

Geophysical Methods as a Tool to Explore Submerged Marine Archaeological Sites

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The marine geophysical methods, particularly boomer/sparker, ORE profiler, side scan sonar and echosounder can be used to discover or identify the marine archaeological objects which are either submerged or buried at depths beyond the normal working range of most of the conventional methods. The paper describes the application of these geophysical techniques to discover or delineate objects such as shipwrecks, anchors, buried structures (trenches, platforms or walls) and their areal extension, under different environmental conditions, from selected locations off Bombay, Goa and Cochin.

INTRODUCTION

Exploration of submerged marine archaeological sites, in India, to an extent, is not very extensive and is confined to very shallow water due to limitations of the conventional methods used, such as underwater excavation or underwater photography. In view of the sea level rise (around 100 m) since 10000 BP, it can be safely assumed that the marine archaeologist may have to venture to discover the objects in deep water well beyond the working limits of divers. Higher turbidity, if present, hampers underwater operations due to poor visibility and may affect the progress of the work. The buried objects in the area beyond water depth of 30 m in most of the cases cannot be delineated or recovered if the environmental conditions are not conducive, and thereby deny valuable information for proper reconstruction of the archaeological set-up of an area.

The application of the marine geophysical methods particularly boomer/sparker, ORE profiler, side scan sonar and echosounder has an added advantage as they can be used to discover or identify the objects which are either submerged at depths beyond the normal working range of most of the conventional methods or buried below the seabed even in the areas of higher turbidity. These methods are well capable of covering relatively a large area in very less time at comparatively low operational cost without endangering the life, and therefore, are very useful to explore new sites. The aim of this paper is to describe the application of these geophysical techniques to discover and delineate the marine archaeological objects such as shipwrecks, anchors, buried structures (trenches, platforms or walls) and their areal extension. The paper discusses the results obtained using these methods under different environmental conditions from selected locations off Bombay, Goa and Cochin.

APPLICATION OF METHODS

1. Identification of Submerged Objects

Echosounder

This equipment is used to determine the depth or to record the bathymetry, and works on the principle of echo. The system

can provide valuable information to identify the submerged objects. Presence of any foreign material alters the normal seabed configuration and helps in the identification of the object. The suitable combination of the power and frequency of the signals improves resolution of the object and helps in its identification. The high power provides better penetration of the signal whereas higher frequency of the signals gives better resolution. As most of the work related to marine archaeology has to be undertaken in the shallow depth (less than 100 m) and the resolution of the object is desirable, high frequency signals are to be used. 210 KHz frequency has been found very suitable for the purpose. Plate 7 depicts a trench delineated at the depth of 10m using this frequency.

2. Submerged or Partially Buried Objects

ORE Profiler

Echosounder, capable of indicating the presence of an object, fails to give the details about its buried parts. It also fails to record any object that is completely buried in the sediments. Therefore, we require a system which has power for penetration in the sediments and may amplify resolution by removing the unwanted signals (noise in the geophysical parlance) to improve the signal to noise ratio for recording the details of the buried parts. ORE profiler is having these facilities. The system has variable frequency selector for the source and the reception of the signals (from 1 to 12 KHz at 1 to 10 Kw power). Time varying gain facility helps elimination of the reverberations and improves the signal to noise ratio. The selection of power and frequency of the transmitted signal and the frequency of the received signal further helps resolution of the objects. For example, in the shallow depth less power (2 Kw) and higher frequency (450 KHz) gives good results. Off Goa, a submerged pillar (about 8m wide) at the depth of 8m (Pl.8) has been located using this combination. The power of the transmitted signals has to be amplified for the deeper penetration. For delineating a buried trench, off Bombay, at the depth of 7-12 m (Pl.9) the signals were transmitted at 350 KHz frequency at 4 Kw power. The incoming signals were also received at 350 KHz frequency. Plate

10 shows the picture of the same trench at a different location at 5 Kw signal power and 300 KHz transmitting and receiving frequency. Note the buried portion and filled sediments (clays in this example).

3. Deeply Buried Objects

Boomer and Sparker System

The submerged objects, cannot be identified or delineated by ORE profiler, if deeply buried or buried in the compact sediments, as the power of the ORE signals (10 Kw) is only sufficient for the penetration in clays or in silty clays. The boomer or sparker, which generates a boom or spark at high power (0.1 to 24 K Joules) can overcome these deficiencies. High power of the signal induces deeper penetration in the sediments and enables the identification of the deeply buried objects.

The power selection of the signals has to be suitable for a particular requirement. This is generally determined based on (a) depth of operation (b) object to be delineated. The high power in the shallow depth leads to the surface and bottom reverberations and ghost image which deteriorates the quality of the received signals. The low power, on the other hand gives weak incoming signals and denies valuable information. One K Joule power has been found suitable for the depth 40 to 100 m. The results (Pl.11 showing a terrace at the depth of 82 m) obtained using this power has been found to be very good. For shallow depth (less than 20 m) 0.30 K Joule power has been found suitable. Plates 12 and 13 show 2 sections of the trench delineated off Bombay at 8 m depth. Note the filling in the bottom of the trench and the presence of the rocks (traps) below the trench.

4. Plan View of the Survey Area and Search of Unknown Objects.

Side scan Sonar

The systems discussed so far are only capable of recording on line information and therefore, the survey has to be repeated at close lines for the areal extension of the object. The search of a new object may take considerable time if the object is small. Side scan sonar, which records features on both sides of the survey tracks, serves as a useful tool to search or to discover lateral extension of the features. The identification of the submerged shipwrecks, anchors and debris of the submerged structures can be obtained using this system. The system has capabilities of recording 250 m on either sides of the track and is very useful for reconnaissance surveys. The range of the system has to be adjusted to the specific use. For the large coverage, as in the preliminary search surveys, higher range (150 m) is desirable. This range has been used to locate a shipwreck (Pl.14) off Cochin, at the depth of 60 m. For the identification of the small objects, or for the areal details of an object, the small range is useful. A submerged pillar and construction debris (broken part of a collapsed bridge) off Goa has been delineated using 25 m range (Pls.15 and 16).

CONCLUSIONS

The examples given hereabove clearly demonstrate that the marine geophysical techniques have tremendous scope for the

marine archaeological use. The echosounder, ORE profiler and boomer or sparker system provide on line details about the submerged or buried object. For the search of an object, side scan sonar has great utility.

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