

Application of High Resolution Shallow Seismic Investigations for Marine Archaeological Sites

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It is well known that our ancient civilization and culture in the beginning had their origin mainly around the river banks, channels and other places of water resources. During the last 5000 years of active civilization, one cannot expect much of submergence and emergence along the coastal belt but for a few meters. In this context, it is important to search for any exposed or buried fluvial channels in the shallow waters. These geomorphic features with which the civilization is associated can be recognised by marine seismic methods. Single channel high resolution shallow seismic reflection data collected by us from the Indian coast have provided evidence of these channels right from the coast to 30 m water depth. Sea level curves have indicated that these channels belong to the middle to late Holocene period which is known for its earlier civilization in India.

In this paper, some cases in and outside India are presented, stressing the importance of the seismic surveys in deciphering these channels, which are known to be the important sites associated with the development of human civilization and nursery of cultural heritage.

INTRODUCTION

Of late, many of the advanced countries and a few of the developing nations have turned their attention to develop the field of Underwater Archaeology. After the second world war, the bad necessity posed a challenge to many of the scientists especially involved in the defence research for the purpose of removing the mines placed in the shipping routes in view of establishing safe navigation in European seas and channels. In order to locate the minute cables and small gun boats in the vast Ocean bed, the Oceanographers and Technologists were deeply immersed to invent new techniques through which the location of the sunken objects can be expedited. Gradually the advancement of science in the field of electronics and instrumentation started to introduce the various modern underwater towing equipments mainly operated on the acoustic sources. After successfully employing these techniques in clearing the defence needs, attempts were made to apply them not only in the underwater treasure hunt for monetary benefits but also for the preservation of the cultural heritage. Thus the Marine geoexploratory devices found their relevance as the essential techniques in the Underwater Archaeological Exploration (Martin, 1981:35-39).

In this paper, we would like to elucidate the importance and usefulness of the high resolution shallow seismics taking one of the geomorphic features in relation to our ancient cultural heritage and try to solve the problems posed in shallow water conditions.

CULTURAL GEOLOGY

The coast in the recent past had repeated transgressions and regressions due to glaciation, a phenomenon well known since Pleistocene times (Fairbridge, 1961:99-185). The effect of this glaciation in varying the sea level is estimated to be more or less 100 m. Supplementing this fact, International Indian Ocean Expedition (IIOE) has brought a clear presence of 50 fathom flat and distribution of oolitic sand in both east and west coasts of India. It is generally agreed that the above flat or oolitic sandy zone could have been the earlier sea level that stood for a longer

duration. These variations have been taking place globally, sometimes locally too, during the geological ages.

As far as our cultural heritage is concerned, the period of last 12,000 years, in which early human civilization has been reported, is quite interesting. However, active civilizations like those of Mohenjodaro, Harappa, Crete, Rome and Greece were considered to be active only in the last 5000 to 6000 years. Geologically, this duration may not be significant in a way to introduce a noticeable major change. When one observes the scale of sea level variation within this period, it is surprising to know that it is only within 20 to 30 m of water depth (Millman and Emery, 1968:1121-1123).

The historical evidences of the earlier civilization indicate that the earlier human settlements are nearly connected around the water resources as it is evident that our ancestors had townships and habitat sites along the river banks or channel courses. Due to this, the explorers of the ancient habitat sites are attracted to the important geomorphological features of ancient river courses, which are preserved in the seabed either as the channel of extensions to the existing rivers or as buried fluvial channels of the previous river courses.

METHODOLOGY

These palaeo-channels with sufficient dimensions and sufficiently different from the surrounding natural sedimentary sequences can be easily recognised by using double frequency echo-sounders and shallow seismic profilers. Generally, sites covered by sediments in a low-energy environment before the marine transgression or the steep portions of the shelf portion that was transgressed during the sea level rising and those occurring within clays and silts have higher preservation potential (Stright, 1986:605-622). These type of channels are noticed in front of the present day rivers particularly in the bathymetric channels off Jaigarh and Bhatye (Rajamanickam, 1983:1-130). These channels of extension of the modern rivers have been located on the basis of the detailed bathymetric map prepared out of the closed grided transverse data.

In the case of rivers like Cauvery, Saraswati etc., shifting of the river course has brought the termination of river discharge and a discontinuity in the channel. In such cases, the recognition of the subsequent deposition of fine sediments in the channel can be traced from the records, obtained through shallow seismic profiler or mud penetrator.

MARINE GEOINSTRUMENTATION

In order to explore the structures below the seabed, it is necessary to use the sound sources of higher energy but of lower frequency than the basic 'echosounder' system which is generally designed to give the profile of the seabed. A continuous high resolution sub-bottom seismic profiling system with the proper graphic recorder, one of the suitable sound sources and receiving equipment, can produce a record showing penetration far reaching beyond the expectation of marine archaeological sources beneath the seabed. Some of the basic energy sources with high resolution are Boomer, Sparker, Spark Array and Mud Penetrator. They are supported by the receiving system of proper hydrophone array, variable band pass filters, amplifiers and a suitable graphic recorder.

Boomers produce low frequency and high energy pulses using a high voltage. The stored energy is discharged through the gap into the transducer coil. The acoustic energy is produced by eddy currents repulsion. The plate is repelled from the coil with a tremendous force when the charge from the capacitor is discharged into the coil. With improved designs of the transducer and better selection of boomer with 165 Joule energy source, a penetration of about 25 m with a high resolution can be achieved in ordinary conditions. A sparker transducer, instead of boomer plate as used in boomer, consists of a small anode with a large cathode return where the current orifice is small enough to produce the minimum electric field density necessary to vapourise the water and produce a pulse and the receiving systems being the same as that of boomer.

A spark array system consists of spark array source, power supply, control bank, hydrophone receiving system and a graphic recorder for recording data. This can be used in places depending upon the sedimentary formations, particularly sands, gravels etc. in which the palaeo-channels were embedded showing the geomorphological features existing previously. The mud penetrator which differs in its operation from the above shallow seismic system consists of transceivers, side mounted transducer array along with the graphic recorder unit, the quality of records obtained by this system being dependent upon the power supply, frequency, bandwidth, pulse length and time varied gain. It gives more penetration about sub-bottom if it is covered with transparent clayey formations.

In all the above systems, the recorders were operated at various sweep rates depending upon the required resolution and penetration. Even in the shallower areas, if the operational techniques are synchronized properly with the knowledge of parameters of water depth, search conditions and the energy applied for sending the acoustic waves into the substrata, one is likely to receive a better resolution with minute featural details. For example, in the Konkan coast placer mineral survey, the first author was asked to obtain a penetration to the basement and

better resolution over the black sandy seabed. On using Huntex 2 A system resolution was there without much penetration. Then viewing the penetration, EG & G Boomer was used using upto the maximum 300 joules energy source, but with no improvement, whereas Spark Array EG & G with only 200 joules energy produced better resolution with optimum penetration. Judging the suitable seismic unit, energy requirements etc. comes out of experience gained in judging the nature of seabed and required penetration into substrata.

During the surveys for placer mineral exploration along the Maharashtra coast by National Institute of Oceanography, Goa, number of such buried channels covered by unconsolidated placer sands and often clays (pls.19 and 20) have been identified in shallow depths (Siddiquie *et.al.*, 1982: 749-762; Rajamanickam, *et.al* 1983: 1-130; 1988: 475-486; Gujar *et.al.*, 1986: 241-246). Buried fluvial channels were observed by the second author around 30 m water depth off Vengurla on the same coast while exploring the geological formations (Subba Raju *et.al.*, 1988). Such channels have been recognised from shallow seismic surveys in the areas of previous sea level stands around Bombay high (Siddiquie, 1976: 115; 1977:26).

Once these channels are recognised, other techniques like magnetics (Subba Raju, 1987: 439-446) for exploring the magnetically anomalous zones and side scan sonar (Vora, 1987: 159-164) for recognising unusual and irregular features, may be deployed to supplement the evidence of the habitat sites that are mentioned in the historical records or oral traditions.

CONCLUSION

Since our ancient heritage is deeply associated with the river banks or water courses, the recognition of the palaeo-channels would be an important step in underwater archaeological explorations that have been explored systematically (Stright, 1986: 605-622; Suter, 1986: 24-37). Sufficient should be taken in recognising such features as the same could mislead if improper operational techniques and interpretations are employed. A well experienced intelligent interpreter with a sound reasoning is always likely to bring success in the use of the marine shallow seismic instrumentation towards archaeological studies (Kraft *et.al.*, 1987:87-120; Pearson *et.al.*, 1986: 1-1156).

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