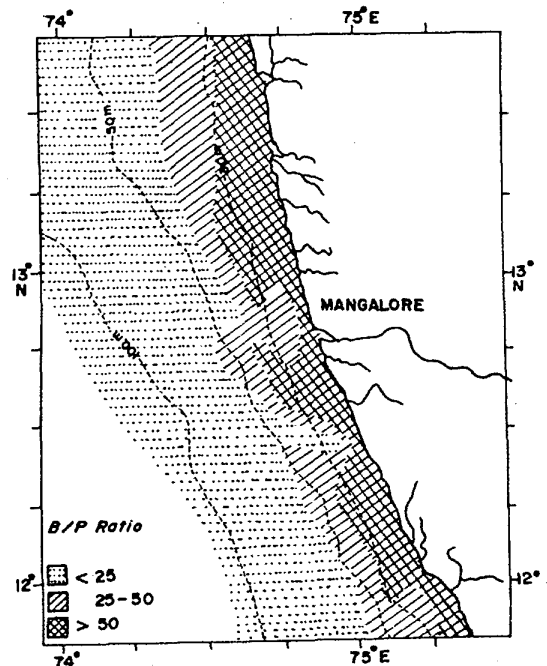


Fig. 2—Benthic and Planktonic (B/P) ratio of Foraminifera in the surface sediments off Mangalore

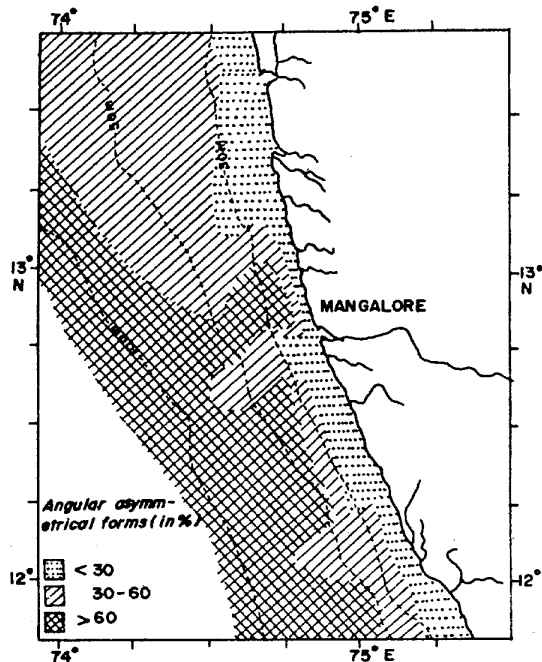


Fig. 3—Distribution pattern of angular-asymmetrical morpho-group in the surface sediments off Mangalore

asymmetrical group is abundant in deeper regions while rounded-symmetrical group being complimentary, tends to flourish in shallow region.

However, the environmental parameters of Indian coastal waters are largely controlled by the monsoons. Differential heating of land and ocean, which originates monsoon winds, finally leads to monsoonal rainfall over the Indian region. Fluctuations in temperature, rainfall, lowering of salinity, increase in suspended load and turbulence, changes in pH, dissolved oxygen, nutrients, CO₂, etc., in coastal waters are various interlinked phenomenon which might be responsible for bringing about the changes in the foraminiferal population in different ways²². Therefore, quantitative data of variations in the external morphology of benthic Foraminifera (i.e. the frequency variations in different morpho-groups) in the surficial sediments across the shallow water shelf region can be correlated with all or any one parameter. It is chosen here to explain morphological changes in benthic foraminifera as a key to monsoonal rainfall in terms of river induced turbulence. It is observed that the periods of monsoonal precipitation are apparently associated with an increase in the turbulence which is more

pronounced at the river mouths. Areal extent of turbulent area within coastal zone depends upon amount of fresh water discharge through rivers. Therefore, such depth related changes in the distribution off Mangalore shelf may be attributed to the sediment turbulence, because an increase in test asymmetry' in deeper water is generally related to abiotic sediment turbulence¹². Earlier also it was observed that sediment turbulence may govern the overall morphology and geometry of the epibenthic foraminiferal species and during the period of higher turbulence, species tend to develop more symmetry²³.

Hence, study of Foraminifera in modern sediments in coastal areas should get higher concentration of turbulence resistant assemblage (i.e. rounded-symmetrical foraminiferal forms) in the regions closer to the river mouths, gradually decreasing with distance from river mouths. The same ecological conditions should have an adverse effect over turbulence susceptible assemblages (i.e. angular-asymmetrical foraminiferal forms). Exactly similar distributional patterns are observed in these forms of benthic Foraminifera (Fig.3). In view of this, an increase in the abundance of angular-asymmetrical forms in the deeper portion where the effect of fresh water river discharge is exiguous is due to low turbulence in the ambient water.

As discussed earlier, the distribution patterns of rounded-symmetrical and angular-asymmetrical forms show an anomaly off Mangalore, where angular-asymmetrical forms are coming closer to the coast (Fig.3). A similar abnormality can also be seen in the distribution of planktonic Foraminifera as revealed in B/P ratio (Fig.2). Such abnormality in the behaviour of Foraminifera noticed off Mangalore is discussed here in the light of the dredging of a channel off the New Mangalore Port.

Since dredging is being done to keep the navigational channel for New Mangalore Port open, it is quite possible that sediments from relatively shallow region off Mangalore are being dumped further deep, increasing the relative abundance of those forms in deeper region which otherwise are supposed to be in shallower region (rounded-symmetrical forms). As a result more angular-asymmetrical forms are available even at shallower depth off Mangalore Port. As the dredging operation is being continued, therefore, further foraminiferal investigation based on living and total foraminiferal distribution in close grid samples from this particular area may be useful as a model to monitor/assess the modification in the environmental set up due to dredging operations in any area.

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