PREFACE

In recent years, based on proxy indicators, the reconstruction of paleoenvironment on geological and historical time scales have gained importance as they provide a background of natural climatic variability within which man’s impact could be evaluated. Amongst the proxy indicators, the foraminifera have great potential as indicator of ancient climate due to their wide spread abundance in space and time and their sensitivity towards environmental conditions. The accuracy and reliability of foraminifer-based paleoenvironmental reconstructions depend upon understanding distributional patterns of modern species relative to environmental factors that limit their occurrences. During the last decade a vast amount of data have been generated on distribution of modern and ancient foraminifera in the world’s oceans. Studies on the ecology and distribution of Recent foraminifera in the different marine ecosystems provide a data base with which fossil forms may be compared and interpreted.

In India, particularly from the eastern Arabian Sea, the examination of literature on Holocene foraminifera shows that most of the work on foraminifera are confined to their distribution in coastal sediments. Realizing the necessity to enhance the data base, a study was taken up of the Recent benthic and planktonic foraminifera from the outershelf sediments off the central (Vengurla-Mangalore) west coast of India, an area which is hitherto not studied in detail. The study deals with fundamental and applied aspects of foraminifera.

The fundamental aspect includes the identification, illustration, taxonomy and quantitative distribution of foraminiferal microfossils in the surface sediment samples
whereas, the applied aspects deals with the paleoenvironmental significance of foraminifera.

The studies carried out and presented in this thesis have been divided into eight chapters for practical convenience.

Chapter 1 deals with the general introduction, review of previous work, nature and objectives of the investigation.

Chapter 2 provides a general insight into the methodology of onboard collection of samples and laboratory procedures. In all seventy six surface sediment samples were collected from the area extending between Vengurla in the north and Mangalore in the south and from 44 m water depth towards the east and 1330 m water depth toward the deeper part of the sea, the western side. These samples were analyzed in the laboratory and the foraminifera were separated into relict and recent comprising of both planktonic and benthic foraminifers.

In order to understand the modern oceanographic conditions and their possible influence on foraminiferal distribution in surface sediments, the physiographic and oceanographic settings and sediment types of the Arabian Sea in general and the western continental margin of India in particular, are presented in Chapter 3.

Chapter 4 deals with the fundamental approach; Systematic Paleontology. Here the different genera of foraminifera have been arranged according to the classification proposed in ‘Foraminiferal Genera and their classification’ by Loeblich and Tappan (1988) wherein different species within a single genus are arranged alphabetically. Synonymies have been reduced greatly with only those references which refer to an important shift in the generic name along with all possible references from the Indian waters. In all 219 species have been identified from this part of the Arabian
Sea. The species encountered during the study are photographed by using a Scanning Electron Microscope JEOL TM 300 and are illustrated in 24 plates.

The results concerning 'Composition and distribution of foraminifera' within the study area are dealt in Chapter 5.

The foraminiferal composition has revealed the presence of 219 species belonging to 54 Families, 31 Superfamilies, and 7 Suborders.

The Planktonic Foraminifera comprise 24 species. The areal distribution of significant species were computed and presented as percentage distribution maps. It was observed that many species like Gallitellia vivans, Globigerina bulloides, Globigerina falconensis, Neogloboquadrina hexagona, and Globigerinella aequilateralis show abundance at stations of shallower depths, whereas Neogloboquadrina dutertrei, Globorotalia menardii, P. obliquiloculata, T. ambitacrenna, Globigerinoides ruber, G. sacculifer, G. tenellus, Globoturborotalita rubescens, Neogloboquadrina pachyderma and Turborotalita quinqueloba are more abundant at the deeper stations.

Out of 195 Benthic foraminiferal species 30 species have been reported for the first time from the Arabian Sea: Siphonaperta minuta, Pyrgo fornasinii, Pyrgoella dokici, Triloculina cf. T. affinis, Pseudohauerina orientalis, Dentalina aff. D protumida, Laevidentalina aff. L. aphelis, Laevidentalina aff. L. subemaciata, Nodosaria ambigua, Nodosaria intercellularis, Mesolenticulina partidiana, Neolenticulina chathamensis, Hyalinonetrion sahulense, Procerolagena gracilis, Pygmaeoseistron hispidula, Fissurina lucida, Lagenosolenia aff. L. soulei, Bolivina spinescens, Ehrenbergina serrata, Sagrinella aff. S. guinai, Globobulimina pervesa, Uvigerina asperula, Uvigerina mediterranea, Eponides regularis, Eponides tenerus, Epistominella narraensis, Nonionella hantkeni, Nonionella pulchella, Elphidium selyense, Valvobifarina sp. However, most of them are rare. The benthic assemblages (in percentage) have been used to study the interrelationship between organisms within the benthic community and the
surrounding environment. It is observed that outershelf and slope fauna differ from the innershelf fauna (studied by earlier workers).

In order to study the inter genera relationship among the benthic foraminiferal population, R-mode cluster and Q-mode factor analysis techniques are employed. The results obtained from these two independent analyses are in agreement with each other.

In Chapter 6, certain characteristics of benthic foraminifera are used to determine paleoshoreline using:

i) **Species depth distribution**
The distribution patterns of mainly benthic species which are roughly arranged along a depth gradient have been used to reconstruct the paleobathymetry. The statistical analyses show that the benthic fauna can be divided into shallow, deep and transitional assemblages.

ii) **Relict foraminifera**
It was observed that there exist a zone between 60—90 m water depth which shows abundance of relict foraminifera. The foraminiferal assemblage is composed of *Amphistegina, Operculina, etc.* The assemblage is mainly indicative of shallow water environment thereby suggesting a paleoshoreline.

iii) **Barnacle fouling on relict foraminifera**
Abundant relict foraminiferal specimens encrusted with intertidal sessile cirripedes *Tetraclita squamosa* were encountered in 9—11 K years old surface sediments in a depth zone between 60 and 90 m on the western continental margin. This species occurs in modern high salinity environments elsewhere, but are absent in the recent environment within the study area. It implies that *T. squamosa* lived in this area and encrusted on foraminiferal tests when sea level was low (about 10 K years B.P.) and salinity was higher. However it could not keep pace with rise in sea level (and also
with change in salinity pattern) and disappeared in course of time. Hence, the encrustation of barnacles on relict foraminiferal specimens can be considered as an additional tool to monitor paleoshoreline changes.

In Chapter 7, Planktonic foraminifera is used to develop a regional model for paleobathymetric determination.

It is well known that there is an increase in the number of planktonic foraminifera as a function of depth. Study of the ratio between planktonic and benthic foraminifera shows that variation in the ratio can be used for paleodepth determination. A regional model for paleodepth determination based on the above relationship has been constructed for the western continental margin of India in the Arabian Sea. This model was derived using a total of 126 surface sediment samples [data from present study along with published / unpublished data available in other reports] and is expressed in the form of the following equation:

\[ D = e^{(0.0496 \times p + 3.036)} \]

where 'p' = percentage of planktonic foraminifera in total fauna
'D' = depth in metres

Comparison of the results from the Atlantic margin of northeast United States, Gulf of Mexico, Timor Sea and Red Sea indicates that in spite of diversity between various areas, the overall pattern indicates a positive correlation between planktonic percentage and depth. However, each regional model shows some minor deviation and this is attributed to regional differences in salinity pattern.

The proposed model is advantageous in certain aspects as it requires no species level identification of the fauna. It is sufficient to separate the fauna into two groups, i.e., planktonic and benthic. This model indicates potential for further research as new paleobathymetric data base can be created for preparing sea level fluctuation curve.
The methodology to determine paleoshoreline and the development of a model to obtain information for paleobathymetry are in line with objectives of many International projects like the Past Global Changes (PAGES) studies under International Geosphere Biosphere Programme (IGBP) and Project 274 of International Geological Correlation Programme (IGCP)] and National programmes [Thrust areas identified by CSIR, DOD, DST, and DOEn].

Chapter 8 synthesises the conclusions of the present study.

This Chapter is followed by references in alphabetical order of the literature cited in text, explanation to the plates, and Appendices.