

# Holocene Sea Levels of Visakhapatnam Shelf, East Coast of India

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**Abstract:** The Holocene sea level changes in the shelf areas off Visakhapatnam was studied from sediment distribution pattern and shallow seismic profiling. Morphological features on the shelf indicate a Late Pleistocene regression down to about -130 m below the present sea level. A major stillstand of the transgressive sea was recorded at about -80 m where coarse carbonates and shallow water fauna predominate. During this period algal barrier reefs with reliefs varying from 2 to 8 m were developed between -85 m ( $10790 \pm 170$  years B.P.) and -100 m ( $12530 \pm 170$  years B.P.). Buried reefs observed at about -60 m give a clue for a possible strandline at this depth. Coarse clastic sand patch having mean size of around 1.0 Phi between -20 to -30 m suggests another strand line. The sea level rise during Holocene transgression seems to be discontinuous with temporary pauses.

**Keywords:** Sea levels, Holocene, East coast of India

## INTRODUCTION

The continental shelf of Visakhapatnam was earlier studied by several researchers and considered to be a drowned coast due to Late Pleistocene deglaciation (Subbarao 1964, Venkataratnam 1968, Rao *et al* 1980, Murthy *et al* 1987 and Murthy 1989). The Holocene transgression has developed different environments in sedimentary processes at different levels over the shelf. The nondepositional environments are well exposed over the central eastern shelf due to insufficient supply of sediment input from the terrestrial regions. In this paper, an attempt is made to study some events relating to the Holocene sea level in the shelf areas off Visakhapatnam.

## MATERIALS AND METHODS

The surficial sediment samples of the shelf between Bhimunipatnam and Pudimadaka (Fig.1) were collected by Peterson grab during R.V. Gaveshani cruise No. 179 during 1987 and by Van Veen grab in the near shore areas on fishing trawler. The subbottom data (shallow seismic sections) were also collected using high resolution continuous seismic profiler (1000

joules EG&G Sparker unit) across the shelf from 50 m isobath to shelf edge during the same RV Gaveshani cruise. The texture of the sediment samples were determined by dry sieving technique for the sand fraction ( $> 62 \mu\text{m}$ ) and pipette method for the mud fraction ( $< 62 \mu\text{m}$ ). The sediment types were classified based after Shepard (1954). Radiocarbon dates for the carbonate rocks were determined by the Birbal Sahni Institute of Palaeobotany, Lucknow.

## RESULTS AND DISCUSSION

The sediment distribution map (fig 1) shows the existence of sandy sediments up to -30 m water depth in which 20-30 m zone is comprised of coarse sediments having the mean size of around 1.0 Phi and the other part is occupied by fine sands. Silty sands appear up to about -50 m water depth followed by silty clays up to -80 m depth. From 80 -100 m silty and coarse sands are noticed in general. Carbonate rocks occur at places in the outer shelf regions.

The shallow seismic profiles (fig 1) revealed significant features like submerged terraces, pinnacles, dome shaped shelf edge reefs and other uneven features (Fig 2). Profile 1

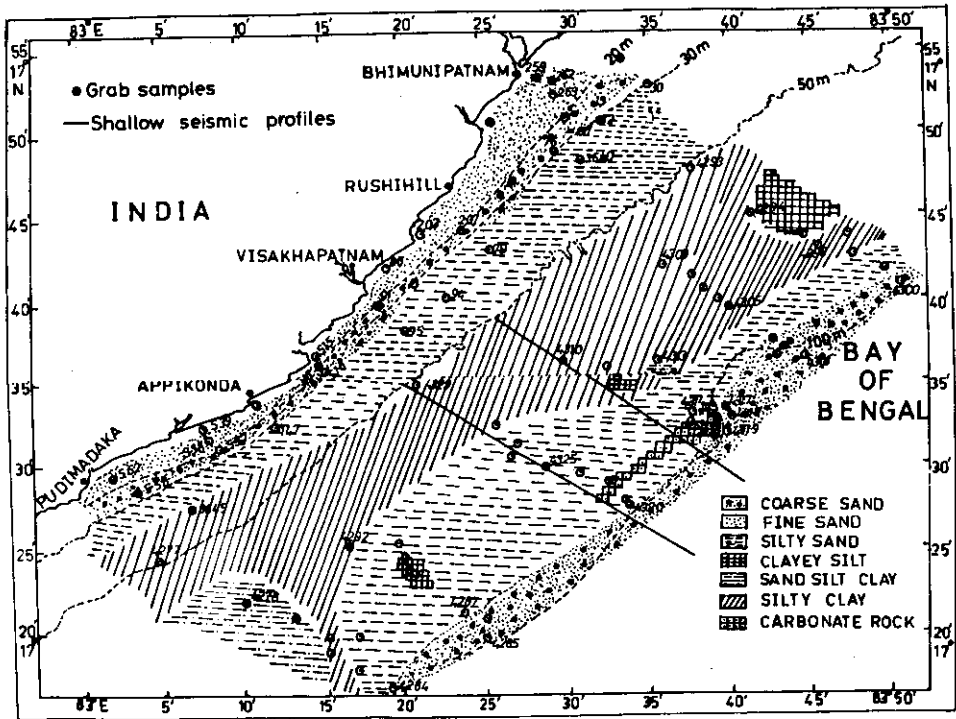


Fig.1. Location map of sediment samples and two shallow seismic profiles and sediment distribution pattern. Profile 1 is off Visakhapatnam and Profile 2 is off Appikonda.

shows the presence of carbonate terrace features (A & B in Fig 2a) with reliefs varying from 2 to 8 m at depths 80-100 m. A dome shaped shelf edge reef (C) of about 15-20 m in relief is recorded on seaward dipping reflection. This suggests that the late Pleistocene regression could have extended up to the depth of -130 m which is in agreement with global studies on the sea level lowering during Late Pleistocene (Milliman and Emery 1968; Bloom 1977; Van Andel and Lianas, 1984). Similar features observed in the profile 2(b in Fig 2) at the same depth indicates that the dome shaped shelf edge reef runs parallel to the coast and forms a barrier reef which is separated by a lagoon from the carbonate terrace complex at 80 to 85 m depth. Similar kind of shelf edge barrier reefs found elsewhere were described as Holocene or Pleistocene relict reefs (Macintyre, 1972 and Lighty *et al* 1978).

The carbonate rock samples collected, one at -100 m (station number 4285 Lat. 17° 19.8' Long.83° 25') and the other at -85 m. (station no.4316 Lat 17° 32.8' Long.83° 39') were subjected for  $^{14}\text{C}$  dating and the dates obtained are  $12,530 \pm 170$  years b.p. and  $10,790 \pm 170$  years b.p. respectively. Though the sample no. 4285 is not falling on the shallow seismic profile, the age obtained for this sample is taken for the same depth of the profile no. 1 for interpretation purpose (fig 2). The radiocarbon dates suggest that the Post glacial Holocene transgression started earlier than 12,500 years b.p. If the age of 18,000 years b.p. for the last glacial maximum (Fairbanks 1989) is applied to this shelf the sea level rise during the initial stages of Holocene transgression is noticed to be rapid. The shelf edge barrier reef without any rugged surfaces, preserving its shape, and partially filled back lagoon (fig 2) also suggests a rapid

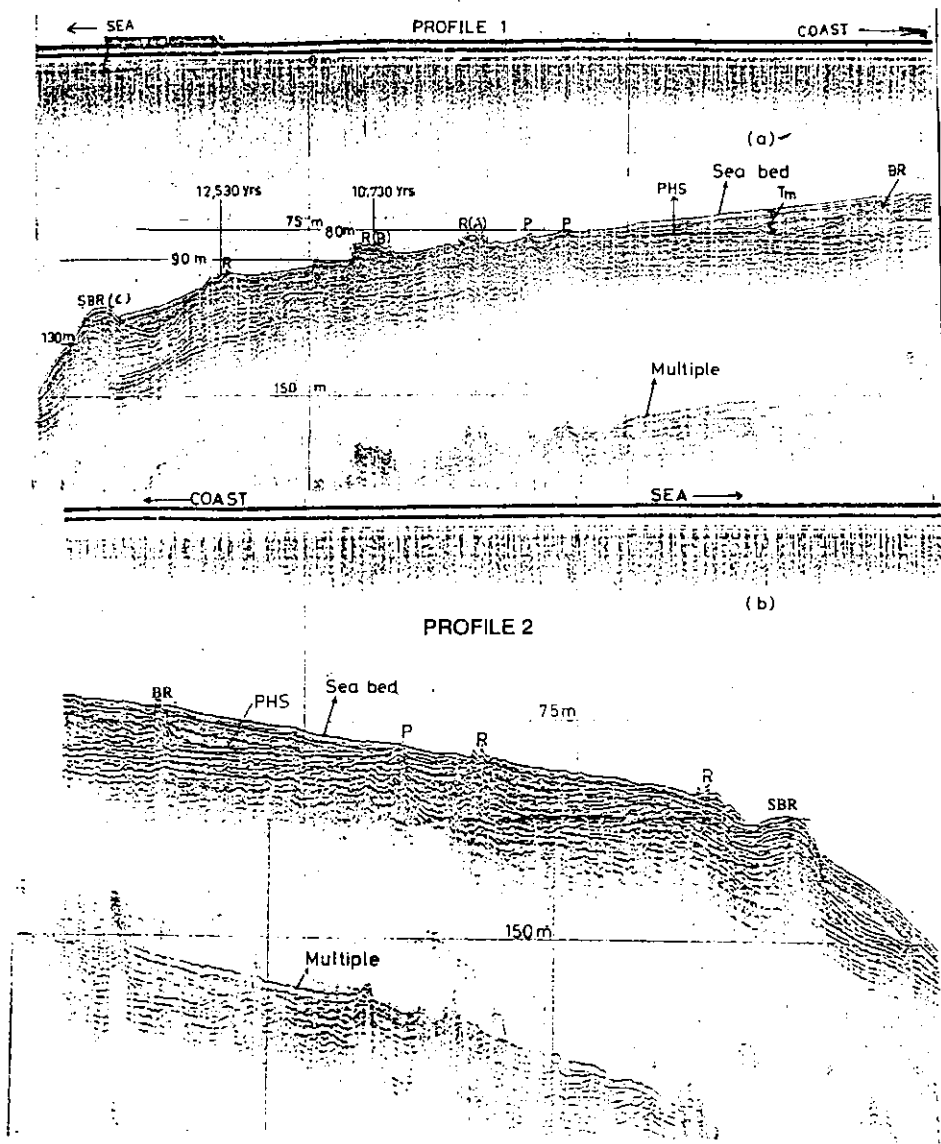


Fig.2. Shallow seismic records of profiles No.1 and 2 showing the features of Holocene reefs (R), shelf edge barrier reef (SBR) buried reef (BR), pinnacles (p), Pre-Holocene surface (PHS) and Terrigenous mudwedge (T<sub>m</sub>).

rise of sea level. Rampino and Sanders (1983) stated that the preservation of morphological characteristics is due to rapid rise in the sea level.

A major stillstand of the transgressive sea was recorded at about -80 m in the outer shelf

where coarse carbonate sands in the form of ooids and shallow water fauna are noticed. Based on the coarse fraction studies, this part of the shelf is attributed to lower sea levels (Subbarao 1964). During this stillstand period algal barrier reefs with reliefs varying from 2-8

m (fig 2) were developed between 85-100 m depth. With rising of the sea level, the reef growth was abruptly terminated leaving the rugged surfaces. The exposure of relict sediments in association with shallow water fauna from -80 m seaward and the gradual thinning of modern terrigenous mudwedge seaward up to -80 m (fig 2) suggest that the sea level rise reached to minimum around this depth (-80 m) where the radiocarbon date indicated the age of around 10790 years b.p. Fairbanks (1989) termed this stage as the beginning of the Younger Dryas Chronozone where the rate of sea level rise was minimum at 11,000 years b.p.

A reef feature (BR in Fig 2a) slightly buried under a thin veneer of sediment cover and grown over a pre-Holocene surface (PHS) at about -60 m in the profile 1 and the same feature cropping out at the same depth in profile 2 suggests that there could be another stillstand around this depth. Exposed features of such type at the same depth of this shelf are attributed to be of barrier reefs developed during Holocene period (Murthy *et al.* 1987 and Mahapatro *et al.* 1992).

The mean grain size of the sandy sediments collected in the innershelf from -5 m to -30 m ranges from 0.8 to 3.2 phi. Fine sands are confined to nearshore regions, that is, from 5 to 20 m depth whereas the coarse sands having the mean size of around 1.0 phi exist between 20 and 30 m depth. Occurrence of these coarse clastic sandy sediments in a relatively low energy conditions compared to the beach environment suggests that they must have been deposited in the littoral zone during the lower sea level times. The existence of similar sand body at these depths is interpreted to be relict shorelines of Holocene period (Mohana Rao *et al.* 1989 and Purnachander Reddy and Durga Prasad Rao 1992). The radiocarbon dating of carbonates

obtained at -17 m depth off Nizampatnam in this shelf gave an age of  $8,200 \pm 120$  years b.p. (Srinivasarao *et al.* 1990). These observations indicate that there was temporary pause in the sea level rise during the Holocene transgression around 8,000 years b.p. Pujos *et al.* (1990) from their studies of French Guiana continental shelf reported that the shoreline was close to -25 m around 8,000 years b.p. which supplements our interpretation of a lower sea level around 20-30 m depth.

## CONCLUSIONS

From the morphological characteristics of the outer shelf and evidences from the carbonate dating of the reef sediments, it is understood that the post glacial Holocene transgression started earlier than 12,500 years. The sea level rise was rapid during the initial stages of transgression. After initiation of the Holocene transgression the sea level was at stand still at about -80 m for some time and it again rose to about -60 m depth. The limited growth of reef features around -60 m suggests that the break was not for a long time. The sea level then advanced to -20 to -30 m depth as evidenced from the clastic sedimentation with coarse sands deposited in the littoral zone and silts and clays seaward. The sea level rise during Holocene transgression was not continuous and was interrupted by temporary pauses.

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