

Holocene Sea Level Fluctuations On Western Indian Continental Margin : An Update

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Abstract : A new Holocene curve is generated for the western Indian continental margin. While constructing this curve careful selection of the dates were made by giving due considerations to the genetic characteristics of the dated material. This new curve shows a low at 100 m depth around 14,500 years BP and a rise to 80 m depth around 12,000 years BP showing a rate of ~10 m/1000 years which was followed by a stillstand for about 2,000 years. From 10,000 to 7,000 years it rose at a very high rate (~20 m/1000 years). Beyond 7,000 years BP it showed minor fluctuations.

Keywords : Holocene, Sea level fluctuation, Sea level curve, Arabian Sea, West coast of India.

INTRODUCTION

In numerous International and National fora it has been emphasized that specific areas should have their own Holocene sea level curves rather than following or adopting the generalized curves generated for other regions. The final report of the International Geological Correlation Programme Project 61 ['Sea level changes during the last hemicycle' (Pirazzoli 1991)] also contains recommendations to this effect.

Even after these recommendations, the situation has not changed for many areas mostly due to non-availability of data. Based on data from areas which were studied in detail earlier, a number of curves for specific areas were generated which were found useful in reconstructing global scenarios (Kraft *et al.* 1987; Pirazzoli, 1991; Tushingham and Peltier, 1993 and references cited in these).

The earliest attempt to study variation within Holocene sea level on western Indian shelf was that of Nair (1974) who tried to construct a curve based on radiocarbon dated samples from the continental shelf. This paper did indicate the provisional nature of the curve and the probable geological causes that needed to be taken into account before a reliable curve

is possible. In the Indian perspective Merh (1987, 1992) has given an exhaustive review of Quaternary sea level studies along the Indian coast. For the Indian region Kale and Rajaguru (1985) proposed a Holocene sea level curve based on then available data from coastal regions mostly from Saurashtra and the inner continental shelf samples for the periods 2000-6000 years BP and 10,000 years BP respectively. In this paper besides the available data, we have incorporated some radiocarbon dates from sediment cores, ranging between 6000-10,000 years BP and inferred dates older than 10,000 years BP (Nigam *et al.* 1992) along with other published dates by different authors (Table I).

EVIDENCES OF LOWERED SEA LEVEL

There are a number of evidences encountered which show that sea level was lower in the past as compared to the present. A number of submerged terraces (Nair, 1975; Wagle *et al.* 1994) were identified on the western continental shelf of India. They are at depths of -92, -84, -71, -65, -55 and -31 metres. The most prominent of these is the Fifty Fathom Flat (-90

Table I. Radiocarbon dates from Holocene deposits of Western Indian coast and Continental Margin.

Locality	Height/ Depth (m)	Material	Age	References
1	2	3	4	5
Manori (Bombay)	-1.0	Littoral concrete	4,245±85	Agrawal & Guzder (1972)
Manori (Bombay)	+1.0	Littoral concrete	4,540±100*	Agrawal & Guzder (1972)
Manori (Bombay)	+3.0	Littoral concrete	4,385±110*	Agrawal & Guzder (1972)
Erangal-Bhatti (Bombay)	+3.5	Littoral concrete	1,765±95*	Agrawal & Guzder (1972)
Erangal-Bhatti (Bombay)	+3.0	Littoral concrete	2,730±95*	Agrawal & Guzder (1972)
Erangal-Bhatti (Bombay)	+0.8	Littoral concrete	5,070±105	Agrawal & Guzder (1972)
Madh Point Bhatt	+0.55	Littoral concrete	2,115±90	Agrawal & Guzder (1972)
St. Xavier Bhatt	+1.55	Littoral concrete	2,800±110*	Agrawal & Guzder (1972)
Mandwa (Kolaba)	+0.05	Littoral concrete	2,050±105	Agrawal & Guzder (1972)
Chaul (Kolaba)	-3.0	Littoral concrete	2,180±95	Agrawal & Guzder (1972)
Korlai-Borlai	+0.50	Littoral concrete	2,410±95	Agrawal & Guzder (1972)
Mirya Bhatti (Ratnagiri)	+5.9	Littoral concrete	2,800±110	Agrawal & Guzder (1972)
Mirya Bhatti (Ratnagiri)	+6.0	Littoral concrete	2,305±95	Agrawal & Guzder (1972)
Willington Island	-16.75	Wood	8,315±125*	Agrawal & Ghosh (1973)
20°10' : 70°26'59"	-73	Sediment	9,830±180*	Rajagopalan <i>et al.</i> (1978)
18°36.0' : 70°39.3'	-98	Oolitic Lst	9,200±135	Nair & Hashimi (1980)
19°30.5' : 70°34.0'	-82	Oolitic Lst	8,960±200	Nair & Hashimi (1980)
19°5.0' : 69°45.0'	-150	Algal Pellet Lst	11,150±130	Nair & Hashimi (1980)
17°00' : 71°59'	-180	Algal Bryozoan Lst	10,415±250	Nair & Hashimi (1980)
Western Continental Shelf	-58	Composite Shell	9,135±130	Nair & Hashimi (1980)
20°24.0' : 69°41.0'	-85	Ooid Concentrate	10,400±300	Nair & Hashimi (1980)
16°40' : 72°48'	-68	Limestone	8,395±145*	Rajagopalan <i>et al.</i> (1980)
16°18' : 73°2'	-60	Limestone	7,845±130	Rajagopalan <i>et al.</i> (1980)
16°9'39" : 72°50'	-90	Limestone	9,435±145	Rajagopalan <i>et al.</i> (1980)
16°0'20" : 73°51'	-97	Limestone	8,380±140	Rajagopalan <i>et al.</i> (1980)
15°50' : 73°12'	-68	Limestone	8,300±135	Rajagopalan <i>et al.</i> (1980)
15°15' : 73°36'	-95	Limestone	11,040±135	Hashimi & Nair (1986)
Madhuvanty Creek	+<2m	Sand	5,000±70*	Bruckner (1989)
Madhuvanty Creek	+<1.5m	Marshy Soil	7,600±155	Bruckner (1989)
18°41'49" : 73°01'50"	-3m	Shell	2,600±60	Bruckner (1989)
Valvati Creek	-1m	Shell	2,260±60	Bruckner (1989)
Valvati Khatan Creek	+2	Shell	2,410±60*	Bruckner (1989)
North West Ratnagiri	+3.5	Shell	2,030±50*	Bruckner (1989)
Uran	+0.5	Sand	1,470±55	Bruckner (1989)
Uran	+2	Shell	1,800±50*	Bruckner (1989)
14°35'59.033"	-19	Shells	3,410±90	Nambiar <i>et al.</i> (1991)
74°13'49.744"				
14°25'37.091"	-32	Carbonized	9,630±120*	Nambiar <i>et al.</i> (1991)
74°12'35.501"		Wood		
14°40'08.631"	-26.8	Carbonized	8,620±300*	Nambiar <i>et al.</i> (1991)
73°54'09.569"		Wood		
14°43'.806	-29	Peat	8,910±160*	Nigam (1991)
74°02'.649				
14°49'.43	-26	Sediment	4,325±65	Nigam & Khare (1992)
73°59'.31		Carbonate		
19°02'10.44"	-81	Ooids	11,500*	Nigam <i>et al.</i> (1992)
71°30'36.36"				
19°02'10.44"	-92	Ooids	13,000*	Nigam <i>et al.</i> (1992)
71°30'36.36"				
19°02'10.44"	-101	Ooids	14,500*	Nigam <i>et al.</i> (1992)
71°30'36.36"				
15°59'.35	-70	Algal Lst.	9,116	Hashimi & Nair (Unpub.)
72°57'.56				
14°43'.806	-29	Peat	9,560±170*	Nigam (unpublished)
74°02'.649				
W.C.S.I	-173	Coralline Algae	14,740	Nair (unpublished)
W.C.S.I	-78	Oolitic Lst	12,510	Nair (unpublished)

* Inferred dates

** Form the basis for sea level curve.

m terrace). Terraces at similar depths have been reported by MacIntyre (1972) and Maxwell (1973) from other parts of the globe. Recently Wagle *et al.* (1994) compared them with different Indian Ocean Island localities. Similarly along the western shelf of India, a relict sand zone consisting of coated grains, ooids, benthic foraminifera of shallow water origin (Hashimi and Nair, 1976) and larger foraminifera encrusted with intertidal barnacles were encountered at the depth range of 60-90 m which also indicate a lowered sea level (Nigam *et al.* 1993).

STATUS OF DATING

A number of different type of samples from the coastal belt as well as the continental shelf have been dated and are considered to be relevant to sea level fluctuation. These dates are summarized in Table I.

CRITERIA OF SELECTION OF DATES

Table I contains dates reported by many workers from the western continental shelf and western coast of India. All the dates summarised in Table I are from the regions south of 21°N latitude (south of Saurashtra). The data from the northern regions are not considered due to uncertainties regarding the tectonic stability of the region (Biswas, 1971). The material used for dating ranges from whole sediments to shells and different types of calcareous and carbonized wood. Similarly, their location/position also varied from few metres above the present Mean Sea Level (MSL) on the coast to varying water depths on the shelf. It has, therefore, become very much essential to select the dates of only those materials which are the true representatives of either the strandline or known to be reliable depth indicators. Consequently, more emphasis has been given on the carbonized material e.g. wood, peat, etc. (Pirazzoli, 1991) which are undoubtedly indicators of extremely shallow water conditions and of paleocoastline. Moreover, calcareous ooids were also taken into account as they are considered to be shallow water indicators (Fuchtbauer, 1974).

SEA LEVEL CURVE AND RELATED PHENOMENA

In order to generate the Holocene sea level fluctuation curve of the west coast of India, a bivariate plot of age *versus* height/depth was prepared (Fig. 1) of all the dates available from the south of Saurashtra Peninsula (21°N latitude to 14°N latitude) ranging from 1,500 to 14,500 years BP, and from the height/depth variation of +6 to -180 m. Among these dates, 36% are from the coastal and 64% from the continental shelf region. It would have been very easy to find out a best fit curve from the data, but what we have attempted is based on geological reasoning and supporting evidences such as the presence of terraces, nature of the samples dated and inferences of sea level rise from similar stable areas elsewhere. However, the generalized envelop curve for this data is also drawn. Consequently, some points (marked with dots in Fig. 1) are left far below the curve. The cause of non-inclusion of these points is the following: when considering the lithology of the samples, we find that they are either algal/coralline limestones or oolitic limestones. Coralline algae have a wide range of water depth for growth and hence are not reliable indicators of shoreline. As far as the oolitic limestones are concerned, two possibilities can be envisaged: firstly, the ooids must have originated at a shallower depth and then transported to the present deeper depth, and secondly, the process of cementation by younger carbonate may have taken place later. This addition of the cementing matter may be responsible for giving younger ages compared to their loose counterparts.

It is obvious that one may not obtain all the imprints of the palaeo-topographic features on the sea level curve. However, there are very clear signals for the presence of the terraces at

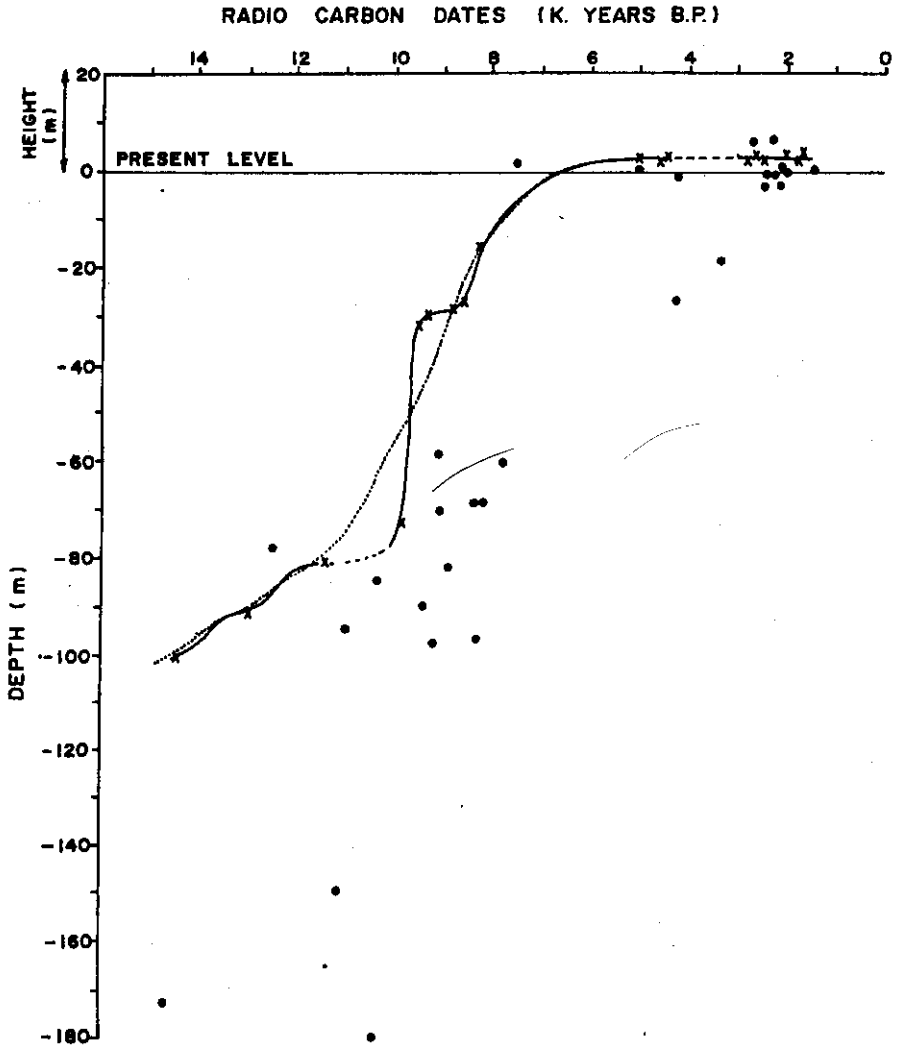


Fig.1. Holocene sea level curve for western Indian continental margin relative to present sea level and the generalized envelop curve (shown by dotted lines). The broken line at -80m (which is the time of the Younger Dryas noticed elsewhere) of the curve represents the event which at present cannot be confirmed with available data. The sample points marked with x are those which form the basis for sea level curve (for details see text and Table I).

-92, -82 and -30 m representing the stillstand of that time at these depths. On the other hand, the other sillstands may not have been of long enough duration to leave their marks.

The curve shows a high gradient between 11,000-7,000 years BP which could be related to the sharp rise in the sea level during the period under discussion. The evidence of sharp

rise in sea level is from the Gaveshani Bank on which no bathymetric features of stillstand in the form of notches, nicks, ledges etc. are found and the sides show smooth profiles (Nair and Hashimi, 1988). The absence of these features were confirmed by the multibeam sonar survey (Hydrosweep) of the bank (Rao *et al.* 1993).

The curve shows a low at 100 m depth around 14,500 years BP and a rise to 80 m depth around 12,500 years BP with a rate of ~10 m/1000 years. It was followed by a stillstand for about 2,500 years. From 10,000 to 7,000 years sea level rose at a very high rate (~20 m/1000 years). After 7,000 years BP it fluctuated more or less at the present level.

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