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REVIEW ARTICLE

QUATERNARY SEA LEVEL CHANGES ALONG INDIAN COAST

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Indian subcontinent has vast coastline and a varied Quaternary history but unfortunately limited data pertaining to the sea level changes have been generated. On the east coast, the available information is based on strandline generated erosional and depositional features. West coast is better investigated and studies on its continental shelf zone provide much data on the low strandlines during the late Quaternary. Information on high strandlines is available from the Gujarat coastline.

A critical analysis of all available evidences including that furnished by the miliolite rocks of Saurashtra, points to a Middle Pleistocene high sea, around 25m asl which subsequently regressed to a level as low as 150m bsl at the close of Pleistocene. Dependable information on late Pleistocene high sea is yet to be generated, but it is not unlikely that its level was more or less the same as the present. During Holocene the sea rose to as much as 6 to 10m asl around 6 kyrs, which has now regressed and stabilised at the present level.

We do not know much about the early Quaternary strandlines. Perhaps, the Lower Pleistocene never witnessed a major transgression or regression. A perusal of the Plio-Pleistocene marine sequences of Kutch, Saurashtra and South Gujarat, and the coastal plain continental sediments of the Central Gujarat, points to the facts that the close of Pliocene witnessed a significant regression and almost all throughout the lower Pleistocene, delicately balanced regressive-transgressive conditions prevailed, thereby giving rise to a considerable thickness of sediments of mixed (fluvio-marine, deltaic) environment.

Key Words: Quaternary; Sea-levels; East-coast; West-coast; Miliolite

Introduction

Indian subcontinent has a vast coastline and a varied Quaternary history, but unfortunately very limited data have been generated pertaining to the sea level changes. Practically, nothing is known about the early Pleistocene, and our information for the late Pleistocene and Holocene strandlines is also fragmentary. About 4 years back I had reviewed the then available information on coastal segments[1]. Since then, more studies have been carried out and in this paper, efforts have been made to highlight the importance of new data.

Along the east coast, sea level studies have mostly been restricted to depositional and erosional features like inland beach ridges, rock terraces and caves, submerged valleys, gravels and shelf breaks. The available information is qualitative and comprises descriptions of strandline generated features near the various delta mouths. West coast provides better information not only on the

coastal erosional and depositional features related to high strandlines, but also on the offshore continental shelf zone. With the help of radiometric dates available now, it is possible to arrive at a reasonably good picture of sea level behaviour along the Indian coast.

East Coast

Bhattacharya and Banerjee[2] giving a preliminary account of the Quaternary geology and geomorphology of the Ajay-Bhagirathi valley in Birbhum and Murshidabad districts of West Bengal, invoked oscillations in the sea level related to glacial and interglacial stages. Banerjee and Sen[3,4] investigated the subsurface Holocene sediments around Calcutta from paleo-biological point of view, and reported existence of mangrove forests about 6000 yrs. B.P. Niyogi[5,6] reported three terrace levels 6.1, 4.7 and 3.8m above MSL in the Subarnrekha river delta and the adjoining coast of West Bengal, and according to him, the entire delta with all its features was post-Pleistocene. In the Orissa and Andhra coasts which are better investigated, a higher strandline extending 20 to 30km inland and of the order of + 10m high is postulated[7-12].

Studies off Visakhapatnam coast of Andhra Pradesh[10-13,14,15] have provided some data on high and low strandlines; features related to these sea levels have been chronologically arranged to indicate an early strandline + 7 to + 10m which regressed to − 25m and then again arose to the present level (Prudhvi Raju and Vaidyanadhan[10]). Perhaps the − 25m does not indicate the ultimate depth of the regression because the late Pleistocene low sea level all over the world has been of the order of − 120 to − 150m. Other workers have reported submerged shorelines at various depths[16,17]. Terraces and karst-like features at − 70 and -130m and carbonate reefs at − 50 to -60m provide evidences of sea stands at various stages of the Holocene transgression. Although no dates are assigned by these workers, they have suggested that the last transgression was post-glacial (Flandrian). The higher sea-stand according to them is related to an earlier transgression. Recently, Bruckner[18] has stated that the Holocene sea along the Visakhapatnam coast was highest around 5100 ± 70 B.P., and according to him the higher sea level reported by other workers was the last interglacial sea. A low sea-stand − 10 to − 11m has been provisionally dated 8000-6000 B.P. by Prudhvi Raju[15] on the basis of drowned valleys and submarine topography.

Southward, around Godavari delta, Sambasiva Rao and Vaidyanadhan[8] have recorded farthest strandline features (almost 35km inland) to be + 8m while the nearest, + 2m high (about 2km away from the coastline), and grouped them in Holocene. Subsequently Bruckner[18] has dated the ones within 18km from the present coast to be around 3600 ± 700 B.P. Comparable beach ridges (4 to 6m high) from Krishna river delta have been reported by others also[12,19]. Ages of samples (peat/wood material, shell fragments, calcrete rich mud etc.) taken from the farthest ancient beach ridge to the nearest one from Krishna delta gave a range of 6500 year B.P. to 2050 year B.P.[20]. 14C dating of mollusc shell from a bar located at about 25 km from the present coastline in the Nizampatnam Bay adjoining western part of Krishna delta, gave an age

of 8200 ± 120yr B.P. suggesting a Holocene strandline of −17m. There appears to have been a rapid rise in the sea level here around 8000yr B.P., when the above barrier island (lenticular sand body) was drowned and the shorezone migrated landward[21]. Evidences of low sea stands at −49 and −56m near Pulicat lake in the form of pebble horizons have been identified by Nageswara Rao[22]. A sequence of ridges from Cauvery delta, indicative of at least three strandlines, each rising 7.2, 6.9 and 5.5 above the present sea level have been described by Sambasiva Rao[23]. Earlier, Meijerink[24] had invoked a low standline −70m at the close of the Wurm glacial stage, which rose rapidly to the present level in the course of post-glacial transgression innundating 11000-12000 years old Pleistocene fluvial deposits.

According to Bruckner[18], during the late Quaternary (Upper Pleistocene) transgression along Tamilnadu coast, the sea level arose between +2 to +8m during last interglacial stage and the Holocene transgression according to him reached its maximum during 6240 to 2740 years B.P., the level hardly rising ½ to 1m above the present. The terraces around Mandapam and Rameswaram coast ranging in height above MSL from 0.62 to 0.20 metres, give ages varying from 5440 ± 60 to 140 ± 45[25].

West Coast

The west coast of India is better investigated, though its southern part has received less attention. Some studies on the Kerala coastline are there but none pertain to sea level changes. According to Vaidyanadhan[12], the Kerala coast indicates filling up of a series of bays during the Holocene with mud and later sands, dating to 4460 yrs B.C. Along Karnataka coast, Vaidyanadhan (quoted by Prudhvi Raju[15]) recognised various geomorphic features pointing to emergence and submergence of coast due to sea level fluctuations.

Central portion of the west coast has been extensively investigated, but most of the studies covering Goa and Maharashtra, are on the continental shelf forms, features and sediments. Maximum contribution has come from Nair and his associates at NIO[26-30] who have studied the shelf configuration and sediments at various depths, and have proposed a carbonate sedimentation model on the western shelf which throws much light on the sea level changes during late Quaternary. Studies by this group constitute most dependable and authentic data on the continental shelf zone, and the findings provide a lot of information on the behaviour of the late Pleistocene-early Holocene sea during its transgressive rise. These workers have recognized four still-stands of sea level indicated by submerged terraces at −92, −85, −75 and −55m. The radiocarbon ages 9000 to 11000 yrs B.P. indicate formation of these terraces during the transgressive phase of the Holocene sea. Rao[31] who examined the pisolitic limestones from a depth of 60m has come across evidences of these pisolites having formed under semi-arid conditions around 9135 ± 130 yrs B.P. Prevalence of inter-tidal to sub-tidal conditions at −120 to −150m around 11040 ± 400 yrs B.P. have been reported by Nair and Rao[32]. They have further stated that around 8950 yrs B.P., vadose conditions prevailed at the −95 to −85m (Fifty Fathom Flat), submergence of which took place during the subse-

quent rise of the sea. The sea level reached its present position between 5000 and 6000 yrs B.P. One of the significant findings by these workers is that of recording the occurrence of an older limestone (130 to 170 kyr B.P.) located at proximity to the coast at a relatively shallow depth of −65m. They consider this rock to belong to a late Middle to early Upper Pleistocene high sea level.

An interesting aspect of the findings of the N.I.O. Group is that the shelf sediments located at different depths point to their formation during various stages of regressive-transgressive sequence, and the radiometric ages provide a clue to their having formed during late Pleistocene and early Holocene. These workers have attempted to correlate the events along Ratnagiri and Goa continental shelf with the global transgressions and regressions envisaged by Moore[33] who showed, six interglacial high sea levels with high points between −40m and +7m, and five low sea level positions (upto −70m) during late Pleistocene (between 28,000 and 135,000 yrs B.P.) relative to the present level. During the high sea levels, carbonate sedimentation took place on the shelf, and during the subsequent regressive phases, the carbonate sediments were subjected to sub-aerial diagenesis. Recently, Rao *et al.*[34] have reported occurrence of 25m thick relect Halimda bioherm on the Fifty Fathom Flat, and these workers, assuming the open ocean Halimeda accumulation rate (5.9m/1000 yrs), have envisaged that Halimeda growth might have started around 14,000 yrs B.P. and have estimated that the sea level was −112m at about 13,700 yrs B.P. This estimate is slightly higher than the global sea level position at this time reported by Fairbanks[35].

As onshore studies did not fall within the scope of activities of NIO, little information has been provided on the strandline-related onshore coastal landforms and deposits. These features have been studied by other workers along Maharashtra and Gujarat coasts. All along the northern part of the west coast, especially in Gujarat, evidences of more than one high strandlines are encountered. Of course, differences of opinion prevail in respect of the heights and ages of these high strandlines.

The first ever attempt to understand and date sea level fluctuations along the Konkan coast with the help of radiocarbon age data of beach rocks, was made by Agrawal and Guzder[36,37]. According to these workers, between 30,000 to 35,000 yrs B.P. the sea was very much lower; it rose around 30,000 yrs B.P. and this was followed by a regression. The sea rose again around 15,000 yrs B.P. attaining a maximum during the Mid-Holocene, and around 6000 yrs B.P., the sea level was almost the same as present, but in subsequent times, i.e., between 6000 and 2000 yrs B.P., a further rise upto +6m is indicated. Kale and Rajaguru[38] have reconstructed the late Quaternary transgressional and regressional history of the west coast, taking into account the studies of their associates[39,40,41] on Konkan coast and synthesizing them with the radiometric dates available from other sources along the west coast. The sea level curve prepared by them shows a low (−138m) sea level around 12000 yrs B.P., a figure which broadly compares with the global findings. These workers postulated a rapid rise of level from 12000 yrs B.P. onwards, finally attaining the present level around 5000-6000 yrs B.P. An important observation

made by these workers pertains to the last interglacial transgression (about 1,20,000 yrs B.P.) when the sea rose almost to the same level as the present, and according to them the sea has always been lower than the present for a large part of the late Pleistocene, while the Holocene sea oscillated above and below the present level several times in the course of the last 6000 yrs.

That the Holocene sea (post-glacial) had arisen several metres above the present level, is amply evidenced by several features along Maharashtra and Gujarat coasts. Occurrence of beach rock (littoral concrete, 'Karal') at heights ranging from 2 to 10m above the MSL along Maharashtra coast all along from Ratnagiri in the south to as far north as Dahanu[41-46] clearly depicts that the Holocene sea had arisen several metres and then regressed to its present level. This Holocene high sea level is very well indicated in Gujarat. Along the Mainland Gujarat coast, beach rocks are absent, but instead a good and conspicuous development of raised mudflats and sandy beaches (with associated stabilised coastal dune ridges) occurring high above the water level (almost + 10m) several kilometers inland, is an obvious evidence of the last high strandline, which has now come down to the present level. In Saurashtra, this high sea is represented by semi-consolidated beach rocks and coral reefs[47-49]. The beach rocks of Saurashtra are identical to those of Maharashtra and more or less occur at same heights above the MSL. Gupta[49] classified the corals into two age groups on the basis of radiocarbon dates viz., 5500 ± 1000 and $25{,}000 \pm 10{,}000$ suggesting that they represented two high sea stands. Somayajalu *et al.*[50] who dated the corals by Uranium decay method, however confirmed only 6000 yrs. group, and according to them the older corals show an age range of 11800-176000 yrs. Evidently, the younger corals point to the Holocene high sea, whereas the older ones grew in a sea that gave rise to miliolite rocks, dating back to Middle Pleistocene. The Holocene sea also appears to have fluctuated in the course of last 6000 yrs, and a marked regression is indicated between 3000 and 5000 yrs B.P.[51].

The best example of the Holocene transgression however is provided by the Ranns of Kutch, which typically represent remnants of a high sea and furnish numerous evidences of strandline regression during historical times. Perhaps this sea rose to almost +6 to +8m and indications of this rise are seen as calcareous grits and swash marks on the rocky islands of the Great Rann, much above the rann level. Sea level fluctuated even during the last 6000 yrs. A number of Harappan sea-ports existed in the Great Rann of Kutch and in the Gulfs of Kutch and Cambay around 4000 yrs B.C. Studies on the Little Rann[52-54] point to sea level fluctuations even within the Holocene. The Great Rann was under water and navigable during 325 BC when Alexander, the Great, invaded India. Till 2000 yrs B.P., the Gulf of Kutch extended upto the Little Rann and joined up with the Gulf of Cambay[55].

Maximum information on Quaternary high strandlines has come from Gujarat, specially Saurashtra, which has been investigated by numerous workers because of the miliolite rocks. These rocks occur not only along the coastal zone as stabilised sheets and dunes, but they also occur several kilometers inland, at various elevations[56]. The occurrence of sheet miliolites at different

heights prompted many workers to invoke a succession of high strandlines during Quaternary. Verma and Mathur[54] recognised five levels and correlated them with the worldwide eustatic high sea levels of Fairbridge[58]. Some other workers[59-61] have also invoked higher strandlines, but they have not been categorical about their correlatability with global levels. A decade back, synthesizing the observations of various workers on miliolite problem, five progressively decreasing levels of marine miliolite occurrences in Saurashtra corresponding to related transgressions during the interglacials were envisaged by me[62]. Subsequently, after encountering a number of new occurrences of miliolite in the northern portions of Saurashtra[63], I came to the conclusion that the high sea which deposited miliolite had never arisen to those heights and the differences in the elevations of sheet miliolites were on account of differential uplifts (subsequent to their deposition) along tectonic blocks. In the absence of any isotopic age data it was assumed that this high strandline dated back to early Upper Pleistocene which regressed to a depth of −20m during the late Upper Pleistocene[64]. This picture however, stands radically modified in the light of new information available. Recent studies on Saurashtra miliolites by my colleague Patel[65] has provided convincing evidence of a +20 to +25m high transline. He has made a very significant observation that the coastal miliolites represent a typical beach-dune complex of several generations and form a series of dune ridges, parallel to the west and south coast, the innermost ridge being almost 15 to 18km inland. The components of coastal miliolites are thus both marine and aeolian, and comprise two formations, a lower one of shell limestone (=consolidated beach rock) and the overlying 'miliolite' *sensu stricto* representing coastal dune material resting over beach sediments, the entire thickness pointing to a shore-line deposition. Significantly, the underlying beach rock extends landward for several kilometers, but only upto an elevation of 25m. Beyond this altitude, nowhere this shell limestone is encountered, and the miliolite is seen resting directly over older rocks. This +25m limit upto which beach rocks occur, typically indicates a high strandline. The present day shoreline and the littoral zone are made up of submerged and dissected consolidated beach rocks and miliolite ridges, which now form underwater platform or project out as stacks or rise above the HWL as 6 to 8m high cliffs. The succession of coastal ridges points to their formation during periods of stillstands of a falling sea. The underwater coastal miliolites formed during the regressive phase are now submerged by the subsequent Holocene transgression.

Radiometric dates do not help much in fixing the dates of transgression precisely, and the available information is rather conflicting. An attempt was made by Agrawal[66-69] to fix the age of miliolites by 14C method. He visualised a high sea around 30,000 yrs B.P. that generated miliolite material. But the subsequent workers do not agree with him, as 30,000 yrs B.P. was a period of global regression, and from nowhere transgressive strandline is reported. More recent radiometric dates based on Th-230/u-234 and 14C studies[69,70] provide some clue towards understanding the behaviour of the sea that gave rise to miliolite. The dates given by them point to three age groups of miliolite formation, 60 to 70, 75 to 115 and 140 to 210 kyrs. These authors have correlated

the two younger age groups with two transgressive sea levels of Moore[33]. In the case of the oldest age group (140-210 kyrs), a high sea level around 170 kyrs is invoked. Baskaran *et al.*[69,70] do not invoke a high sea level and their Quaternary sea that generated miliolites (now occurring at various heights) was never higher than the present. They explain their present elevations by invoking tectonic upliftment of the order of 0.23 to 2.2mm per year during the late Quaternary. An upliftment of such magnitude is not acceptable to most workers, nor the abundance of typical and diagnostic aeolian features preserved in most of the inland occurrences can be ignored.

Miliolite rock, especially the inland ones occurring at various altitudes, does point out to it having been formed by reworking, deflation and re-deposition of coastal carbonate sand, and Gupta[71] has expressed his reservations about the dates given by Baskaran *et al.*[70]. The role of neotectonism and the uplift of the magnitude envisaged[70,72] are very difficult to comprehend because such uplifts could not have been selective affecting only the miliolite occurrences. Bruckner *et al.*[73] also do not accept a marine origin for all miliolite occurrences, and on the basis of chronostratigraphic, petrologic and palaeontological evidences, these workers have concluded that the inland miliolites were of aeolian origin, point to a meteoric-vadose cementation and that no feature was indicative of a marine origin; the inland miliolites thus indicated neither late Quaternary marine transgressions nor any uplift. According to these authors, only 10-15km wide miliolite belt along the coast pointed to a marine origin. The radiometric dates have also been disputed by these workers, as they have found that the untreated rock specimens would give mixed ages only because the dated carbonates comprised forams as well as the cements. On the basis of ESR dates, they have assigned an age of 125 kyrs to coastal miliolites deposited during the last interglacial transgression.

I, therefore, find the radiometric data useful only to a certain extent in fixing a broad age range (Middle Pleistocene to Upper Pleistocene) to the high strandline which progressively fell down to a very low level (-150m) by the close of Pleistocene. The fall must have punctuated by a number of transgressions and regressions. Bruckner *et al.*[73] invoked a high strandline ($+30$m) during 'Old Middle Quaternary' and a $+5$ to $+3$m high sea during the last interglacial.

The Pleistocene sea level picture, thus is quite confusing, and it is rather difficult to take rigid postures in respect of the absolute ages and values of the various sea levels. Particularly when this is done on the basis of Saurashtra carbonate rocks which are of more than one generation, deposited under marine, aeolian and fluviomarine environments over an extended time span. The radiometric dates however do help us in establishing that the material of the miliolite rock originated during several sea stands going back up to almost Middle Pleistocene.

The terminal Pleistocene sea had gone down to almost -150m along the western continental shelf. It is difficult to categorically state anything about the late Pleistocene transgression during the last interglacial. If at all it took place, either it never arose above the present level and we would never come across exposed *in situ* carbonate sediments of that sea, or it not unlikely that the mili-

olite of the youngest age group comprised aeolian derivatives of the products of the late Pleistocene high sea.

Considering all aspects and various field evidences I would tend to agree with Patel that the highest strandline in Saurashtra was around +25m. Evidences of this Middle Pleistocene high strandline from other parts of the Gujarat coast have also been recorded. Along the Kutch coast, several geomorphic features, especially the behaviour of streams have been taken as indicative of this high strandline[74,75]. In North Gujarat, the reported occurrences of 'oolitic limestones' and 'grapestones' from Mehsana district[76,77] have been correlated with the miliolites of Saurashtra. To establish this high strandline in North Gujarat, it is essential that the NNW-SSE trending chain of stabilised dunes extending from Tharad to Ahmedabad, be examined to find out it they constitute coastal dune complexes related to the Middle Pleistocene high sea. Patel and Desai[78] consider these dunes to be of much younger age and according to them, they do not have any Pleistocene strandline significance.

The high strandline so ideally seen in Saurashtra, is well recognised along the Mainland coast, in the blue-green clay beds in Narmada Formation. Further south, towards Maharashtra, a well-defined planation surface 20 to 25m high, abutting against the trappean highlands to the east, could also be a feature indicative of this high sea.

Whereas, the picture of sea level changes since Middle Pleistocene upward is somewhat clearer, we have little information regarding the Lower Pleistocene. Very high strandlines as postulated by some earlier workers[58,79-82] are now not accepted and none of the recent global sea level curves provide any information on early Quaternary. Only Chappell and Shackleton[83] have shown sea level behaviour prior to the Great Interglacial transgression (Middle Pleistocene), but their curve stops at 250 kyrs, showing a regressive trend. Authentic data on Lower Pleistocene global sea levels is not available from any part of the world, and along the Indian coast too, information on early Pleistocene marine sediment is too scanty. None of the coastal segments have undoubted Lower Pleistocene sediments, nor do they show any other diagnostic geomorphic features which could throw some light on the then prevailing sea levels. Miliolites which were thought to be Lower Pleistocene have now been dated to be of Middle Pleistocene age. Apart from radiometric dates, indirect support has been provided by morphotectonic studies on Kutch by Biswas[84].

Knowledge on Pre-Miliolite events in Gujarat is scanty and the lowermost part of Quaternary, from the information point of view, forms a 'grey area'. We have therefore to only visualise a conjectural picture based on indirect evidences. But from the point of the behaviour of sea level prior to Middle Pleistocene, Gujarat coastline does offer a potentially promising terrain where Neogene-Quaternary sequences occur in onshore areas. A critical perusal of the works of various agencies (G.S.I., O.N.G.C., C.G.W.B. State Irrigation Dept.). published and unpublished, has led me to a few important observations which are relevant to the problem of early Quaternary sea levels.

The close of Pliocene heralded a major regression, bringing about withdrawal of the Tertiary sea from all over the west coast. This fall of sea level

marked the onset of the glacial age. Thus, with the onset of Pleistocene, marine sedimentation changed over through fluvio-marine to fluvial. The first major transgression took place in the Middle Pleistocene. Practically all over the Gujarat coast evidences of prevalence of continental conditions prior to miliolite deposition are recorded. At several places along the Saurashtra coast, occurrences of gravels and fluvial sands below the base of miliolite[85-87] point to these representing fluvial material of the then existing rivers which emptied their waters in a regressive sea. The gravels, according to me, are correlatable with the conglomerates of Ghogha near Bhavnagar in Saurashtra[88,89] and pebble-cobble conglomerates resting over the Jhagadia Formation of Broach district, comparable with the sub-surface conglomerate beds of the Jambusar Formation[90] and could be of early Pleistocene age. In the alluvial plains of central Gujarat, the Middle Pleistocene high sea is represented by the blue-green clays. The strata beneath and belonging to Lower Pleistocene have been reported to comprise fluvio-marine/deltaic sediments indicating a mixed environment fluctuating between shallow marine and continental conditions, (Jambusar Formation of Chandra and Chaudhary[90] and Narmada Formation of Agarwal[91]). Thus, there is a strong possibility that the Lower Pleistocene was marked by a low strandline and the sea level so fluctuated that fluvio-marine conditions prevailed all throughout.

Resume

Unfortunately, our overall knowledge about Indian Quaternary deposits is scanty, and there is no dependable information on the early Quaternary sea levels. However, it is now established that the close of Pliocene was marked by a major regression, which brought about the termination of the Tertiary marine sedimentation, and with the advent of Quaternary, the strata (along the west coast) show a change over to continental facies. As has been already mentioned earlier, it is not unlikely that the fluvio-marine/fluvial sediments of the so-called Pliocene of the various basins, could very well be comprising earliest Quaternary deposits. There are few evidences of high strandlines during Lower Pleistocene, and it appears that during its major part, the sea level was mainly regressive and fluctuated only marginally, thereby giving rise to a thick sequence of sediments of mixed environments. On the east coast, little authentic information on the older Pleistocene marine strata, is available, and according to Bruckner[73,92], deposits of early and middle Quaternary are missing. On the west coast too undoubted marine strata of Lower Pleistocene have not been reported by any one. The first major transgression took place only during the Middle Pleistocene and the sea level went up to almost +25m. This high sea level was attained during the 'Great Interglacial Stage'. The Last Glacial Stage' was a period of regression when the sea level went down to almost −150m. Regressive conditions prevailed upto 11,000 yrs B.P., and with the advent of Holocene the sea started rising again; between 6000 to 4000 yrs B.P., it attained maximum height, which along the Indian coast appears to have been around +6 to +8m. This Holocene rise of sea level was punctuated by a number of stillstands or minor regressions.

Strandline conditions during Upper Pleistocene are not fully understood. But considering the recent global sea level curves[33,82] there is a strong case for a number of transgressions and regressions between the period marked by the Middle Pleistocene highest sea level and the Terminal Pleistocene lowest sea level. But if at all there were transgressions and regressions during this period, the sea never arose above the present level. According to Caratini *et al.*[93], the sea level during the last interglacial, around 125 kyrs B.P. could have been around the same as present day. It is not unlikely that the high strandline features supposed to be related to the late Pleistocene (Last interglacial) reported by Bruckner[18,73,92] from east coast and Saurashtra, perhaps are much younger and related to the Post-glacial (Flandrian) high sea, which has since come down to the present level. The Holocene sea also fluctuated in the course of the last 6000 yrs, and in some parts of the Indian coastline, the highest sea level might have been attained around 4000 yrs B.P.

The existing heights of the various depositional and erosional features related to the successive high strandlines have, however to be considered, keeping in mind local tectonism and effects of isostatic uplifts.

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