

Need of Paleoclimatic Reconstructions to understand Natural and Anthropogenic Climatic Hazards

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Origin, existence and welfare of man have inseparable relationship with climate. In past, change in climate caused rise and fall of many civilizations in different parts of the globe. Droughts and floods, storms and tsunamis, changes in fisheries pattern are some of the natural climatic hazards affected the human life in many ways particularly in coastal areas of 7000 km long Indian coast line. However, human race has absorbed number of such changes and kept on flourishing as changes were natural and spread over long spans thus giving sufficient time for adaptation and some time even migration. But lust of man for consumerism in 20th century presented the looming danger of global warming in 21st century to its own race. However, pace of changes this time may be faster and difficult to adjust.

To formulate the future plans for guarding against the furies of the nature, either due to natural or anthropogenic climatic disasters, understanding of paleoclimatic fluctuations, particularly of the Holocene is of immense use. Over the years, we attempted to enhance our understanding of past climate changes through studies of marine sediments as such information is prerequisite to develop reliable long term predictive models.

In recent years, we are studying marine sediments to generate high resolution proxy climatic records and objectively contributed in the field of paleosealevels, paleomonsoons, paleostorms / tsunamis and paleofisheries. Results of these studies and their applications in understanding of natural/anthropogenic changes are briefly discussed below.

In order to accurately assess the magnitude of suspected future rise in sea level due to global warming, it is important to document sea

level fluctuations in the past. In order to reconstruct past changes in relative sea level, two fold strategy should be followed, *i.e.*

- (i) To identify the time when sea level was higher than today (for such records, coastal areas may be explored for erosion or depositional features), and
- (ii) The time when sea level was lower than today (for such records, sea bottom sediments may be explored for shoreline movements or depth variations).

By following the above approach, we produced the updated curve for the Late Pleistocene - Holocene sea level fluctuations along the west coast of India. We succeeded in demonstrating that, as compared to present, sea level was lower by ~100 m at about 14,500 years BP, and ~60 m at about 10,000 years BP. During the last 10,000 years, three major episodes of sea level fluctuations were also reported. Similarly, there are evidences that sea level was higher than present ~6000 years BP. Our efforts also helped solve few of the unresolved issues pertaining to ancient human civilizations. With the help of sea level curve and foraminiferal (exclusively marine microfossils) occurrence, it was conclusively proved that the rectangular structure at Lothal (a ~4000 years old Harappan Settlement, near Ahmadabad) was a dockyard (first Naval dock yard of the world as claimed by archaeologists) and not a fresh water storage tank. Recently, with the help of the sea level curve, we have explained the discovery of Neolithic settlements (at 30-40 m water depth) in Gulf of Khambhat - the oldest civilization site known to man particularly in Indian subcontinent. There are number of attempts to enhance our understanding of sea level fluctuations along the east coast of India. However, compilation of the available data to produce an updated composite curve is need of the hour. Similarly, based on ecology of relict foraminifera and AMS radiocarbon dates, attempts are being made to study sea level fluctuations off Myanmar. The resultant curve, though preliminary in nature, indicated subsidence of bottom off West coast of Myanmar.

The above examples clearly indicate that sea level fluctuations played an important role in shaping the destiny of ancient cities in

coastal areas. The understanding developed, about the signatures of the past sea levels helped to demonstrate that it is in public interest to respect implementation of coastal zone management plans of the country. At the same time mangroves and other coastal vegetations and sand dunes should be preserved as natural barrier against the furies of the nature.

Monsoonal rain is among one the most important elements of climate, which often appears in the form of devastative floods and droughts. For India, it is all the more necessary to assess the impact of the changes in monsoon rainfall as her economy largely depends on rainfall. Such climatic events (floods, droughts etc.) and their effects on society were recorded right from early historic period. Such historical climatic records are mostly available in the inscriptions. In order to get an idea of the future changes, the high-resolution (decadal to century) proxy records (for the last few thousand years) for paleomonsoonal precipitation are the need of the hour over which man's impact could be more easily evaluated. Such information is prerequisite to understand the climatic systems and to develop/test reliable long-term predictive models. In quest for high resolution records, using foraminifera (marine organisms) as proxy for rainfall, core samples off Karwar, west coast of India were analysed. The results clearly showed high rainfall around 4000 and 3500 years BP and reversals of rainfall condition since 3500 years BP with a marked low at 2000 years BP. Geophysical and palynological investigations also support these findings. In addition to this, a cyclicity of approximately 77 years in concentration of drought years was also deciphered. There is a possibility of correlation between inferred monsoon intensity cycle and Gleissberg solar cycle.

Storms and/or tsunamis are most severe natural calamities that affect Indian coasts which causes a huge loss of lives and wealth. To predict such events, the knowledge of past events during the historic as well as pre-historic periods is very much required. The recent study reveals the utility of foraminifera to decipher paleo storms / tsunamis. One of the most storm-prone areas of the west coast of India, the Kachchh, was studied in search of presence of paleostorm signatures. The study shows that after ~8,000 years BP, older sediments of ~10,000 to ~12,000 years BP age, were eroded from the deeper region

by severe storm(s)/tsunamis, transported and redeposited in the shallower region thus giving rise to an inverted sequence deposited between ~8,000 and 7,000 years B.P.

Similarly, change in the marine fishery is one out of several consequences of global warming. A slight change in the climatic condition will lead to the migration or extinction of the fishes, which would in turn affect the economy of the country. Along the Indian coast line, no direct evidence is available to understand the migratory changes of fishes in the past. Quest for an additional tool to decipher such eventualities in the past guided us to fish remains-Otoliths. Otoliths are calcified concretions found within the membranous labyrinth of bony fishes, have been traditionally used for determining the age of fishes by counting the growth rings. Oxygen isotope studies on Otoliths help the paleontologists in determining the paleoclimate / paleotemperature, and are as useful as foraminifera and other calcium carbonate bearing shells. A conceptual frame work is proposed to exhibit how otoliths can be used to determine history of changes in fisheries pattern through the Holocene.

All these studies indicate that paleoclimatic reconstructions help to understand nature and timing of natural climatic variability along with hazardous events. Such information, through extrapolation can also provide the idea of future changes. However such studies are still fragmentary and more efforts are required to produce reliable and comprehensive understanding of past climatic changes.