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## MARINE MAGNETIC SURVEYS OVER AN ANCIENT SUBMERGED PORT OF TAMILNADU

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### ABSTRACT

Total magnetic intensity surveys carried out in shallow waters off kaveripoompattinam, an ancient submerged port of Tamilnadu, showed the concentration of magnetically anomalous zones having an amplitude ranging from 25 to 2250 nT in water depths ranging from 7 to 23m. Anomalies in these zones have been interpreted due to the underwater archaeological remains rather than sunken ship wrecks and its associated objects. The masses of the archaeological objects have been derived by using the theoretical formulae and are found to be nearly from 0.5 to 150 tons. These observations imply the fact that the interpreted bodies require a thorough underwater study for their confirmation.

### INTRODUCTION

The usefulness of the Proton Precession Magnetometer in underwater archaeology is stressed by various authors<sup>1-5</sup>. It has been taken up quite recently in India to explore the marine archaeological remains, steel or wooden submerged ship wrecks through surficial underwater findings<sup>6</sup>. The feasibility of the marine magnetic surveys to find out the remains of the suspected submerged port or any ship wrecks is not attempted so far in Indian waters. An attempt has been made in this direction first time in India by National Institute of Oceanography to find out the remains, if any, of the submerged port of Kaveripoompattinam off Tamilnadu coast or any ship wrecks, by using marine magnetics.

### HISTORICAL BACKGROUND

Kaveripoompattinam, also known as Pumpuhar was a flourishing port in the beginning of the Christian era on the east coast of India, at the confluence of river Cauvery with Bay of Bengal. This port suddenly lost its glory and eminence for it was swallowed by the sea, probably in the first century B.C.<sup>7</sup> Reports by local fishermen, finds of household articles

in their nets and also submerged structures like temples etc. where fish shoals also occur abundantly, formed the base of the survey.

## INSTRUMENTS AND METHODOLOGY

A Barringer Oceanographic Proton Precession Magnetometer was used to detect any magnetic anomalies associated with submerged or exposed magnetic objects and shipwrecks by collecting the total magnetic intensity data of the earth's magnetic field in water depths ranging from 7 to 23 m (Fig.1). The data were recorded at an interval of 6 sec. continuously. The sensor was towed at a distance of 25m from the boat to avoid any magnetic effect due to the engine and other iron fittings of the boat. The total magnetic field (in nT) was displayed in digital/analog form with an accuracy of 1 nT. Reconnaissance surveys with a track spacing of about 250m (Fig.1) were conducted initially. For position fixing, MRS III Navigation system which has great accuracy and excellent repeatability, was used. Sextants were used with shore markers as an alternative when the navigation system developed some faults. Since magnetometer sensor was deployed 25m behind the boat, corrections to that effect along the tracks from the position of the boat was given in preparing the magnetic profiles. The course was maintained straight almost inspite of some deviations due to currents and wind. Altogether 23 lines in various directions totalling 105 lkm were surveyed. Simultaneously side scan sonar, bathymetric data were collected<sup>8</sup>.

## RESULTS AND DISCUSSION

The results of the total field magnetic intensity data show a smooth variation in the magnetic field of the earth in the region. This is disturbed by the sources on or beneath the seabed creating considerable anomalies in the magnetic field. Most of the major anomalies appeared in water depths between 7 and 23m. Table I shows the particulars of the source and the sources are termed as M1 to M8. Fig.2 gives the magnetic profiles on the concerned lines.

M1, M3 and M6. The source of the anomaly is due to the shallow and wide body appearing with two or more peaks.

M2, M4 and M7. The source with a single peak can be due to the single body.

M5. This anomalous zone with a maximum amplitude of 640 nT can be due to the bodies spread irregularly or haphazardly on the seabed.

Table I - Particulars of the location of the causative source and the amplitude of the magnetic anomaly.

No. of of the Source	Fix No.	Line No.	Depth to the seabed (in m)	Amplitude of the magnetic anomaly (in nT)
M1	279-280	16	22	25
M2	289-290	16	17	22
M3	315-317	18	11	20
M4	326-327	18	19	20
M5	418-423	24	18	640
M6	355-357	20	17	2250
M7	481-482	28	17	60
M8	483	28	18	265

M8. The source of the anomaly may be same as that of M7. However, the susceptibility and size of the body may be higher than that of the source M7.

From the profiles given in Fig.2, it is clear that the local anomaly due to the sources is superimposed on the regional trend of the earth's magnetic field. In all the profiles, the gradient of the regional field appears to be smooth either increasing or decreasing, except line No.18, where it has reduced to 17m water depth and afterwards it has increased towards east.

Geologically, the study area lies in the Cauvery basin and the Archaean basement has an average depth of 4000m. A well, drilled upto 3500m near Mayavaram, about 20km west of it encountered 2400m of Tertiary sequences, the rest being Cretaceous. It may be considered that the local anomalies super-imposed on the earth's magnetic field are due to the local geology or man-made bodies present on or beneath the seabed. The Tertiary and Cretaceous sequences, in this area are expected to give rise fairly smooth magnetic field since they consist mostly of sedimentary rocks lying at moderate depths. The local anomalies were therefore inferred due to man made bodies, if not by any meteorities.

Due to the magnetic nature of the material, the type of signatures differ. Single sided curves as like in Fig.2, are likely to be produced by objects having predominantly permanent magnetism. The cause of the sign of the anomaly (+or-) depends on the direction in which the field of the object lies. The weight of the objects were derived by using the formula taking into consideration that the objects may be on the seabed.

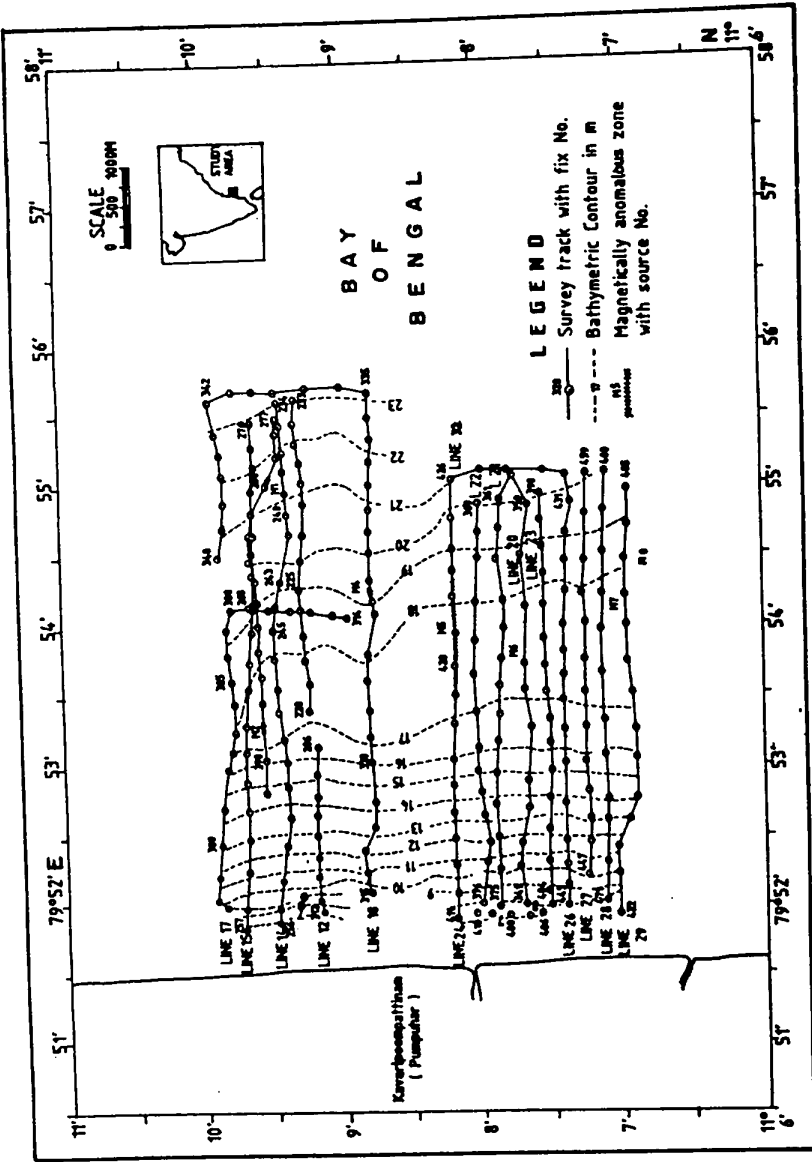


Fig.1. Map showing the location of the lines of survey tracks with bathymetry and magnetically anomalous zones.

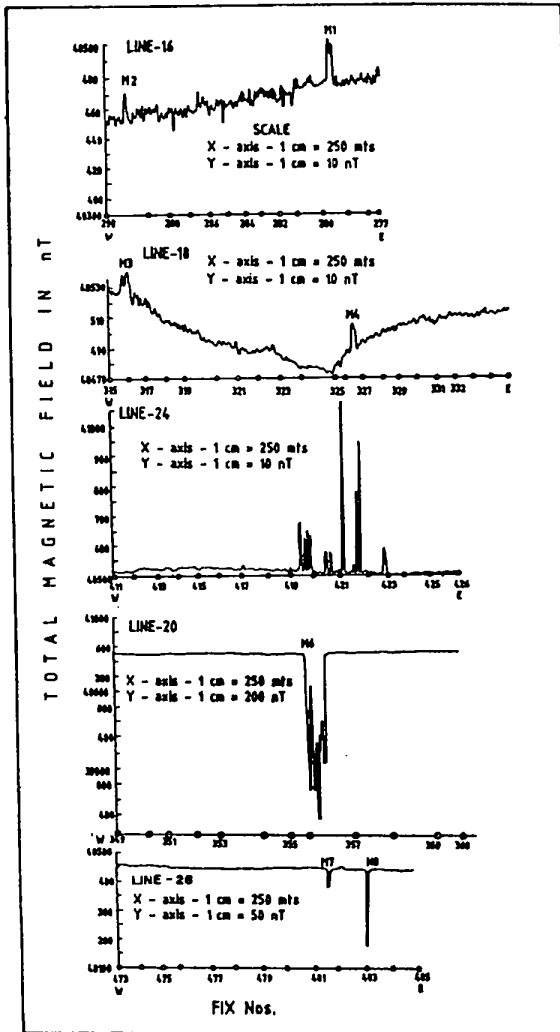


Fig.2. Total magnetic intensity profiles on lines 16, 18, 24, 20 and 28.

$$T = M/r^3$$

where T = magnetic anomaly in nT, M = magnetic moment in cgs units and r = distance of the source and the sensor in cm.

The anomalies having an amplitude more than 5 nT are taken into account as less than that and those having high frequencies are ignored since the hydrodynamic action of the waves coupled with twisting of the magnetometer sensor can create the anomalies as high as 3 nT.

A formula  $M = 10^4 \cdot A/B \cdot w/d^3$  was adopted for calculation of the weight of the causative bodies for assessing the above results<sup>3</sup>, where M = magnetic anomaly in nT A/B = ratio of length to width of the object, w = weight of the object in g, and d = distance of the object in cm.

Table II gives the weight of the source by using both the formulae. In the first one, the magnetic moment M has been taken in between  $10^5$  and  $10^6$  cgs units per ton, while the second assumes the ratio A/B as 5.0.

The values of the weights of the objects derived by using the latter formula<sup>3</sup> coincide with those derived from that of the nomograms<sup>12</sup>, assuming the dipole moment as  $M = 5 \times 10^5$  cgs units/ton of iron.

Through C<sup>14</sup> dating, it is noticed that iron is introduced in South India through the sea route around 1000 B.C.<sup>13</sup> It is also observed that 100 B.C. - 500 A.D. may be the age of steel making in India<sup>14</sup>. In this circumstances, it is not reasonable to say that the targets such as sunken iron ships, anchors or cannons might be the reason for those anomalies as in the prehistoric period, ships were made up of wood<sup>15</sup>. It may be mentioned that higher than normal values of the Earth's normal magnetic intensity over the archaeological features such as ditches and

Table II - Results of the derived masses of the object.

No. of the Source	Weight of the causative source (in tons)	
	$T = M/r^3$	$M = 10^4 A/B \cdot w/d^3$
M1	2.00 to 20.00	4.00
M2	0.74 to 7.40	1.48
M3	0.15 to 1.50	0.29
M4	0.98 to 9.80	1.96
M5	26.20 to 262.00	52.40
M6	75.90 to 759.00	151.80
M7	2.02 to 20.20	4.04
M8	10.80 to 108.00	21.60

pits and also a large number of constructions made up of stones, give rise to anomalies lower than normal magnetic field intensities due to the contrast between the stone and earth deposits elsewhere<sup>16</sup>. Sometimes fired rocks provide the most significant magnetic targets for prospection and rock lined hearths can be magnetically detectable at much greater distance<sup>17</sup>. Fluctuation of the order of even 300 nT over the building site while there is only negligible scatter in the part of the profile outside the building, is attributed to the fired clays<sup>18</sup>.

### CONCLUSIONS

1. The magnetic anomalies observed in shallow waters off Kaveripoompattinam are due to ferromagnetic objects associated with underwater archaeological remains rather than a sunken ship wrecks, anchors and cannons etc., 2. Marine magnetometer proved to be useful to find out the underwater archaeological remains & 3. In this kind of marine magnetic search, more useful and detailed information can be obtained by reducing the spacing between the search tracks before taking up the diving operations for confirming the identified objects.

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