

# RECENT ADVANCES IN MARINE ARCHAEOLOGY

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# Relevance of Topography and Sediment in Ship Wreck Exploration – Examples from Goa waters

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Ship wrecks are the tools to open the secrets and to decipher the mysteries of the past. A number of ship wrecks of historical importance have been reported along the Goa coast viz. Amee shoals, Aguada bay, Calangute. To assess the state of preservation of these wrecks, topography and type of sediment are found to be the vital parameters.

The technique of comparing the bathymetric profiles of the surveys separated in time (1881 – 1976) of Goa coast provided information about the environmental impact and estimation of sediment movement. Thus it can be useful to visualise the environmental set up in ancient time and provide a scientific explanation to the condition of the ship, once she ran aground. Furthermore, this study indicates a strong correlation between bathymetry and the type of sediment in the model areas of Marmagoa and Aguada bays. In these areas it is observed that the high energy shallow water region are dominated by sandy sediments while the topographic low areas with low energy conditions have muddy sediments.

The recent discovery of the ancient guns once carried by a ship which wrecked on Amee shoals in Marmagoa bay shows that the region having high energy shallow water topography covered with sand and shells is not conducive for the preservation of the wreck, whereas the low energy region of deeper depth such as off Calangute area is conducive for the preservation of the ship wrecks.

This study may be used as a model for understanding the relevance of topography and the nature of sediment for the state of preservation of the ship wrecks.

## INTRODUCTION

India with her vast coastline had a very vital role in the maritime trade from ancient time. Through these maritime activities the great cultures of the old world were interacted. Archaeological evidences of maritime activities dated back to middle of the third millennium BC onward are available in the form of docks and ports (Joshi, 1987). The history of maritime activity of the past is lying underwater in the form of historical relict features known as ship wrecks. Long experience has shown that these artifacts are the best source of information and may be studied as primary documentary evidence in reconstructing the past. The Marine Archaeological Unit of the Institute has compiled the vital information pertaining to more than 200 ship wrecks on the Indian Continental Shelf (Rao, 1983).

Before prospecting for such a large number of shipwrecks the most important step is to visualise the environmental set up of prospective locations. Topography and the sediment distribution of a particular area plays a potential role in the preservation of a ship wreck.

In order to provide the meaningful basis for making extrapolation and interpolation concerning the ship wreck preservation, the present study from the location of Goa waters where the environmental and historical data is available can serve as a model for other areas. The chosen study area can be divided in the three geographical sites of different environment models. The resulting data have been

analysed to define the effects of the topography, sediments, currents and wave characteristics for the state of preservation of ancient ship wrecks.

The purpose of this paper is to provide technique for identifying the state of ship wreck and related finds to assist marine archaeologists in assessing the state of ship wrecks in similar environment.

## MATERIAL AND METHOD

This paper is based on the bathymetric surveys carried out by using the Atlas Deso-10 Echosounder with dual frequencies of 30 KHz and 210 KHz. The 210 KHz frequency gives better resolution and 30 KHz provides the sub-bottom information. The mini ranger MRS III system was used for position fixing with accuracy of  $\pm 3$  m. The positions were recorded at every 15 sec interval and the corresponding event marks were put on all records. During the evaluation of the record these event mark positions were used as a descriptive unit. The tidal corrections were applied by using the oscillations recorded at every 30 minutes on a tidepole/guage installed at Panaji and Mormugao Harbour.

Bathymetric profiles based on available charts of 1881 and 1976 surveys were compared for understanding the erosional or depositional condition. Textural sedimentary data was used for studying the topography v/s sediment correlation.

## RESULT AND DISCUSSION

Rao (1983) has published prospective locations of ship wrecks along the west coast of India. In order to test the environment v/s preservation of ship wreck concept, three different types of areas i.e. Aguada bay, Amee shoals in Mormugao bay, and Calangute areas were chosen from Goa waters. These areas are categorised as Site 1, Site 2 and Site 3 (Figure 1).

### Site 1: Aguada bar

The Aguada bar referred to in Portuguese hydrographic map as Barra de Agoada and in recent hydrographic charts as Aguada bar is a coastal fixture (Fig. 1). The bar is having a least depth of 2.8 m and is being navigated by shallow draft vessels with a local knowledge of the navigation channel. The Mandovi River may be classified as a Ria which is defined as a river system which is partly or wholly drowned by the sea due to Handrian Pleistocene Glacial Transgression or Subsidence of land areas (Ahmed, 1972). Coastal processes have created a narrow entrance which is being kept open by river flow and tidal circulation. Formation of sand bar has narrowed down the river mouth. The river carries a mixture of fine sand and flocculated fine cohesive sediment. The suspended sediment load (surface) is about 30 mg/litre in fair weather 100 mg/litre in the monsoon season (Murty and Das, 1972, Murty et al., 1976).

Visual observation during monsoon indicates a line of breakers near the bar. The wave breaking phenomenon may be associated with the strong ebb current from the river opposing the wave advancement, and thus the waves steepen and break more easily.

The bathymetric charts of these areas show that the isobaths (line joining points of equal depth) are fairly parallel to the shore line in the Miramar area. Typically the isobaths are tending towards the Aguada bar in the area. These isobaths are converging and giving rise to a saddle at the head of the Aguada bay where the river flows into the bay. In general, water depth in this area is 5.4 m bay ward side of bar to 10 m river side with minimum 2.8 m on the bar, whereas river mouth is very steep (Fig. 2). However, it slopes gently towards the bay side and it appears that the flow area is decreased considerably at the throat area thus causing an increase in current velocities. The increased velocity has greater scour capability (Escoffier and Walton, 1979). The comparison of pre- and post-monsoon surveys shows that the freshwater outflow in the monsoon season has a flushing and scoring effect (Pathak et al., 1988), but during the lean season the channel returns to its original depth. Comparison of bathymetric profiles shows that there is no significant topographic change during the last 100 years. Dredging was carried out to deepen the navigation channel but subsequent surveys showed that the channel in between

the bars (Aguada bay in the south and Reismagos bar in the north Fig. 1) silted upto its original depth. In spring low water both the bars are visible during fair weather season. It appears that the tendency of the waves is to align themselves parallel to the bottom contours.

There is greater movement of sand from Aguada bar side. The Reis Magos bar consists of rock reef. The considerable turbulence and the river outflow prevent the sediment deposition in this area. The material transported by river outflow is being deposited in greater depth. The topographically high area with considerable activity may be defined as high energy area. This high energy area, is all along covered with sandy bottom associated with the gravel. Recent dredging activity resulted in the recovery of an old anchor probably belonging to a ship wreck; except the anchor no other object of archaeological interest was recovered from the area. The shallow uncharted depth on the bar channel could be the cause of wrecking most of the ships.

### Site 2: Amee shoal in Mormugao bay

The Marmugao bay is referred to in Portuguese hydrographic map as Baia de Mormugao and in recent hydrographic chart as Mormugoa harbour. The entrance of Mormugao bay lies in between two promontories Cabo in the north and Mormugao in the south (Fig. 1). The Southern side of Mormugao bay is mostly a bold and rocky rising island to table land from about 30 to 80 m in elevation. The Zuari River flows into the head of Mormugao bay through a constricted passage. Amee shoals, a site where the information about ship wreck is available, is located northward of the Mormugao Harbour approach channel and nearly in the centre of the bay. The rocky shoals and reefs extending north-south across the entrance of the bay act as a barrier at the approaches.

The river discharge is modulated primarily on the seasonal time scale. Increased level of river discharge during the monsoon months promotes erosion and suspended sediment transport. The isobaths in this region indicate a gradual slope towards the west. The water depth in the Amee shoal area is ranging from 1.8 to 11 m. The minimum depth recorded in the middle of the Amee shoals is 1.8 m. The bay floor is characterised by prominent submerged rock outcrops. In between these shoals the bathymetric lows are also noticed. This may be the combined effect of the current and topography. The comparison of the bathymetric chart of year 1881 with that of the year 1976 shows that the area is not conducive for sediment deposition.

The sea bottom in this area is covered with shelly sand, lithified sediment or a rocky bed thinly covered by sediment (Wagle, 1988). The ebb currents are of the order of 3 knots, the flood currents are 1.5 knots during the spring tide. In the Amee shoals region the wave heights are maximum in the southwest monsoon season. The sea breaks heavily along

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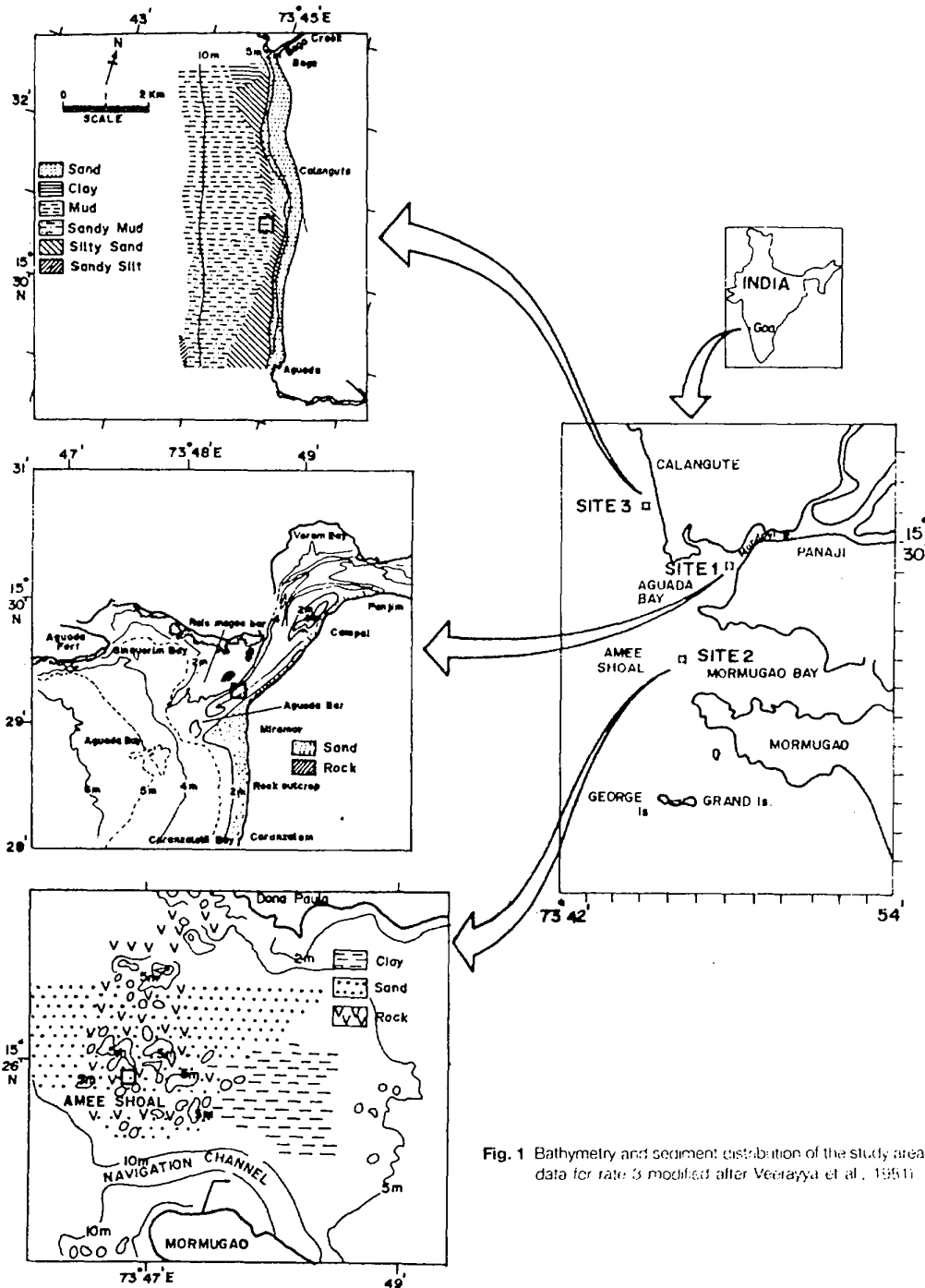


Fig. 1 Bathymetry and sediment distribution of the study area (Sediment data for rate 3 modified after Veerayya et al., 1951)

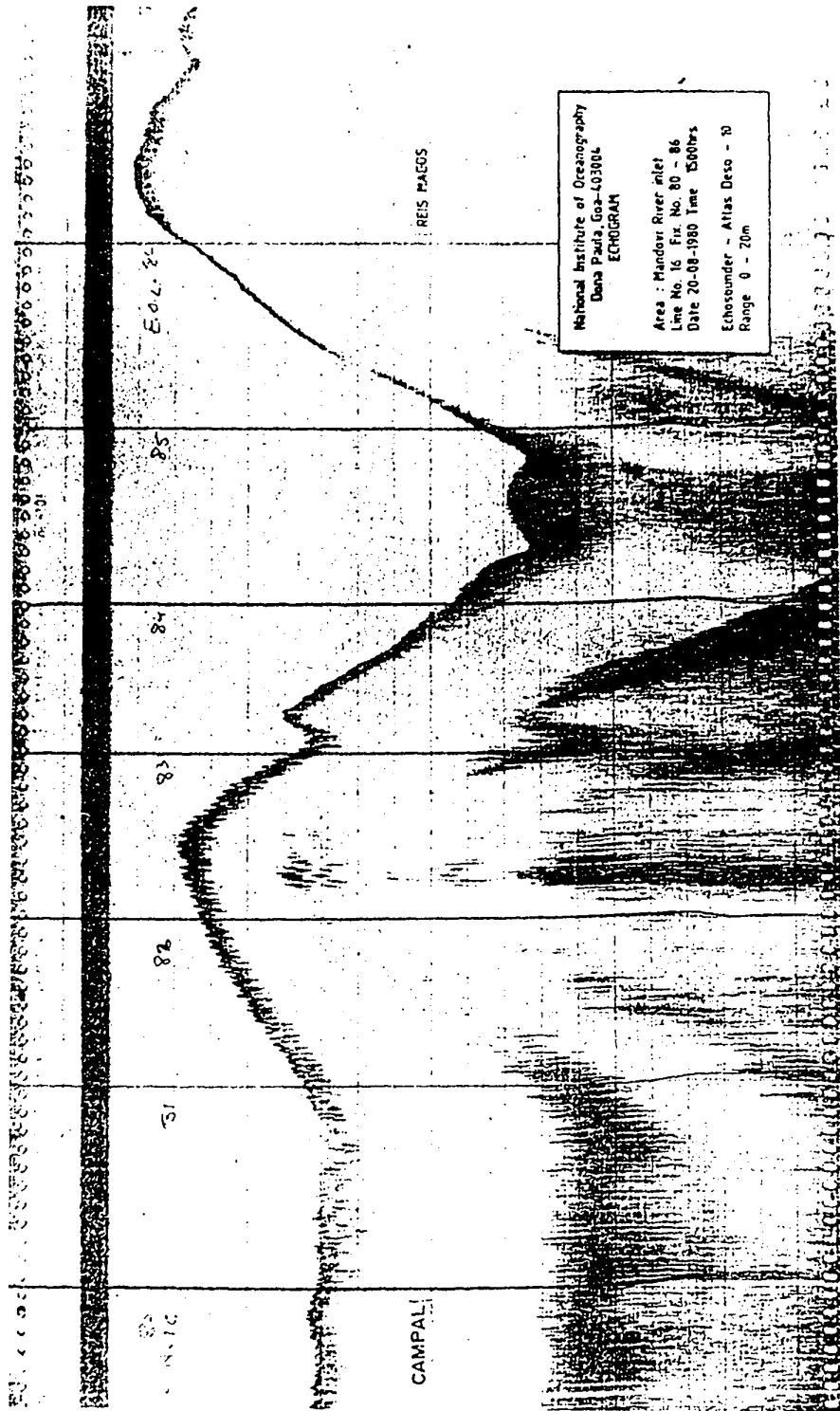


Fig. 2 Echogram across Mandovi River inlet.

this track. The area may be defined as high energy area which does not allow sediment deposition.

Recently the divers of Marine Archaeology Unit while searching for the ancient ship wreck found the heavy guns of ancient time.

### Site 3: Off Calangute

The topography of the area is very smooth. The isobaths of the area are fairly parallel to the shoreline (Fig. 1). In general the water depth in the ship wreck area is fairly large being in the range of 7-10 m. The sea floor is covered with soft mud. Comparison of the bathymetric profiles shows that the topography in the area is stable. The reported wreck is situated in the clay covered area. It seems that due to the weight of the ship with cargo caused a part of the ship to sink into the clay.

The selected regions corresponding to the different topographic and sediment regions are observed from Site 1 and 2 which correspond to the high topography and incompressible bottom. From these locations only heavy artifacts such as anchors and guns were located. This indicates that the chances of damage from the direct lift and drag forces in high energy area might have resulted poor preservation of the ship wreck. The experimental evidence (Castial et al., 1979) indicated that the objects located on the hard bottom surface experience the maximum force. In Site 3 the topography is smooth and the bed is covered with soft mud. This topographically low area is a low energy zone covered with the soft mud providing a cushion like effect to the ship wreck. The ship wreck is reportedly preserved in this zone.

The resulting data shows that the high energy area covered with sand is not conducive for the preservation of ship wrecks and the low topographic area covered with soft mud is conducive for the preservation of the wreck. It also shows that the potentiality for preservation of ship wreck is also controlled by the degree of slope, nature of the material in the slope and ground conditions.

### CONCLUSIONS

The discussion above has shown the usefulness of the environmental study methods as a systematic approach for better understanding of the complex inter-relationship of topography, sediment and preservation of ship wreck. This method allowed a systematic analysis for identifying the potential areas and information can be used as a part of the

exploration and excavation programme. Thus the environmental study method can be used as a predictive tool and as an investigative method in determining the state of ship wreck in a prospective area.

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