Chapter 5

Relict benthic foraminifera: Sea level fluctuation

5.1. Introduction

A general interest has been created worldwide in the current and future global sea-level change. This interest has grown along with the concern over global warming due to the increasing amount of greenhouse gases. Out of several consequences of global warming, accelerated sea level rise is a matter of great concern. A number of projections have been given (Fig. 5.1) indicating the amount of sea level rise in the coming century (IPCC report, 2007). Even for the Indian region the recent reports indicated that sea level is rising along the Indian coast at the regional average rate of 1.29 mm/ year (Unnikrishnan and Shankar, 2007).

In order to develop predictive models for sea level changes, a stage has been reached where investigators of climate and sea level relationships call for long term records of sea level changes in the past and more so since the end of the last glaciation. The past sea level records are required for two purposes; 1. To check the
validity of predictive models based on tide gauge record by applying them for estimating the past sea level changes. Besides anthropogenic changes, there are number of natural causes for sea level fluctuations. Therefore, it is necessary to have the natural climatic variability over which man's influence can be evaluated.

In view of the above, quite a few attempts have been made to decipher sea level fluctuation along the west coast of India (Bruckner, 1989; Merh, 1992; Hashimi et al., 1995; Rao et al., 1996; Vora et al., 1996; Mazumder, 2005). For this reason Hashimi et al. (1995) proposed a comprehensive sea level curve for the west coast of India. Although there are few attempts to generate an idea about sea level curve for the east coast of India (Vaz, 1996, 2000; Vaz and Banerjee, 1997; Banerjee, 2000 and Rana et al., 2007), no comprehensive sea level curve could be proposed for east coast of India due to less number of studies from east coast of India. In order to enhance our available information for sea level change along east coast of India, an attempt has been made in the present study.

Foraminifera have been used extensively worldwide to generate information regarding sea level changes. Out of several parameters of foraminifera (Nigam and Henriques, 1992), relict foraminifera have also been used for this purpose. Based on the distribution and ecology of relict foraminifera, sea level fluctuations have been documented for the west coast of India (Mazumder, 2005) and off Myanmar coast (Panchang et al., 2008). As relict foraminifera have been encountered in few surface sediment samples in present study, they may provide an idea about sea level fluctuation along the east coast of India. The objective of the chapter is to present foraminiferal evidence for sea level fluctuation along east coast of India, supported by presence of sclerite fauna.

5.2. What are Relict Foraminifera?

Relict foraminifera are those foraminifera which remain exposed on the seafloor for long geological periods without any major transportation, and can be identified by their earthy colour, dull luster, broken parts with deposition of some secondary material (Murray, 1991). The larger foraminifera, in contrast to recent foraminifera, are earthy and dull in appearance and identified as relict foraminifera. Apparently, lack of burial in the sediments is the reason that these tests remained exposed on sea bed/floor for thousands of years and so this dull appearance. The larger foraminiferal
genera encountered in the present study mainly include *Amphistegina*, *Operculina*, *Calcarina* and *Alveolinella* (Fig. 5.2).

![Fig. 5.2 Soft coral sclerites (A) and relict larger foraminiferal assemblage typical of coral reef: *Calcarina* (B), *Operculina* (C), *Alveolinella* (D) and *Amphistegina* (E), found in the study area.]

5.3. Distribution of relict foraminifera

Out of 79 surface sediment samples analysed, 16 samples (Fig. 5.3) have relict fauna. The samples were collected from a water depth range of 36 – 110 m.

5.4. Supporting data

In addition to foraminiferal fauna, sclerites belonging to soft coral assemblages were also found (Fig. 5.4). Similar fauna was found off Myanmar region and Panchang *et*
al. (2008) has given an excellent account of how this information can be used as supporting information for coral indicator benthic foraminiferal fauna. The table
given by Panchang et al. (2008) is reproduced below (Table 5.1).

According to Panchang et al. (2008), “Based on the average of the depth preference of the different soft coral species 17.5 m is taken as the common depth and added to the depth at which the relict fauna occurs”. In addition to this, an error bar of ± 12.5 m was used to generate sea level curve, which accounts for a variation from 5 – 30 m (Fig. 5.4). This information is used in the present study. In absence of the dating of relict fauna, five published radiocarbon dates (Vaz, 1996 & 2000; Rao et al. 1990 and Mohana Rao and Rao, 1994) from the region off the east coast of India were used as a function of the depth for the samples where relict fauna were found.

| Table 5.1: The ecological depth preferences of soft coral assemblages (Panchang et al., 2008) |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Name of Soft Coral species                      | 0-5             | 6-10            | 11-15           | 16-20           | 20-25           | 25-30           |
| *Siphonogorgia godeffrayi* Kolliker, 1874        |                 |                 |                 |                 |                 |                 |
| *Chironephthya* cf. *macrospiculata* Thomson & Henderson, 1906 |                 |                 |                 |                 |                 |                 |
| *Subergorgia suberosa* (Palla, 1766)            |                 |                 |                 |                 |                 |                 |
| *Acalycigorgia* sp.                            |                 |                 |                 |                 |                 |                 |
| *Ctenocella* (Ellisella) sp.                    |                 |                 |                 |                 |                 |                 |

5.5. Discussion

The larger foraminifera *Amphistegina, Operculina, Calcarina* and *Alveolinella* found in the present study are considered as typical fauna for coral reef environment (Langer and Lipps, 2003). Secondly the samples containing relict foraminifera also contain abundant soft coral sclerites (Fig. 5.2). Such relict foraminiferal and coral sclerite assemblage suggestive of presence of coral reefs in the past, have also been reported along the west coast of India (Mazumder, 2005) and west coast of Myanmar (Panchang, 2008). The sclerites found in the present study belong to the soft coral assemblage of *Lemnalia, Chironephthya* and *Acalycigorgia*, and have a depth preference for 5 to 20 m and inhabit flat reefs (Gosliner et al., 1996). The occurrence of these sclerites strengthens our postulation about the existence of former corals at a depth approximately between 60 to 80 m.

Fossil coral reefs have been reported in the study area, off Mahabalipuram (115 m) and off Karaikal (125 m), and were suggested to represent the globally lowest
sea level stand during the Last Glacial Maximum (LGM) (Vaz, 1996, 2000). Singh & Swamy (2006) have compiled all the reports of relict sediments from east coast shelf and the records of low sea-level stand which includes heavy minerals enriched sands, peat beds, oolite, carbonate sand and carbonate buildups. These evidences of low sea stands have been assigned to three spatially pronounced depth zones (Mohana Rao and Rao, 1994; Banerjee and Sengupta, 1992) approximately 30 m, 60 m and 110 m. These different sea stands have been attributed to episodic events of sea level rise and stand. However, the samples containing relict fauna occur within a depth zone of ~36 to 110 m, though majority of the locations are within the water depth zone of 60 to 80 m. When these sample locations were plotted on the near shore bathymetric map (Fig. 5.3), they coincided with relict sand zones deposited during the past low sea stands. Mohana Rao & Rao (1994) had postulated the possible presence of a reef feature slightly buried under a thin veneer of sediment at ~60 m depth. The occurrence of abundant relict reef fauna at this depth in the present study confirms that postulation.

To reconstruct the pliable sea-level curve in the study area, the ecology of the soft coral species (as interpreted from the sclerites) was used. The applicability of coral sclerites is due to the fact that different species of soft corals produce different forms of sclerites and thus serves as the basis of identification. The distribution of soft coral assemblages are depth dependant and thus in the present work can help in assigning the sea level. As per Panchang et al. (2008) the soft coral assemblage found in this region suggests a depth preference of 5-30 m. Considering 17.5 m as an
average optimum depth for the proliferation of the coral fauna; a pliable sea level is being proposed for the study area, representing the geological time between 8,900 and 13,850 years B.P. Based on this data, it can be said that during these ~5000 year period, sea level rose to approximately 70 m.

5.6. Conclusion and implication

Occurrence of relict fauna at three different depths 110-80 m, 80 to 60 m and 30 m probably indicates different sea stands, suggesting episodic sea level rise during Late Pleistocene and early Holocene. A tentative sea level curve is proposed for the period between ~14,000 to ~9,000 years B.P. for the central east coast of India. The reconstruction of paleosealevel variation over the Bay of Bengal region during the last few thousand years is still in its infancy. A comprehensive sea level curve for the Bay of Bengal similar to the one proposed for the eastern Arabian Sea (Hashimi et. al., 1995) is the need of the hour.