ANALYSIS OF TEMPORAL CHANGES OF MAGNETIC (TF) ANOMALY AROUND BARREN AND NARCONDAM ISLAND AND ITS SIGNIFICANCE IN TERMS OF THE THERMAL STATE IN THE CRUST

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Magnetic surveys around Barren and Narcondam Island have brought out different anomaly pattern during different period of surveys since 1990. This variation in amplitude of anomaly pattern in the magnetic signal, which is responsible for Curie Isotherm Depth (CID), shows distinct picture of thermal eruption from 1990 to recent past. This in turn will raise or lower the CID, which is reflected in the present study. Data collected from the various cruises of *R/V Samudra Manthan* (SM-61, 78, 113, 136 and 157) of the Geological Survey of India are analysed here.

Introduction

The Barren and Narcondam Islands are uninhabited landmasses in the Andaman Sea and are a part of the Andaman-Nicobar-arc-trench system Together with the Burmese arc to its north and the Sunda arc to its south, this is an important tectonic link between the Himalayan collision zone to the north and the major island arc trench systems of south Asia (Chhibber, 1934) Results of the International Indian Ocean Expedition conclusively prove that the Barren and Narcondam Islands, along with the invisible Bank, form the western fringe of the inner volcanic arc This is also borne out by the results of seismic reflection, magnetic and gravity data in the Andaman sea (Peter et al 1966, Curray et al 1982) The Indian plate west of this arc, subducts below the Burmese plate upto a depth of almost 200-220 km.

The Barren-Narcondam active volcanic arc continues upto the Simenko rift in Sumatra (Rudolfo, 1969) The volcanism in Sumatra, Borneo and the Andaman basin has been intermittent in the Oligocene, Miocene periods before being vigorous in the Pliocene Presently though it has ceased in Borneo, but in Andaman basin it has still been active The Pliocene tectonism in Andaman is borne out through seismicity and increased heat flow characteristics

Magnetic surveys can bring out useful information on the crustal structure below the islands specially in relation to the thermal history of the crust From the known thermal history of this area, including the volcanic eruptions in the recent past, perturbations in the geoisotherms below these islands are certain Obviously such episodic rise and fall of the geoisotherms below these eruptive volcanoes will raise or lower the Curie Isotherm Depth (CID) Thus, the magnetic signal which is significant only upto CID, will also be random due to partial or complete loss of magnetism Hence magnetic surveys on some E-W profiles cutting across such arc system will give vital information on the thermal state of the volcanic system. Magnetic surveys on board *R/V Samudra Manthan* reveal that Barren Island volcano became active in 1991 and continued up to 1995 Even in 2001 it was found active So periodic monitoring of temporal changes of Magnetic (TF) anomaly along with Curie point determination has become necessary With these objectives four East-West traverses as shown in Fig 1 near the Barren and Narcondam Islands volcano have been covered by magnetic surveys during cruise SM-157 in 2002 which was carried out for repeated monitoring the temporal changes in magnetic (TF) anomaly from 1990 to 2002 The results are discussed in the following sections

Results

In Fig 2 four E-W magnetic (TF) anomalies recorded in different times over the same traverses have been shown in different symbols along with bathymetry The location of Barren and Narcondam Islands have been plotted on one profile These traverses are along 13°20' N, (2a) 12° 25' N, (2b) 12°20' N (2c) and 12°15' N (2d) latitudes and lie in between the transverses 93°15' E and 95°30' E It is clear from the profiles, that in post- eruptive period of Barren volcano (1999, 2002) the magnetic (TF) anomalies along 13^0 20' N latitude are identical in shape, with a relative shift in the amplitudes The same is true along 12°15' N which has been observed in post eruption scenario (1996, 2002) But in the profile along 12°25' N, which has been reoccupied twice (1992,2002) after the eruption (1991, 1995), there is a substantial change in the amplitude of the anomaly patterns, though qualitative nature remains the same But the most significant change is in magnetic (TF)

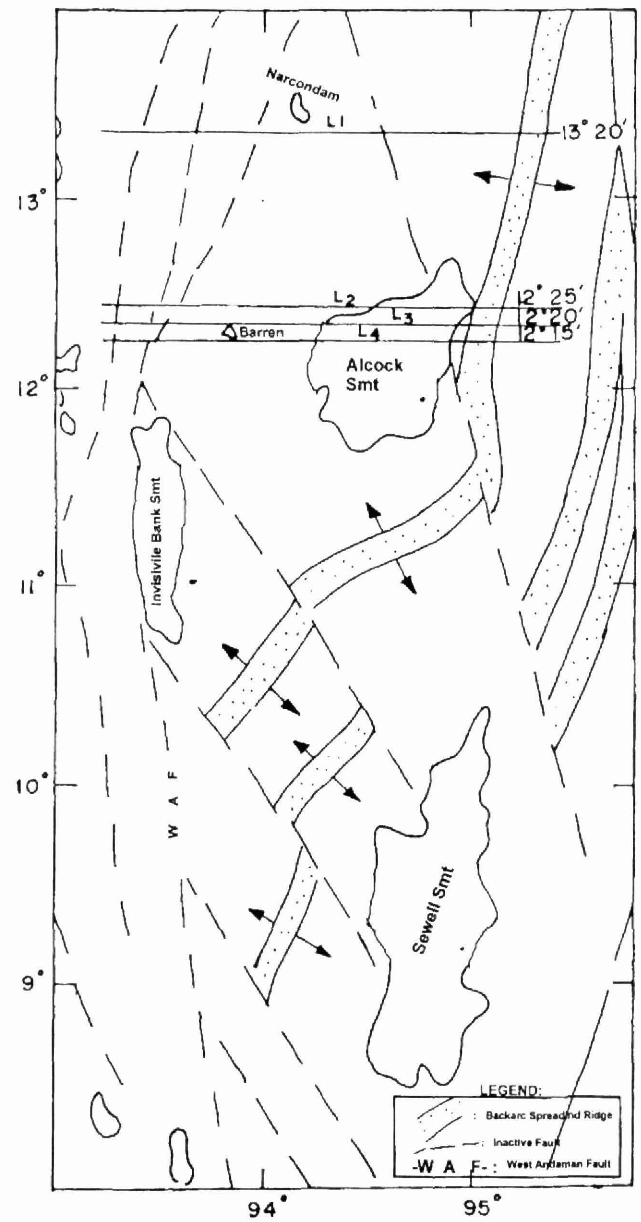

Fig.1. Location map of the survey around Barren and Narcondam island along the lines L1, L2, L3 and L4 (compiled after Hamilton, 1978; Curray et al. 1979, 1982).

anomalies along 12°20' N which is north of the Barren island (12°16' N; 93°52'E). This has been surveyed both before eruption as well as after the eruptions (1990 and 2002). Actually Barren erupted in two phases, one between April-September 1991, and the other around January-July 1995. It is interesting to note that during the post eruptive phases, the magnetic anomaly has increased substantially, because of increment in the thickness of the magnetic crust, due to lowering of the CID. Just before eruption, the geoisotherm was raised above, up warping the CID and reducing the thickness of the magnetic crust substantially.

Thickness of the Magnetic Crust

In order to have a first hand estimate of the magnetic crustal thickness, we have used the conventional analyses through power spectrum (Treitel et al. 1971; Pederson, 1971). The results have been shown in Fig.2.

From the power spectrum, two different sediment layers have been identified in all the traverses both for the earlier profiles observed during nineties and again when these were repeated during 2002. The first layer includes bathymetry with the computed basement which is about 4 to 5 km in all profiles from which it can be safely inferred that the thickness of Holocene sediments in this part of the Andaman sea is around 1-1.5 km.

The final layer is disposed around a depth varying from 6 to18 km. Since this is the deepest horizon which could be mapped with the magnetic anomaly we consider this as the depth to the magnetic crust below which the rocks have lost its magnetic property. Indirectly this may be termed as the CID.

A perusal of the fluctuations of this third layer from Fig.2a through 2d suggests that near the Barren Island (BI) volcano, the shallowest thickness of magnetic crust is around 6 km in 2002, compared to its 1996 counter part which is around 10 km. Thus an upwelling is suggested with the passages of time. In Fig.2c, identical value of 6 km is seen in 2002. But the picture from 1990 is not conclusive because of a very short segment recorded. In Fig.2b the thickness of the magnetic crust near BI is around 10 km, although the shallowest part occurs further to the east at 95°E longitude. With respect to the 1992 situation, the thickness shows an increase i.e, lowering of the CID. It is significant and heartening to note almost no fluctuation in the thickness of the magnetic crust along 13°20' profile (Fig.2a) from 93.6°E to 94.2°E, which is farthest from BI. The minimum value of the thickness of the magnetic crust along this profile is around 6.5 km, around 94.4° E in 1999 which has gone down by almost 2 km at the same point. A tentative disposition of the uppermost part of the CID has been shown in the Fig.2, as a cartoon diagram. This immediately suggests that the upwelling of the geoisotherm is gradually shifting NNE from the Barren Island volcano. Incidentally the Benioff zone, which has been running N-S in the area also bends in the same direction, slightly north of this feature. This is very significant. Probably the urge of the cold felsic rocks and sediments prevent the migration of the volcanic matter further to the west, and as a result the eruption takes place through the Barren Island volcano.

Banerjee et al. (1998) and Banerjee and Shaw (2001)

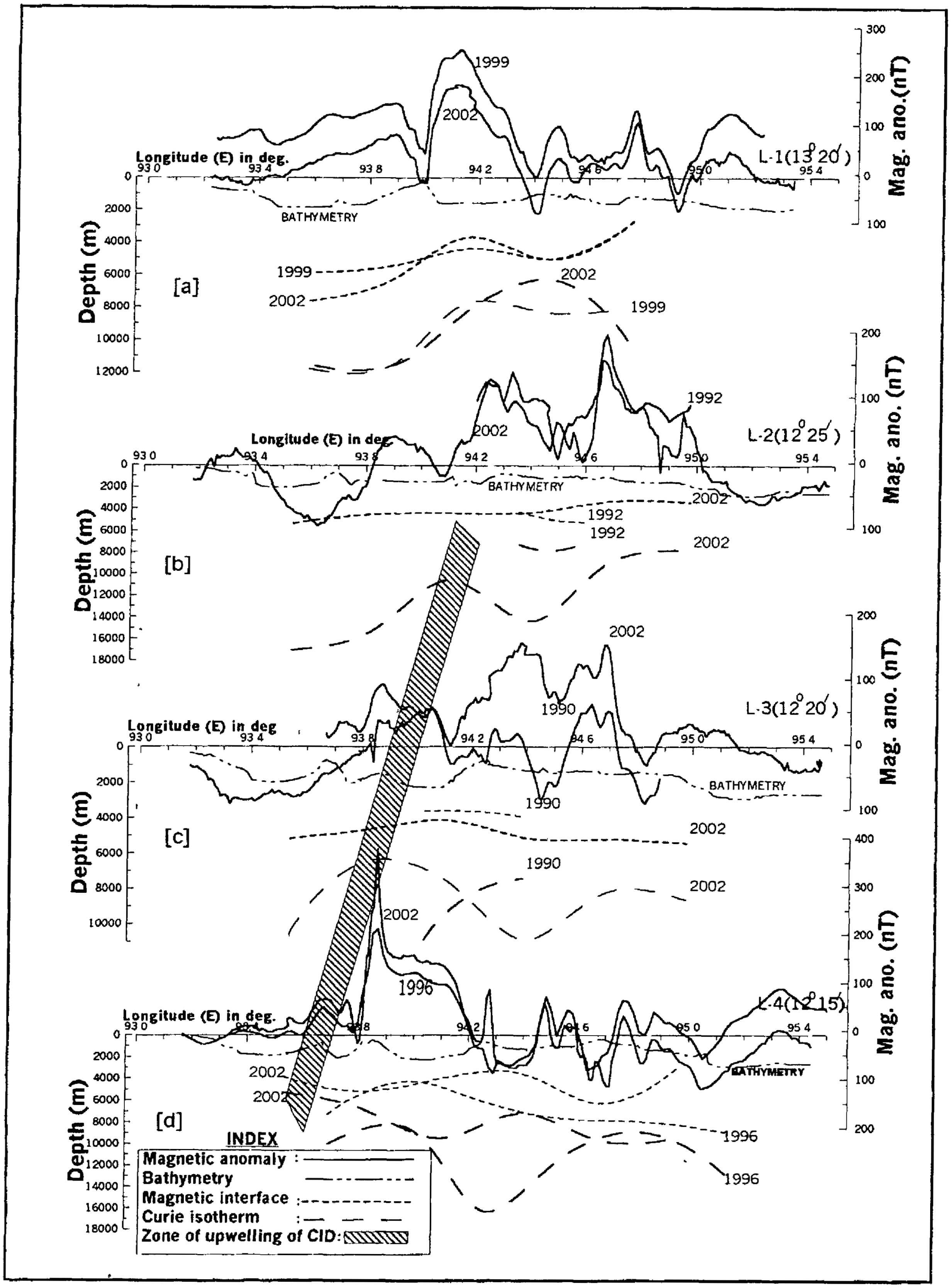

Fig.2. Magnetic (TF) anomalies along the four traverses around Barren and Narcondam island and the changes in geoisotherms since 1990

suggested rising of the CID around BI volcano both from the conventional analyses of the power spectrum and from the maximum likely hood function (Davies, 1982), along two profiles that were run along 12° 15' N and 12° 18' N In their analyses, the CID was found to vary from 5 to 10 km depth from M S L. which indicates 2 km from the basement.

Conclusions

The magnetic (TF) anomaly map has been successfully used to monitor the changes in the geoisotherms in the areas near to Barren and Narcondam Island volcano in the Andaman Sea

The probable disposition of the upwelling in NNE and is parallel to the Benioff zone, which also turns NNE north of this area from its normal N-S course If this perturbation of the geoisotherms persists over a longer time, this zone (marked by hatching in Fig 2) may act as a potential zone of volcanic arc formation in the future

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