

Geological significance of stone anchors from Dwarka waters, Gujarat, India

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Abstract

A number of underwater man-made stone structures have been noted, that may be the remains of an ancient jetty, as a large number of stone anchors have been recovered off Dwarka, Gujarat. The archaeological importance of these artefacts is postulated based on the other antiquities associated with them and by correlating with similar finds in other parts of the world. We present the geological significance, in terms of the offshore topography wherefrom the anchors were recovered, and the composition of the anchors in terms of the rock type and their availability. Four anchors were sampled for petrological investigations of which one is basalt, one is sandstone, and two are limestone. The latter two rock types are abundant in the vicinity of Dwarka, while the basaltic anchor must have been manufactured from the basalt quarried either from nearby coastal dykes or else from Junagarh hills, 200 km east of Dwarka.

Introduction

Marine archaeology in India is a gradually evolving, nascent discipline. Initially, developed as an offshore extension of routine, land based archaeology, the field of marine archaeology is increasing with advent of technology and interaction with other disciplines of science, especially marine sciences. Aspects such as change of sea level, their effect on shoreline, siltation, corrosion of metals and consequent necessary preservation techniques, remote sensing, acoustic search methods provide examples for interactive science.

Marine archaeological explorations at Dwarka were initiated in 1983 and continued almost every year till AD 2000 (Rao, 1990, and Gaur et al., 2004). The underwater finds provide a case in favour of submerged structures, which could be the part of a port, a break-water or berth to bring boats/ships-alongside (Gaur et al. 2005). Due to transgression by the sea, the structure was subsequently submerged. The major finds also include remnants of fallen wall lying between inter tidal zone to 6 m water depth. These finds provide very useful information as to the type of materials used, the way the structures were constructed etc. The associated findings from Bet Dwarka, which is about 30 km to the north, are also very pertinent, especially a seal with an animal motif and inscribed potsherd of the late Harappan period (Rao, 1999).

Thermoluminescence (Vora et al., 2002) and radiocarbon dates (Gaur and Sundaresh, 2003) have helped to establish an age of about 3500 years BP for the habitation at Bet Dwarka Island.

The submerged structures of Dwarka, on their own, have not been dated by any means i.e. direct, indirect or inferred. However, associated with these structures, are some stone anchors (Rao, 1987, 1990), which are similar to those, found at Cyprus and Syria, the age, which is been believed to be 3500 years BP. Recent researches on the stone anchors suggest a later date (Gaur et al., 2004).

The determination of age of anchors found from Dwarka waters is critical for many reasons, but so far no suitable means have been found. However, it is equally vital to determine whether these anchors were made from locally available materials, as these can also throw some light on the many loose links in unravelling the mystery of the submerged Dwarka.

The application of geological methods and tools are limited especially in the Indian context. Any archaeological site could be considered as a potential geological location and the artefacts recovered from such sites could be treated as equivalent to a geological sample. For instance, (i) the sediment or soil analyses, could be carried out to determine the source (river,

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lake, sea etc.), (ii) the rock type could be correlated with the local geological formation, (iii) the samples could be examined and analysed using normal petrographic methods, (iv) sophisticated instruments such as scanning electron microscope and microprobe could be used, (v) the age of the artefacts could be known through radiometric and thermo luminescence methods. In fact, Renfrew (1976) introduced the term 'geo-archaeology' to imply the usage of earth science techniques in archaeology.

In the above background, a beginning was made to carry out the petrographic analyses of the anchors and the findings have been correlated with the local geology. The present study is an example where traditional geological technique has been used for the purpose of verifying provenance of the materials used in the making of the stone anchors.

Materials and Methods

One hundred and twenty-two anchors obtained from Dwarka waters, were examined (Fig. 1). The various parameters of the samples such as length, breadth, diameter of the holes, etc. were measured (Table 1). Dilute HCl acid was used to test the presence of calcareous materials. Since the samples are unique and all could not be sampled, only four samples (A to D) were chipped for making thin sections for petrographical studies. A portion of the chips were powdered, packed in an aluminium holder and scanned by means of a Philips X-ray Diffractometry (XRD) for identification of the mineral phases.

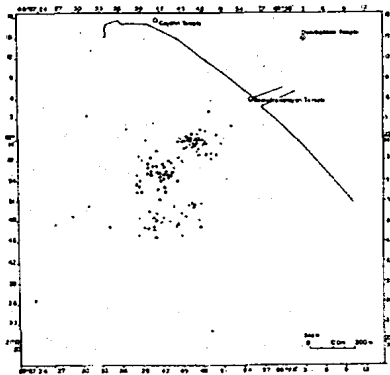


Figure 1. Location map showing archaeological finding off Dwarka.

Table 1. Dimensions (in cm) and rock type of the anchors studied.

Parameters	Sample A	Sample B	Sample C	Sample D
Anchor type	Ring stone	Triangular	Building block	Two holed
Length/Dia	67	77	49	83
Width	—	50	45	57
Thickness	—	12	16	12
Dia of upper hole	22	14, 11, 11	—	10.8
Distance of holes from apex	32	82, 56, 55	—	20, 50
Depth of holes	17	10, 11, 12	—	14, 15

Results

A total of 122 anchors were collected of various shapes and sizes. The 25 rounded or ring stones (Pl. 42) are 30-70 cm in diameter, 34 triangular (Pl. 43) ones are 180 cm to 55 cm long while the 63 grapnels (Pl. 44) are 237 to 55 cm. The underwater topography varies from a sandy seafloor and there are also presence of rocky outcrops and cliffs. The artefacts occur between inter tidal zones to 16 m water depth.

Table 2 shows the sample types and the related petrographical features. Of the four samples, sample A is a coarse grained basalt exhibiting a single large hole of 67 cm diameter. Samples B and C are limestone as identified by the presence of low-Mg calcite through XRD and by the presence of calcite and shell fragments under the microscope. Sample B is a three-hole stone anchor and sample C is a solid block. Sample D is two-hole calcareous sandstone with abundant calcite, quartz and a few shell fragments (Fig. 5).

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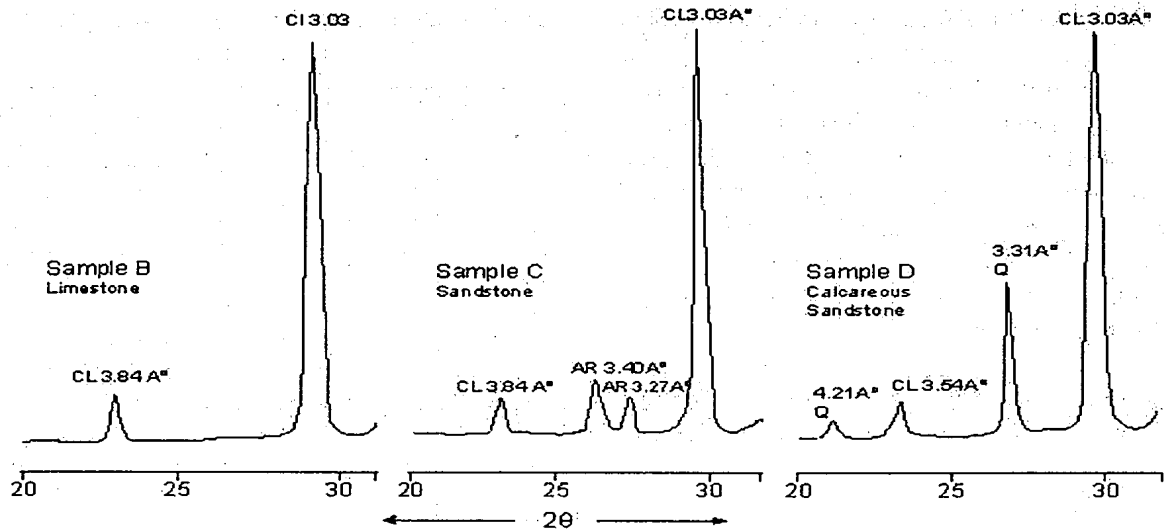


Figure 2. X-ray diffractogram of the studied samples. Cl = Calcite; Q = Quartz, Ar = Aragonite

Table 2. Petrographical characteristics of the anchors studied

Samples	Water depth	Microscopy	XRD	Remarks
A	8	Slightly altered, coarse grains of plagioclase olivine pyroxene	-	Basalt
B	5	Abundant oval oolites, a few shells	Low-Mg Calcite	Limestone
C	5	Calcite dominant	Low-Mg+Aragonite	Limestone
D	5	Quartz, calcite rich, a few shells	Low-Mg Calcite+ quartz	Calcareous sand stone

Discussion

It is reported that the rock types in and around Dwarka are mainly sandstone, conglomerates, grits, clays (all of Neogene age) and limestone and marl clays of Palaeocene age (Merh, 1993). The former group constitutes the country rocks in the study area and the latter rock types occur ~25 km from Dwarka. It is probable that samples B and C (limestone) and sample D (calcareous sandstone) are locally derived, transported, trimmed and shaped. As these rocks are composed largely of calcite (a mineral with low hardness, Moh's scale = 3), these could be easily cut and shaped for the requisite purpose such as for anchors

and building block. Sample A on the other hand, being basalt (a hard, compact volcanic rock) could have been quarried either from a nearby coastal dyke or from the famous Junagarh/Mt. Girnar hills, which is about 200 km away. This rock being hard was possible only to be shaped in a circular manner with a large single hole i.e. as a ring stone.

It has been suggested that the samples under study were used as stone anchors (Gaur et al., 2001). We do not context this fact but are puzzled by the absence of rope groove marks and of crushed calcite in thin sections of the samples under the microscope.

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However, it is possible that wooden stock may have been inserted on the upper hole and rope could have been tied from both sides for lowering the anchor. The various types of anchors may indicate that a boat might have been carrying them for anchoring the vessel in different type seabed (like sandy, uneven, and rocky). In other words, the anchors may have been used site-specifically.

Conclusion

Together with other archaeological tools, routine geological observations of the archaeological sites and the recovered artefacts could aid in an understanding of the origin of the raw materials used in the past. The stone anchors of limestone could be of local origin while anchor of basalt would have been brought from the closest site from Junagarh hills. We envisage that in the future the application of geological tools could be used better to unravel the archaeological problems.

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