Marine magnetic anomalies off the southwest coast of India and their analysis

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Abstract

The observed magnetic anomalies are explained by sources equated to magnetized dykes, tabular bodies and semi-infinite slabs running NNE - SSW and lying at depths ranging from 2.5 km - 8.0 km. These may be attributed to intrabasement faulting in the magnetic basement and intrusives into the weaker zones of the basement. The observed relief of the magnetic basement may be attributed to the faults in this region. Several steep flanked highs and a regional prominent flat-topped terrace were noticed from the bathymetry.

Introduction

A qualitative and quantitative interpretation of the total magnetic intensity values and the bathymetric data collected during the cruises of Glomar Challenger Leg 23, VEMA - 19 and CONRAD - 9 is attempted here. The results of the present study might be of use to demarcate the regions deserving detailed geophysical exploration and also for understanding the tectonogenesis of the area. The data of Glomar Challenger Leg 23 collected during march 1972 was given to us by H. N. Siddiquie of the National Institute of Oceanography, Goa. The data of CONRAD - 9 collected during 1965 and of VEMA - 19 collected during 1963 was supplied on request to us by Lamont-Doherty Geological Observatory, USA.

General structure

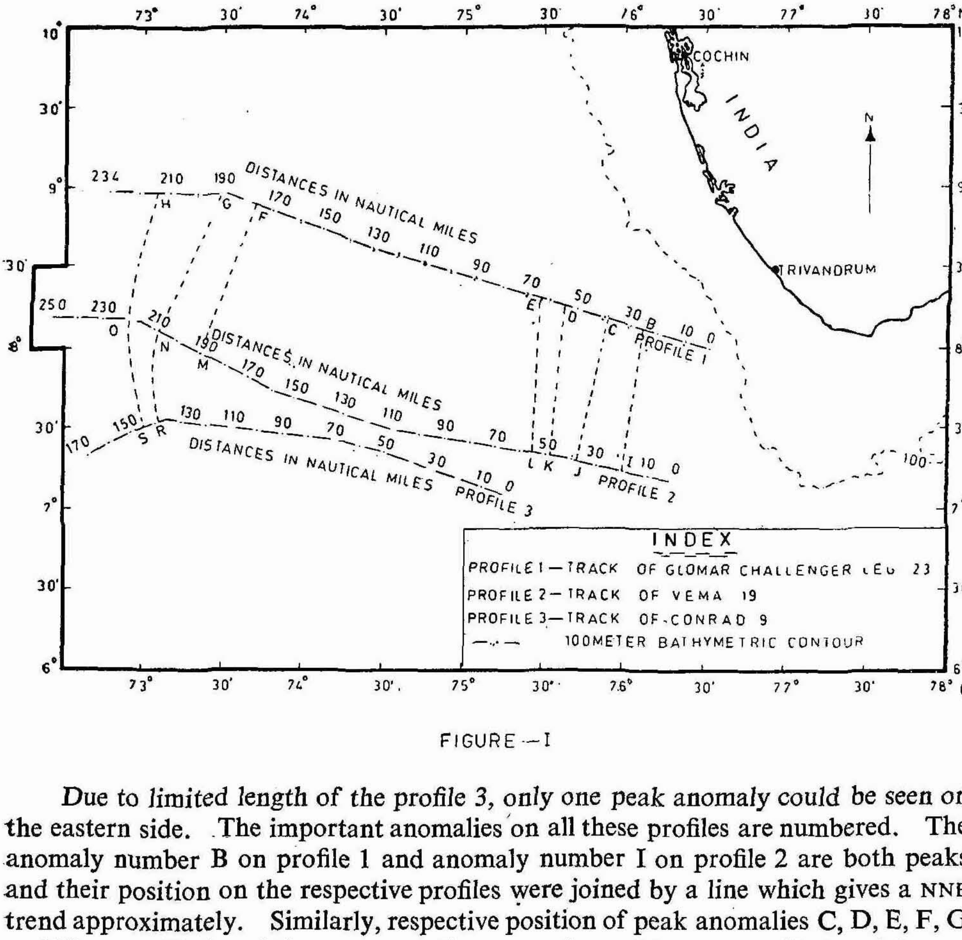
The ancient part of the Indian shield—a part of Gondwana land and composed of different fold systems were considered to have extended up to the west of Lakshadweep Islands (Krishnan 1968; Eremenko 1969). According to Eremenko (1969), the fragmentation of Gondwana continent resulted in the subsidence of some of the fragments in the Indian ocean and in considerable structural changes beginning with the lower Mesozoic. Tectonic map of India by Eremenko & Negi (1968) depicts several NW - SE and WNW - ESE trending faults in the crustal layers in this area. Whitmarsh (1972) reports NNE lineations of surface and sub-surface structures adjacent to the region under study. Harbison and Bassinger (1973) concluded that linear block fragments create the basement ridge of the northern region of Chagos-Maldive-Laccadive which extends up to 20°N. Rao and Bhattacharya (1975) interpreted a down faulted terrace adjacent to shelf edge and a bathymetric high with steep flank in the deep sea off Quilon.

The magnetic anomalies

The observed total magnetic intensity values collected along the tracks shown in Fig. 1 were corrected to the International Geomagnetic Reference Field for the year 1965 and the anomalies were computed. Fig. 2 shows the three magnetic profiles, the computed depths along these tracks and the topography of the ocean bottom.

On profile 1, in between 0 to 70 nm and 76 to 150 nm, fluctuating anomalies are observed while the ocean bottom is flat. Similarly on profile 2, in between 0 to

40 nm and 70 to 160 nm, and on profile 3 in between 0 to 100 nm, fluctuating anomalies are observed although ocean bottom is flat. This clearly indicates that the anomalies in general are not related to the topographic features of the ocean bottom. An interesting feature noticed on the three profiles is the presence of high magnitude anomalies of a similar nature at the beginning and end of the profile and a band of small amplitude anomalies over the central portions in all the three profiles. This similarity in anomalies is made use of in deciphering the trends of the anomalies.



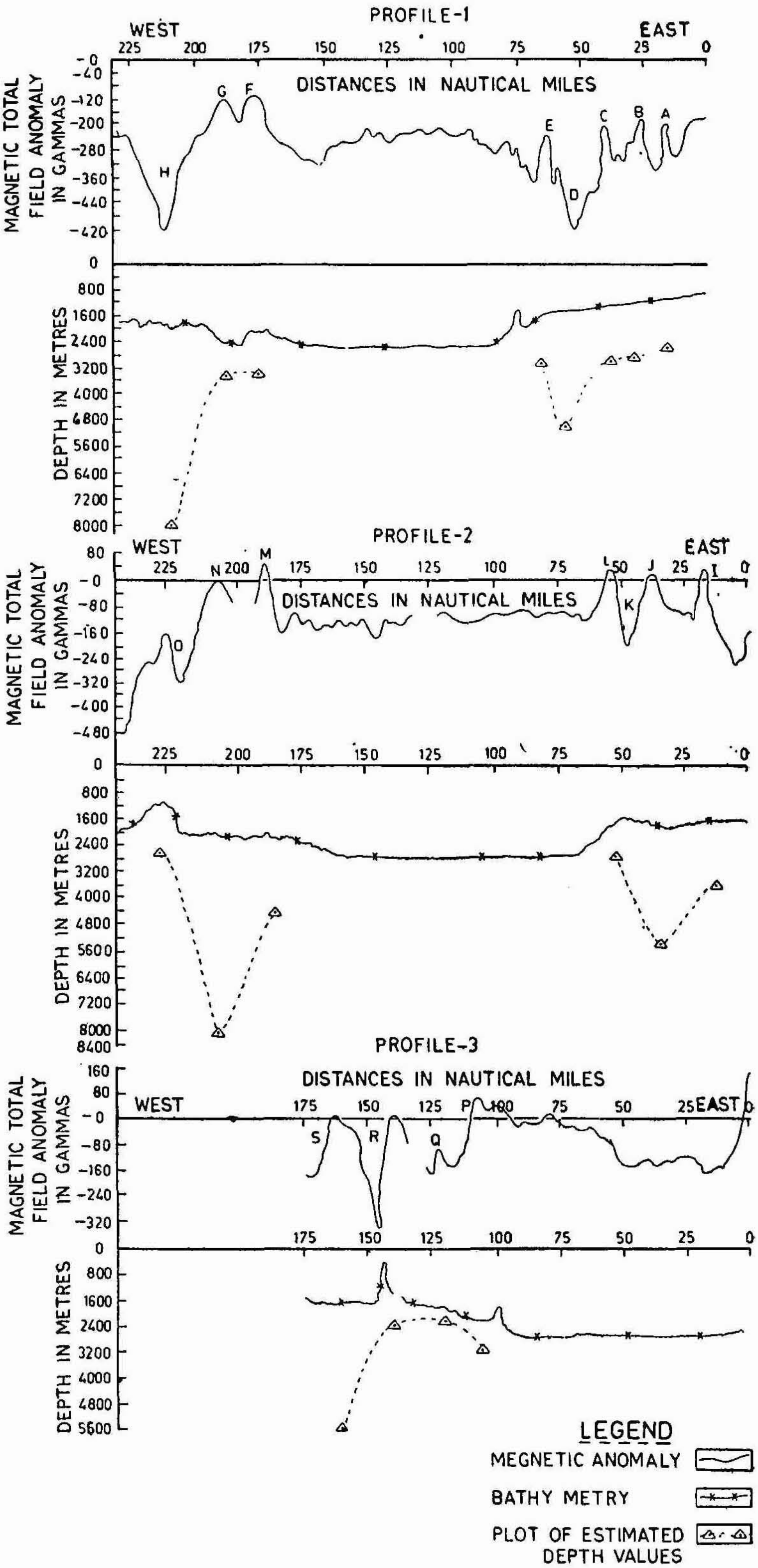
FIGURE—I

Due to limited length of the profile 3, only one peak anomaly could be seen on the eastern side. The important anomalies on all these profiles are numbered. The anomaly number B on profile 1 and anomaly number I on profile 2 are both peaks and their position on the respective profiles were joined by a line which gives a NNE trend approximately. Similarly, respective position of peak anomalies C, D, E, F, G and H on profile 1 and the corresponding anomaly positions on profile 2 and 3 were joined. They reveal NNE trends.

The anomalies on all the profiles are interpreted quantitatively assuming the source causing the anomalies to be dykes, tabular bodies and semi-infinite slabs. The method of interpretation used in this connection is that of Koulomzine *et al.* (1970) for dyke model and of Bean (1966) for tabular body and semi-infinite slab models. The interpreted models, their widths and depths are given in Table I.

Discussion

The prominent features of bathymetric profiles are: a flat ocean bottom, a terrace nearly 110 km wide at the eastern end of the profiles 1 and 2; and a steep flanked



PROFILE-1
WEST
EAST
DISTANCES IN NAUTICAL MILES
MAGNETIC TOTAL FIELD ANOMALY IN GAMMAS
DEPTH IN METRES
PROFILE-2
WEST
EAST
DISTANCES IN NAUTICAL MILES
MAGNETIC TOTAL FIELD ANOMALY IN GAMMAS
DEPTH IN METRES
PROFILE-3
DISTANCES IN NAUTICAL MILES
WEST
EAST
MAGNETIC TOTAL FIELD ANOMALY IN GAMMAS
DEPTH IN METRES
LEGEND
MEGNETIC ANOMALY
BATHY METRY
PLOT OF ESTIMATED DEPTH VALUES

Figure 2.

TABLE I

ESTIMATED DEPTH AND WIDTH VALUES

Profile 1				Profile 2				Profile 3			
Anomaly No.	Accepted model	Depth in km	Width in km	Anomaly No.	Accepted model	Depth in km	Width in km	Anomaly No.	Accepted model	Depth in km	Width in km
A	Dyke	2.45	1.3	I	Dyke	3.7	6.5	P	Semi-infinite slab	3.1	—
B	Dyke	2.76	3.3	J	Dyke	5.2	8.1	Q	Tabular body	2.2	4.8
C	Dyke	2.8	3.5	K	Dyke	2.8	5.3	R	Semi-infinite slab	2.2	—
D	Semi-infinite slab	4.96	—	L	Tabular body	4.6	5.0	S	Semi-infinite slab	5.5	—
E	Semi-infinite slab	2.94	—	M	Semi-infinite slab	8.0	—	—	—	—	—
F	Dyke	3.2	—	N	Semi-infinite slab	4.3	—	—	—	—	—
G	Dyke	3.2	—	O	Tabular body	2.8	—	—	—	—	—
H	Semi-infinite slab	6.0	—	—	—	—	—	—	—	—	—

bathymetric High (70-75 nm) and an escarpment (180-185 nm) on profile 1. Other bathymetric features present are two similar bathymetric Highs, one at 30-65 nm and the other at 220-230 nm on profile 2 and one at 100-105 nm and the other at 140-145 nm on profile 3.

High amplitude anomalies are observed at the eastern and western ends of the profiles. The central portion in each profile is characterised by low amplitude anomalies of 40 to 60 Gammas, whereas in the eastern and western ends of the profiles, anomalies are of the order of 200-300 gammas in magnitude. The relatively less disturbed portion of the anomaly profile, which can be attributed to the regional trends lies between 25-100 nm on profile 3. In profile 2, this smooth part occurs in between 60-170 nm while in 1 the anomaly has an anticlinal shape between 70-160 nm. These low amplitude anomalies in the central region might be due to undulations or small magnitude structural reliefs in the magnetic basement.

The terrace like feature observed from the bathymetric data resembles the terrace reported by Rao and Bhattacharya (1975) and it appears to be a regional feature as shown on the bathymetric charts. Several high amplitude anomalies which are present at the eastern side of terrace, are possibly due to intrusive material of relatively high magnetization. The computed depths and widths for these anomalies also support this surmise.

The estimated depths plotted indicate (i) a steep fall in the magnetic basement to the west around 175 nm on all the profiles. In addition, some fall is also noted between 50-75 nm on profile 1 and 25-50 nm on profile 2, (ii) the computed widths from the anomalies are more than 5 km, except on profile 1 in between 0.25 km.

The locations of escarpment and the bathymetric Highs appear to correspond to the regions of the deepening of the magnetic basement, which might be the result of block faulting in the offshore regions as postulated by Eremenko (1969).

The observed NNE trends of the magnetic anomalies in the present study area helps to infer that the intrabasement faults also have the same trend. The trends observed do not correspond to the trends reported by Eremenko (1969) but closely resemble the trends reported by Whitmarsh (1972) in between 72°E and 72°30'E in the study area from his seismic reflection profiles.

Since the sediment thickness in the study region is generally of the order of 1.5 km and even more, in the downfaulted areas, and high organic matter (11%, Marchig) is associated with slope sediments (western shelf of India is a prominent area of upwelling since lower Eocene) it is likely that this area will prove to be of interest from the point of view of exploration for petroleum.

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