

Evidence of Shoreline shift on the Northern Saurashtra Coast: Study based on the submerged temple complex at Pindara

Change in shoreline due to sea-level fluctuations, erosion, sedimentation and tectonic activities, is a well-known phenomenon in any part of the world. Any change in the coastline directly affects human habitation of the coastal area, which can play a vital role in understanding the shoreline behaviour in the past. Archaeologists have long been aware that in the past the coastline had been the focus of man's activities and thus archaeological sites could be one of the most promising indicators of shorelines. For instance, the history of the Baltic Sea during the late Pleistocene and Holocene has been recorded through several prehistoric sites discovered from its bed¹. Similarly, a few Mesolithic sites recorded from Sweden² suggest a lower sea level during the early Holocene. A large number of prehistoric and historical period sites discovered off the southern California coast³ indicate shoreline change over 2 to 6 km.

There are numerous instances of submergence of ancient settlements along the Indian coast. Also, ancient Indian literature mentions the devastation of coastal towns by the sea. The *Mahabharata* mentions the submergence of the city of Dwarka on the west coast and *Manimekhalai* (ancient Tamil text) mentions the submergence of Poompuhar on the east coast of India. Marine archaeological investigations have brought to light the partially submerged historical period remains off Poompuhar⁴ and the remains of an ancient harbour at Dwarka⁵. Mahabalipuram on the east coast is another site where several temple complexes are found under water⁶.

These findings suggest that the Indian coast promises a great deal of opportunities for finding underwater archaeological sites.

The present communication deals with archaeological remains (damaged temple complex) discovered during low tide off Pindara on the northwestern coast of Saurashtra in relation with change in coastline during the recent past.

The ancient temple site of Pindara juxtaposes to the northern Saurashtra coast in the Gulf of Kachchh (Figure 1) about 36 km west of Khambhalia and 24 from Kalyanpur. On the west of Pindara is a vast marshy land known as Okha Rann. Pindara way is a well-sheltered area free from open sea waves. It comprises mud flats up to a distance of 2 km from high waterline and a gentle slope with a minimum water depth of 1 to 2 m to a distance of 8 km, while the next 4 km has a water depth of more than 5 m. The average tidal range in the region is 1 to 4 m. Geologically, the formation comprises the Deccan trap overlain by the Gaj Formation, which is further subdivided as Ranjipur limestone⁷. The unit is comprised of typical yellow to brown-coloured fossiliferous limestone that is extensively bored and contains recrystallized shells and fragments of coral. The lower age of this unit is lower Miocene⁷.

The site was known as 'Pinda-taraksetra', and was famous for pilgrimage even by the 8th century⁸. It derives its name from kund (pond) called Pindatarak. It is said that a city called Devpuri existed even before Dwarka and that Durvasa Agastya and other rishis resided there. Pindara is mentioned as Pindaraka in the *Mahabharata*, as a place of pilgrimage⁹. The ancient site of Pindara is situated about 3 km north of the present village. The oldest archaeological antiquity of Pindara dates back to Early Palaeolithic (Mid-Pleistocene)¹⁰. A small-scale excavation yielded red polished ware and pieces of amphorae, suggesting an early historical settlement and overseas interaction with the Mediterranean Sea⁸ during the early centuries of the Christian era. Later, it was an important centre of temple architecture, as a huge temple complex was built between the 7th and 10th century AD. Pindara is also a minor port of Gujarat, where primarily fishing activities are being undertaken.

On the shore a huge temple complex is situated, which is a 'Protected Monument' (Figure 2). These temples date back to the 7th to 10th century AD¹¹. The temples at Pindara comprise a square sanctum (Garbha griha) and a heavy super structure over it. Most of the temples face towards

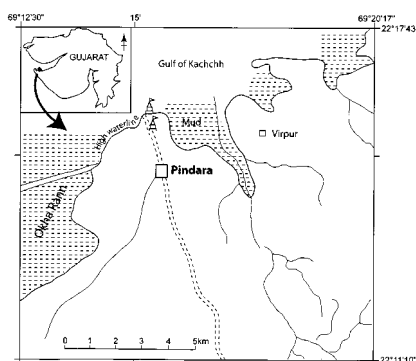


Figure 1. Location of Pindara on the northern shore of Saurashtra coast.



Figure 2. Protected temple complex on the shore of Pindara. The temples date back to 7th to 10th century AD.

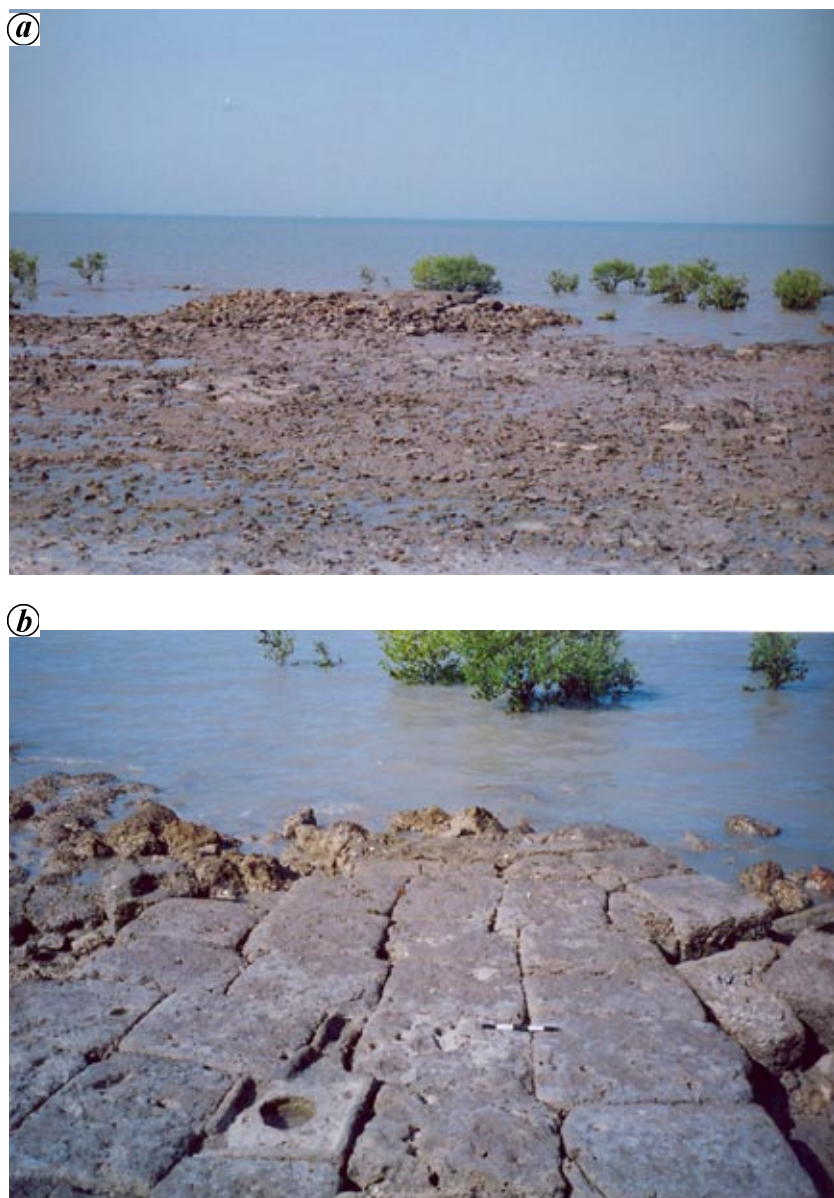


Figure 3. *a*, Temple site located about 300 m offshore from high water line at Pindara. The site is exposed during low tide. *b*, A submerged temple complex in intertidal zone of Pindara and exposed during low tide. The temple was dedicated to the Lord Shiva.

the east. The walls of the temples are plain. The most famous among these is the Sun Temple, which is located landward about 100 m from the high water line.

A huge temple complex (10×10 m) is exposed during low tide in Pindara (Figure 3 *a*) about 300 m from the high water line. Presently, floor area made of dressed limestone blocks is well preserved, while the superstructure has been destroyed and the stone blocks have been washed or taken away. Dressed limestone blocks have been used for the construction of this temple. The temple is oriented in the E–W direction and the entrance appears to be on the

eastern side. This temple was dedicated to Lord Shiva, as a yoni is present in the middle of the temple complex (Figure 3 *b*). The majority of the limestone blocks are measured $60 \times 45 \times 25$ cm. The remaining part of the sanctum (Garbha griha) measures 4.75×4.5 m. The yoni measures 40×40 cm. The architectural feature of the submerged temple corresponds more or less with the existing temple on the shore of Pindara. The size of the submerged temple must have been as big as other surviving temples in the Pindara group of temples dating back to the 7th to 10th century AD.

The ancient coastlines, particularly of the Pleistocene and Holocene of Gujarat, have been well recorded on the basis of geological formation and at least two higher strandlines were recorded +20 m and +6 to +10 m dating back to the Pleistocene and Holocene respectively^{12,13}. Changes in the coastline of Gujarat have also been studied on the basis of archaeological findings¹⁴. It suggests that the sea level was higher during the mid-Holocene period. East of Pindara are three small port towns of the Harappan period¹⁵, namely Amra, Lakhawel and Vasai. These are located along the back-water region. However, at present tidal water does not reach up to the site that indicates a higher sea level during the Harappan times¹⁴.

This is the first instance of submergence of a temple complex in the northern Saurashtra coast. However, there are other instances of submergence of coastal temple complexes dating back to the 6th to 8th century AD at Mahabalipuram⁶ on the east coast of India. Similarly, temples dating back to the 11th–13th century AD have been damaged by sea near Poompuhar and Tranquebar on the east coast¹⁶. An archaeological site was excavated at Bet Dwarka Island close to Pindara. It yielded evidence of lower sea level about 2000 years ago¹⁷, which suggests that this coast has been unstable during the last two millennia. The above-mentioned evidences indicate that the sea level was lower between 2000 and 1000 years along the Gujarat coast and it has risen by 1–2 m during the last 1000 years. It is difficult to assign a particular reason for the submergence of this temple complex. However, it is well known that the area is seismically active¹⁸ and could have played an important role in submergence of many sites along the coastal belt of Gujarat. Recently it has been strongly argued that many archaeological settlements must have been destroyed by the tsunami. However, we need additional evidence to establish this fact. This submerged temple complex has certainly opened up a new arena for study of coastline and shoreline changes during the last 1000 years in Gujarat.

Archaeological sites are the storehouse of information of past events such as climate and coastal morphological changes. Gujarat coast has been the focal point of human activities since the earliest time and has provided ample opportunities to understand natural phenomena that occurred in the past. Pindara is an impor-

tant archaeological site to understand the coastal behaviour of the southern coast of the Gulf of Kachchh in the recent past. The coastline has advanced landward at least by 300 m during the last 1000 years or so. The exact reason for submergence of the temple is not known. Being in the seismic zone, tectonic disturbances and sea-level rise could have played a vital role in the destruction of the temple complex.

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ACKNOWLEDGEMENTS. We thank the Director, NIO, Goa for permission to publish this paper. Thanks also due to K. H. Vora, Project Leader, for critically reviewing the manuscript. We also thank S. B. Chitari and R. Uchil for illustrations and the anonymous reviewer for suggestions to improve the manuscript. This is NIO contribution no. 4206.

Received 24 July 2006; revised accepted 18 October 2006

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MEETINGS/SYMPOSIA/SEMINARS

12th Annual Conference of Gwalior Academy of Mathematical Sciences (GAMS) and All India Symposium on Computational Biology

Date: 6–8 April 2007
Place: Gwalior

Topics of the conference include: Mathematical modelling and simulation etc.; Computational mathematics and computer applications; Biomathematics; Bio-computing; Bioinformatics; Financial mathematics and informatics; Information theory and coding; Computational models for data mining; Special functions, differential equations; Analysis, algebra, topology; Industrial mathematics; Modelling atmospheric pollution and natural disasters; Energy informatics.

Topics of the symposium include: Computational sequence analysis; Computational genomics and proteomics; Computational phylogenetics; Modelling gene expression; Modelling metabolic pathways; Modelling population dynamics and epidemics; Modelling bioprospecting and biodiversity; Modelling ecology, energy and environment; Modelling clinical research trials.

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Training Workshop on Immunological Techniques

Date: 30 April–12 May 2007
Place: Madurai

‘Hands on’ training in techniques includes: Raising and isolation of antibodies; Humoral immune (antibody) response (agglutination, immunodiffusion, Immunoprecipitation, immunoelectrophoresis, ELISA, Western/immuno blot, etc.); Cell-mediated immune response (DTH response, allograft rejection); Nonspecific humoral immune mechanisms such as serum: Antiprotease, myeloperoxidase, haemolysin, alternate complement and lysozyme; Nonspecific cellular immune mechanisms especially phagocytic killing mechanisms such as ROS, RNS and myeloperoxidase production.

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