

Magnetic Anomalies in Central Bengal Fan

T C S RAO, S LAKSHMINARAYANA & K V L N S SARMA

National Institute of Oceanography, Regional Centre, Waltair, Visakhapatnam 530 017, India

Received 24 February 1986; revised received 8 December 1986

Total magnetic field anomalies recorded over the Central Bengal Fan are analysed and the depths to the magnetic basement are computed using the analytical signal and the Werner deconvolution methods. To the west and east of 85°E, the basement layer delineates the basement high and the Graben, both trending nearly parallel to the east coast of India. The basement high recorded from the present studies nearly coincides with the 85°E ridge and the western flank of the Graben reported earlier in this region.

The Bengal Fan, which extends up to 3,000 km starting from 'Swath of no Ground' on the north to 7°S to the south, is considered as one of the largest and thickest sedimentary fans of the world. Except for the surveys¹⁻⁴ very few geophysical investigations have been undertaken in Bay of Bengal. Thus very little is known about the nature of the crust as well as the structure and tectonics of its basement. Therefore, detailed geophysical surveys to record the continuous bathymetric, seismic profiling and the total magnetic data have been planned in the Bengal Fan to study the nature of the crust and to delineate the major structural features.

Materials and Methods

During the 142 (Sept. 1984) and 156 (June 1985)

cruises of *RV Gaveshani* total magnetic field intensities were recorded in the western part of Bay of Bengal along the profiles placed at half degree interval between 19°30' and 14°30'N (Fig. 1). The profiles were extended from the continental shelf up to 88°E in 142 cruise and only up to 86°E in 156 cruise. Position locations were obtained from the SATNAV system installed on board the ship.

Proton precession magnetometer (Earringer M123) was used for measuring total magnetic field intensities. The sensor was towed about 180 m astern of the ship to eliminate the interference of the ship's magnetic field and data was recorded at 1 min interval. The data recorded along 16°N were found not satisfactory due to some trouble in the sensor. From the intermittent good fixes obtained from the SATNAV

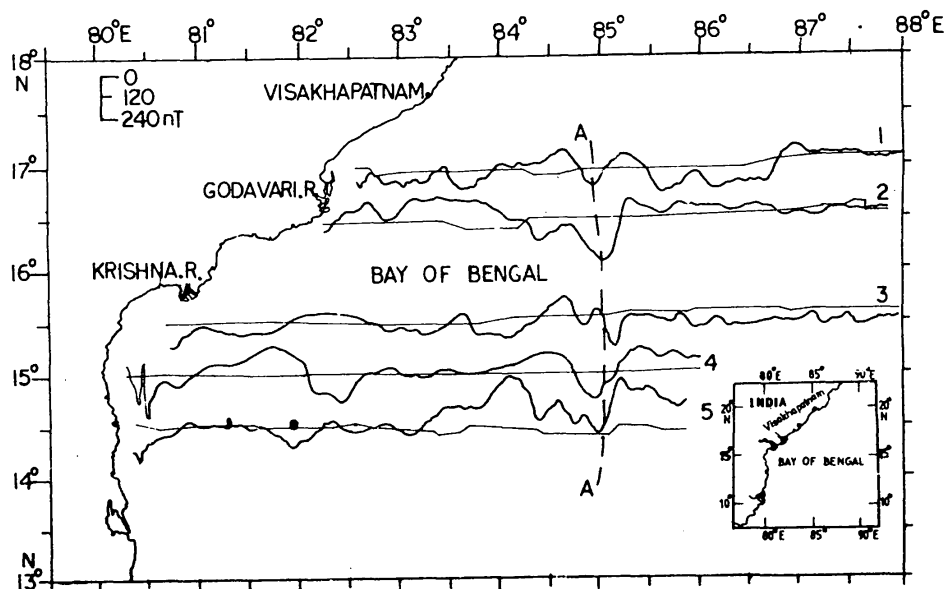


Fig. 1—Total field magnetic anomalies plotted over the profiles

system, the coordinates and the distances for each data point were computed. The total field anomalies calculated from these data were interpolated at 1.852 km interval and plotted on the respective profiles.

During the observational period the ship drifted considerably due to rough sea and the profiles became irregular. Therefore, the anomalies recorded were very much distorted due to the interference of noise and poor navigation. From the general trend of the anomalies, it could be observed that the anomalies recorded between the east coast of India and about $83^{\circ}30'E$ were of long wavelength and low amplitude. They were quite significant on profiles 3 to 5 and suggest deeper magnetic basement. Rao and Rao³ delineated a deep structural feature called 'marginal basin' from the topography, gravity and magnetic data recorded in this area. The anomalies recorded to the east of $86^{\circ}E$ were weak representing the magnetic quiet area which could be due to the relatively deep and tectonically undisturbed basement. The magnetic anomalies recorded between $83^{\circ}30'$ and $86^{\circ}E$ were generally well pronounced and distinct. The narrow and high amplitude anomalies in this area were smoothed using 9 points average and further analysed. The peak to peak amplitudes of these anomalies were of the order of 250 to 350 nano tesla and showed good correspondence from one profile to the other. Significant among them was the magnetic low recorded at about $85^{\circ}E$ (A in Fig. 1). However, this low was interrupted by a peak trending to be positive on profile 3 whereas on profile 5 the peaks were of less amplitude. In the present study, only those anomalies recorded between $83^{\circ}30'$ and $86^{\circ}E$ (in Fig. 1) were analysed and interpreted to delineate the structures and to correlate them with the structures reported earlier in this region.

From the several methods available for the analysis of magnetic anomalies, the inverse methods were employed to analyse the present data because the parameters for the causative sources could be deduced directly from the observed data and thus did not require any prior assumptions regarding the shape and size of the causative sources. The deconvolution method of Werner⁵ later refined by others⁶⁻⁸ and the analytical signal method^{9,10} were employed for analysing these anomalies. Programmes were developed for both the deconvolution and the analytical signal methods for computing the depths to the causative sources from which the configuration of the magnetic basement was constructed. It is observed that the results obtained from the analytical signal method were less consistent whereas the deconvolution method yielded the results that were more accurate and consistent.

Results and Discussion

Analytical signal functions, computed from the horizontal derivatives of the observed anomalies (Fig. 2), besides being not symmetrical are associated with several low amplitude peaks resulting from the noise associated with the data. The functions that are nearly symmetrical and prominent are chosen for computing the depths. On profile 1, 4 analytical signal functions that are nearly symmetrical are obtained while on profiles 2 to 5 functions of variable nature are obtained. Since the analytical functions obtained are not symmetrical, additional control is exercised by splitting these functions into symmetric and asymmetric functions following Koulomzine *et al*¹¹. Depths to the causative sources are computed using the half maximum, half width rule as suggested by Nabighian⁹. The depths obtained are plotted and joined to construct the basement profile (Fig. 3). The basement on profile 1 is about 6.5 km deep at $84^{\circ}46'E$, 10 km between 85° and $85^{\circ}20'E$ and 6 km at $85^{\circ}43'E$. The basement configuration obtained by joining these depths delineates the structure resembling the Graben. The basement on profiles 3 to 5 delineates a fairly well defined uplift between $84^{\circ}30'$ and $85^{\circ}E$. The width of the basement uplift varies from 30 to 34 km on profiles 3 and 4 and is only about 18 km wide on profile 5.

For the same anomalies, the Werner deconvolution method was employed both on the total field anomalies and their horizontal derivatives to compute depths to the causative sources. In this method, the depths, and the other parameters such as the horizontal distance, dips and susceptibilities yield more accurate and consistent values when the Werner operator of proper size, defined by Ku and Sharp¹² operates over the anomalies and they will be erratic when it operates outside the anomalies. From such group of con-

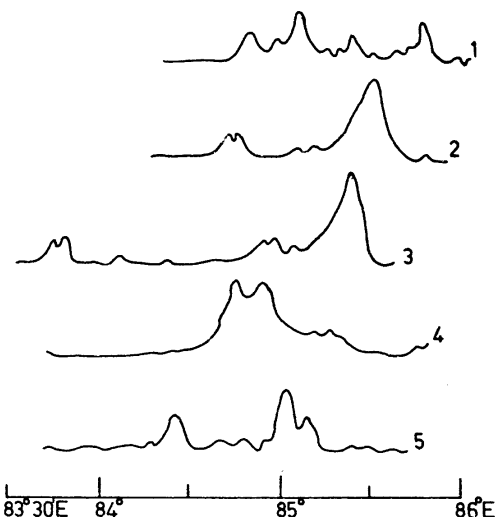


Fig. 2—Analytical signal functions (Y-axis scale arbitrary)

sistent values obtained for each anomaly, the average values are computed for the respective parameters. The depths thus computed are plotted and joined by taking into consideration the respective dips and the horizontal distances to construct the basement configuration (Fig. 4). The susceptibilities computed are in the range between 0.002 and 0.0045 CGS units which agree with the values for the basaltic layer given by Nettleton¹². The basement configuration on profiles 1 and 2 delineates the wide and deep Graben structure to the east of 85°E. On profiles 4 and 5, the basement configuration clearly demarcates the basement uplift and the Graben. On profile 3, both these structures are partially delineated. The width of the basement uplift is about 34 km on profiles 3 and 4 and only about 12 km on profile 5.

The Graben structures deduced from the analytical signal method on profile 1 in Fig. 3 and from the deconvolution method on profiles 1, 2, 4 and 5 in Fig. 4 coincided with the north-south trending Graben structure between 10°N and 17°N deduced by Rao and Rao³ from the magnetic and the negative free-air

gravity anomalies recorded in this area. However, Liu *et al.*⁴ analysed and interpreted the free-air gravity anomalies and ascribed the negative gravity anomalies to a subsurface ridge which was formed when the lithosphere was hot and only about 10^7 y old and was buried under the thick sediments when the lithosphere was $4-8 \times 10^7$ y old. From the vertical seismic reflection measurements carried out in this area Cur-ray *et al.*² recorded a subsurface 'high' called 85° East Ridge on the profiles along 10, 13 and 17°N. It was relatively narrow and prominent along 10°N and gradually diminished towards north and appeared as a broad subdued bulge along 17°N. The basement 'up-

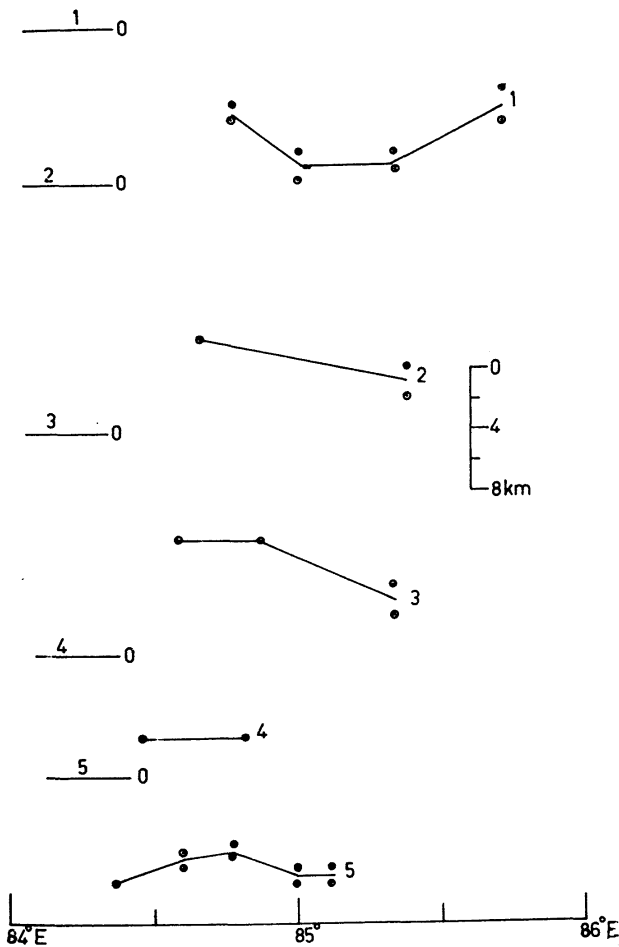


Fig. 3—Basement depths and configuration deduced from analytical signal

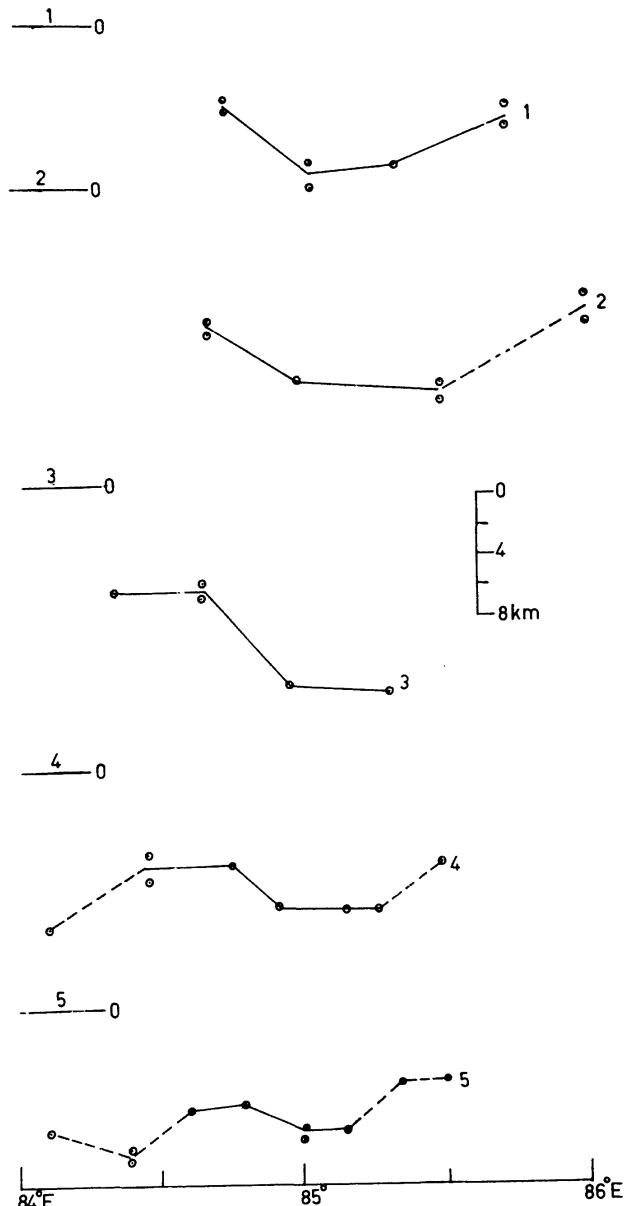


Fig. 4—Basement depths and configuration deduced from deconvolution method

lift' deduced from the present studies was also narrow on profile 5 and became wider towards north. It trended nearly north-south and was located almost in the same area where the 85° East Ridge was reported by Curray *et al.*².

Though the present studies are of very limited nature, it is possible to delineate the Graben structure associated with the basement uplift to its west. However, it is not clear whether the 85° east ridge that trends subparallel to the east coast of India is either an isolated structure as reported by Curray *et al.*², or it is only a manifestation of the basement uplift that separates the marginal basin to its west from the Graben to its east as reported by Rao and Rao³. Detailed magnetic, gravity and seismic data collected at much closer profile intervals are required to demarcate these subsurface structures which have greater significance in understanding the origin and development of Bengal Fan as well as its economic potential.

Acknowledgement

The authors are thankful to Dr H N Siddiquie, for-

mer Director, for his encouragement and permission for publishing the results. They also extend their thanks to the Master and Crew of *R V Gaveshani* for their kind co-operation in the collection of data.

References

- 1 Naini B R & Leyden R, *J Geophys Res*, **78** (1973) 8711.
- 2 Curray J R, Emmel F G, Moore D V & Raitt R W, in *The Indian Ocean*, Vol. 6, edited by A E N Nain & F G Slehi (Plenum Press, New York) 1982, 399.
- 3 Rao T C S & Rao V B, *Tectonophysics*, **124** (1986) 141.
- 4 Liu C S, Sandwell D T & Curray J R, *J Geophys Res*, **87** (1982) 7673.
- 5 Werner S, *Sveriges Geologiska Undersokning, Stockholm, Arsbok*, **43** (1949) 130.
- 6 Hartman R R, Tesky D J & Friedberg J L, *Geophysics*, **36** (1971) 891.
- 7 Jain S, *Geophysics*, **41** (1976) 531.
- 8 Ku C C & Sharp J A, *Geophysics*, **48** (1983) 754.
- 9 Nabighian M N, *Geophysics*, **37** (1972) 507.
- 10 Nabighian M N, *Geophysics*, **39** (1974) 85.
- 11 Koulomzine T H, Lamontague Y & Nadean A, *Geophysics*, **35** (1970) 812.
- 12 Nettelton L L, in *Gravity and magnetics in oil exploration*, (McGraw-Hill Book Company) 1976, 365.