

Magnetic Studies in the Northern Bay of Bengal

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Abstract. Total magnetic intensity and bathymetric surveys were carried out in the northern Bay of Bengal between 6° to 11° 45' N latitudes and east of 84° to 93° 30' E longitudes. The hitherto known 85° E Ridge is characterised as a subsurface feature by a large amplitude, positive magnetic anomaly surrounded by Mesozoic crust. A newly identified NE to NNE-SSW trending magnetic anomaly between 7° N, 87° 30' E and 10° 30' N, 89-90° E may be one of the unidentified Mesozoic lineations in the northern Bay of Bengal. The Ninetyeast Ridge is not associated with any recognizable magnetic anomaly. The Sunda Trough to the east of the Ninetyeast Ridge is characterised by a positive magnetic anomaly. A combined interpretation, using Werner deconvolution and analytical signal methods, yields basement depths ~10 km below sea level. These depths are in agreement with the seismic results of Curray (1991).

Introduction

The Bengal geosyncline is the combined sediment accumulations of the Bengal Basin and the Bengal and Nicobar Fans (Curray, 1990). GEBCO (1983) depicts the physiography of the Indian Ocean, including the Bay of Bengal. One active turbidity current channel and several abandoned ones extend from the head of the Bay of Bengal to south of Sri Lanka (Curray and Moore, 1974). The most prominent topographic feature in the Bay of Bengal, other than the Bengal Deep Sea Fan, is the Ninetyeast Ridge, which divides the Bengal Fan into the Western Bengal Fan (west of the Ninetyeast Ridge) and the Nicobar Fan (east of the Ninetyeast Ridge and southwest of the Sumatra and Sunda trenches).

A number of geological and geophysical investigations have discussed the growth of the Bengal Fan, sediment distribution, regional (Miocene and Eocene) nonconformities, the 85° E Ridge, the Ninetyeast Ridge and basement depths (Moore *et al.*, 1974; Curray and Moore, 1971, 1974; Naini and Leyden, 1973; Curray *et al.*, 1977; Rao and Bhaskara Rao, 1985, 1986; Rao *et al.*, 1987; Stow and Cochran, 1989). The single channel seismic reflection data (Curray *et al.*, 1982) parallel to 10° N and 13° N show a maximum sediment thickness of 2 km on the 85° E Ridge crest, more than 8 km thick sediments east of the 85° E Ridge and a thin veneer of sediments over the Ninetyeast Ridge. Weiss *et al.* (1991) proposed that the Ninetyeast Ridge forms a major part of the 115 Ma hotspot trace formed by the Kerguelen Heard plume.

The Indian Ocean is the result of seafloor spreading between the Africa, Antarctica and Indian plates (Schlich, 1982). Identification of the oldest late Cretaceous anomaly (Chron 34) in the southern Bay of Bengal by Royer *et al.* (1989) suggests the presence of Cretaceous Quiet Zone (CQZ) between the east coast of India and north of anomaly 34 lineations. Although several researchers (e.g., Curray *et al.*, 1982; Curray, 1991; Rao and Bhaskara Rao, 1985, 1986) have carried out geophysical investigations in the Bay of Bengal and published isopach maps of total sediments as interpreted from seismic refraction measurements, the basement configuration and nature of the crust still remains speculative. The present investigations (Figure 1) were planned to study the magnetic anomalies for better understanding of the nature of the crust and associated structures.

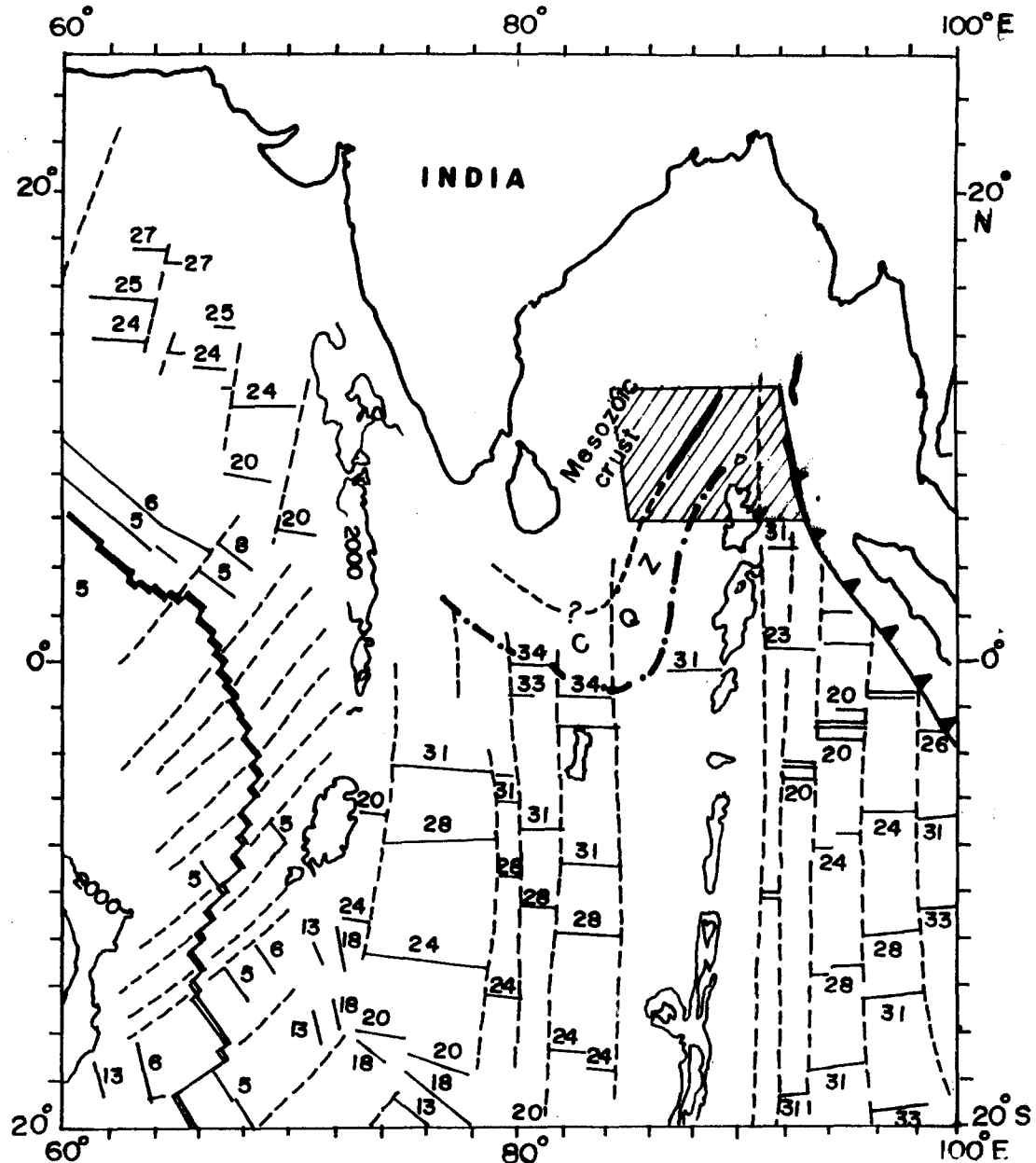


Fig. 1. Structural style and anomaly lineations of the North Eastern Indian Ocean (after Royer *et al.*, 1989). Map showing the probable extent of late Cretaceous crust and Cretaceous Quiet Zone (84 Ma to 118 Ma). Box shows the study area.

Data

The surveys were carried out onboard DSV NAND RACHIT during the field season 1989–1990. About 8200 line km of bathymetry and total magnetic intensity data were collected along six east-west profiles, spaced at intervals of about one degree, with one north-south tie line (Figure 2). The positions were obtained by Satellite Navigation System (Magnavox 1107).

The bathymetry data were collected with a 12 KHz deep sea Raytheon echosounder. Total magnetic intensity values were recorded with the Geometrics proton precession-type magnetometer, and the data were reduced by subtracting the International Geomagnetic Reference Field of 1990 epoch (DGRF, 1986), computed at each observation point. The reduced magnetic anomalies were then plotted perpendicular to the ship's tracks (Figure 2).

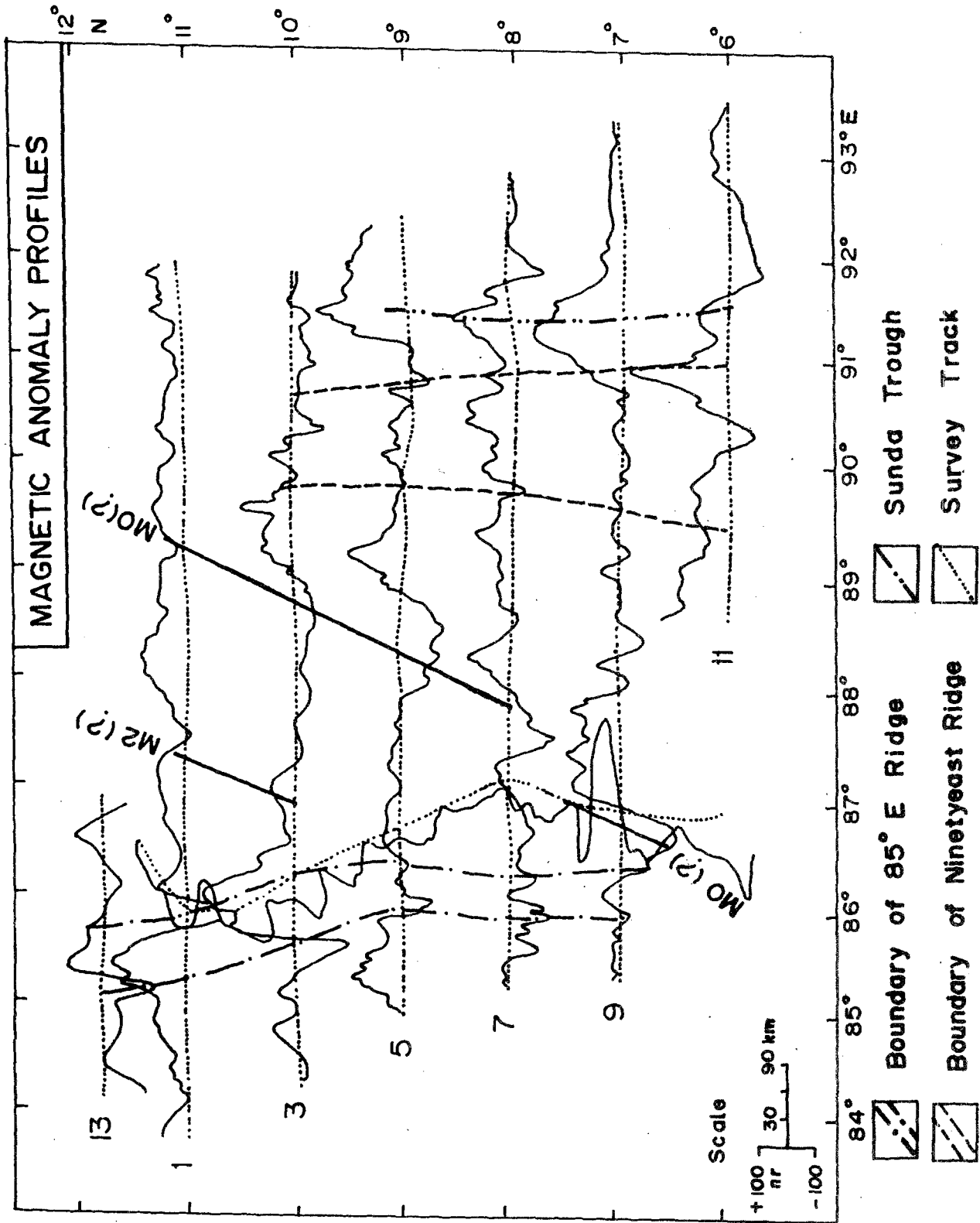


Fig. 2. Stacked magnetic anomaly profiles.

Results

The processed magnetic data have been presented in the form of a stacked anomaly map (Figure 2). We would like to mention here that although the 85° E Ridge north of this survey area is near 85° E longitude, in the present study area, the observations show that the ridge is situated ~86° E Longitude. Further, the Seasat altimetry-derived gravity mosaic (Haxby, 1987) confirmed this observation. The 85° E Ridge exhibits a positive magnetic anomaly over the ridge crest. Geophysical anomalies over the 85° E Ridge have been discussed by Liu *et al.* (1982) and Chaubey *et al.* (1991). The stacked anomaly map also depicts a NE to NNE-SSW striking magnetic anomaly between the 85° E Ridge and the Ninetyeast Ridge, conspicuous between 7° N and 10° N latitudes. This anomaly is characterised by a broad negative and positive peak with 250–300 nT amplitude, comparable to the M0 anomaly (118 Ma) of Kent and Gradstein's (1985) revised geomagnetic polarity time scale. The Ninetyeast Ridge exhibits no characteristic anomaly. The Sunda Trough is associated with a high amplitude, positive magnetic anomaly.

Discussion

In general, the amplitudes of the magnetic anomalies are subdued, on the order of 100–200 nT, except over 85° E Ridge and the NE to NNE-SSW trending magnetic lineation between 85° E Ridge and the Ninetyeast Ridge, where the anomalies are around 300 nT. The amplitudes of the anomalies observed over the Ninetyeast Ridge are subdued and ill-defined. Basalts drilled from the Ninetyeast Ridge show similarities to those of the Kerguelen and Heard Islands, inferring their genetic link (Von der Borch *et al.*, 1974 and Weis *et al.*, 1991). The observed variable amplitude, magnetic anomaly (Figure 2, Profiles 11, 7 and 5) on the eastern flank of the Ninetyeast Ridge appears to originate from an intrusive-like body along the strike-slip motion of the Ninetyeast Ridge and Australian plate. Alternatively, the crust of the Ninetyeast Ridge in this region may be very brittle due to the ongoing process of subduction and the deep-seated magmatic material which, poorly magnetized, may have intruded through the developed flexures.

Royer *et al.* (1989) reviewed the geophysical data and published the tectonic summary chart of the Indian Ocean which depicts the presence of late

Cretaceous crust in the southern Bay of Bengal. An imaginary boundary of the extent of the late Cretaceous crust is drawn using the A34 isochron (Figure 1). Existence of the Cretaceous Quiet Zone (84–118 m.y.) can be inferred in the northern Bay of Bengal from the studies of Powell *et al.* (1988) and Royer *et al.* (1989). Most of the anomalies observed in the study area resemble seafloor spreading anomalies with low amplitudes. The presence of low amplitude anomalies may be due to the large overburden thickness or, as suggested by Kent and Gradstein (1985), because the Pre M25 anomalies are of small amplitudes. No attempt was made at this juncture to generate the realistic oceanic crust model, as we feel that these data are inadequate; also, part of the data appears to cross the Cretaceous Quiet Zone.

If we consider the pre-breakup scenario of Gondwanaland (Powell *et al.*, 1988), the eastern margin of India is a conjugate part of Antarctica and Australia. Further, the Mesozoic anomalies are well mapped on the continental margins of Antarctica by Bergh (1977) and in the western Australian basin by Markl (1974). Similar Mesozoic lineations may also occur on the eastern continental margin of India. The observed NE to NNE-SSW trending magnetic anomaly lineation (Figure 2) appears to be one such Mesozoic lineation, most probably M0 (?). If so, the zone between M0 and A34 chron should represent the Cretaceous Quiet Zone marked in Figure 1. Detailed geophysical investigations are required to examine the extent of Cretaceous Quiet Zone and Mesozoic crust.

Seismic reflection and refraction results (Curry *et al.*, 1982; Naini and Leyden, 1973) along 10°, 13° and 17° N latitudes show that more than 7–8 km thick sediments overlie the acoustic basement. To corroborate the above results we used Werner deconvolution and analytical signal methods (Ku and Sharp, 1983; Nabighian, 1972) due to their merits and derived the basement depths. In general, the depths are ~10 km from the mean sea level (Figure 3) and are well correlatable with the seismic results of Curry (1991).

Conclusions

The magnetic anomalies appear to originate from Cretaceous Quiet Zone and Mesozoic crust. Positive magnetic anomaly persists over the 85° E Ridge. The Ninetyeast Ridge is devoid of any significant correlatable magnetic anomalies. If we consider the observed NE to NNE-SSW trending

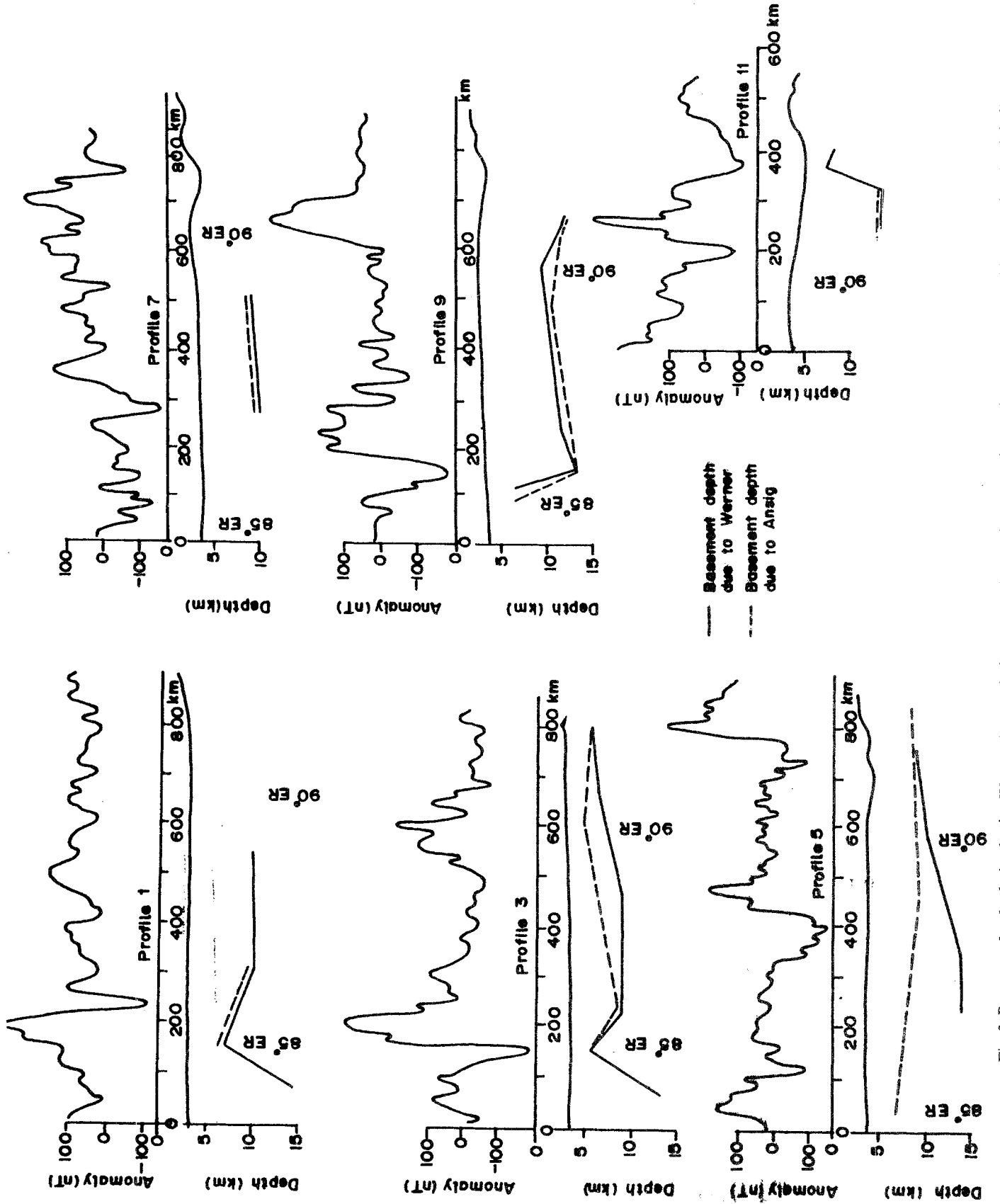


Fig. 3. Basement depths derived using Werner deconvolution and analytical signal techniques of Ku and Sharp (1983) and Nabighian (1972).

magnetic anomaly as one of the Mesozoic lineations, further surveys are to be planned for exploring the extent of the Cretaceous Quiet Zone and Mesozoic crust in the Bay of Bengal.

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