Relict benthic foraminifera in surface as well as sub-surface sediment off Gopalpur- Palur, Odisha: Indicator of sea level changes

Sachin Kumar Tripathi & Sarath L.G.

1Geological Survey of India, M &CSD, Kolkata, 700091, India
2Geological Survey of India, M &CSD, Mangalore, 575001, India

[*E-mail: stripathi208@gmail.com]

Received 24 April 2015; revised 13 June 2016

A conceptual framework was proposed based on the occurrence of relict foraminiferal assemblage and soft coral sclerites at different water depth between 60, 70 to 100 m, explain the sea level variation during different times in the geological past. Faunal ecology and presence of relict sand body at different isobaths suggests an episodic sea level rise in this region.

[Keywords: Coral Sclerites, Sea level variation, Isobaths, faunal ecology].

Introduction

Despite of change in the atmospheric variables, global sea-level rise is one of the good markers of climatic change. Global atmospheric temperature rise has a direct effect on ocean, causing rise in ocean temperature and melting of glaciers since Last Glacier Maxima (18,000 yrs BP). Both these processes lead to rise in global sea level changes. These changes recorded in oceanic sediments and it would consider as most valuable record of palaeoclimate. Since Bay of Bengal is one of unique sedimentary basin in the Indian vicinity, where Ganga and Brahmaputra river system bring a huge quantum of sediment from Himalayan province and deposited over continental shelf to form a vast deltaic and pro-deltaic domain in the part of Bengal basin. Introspect the palaeo-climatic changes and nature of occurrences of smaller benthonic foraminifera, recorded within the sediment column of the study area was considered for detailed study. Because these microorganisms are widely distributed in the marine clam and are used as stratigraphic guide. To understand the paleo-ecological behavior of the microorganism, present work was taken up along the Gopalpur - Palur coast area (Fig. 1). Where, eastwardly flowing peninsular river is debouching a huge load of sediments and fresh water into slightly steeper continental shelf and modifying the sub aqueous setup of the study area. River discharge also affecting the morphology, chemistry and ecological processes of the fluvio-marine setup of the continental shelf. The coarse sediment deposited at various depths in the study area is not associated with present day near shore sediments.

Materials and Methods

Twenty two (22) sediment samples (subsamples of the gravity cores and representative samples of grabs), collected from the water depth 50 to 120m along the coast off Gopalpur- Palur between latitude 19° 00’-19° 18’ N and longitude 85° 00’ to 85° 18’ E during R.V. Samudra Kaustubh cruises, as part of annual field season programme of Geological Survey of India, were used for present study. Here smaller benthonic foraminifera have been used as a proxy for relative sea level changes.
In laboratory, seabed samples were naturally dried and reference portion of samples were systematically taken for analysis. Reference samples were soaked in 60 ml of 6% H$_2$O$_2$ (Hydrogen Peroxide) and left over night to remove organic content. Soaked samples were wet sieved with running distilled water through fine nozzle over 230 ASTM and 100 ASTM mesh sieves. The separated +230 and +100 fractions were weighed and preserved in separate labeled containers. Representative parts of each sample were thoroughly examined under stereo zoom microscope for estimation of both terrigenous and biogenic constituents in the samples. Tests of micro fauna were picked, grouped and mounted on micropaleontological trays.

**Results**

Washed residue of reference samples of 20 grab and subsamples of two gravity core samples were analyzed, in which 11 samples contain relatively large sized relict benthonic foraminifera along with recent benthonic foraminifera, are comparatively smaller in size with smooth shells. Occurrence of anomalous sediment in surface as well as sub surface samples contain oxidized sand, chunks of carbonate material with coral fragments, benthic foraminifera, oolites, bivalves, gastropods and burrows over submarine ridges. It seems that the relict sand bodies at most of the places are covered with recent sediment and their exposures are limited throughout the east coast. Sample from the relict zone contains large sized benthonic foraminifers along with oolite grains. At some locations the coral polyp and *Amphistegina* sp., are highly broken and showing some mechanical breaking on their test due to transportation. Apart from surface samples; some sub surface samples (ST-217/GC-11* and ST-219/GC-3*), below 50 to 80 cm from the sea surface, sediment samples contain ample number of oolite grains and relict foraminifer tests (Fig. 2). The occurrence of relict sand with relict foraminifera and typical shallow water benthic foraminiferal taxa at different deeper isobaths (60m, 80m and 110m water depth) is also observed.

**Discussion**

The relict foraminifera are dull and earthy in appearance as compared to recent foraminifera. Their dull and earthy luster may be due to lack of burial in sediments which means that these tests were exposed for a longer period and resulted destruction of body texture. This implies that these benthic foraminiferal tests remain attached to the host sediment and develop secondary feature by virtue of taphonomy. They had also been noticed by Murray$^4$ and Lahiri A$^5$. Among these relict tests some are prominent i.e. *Amphistegina lessoni*, *Amphistegina radiata*, *Calcarina* sp., *Ocerculina ammoniodes*, *Aveolinella* sp., and coral sclerites (Plate-1). Recorded sclerites belong to soft coral assemblage of *Siphonogorgia*, *Lemnalia*, *Chronophthya*, *Subergorgia*, *Acalvoigorgia* and *Ctenocella* confirm the prevalence of shallow marine environment. Similar observations have been reported along the west coast of India and
coast of Myanmar in Andaman Sea, suggesting presence of coral reef in geological past\(^6\); \(^7\), Amphistegina sp., Oперculina sp., Calcarina sp. and Aveolinella sp. found in the study area are considered as a typical fauna of coral reef environment\(^8\).

The existence of sclerites in the study area at 65m, 80m, 90m and 110m depth, suggest lowest sea level stand during Last Glacial Maxima (LGM). Singh and Swamy\(^9\) has compiled all the reports of low sea level stand including heavy mineral enriched sand, peat bed, oolites, carbonate sand and carbonate buildups providing strength to the present study. Reef features observed under thin layer of sediments at depth approximately 60m and 110m water depth, as similar observation was also noticed in the study of Rao, K. M and Rao, T C S\(^10\). Occurrence of relict fauna and coral sclerite at this depth in study area support postulation of low sea stand. Different species of soft corals produces different form of sclerites at different depth and it serves as tools for assigning sea level. Modern day corals exist both in temperate and tropical shallow waters. Where, tropical coral do not grow at water depth of over 50 meter\(^11\). But in the study area, coral assemblages noticed below 80 to 110 meter water depth within relict sand body indicates rise in sea level.

Study of the earlier researcher\(^12\),\(^13\),\(^14\),\(^15\) around the world, revealed the fact of Last Glacial Cycle around 35 ka yrs B P and it reached 122m below present sea level about 20-18ka B P, from here begins with the warming of the global climate which ultimately led to the transgression. This event was followed by slighter cooler phase at 8690 yrs BP\(^12\), during this period the sea level was 76- 80 m below the present day sea level and it ended with the rise in sea level and it reached its present level about 6 ka yrs. BP. Then further, there was rose of sea level by at least 4.7m and it was followed by cooler phase\(^12\), which lowered the sea level to about 2.7m above the present sea level. Moreover the study area is characterized by a series of regressive and transgressive sequences, which carried the signal of climatic changes and sea level oscillations in form of relict sand bodies along with relict foraminifer test at different water depth along the coast.

The interpretation by Rao et al.\(^16\), Rao, K. M. and Rao T C S\(^10\), Vaz G. G\(^17\),\(^18\), and Rana et al.\(^19\) on age and paleo-environment correlation have been taken as reference to compare the paleo environment and age of sediments for present study. Panda et al.\(^20\) dated carbonaceous matter from Gopalpur- Malud area at a water depth of 52 m, shows an age of around 10,690±120yr BP matches with the observation of the present study. Based on the published age data the average rate of sea level rise during the period (8,900 to 13,600 year) was approximately 1.5 cm/ year\(^19\).

Plate 1- (scale bar = 0.33 mm): 1- Calcarina sp. 2 &5- Coral sclerites. 3- Aveolinella sp; 4-Ammonia beccarii. 6- Relict Quinqueloculina sp. 7 Reworked Coral polyp. 8- Reworked Amphistegina sp.

Sea level rise postulation is not only supported by the coral reef environment but also the interpretation based on facies study and clay mineralogy of sediment column, revealed episodic sea level changes. Low Chlorite to Illite ratio found in the down-core sediment column in present study reveals that the palaeo-climate and environment of deposition would have been very humid in nature, and influenced by strong monsoon during the sea level rise that happened in the Inter-glacial period after LGM\(^21\). According to Rao and Rao\(^10\) regressive phase of deposition was overlain by transgressive phase of sedimentation. These cycles of relative sea level changes might have been developed due to global changes in sea level during late Pleistocene to
Holocene and recent. Sea level oscillations have left its imprints in the form of coast parallel topographic highs (Aeolian sediments) in the study area are suggested to be formed by successive dunes building arid phase during LGM and middle Holocene.22, 20. Presence of many epifaunal benthic foraminifera such as Amphistegina sp., Quinqueloculina sp., Spirorculina sp. and Bolivina sp., as nucleus of the oolites both in surface as well as subsurface samples at different horizons in the cores, implies the prevalence of shallow marine environment. Oolites grains are characteristic of shallow water, high energy, hypersaline environment of deposition and may be contemporaneous with the low sea stand (Fig. 2). The presence of planktonic foraminifera Sphaeroidinella dehiscens, Globigerina bulloides, Globigerinoides ruber, Gs. Sacculifer along with Globigerinella calida, Gr. tosaensis and Gr. peripheroronda in the sediments of the survey area provides a probable age of Late Pleistocene to early Holocene 23, 24, 25.

Conclusion
Presence of anomalous sediments at deeper isobaths (50,70 and 100m) like oxidized sand, chunks of carbonate material with coral fragments, relic benthic foraminifera, oolites, and burrows over the submarine ridges indicate a very shallow marine environment. Ferruginous and oxidized surface of concretionary materials confirms its exposure above sea level during regression. Occurrence of relict foraminifera like Amphistegina, Operculina, Calcarina and Alveolina at different isobaths suggesting the periodic sea level rise during Late Pleistocene to early Holocene. Presence of soft coral sclerites at different water depth between 60 to 100 m indicates episodic sea level changes. Sea level oscillations has left its imprints in the form of coast parallel topographic highs/ridges, traced within the water depth range of 70 m to 80 m, 90 m to 96 m and 102 m to 110 m, which can be termed as the palaeo-strandlines/beach ridges. Presence of oolites, detritus and shallow water biota at 70 m to 80 m and 125m isobaths indicates the position of paleo sea stands. Planktonic foraminifer such as Sphaeroidinoida dehiscens along with Globigerinella calida, Gr. tosaensis and Gr. peripheroronda provides an age which could be Late Pleistocene to early Holocene.

Acknowledgement
Authors are grateful to Deputy Director General, ER GSI Kolkata and Dr. Amitava Lahiri, Director, M&CSD Kolkata, for his guidance and encouragement during this study.

References


