

Short Communication

Basement configuration of Visakhapatnam - Paradip continental margin from inversion of magnetic anomalies

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Inversion of magnetic data was carried out on 40 profiles collected across the continental margin of Visakhapatnam at a spacing of about 10 km and magnetic basement map for this region is prepared. The map reveals complex anomalies particularly beneath the inner shelf with amplitudes reaching as high as 1800 nT. These anomalies appear to be associated with the complex basement structure reported earlier. The significant features inferred include, (a) a shallow and highly faulted basement, in the inner shelf; (b) a NE-SW ridge-trough configuration in the mid shelf; (c) NW-SE trending basement upward off Bhimunipatnam to Kalingapatnam and (d) N-S trending shallow basement trend off Chilka lake.

Curry *et al.*¹ presented a detailed study of the structure, tectonics and geological history of the northeastern Indian Ocean. During 1985-87 geophysical studies were carried out mainly related to the near shore structure and tectonics of the eastern continental shelf²⁻⁹.

In earlier studies Murthy *et al.*⁶ analysed the magnetic and bathymetry data of this offshore region up to about 150 km seaward, extending from Paradip (20°15'N) to Kakinada (17°40'N) and reported major structural lineaments from magnetic and bathymetry maps. Subrahmanyam *et al.*¹⁰ analysed the anomalies and reported a two stage evolution of this region namely (a) the rift stage evidenced by dyke intrusions and (b) post-rift stage, characterised by vertical tectonics in the form of horst and graben type continental basement. In the present study, the magnetic data are analysed by inversion scheme to bring out magnetic basement configuration of this offshore region.

About 40 perpendicular profiles (Fig 1.) of magnetic and bathymetry data were collected on-board *R.V. Gaveshani* during 1989. The profiles are at 10 km interval covering 30-3000 m water depth. Magnetic data were collected using proton precession magnetometer (Barringer, Model 123) at one minute polarisation interval corresponding to a distance of about 230 m at ship speed of 8 knots. The magnetic data were corrected for regional field using IGRF 85 coefficients and the residual data were utilised for

further analysis using inversion scheme. In this part of Oshelf magnetic data indicates (a) high amplitude, short wave length anomalies caused by juxtaposing intrusive bodies (Fig. 2), (b) low amplitude, long wave length anomalies characterised by deeper basement structure (Fig. 3). Radhakrishna Murthy¹¹ gave brief description of this inversion scheme.

Magnetic data were inverted using an inversion scheme to determine the magnetic basement. In the present inversion, the basement topography is equated to a series of juxtaposing prisms, one below each anomaly point and the depth to their top are determined and the method modifies them by iteration to bring out the refined depths to the top of the prisms using least squares. Assumed mean depth of the

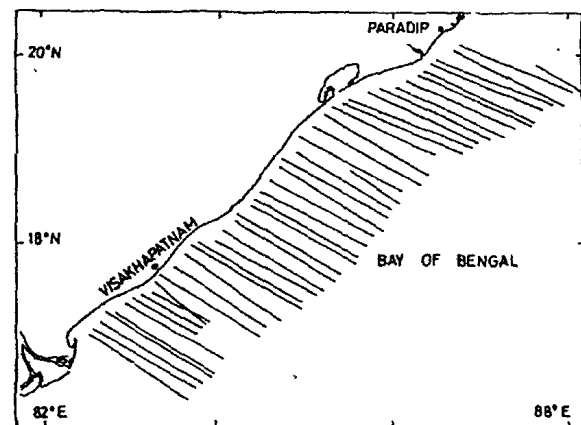


Fig 1—Study area.

undulating basement (Z), field strength (J), direction (ϕ) and magnetisation parameters of the study area are used to compute regional field. The prism thicknesses are refined iteratively based on the difference between the observed and calculated anomalies. Joining the top of the refined prism edges, therefore, yield the possible magnetic basement.

Using the inversion routine with local field parameters like field strength J , direction ϕ , profile strike etc., as input, each magnetic profile is inverted and at the end of final iteration the refined magnetic basement depths are obtained. With a suitable scale, basement depths are plotted against distance, and this procedure is adopted to all profiles and then basement contour map is generated (Fig. 4) with depths varying from 2 to 7 km. The map indicates shallow and deeper basement regions indicated with highs (H) and lows (L). To check the results obtained by this inversion scheme, magnetic data along two representative sections viz., south of Paradip, and north of Kalingapatnam (Figs 2, 3) were analysed to delineate the basement structure of the study area using

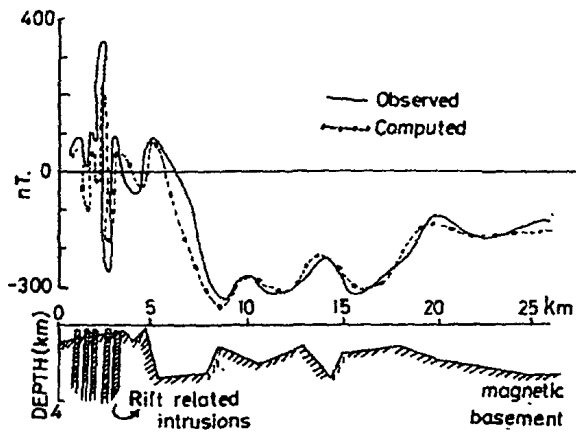


Fig. 2—Magnetic anomaly off Kalingapatnam.

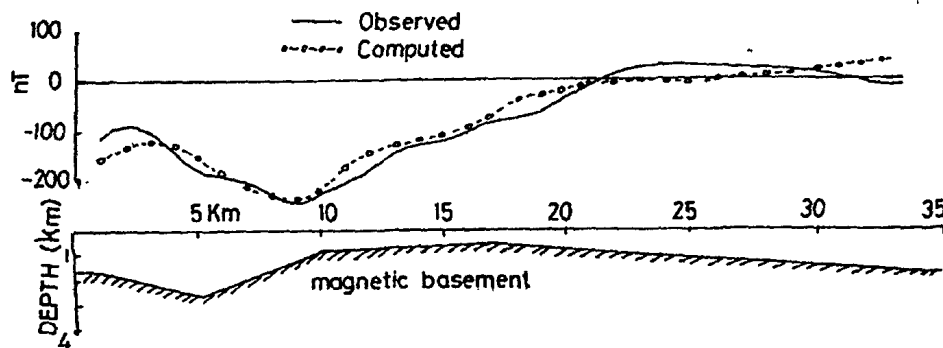


Fig. 3—Magnetic anomaly off Paradip

Talwani & Heirtzler¹² model studies. The observed and computed magnetic anomalies and the resulting basement structure are shown in these two figures. The basement depth values obtained by these model¹² studies are tallying with the corresponding section by the present inversion scheme.

Magnetic basement map (Fig. 4) for the shelf-slope region between Paradip and south of Visakhapatnam revealed significant features. In general the contours are running sub-parallel to the coast. In the near-shore region, deeper basement (L) was observed south off Paradip and south off Pudimadaka. Off Chilka lake very shallow basement (H) was observed in the near-shore region, where magnetic anomalies of the order of 1800 nT are observed. Off Chilka lake basement becomes deeper in N-S direction. North of Pudimadaka, significant change in contour pattern was observed probably indicating a fault zone. To study the basement features the study area was divided into three regions running sub-parallel to the coast viz., near-shore, mid-shelf and outer-shelf. In the near-shore regions covering Puri, Chilka lake, Baruva, Kalingapatnam and Visakhapatnam, basement high (H) was observed characterised by high amplitude, short wave length magnetic anomalies.

In the mid-shelf region, off Kalingapatnam a deeper basement (L) and a shallow basement (H) was observed off Pudimadaka. In general, in outer-shelf a deeper basement was observed throughout. Horst and graben basement structure inferred from our studies can be spatially correlated to the basement structure obtained from Deep Seismic Sounding (DSS) studies¹³ on the adjacent coastal region. Shallow basement trend off Chilka lake inferred from the present basement study correlates well with the trend associated with northward extension of 85°E lineation reported earlier by Subrahmanyam *et al.*¹⁰

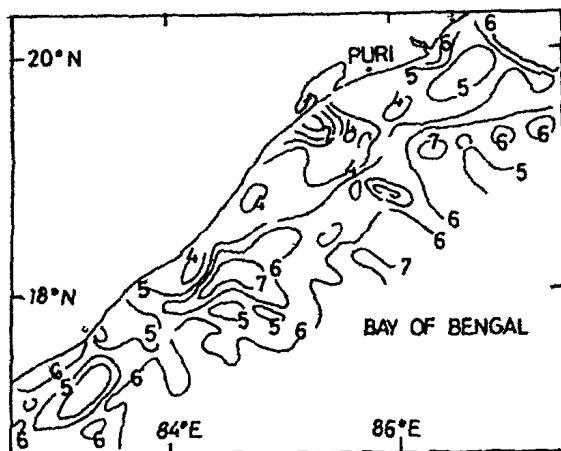


Fig. 4—Magnetic basement contour map.

From the magnetic basement contour map, it is inferred that the basement in this region is of horst and graben type. This study mainly emphasizes the nature of the magnetic basement over the eastern continental shelf between Paradip to south of Visakhapatnam.

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References

- 1 Curray J R, Emmel F J, Moore D G & Raitt R W, in: *Ocean basins and margins*, 6 (Plenum, New York) 1982, pp. 399-450.
- 2 Rao T C S & Murthy K S R, Magnetic surveys over the continental shelf off Visakhapatnam, *Mahasagar - Bull Nat Inst Oceanogr*, 13(1980) 83-89.
- 3 Rao M M M, Lakshminarayana S, Murthy K S R, Subrahmanyam A S, Two computer programs for the analysis of marine magnetic data, *Computers & Geo Sci*, 5(1993) 657-672.
- 4 Rao T C S, Machado X T, Murthy K S R, Topographic features over the continental shelf of Visakhapatnam, *Mahasagar - Bull Nat Inst Oceanogr*, 13(1980) 23-28.
- 5 Rao T C S & Rao V B, Geophysical studies over the continental margins of the east coast of India, *Mar Geol*, 67(1985) 151-161.
- 6 Murthy K S R, Rao T C S & Rao M M M, Delineation of Structural lineaments from marine magnetic anomalies of Lawsonsbay, east coast of India, *Indian J Mar Sci*, 16(1987) 19-21.
- 7 Murthy K S R, Rao T C S & Sarma K V L N S, Sub-bottom profiling over the inner shelf off Visakhapatnam, east coast of India, *Indian J Earth Sci*, 14(1987) 109-113.
- 8 Murthy K S R, Rao M M M, Rao T C S & Subrahmanyam A S, A comparative study of Werner deconvolution and conventional modelling of marine magnetic data, *Geophy Res Bull*, 25(1987) 152-157.
- 9 Murthy K S R, Rao T C S, Subrahmanyam A S, Rao M M M & Lakshminarayana S, Structural lineaments from the magnetic anomaly maps of the eastern continental margin of India (ECMI) and NW Bengal Fan, *Mar Geol*, 114 (1993) 171-183.
- 10 Subrahmanyam A S, Murthy K S R, Rao M M M, Lakshminarayana S, Venkateswarlu, K & Rao T C S, A two-stage evolution of Visakhapatnam - Paradip shelf, east coast of India from magnetic studies, *Proc Indian Acad Sci*, 103(1994) 17-26.
- 11 Radhakrishna Murthy I V, Magnetic anomalies of two-dimensional bodies and algorithms for magnetic inversion of dykes and basement topographies, *Proc Indian Acad Sci*, 99 (1990) 549-579.
- 12 Talwani M & Heitzler J R, Computation of magnetic anomalies caused by two-dimensional structures of arbitrary shape, in: *Computers in the mineral industries*, edited by G A Parks (Stanford University Press, Leeland, California) 1964, p.464-480.
- 13 Kaila K L, Tewari H C & Mall D M, Crustal structure and delineation of Gondawana basin in the Mahanadi delta area, India from deep seismic soundings, *J Geol Soc India*, 29(1987)293-308.