

Geophysical Techniques to Locate Pre-historic Sites and Artifacts on the Continental Shelf

RAO T C S

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Application of geophysical techniques to archaeological investigations has brought out another field of prospection called archaeological prospection similar to mineral prospection and oil prospection. This paper presents an overview of the application of geophysical methods to marine archaeological investigations with special emphasis on the magnetic methods for the location of underwater metallic objects and the seismic profiler and side scan sonar surveys to delineate the geomorphic features over the continental shelf.

Andhra Pradesh with about 600 km long coastline has two major river confluences in Godavari and Krishna in addition to several ports like Visakhapatnam and Kakinada that are currently in operation and the ports like Machilipatnam, Bhimilipatnam and Kalingapatnam that are centuries old and abandoned. So far no archaeological investigations have been initiated in the offshore regions of Andhra coast. Some selected areas along the Andhra coast that could bear high potential for archaeological investigations are presented wherein the detailed investigations could lead to locate the prehistoric sites and artifacts.

INTRODUCTION

Similar to mineral prospection and oil prospection, the application of geophysical techniques to archaeological investigations has brought out another field of prospection called "Archaeological prospection". In some contexts it is also called as "Archaeogeophysics" and "Rescue archaeology". The geophysical methods to survey the archaeological sites have been used since late 1940's. Several different geophysical methods have been used at archaeological sites but the most widely used are earth resistivity measurements, ground penetration radar and magnetometry. In marine archaeology the magnetic and seismic profiler surveys are widely used. Among the seismic profiler, the high resolution seismic profilers are more used than the conventional sparker and boomer.

In this paper an overview of the marine archaeological investigations by geophysical methods is presented with special emphasis on the location of submerged objects such as shipwrecks, anchors etc. by magnetic surveys and the location of geomorphic features of the ocean floor by seismic profiler that could lead to archaeological importance of prehistoric nature. The potential areas for marine archaeological investigations in the offshore regions of Andhra Pradesh coast are discussed in relation to the existence of old and abandoned ports and the associated ancient maritime trade.

MAGNETIC METHOD

Either it is on land or at sea, magnetic surveying is the most frequently used geophysical tool by the archaeologists and was first tried on land in 1958 in England. These surveys are routinely used to map buried stone foundations and to outline the locations of forges and kilns, hearths and campfire sites. Proton precession magnetometer is most widely used in these surveys. However, under some specific circumstances fluxgate gradiometers and op-

tical or Electron pumped sensors are also used. Recent magnetic surveying innovations in archaeology have started using microcomputer-based magnetic data-gathering systems to acquire very large data bases necessary for whole site evaluation. Archaeo-magnetism is another newly developing science wherein the site occupation dates could be obtained from the orientation of the remnant magnetic field found in ancient stones or kilns.

The archaeological features are frequently more complex in shape and have more pronounced geometric forms than structures encountered in conventional geophysical prospecting. It therefore requires more careful planning and execution of the surveys. Depending upon the susceptibility contrast between archaeological features and the surrounding soil the anomalies produced by them may be as low as 0.1 nT or as high as 500 nT. Therefore, for lower values, differential or gradient operation is imperative to prevent local industrial disturbances and diurnal magnetic fluctuations from causing problems during the survey.

In marine archaeological investigations the magnetic surveys are usually conducted by using the proton precession magnetometers to locate the shipwrecks and metallic anchors. Under favourable conditions these surveys are also employed to locate the submerged foundations, structures and buildings including the temples in the nearshore region. However, the magnetic field recorded in the nearshore regions is of complex nature because several other geological features such as rock outcrops, placer deposits, extension of coastal features into the offshore region produce the anomalies. But with the prior knowledge of the geology of the area, the approximate location and nature of the underwater objects and by using the digital data interpretation techniques the magnetic surveys could be successfully employed for locating the underwater objects that are either buried or exposed at the ocean floor.

Recently detailed magnetic, seismic profiling and bathymetric

surveys were carried over the inner continental shelf off Visakhapatnam. Besides the normal magnetic anomalies that are produced by the geological formations some sharp and isolated anomalies are recorded in Bhimilipatnam Bay, Samala Konda Bay and Pudimadaka Bay (Figs. 1, 2 and 3.). From the nature of the anomalies it appears that they are not produced by any geological features and more resemble the anomalies that are caused by some isolated submerged objects. As such it is suspected that the sources causing these anomalies may have the archaeological importance. However no work has been carried out in this aspect so far.

SEISMIC PROFILER SURVEYS

The late Wisconsin glaciation (25000 to 6000 BP) caused worldwide lowering of sea level and many portions of the continental shelf were exposed which are expected to yield physical and cultural remains of the prehistoric man (12000 BP). Thus the remains of the prehistoric man on the now-submerged shelf may provide new information on cultural contacts, migration patterns and environmental adaptations. The portions of the shelf that are subaerially exposed are estimated from the sea level curves which are obtained by using carbon 14 datings of the in-place organic-material such as peats, shells and tree roots.

Prehistoric man's physical and cultural remains may occur anywhere along subaerial surfaces but the areas of high archaeological potential should be looked upon in conjunction with the geomorphic features like fluvial channels, bays, lagoons, salt or

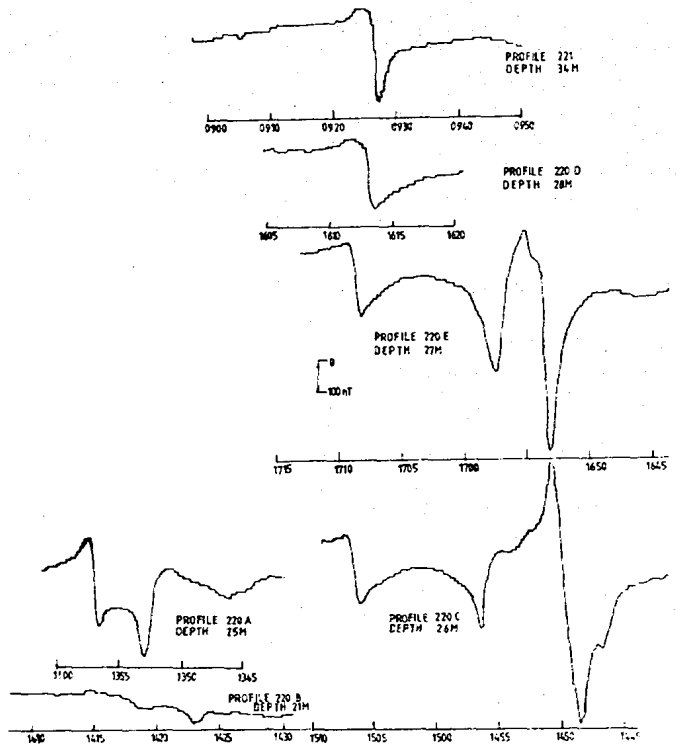


Fig. 2 Total Magnetic Field Intensity in the Samala Konda Bay

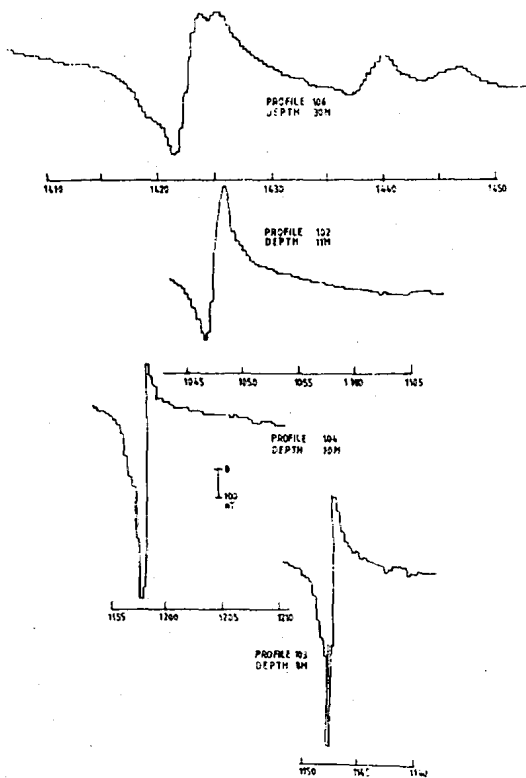


Fig. 1 Total Magnetic Field Intensity in the Bhimilipatnam Bay

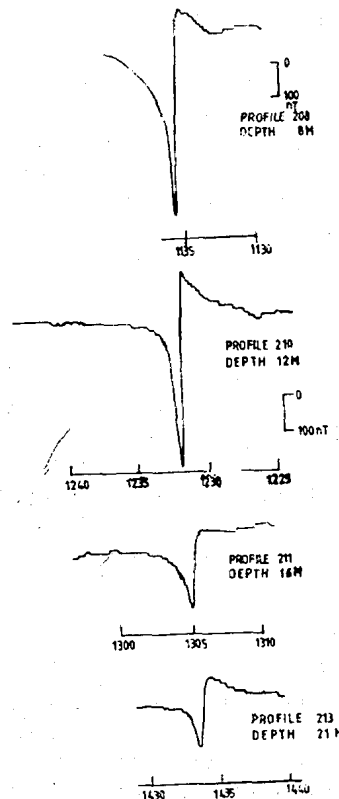


Fig. 3 Total Magnetic Field Intensity in the Pudimadaka Bay

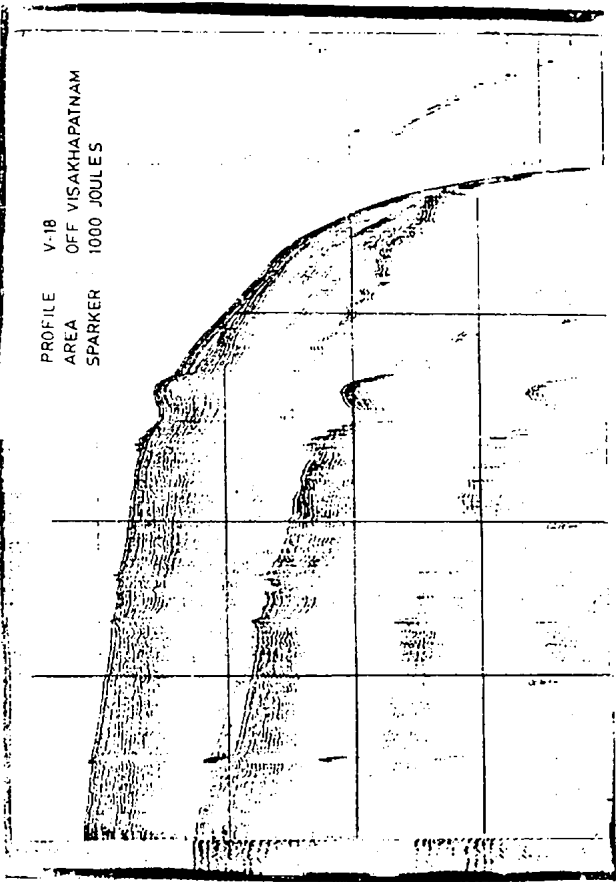


Fig. 5

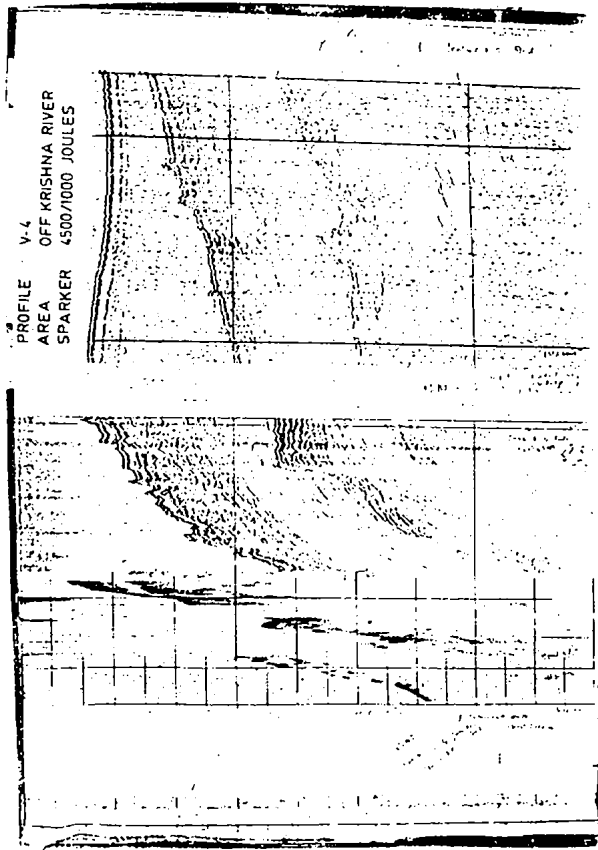


Fig. 7

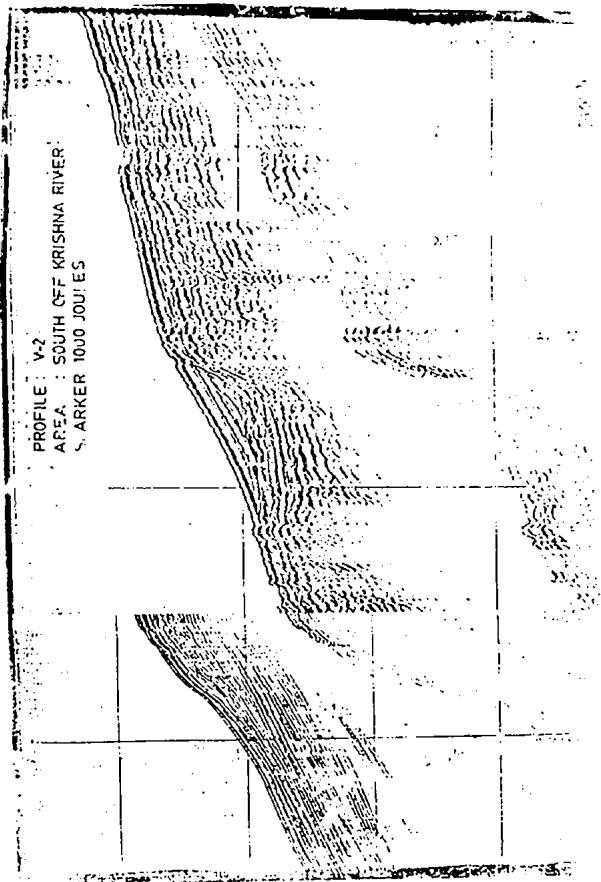


Fig. 4

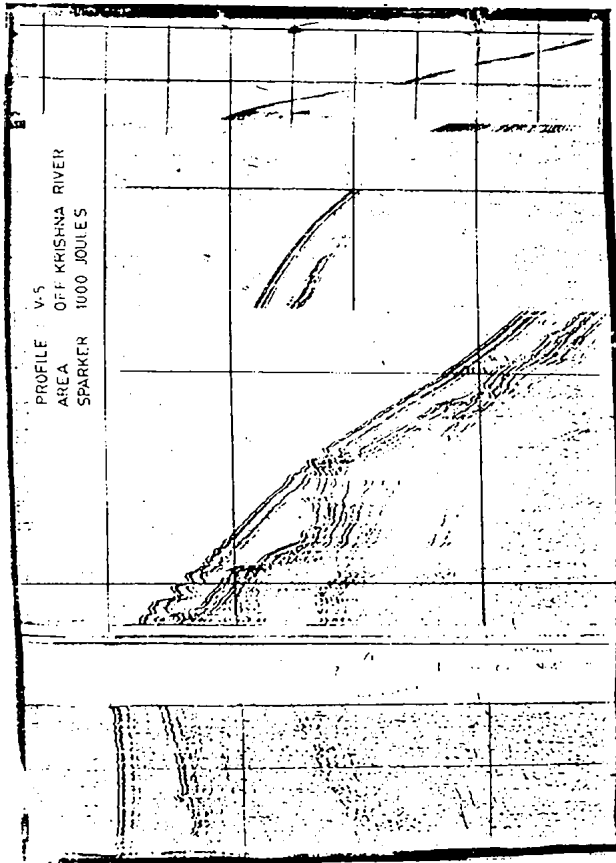


Fig. 6

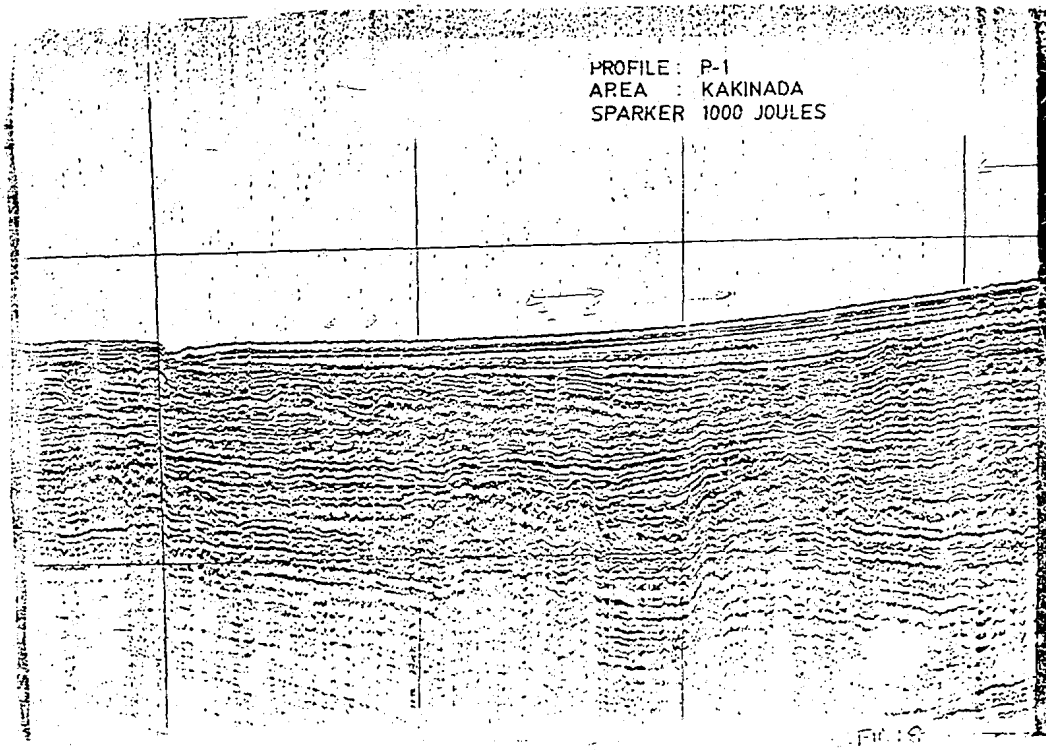


Fig. 8

shale diapirs and karst structures which served either as source of fresh water supply or as topographic highs and terraces. Although the archaeological features or the sites are not of the sufficient size or of sufficient difference from the surrounding sedimentary sequences to be resolved by high resolution seismic profiler (3.5 or 7.8 khz) the geomorphic features as such, with a high potential for associated archaeological sites could be easily detected. Regional geological studies of late Pleistocene and Holocene geology provide a framework for interpreting the seismic data which is the basis for assessing the age and type of geomorphic features detected from the seismic profilers.

Having recorded the geomorphic features from the seismic profiling, their preservation characteristics and the type of sediments should be considered to assess their archaeological potential. The geomorphic features that have high degree of preservation include the sites covered by the sediments in low energy environment (river-terraces, bays, lagoons etc) prior to marine transgression and also the sites on relatively steep portions of the shelf which were transgressed when the sea level was rising quickly. Similarly the sediment type also governs the site preservation. The sites associated with silts and clays have high preservation potential than the sites occurring within the sands and gravels because the finer grain sediments usually indicate the low energy environment and their great cohesiveness allows less oxidation. Relict geomorphic features having potential for both site occurrence and preservation should be sampled by coring to confirm the presence of an archaeological site.

High resolution seismic profiler surveys are being extensively used in the near-offshore regions to examine paleobeach deposits

for potential sites of ancient human occupation. Side scan sonars that operate on high frequency mode are also used to locate the objects that are exposed over the ocean floor. Conventional seismic profilers such as sparker and boomer records are also found to locate the geomorphic features that bear importance for archaeological investigations.

Recently geophysical surveys comprising of sparker, magnetic and bathymetry are carried out over the continental shelf and slope of east coast of India between 14° 40' N and 20° 30' N. Some sections of the sparker records that show the geomorphic features such as paleobeaches, terraces, sediment bars, subsiding deltas and submerged channels are presented in the Figs. 4,5,6 and 7.

COAST OF ANDHRA PRADESH

Andhra Pradesh is one of the coastal states of India located on the central east coast of India. It has about 600 km long coastline containing several ports of minor and major types as well as the perennial rivers like Krishna and Godavari that build up large deltas and estuaries (Fig. 8). Among the ports on the coast of Andhra Pradesh, Visakhapatnam and Kakinada are the major ports that are active from the recent past and are currently in operation. In addition there are several other ports that were active in ancient times and are abandoned now. These include Machilipatnam, Bhimilipatnam and Kalingapatnam. From the historical record of Andhra Pradesh and particularly of the abandoned ports it could be gathered that there was active maritime trade between these ports and other countries like Burma, Malaya etc. It is told that the Bhimilipatnam port used to be the main port along east coast of India before the inception of Vis-

akhapatnam port and it was in operation for a few centuries and several ships belonging to other countries used to call at this port. Machilipatnam and Kalingapatman ports were used mainly for the internal trade and transportation. Therefore it is quite possible that some shipwrecks of ancient origin could be found if proper surveys are undertaken at these ports. Recently some artifacts belonging to Buddhist sculptures are recovered in the coastal regions of Bhimilipatnam. In addition to this there are reports that several shipwrecks are present in the offshore regions along Andhra coast, for example, Baruva, Bhavanapadu, Kakinada etc. There are also verbal and visual reports from the inhabitants of Visakhapatnam that a temple called "Visakeswara Temple" against which this city is named as Visakhapatnam was submerged and is approximately located at about 10 to 15 m water depth almost opposite to coastal battery.

There are several reports of controversial nature regarding the location of "Lanka of Ravana" depicted in Ramayana. D.P. Mishra in his book entitled "The Search for Lanka" has reported that the "Lanka of Ravana" may be present in the Godavari mouth which is now submerged. Some of the seismic sections in the Krishna-Godavari delta region, reported above recorded the

paleobeaches overloaded with more than 50 m of recent sediments as well as the sediment slumping and submergence of land masses. Detailed investigation in this area may lead to infer about the "Lanka of Ravana" as reported by D.P. Mishra.

The Regional Centre of National Institute of Oceanography at Visakhapatnam besides being ideally located at the central portion of east coast of India has all the marine geophysical equipment like seismic profilers, Side Scan Sonar, proton precession Magnetometer and echo sounders to undertake the marine archaeological studies along the Andhra coast and other parts of east coast of India. Given the necessary support and impetus this new field of technology could be successfully employed for marine resources development not only to unravel the maritime aspects of past cultures and civilization in India but also perhaps to locate hidden treasures and other artifacts.

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