

Marine Magnetic Anomalies as a Link between the Granulite Belts of East Coast of India and Enderby Land of Antarctica

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Abstract: Magnetic data of the eastern continental margin of India (ECMI) helped in demarcating the offshore extension of the granulite belts of east coast of India and their possible link to those of the East Antarctica. Short wavelength and high amplitude negative magnetic anomalies (200 to 1600 nT) are observed over the northern part of ECMI between Kakinada and Chilka lake and also off Madras shelf, the coastal regions of which are associated with granulite facies rocks. This part of the shelf is associated with structural lineaments with predominant NE-SW trends. In contrast, the offshore basins off Cauvery, Krishna - Godavari (K-G) and Mahanadi rivers are associated with subdued positive anomalies (less than 200 nT) indicating subsidence off these basins by heavy load of Phanerozoic/younger shelf sediments. Structural lineaments with NW-SE or W-E trends delineated over these basins are related to the offshore extension of these rift related Gondwana grabens. Similarity in the trends of the magnetic anomalies and the granulite facies on the east coast of India and their correlation with the granulite belt of Enderby Land of Antarctica supports the view that the entire region comprised of a single and stable block of granulite rocks prior to the fragmentation of the Gondwanaland. The study also suggests probable continuation of Mahanadi and Godavari grabens into East Antarctica.

Keywords: Marine Geophysics, Magnetic Anomalies, Eastern Ghat Granulite Belt, Enderby Land, Antarctica.

INTRODUCTION

Crawford (1974) and Fedorov *et al.* (1982) observed similarity of Archaean granulite facies metamorphic rocks of Peninsular India, Sri Lanka and East Antarctica (in the region between 35° and 90°E). According to this, a single and stable granulite belt of Archaean age was split into two separate granulite coastal belts, as a result of the fragmentation of Gondwanaland in Mesozoic time (around 140 Ma).

Geomorphic and tectonic map of east coast of India (Subramanian 1967, Crawford 1974) indicate granulite rocks near Madras coast and all along the coastal belt between Visakhapatnam and Chilka lake (Fig 1). Over much of the Tamil Nadu margin including the Cauvery basin and also off Krishna - Godavari (K-G) and Mahanadi basins, the coastal belt comprises of Phanerozoic sedimentary rocks (Fig 1). The concave portion of ECMI comprising of the Nizampatnam Bay and K-G basin around 15°N

separates the granulite belt of southern and northeastern Indian margin (marked as zones 1 and 2 in Fig 1). The Madras coast appears to be the northern limit of zone 1 whereas

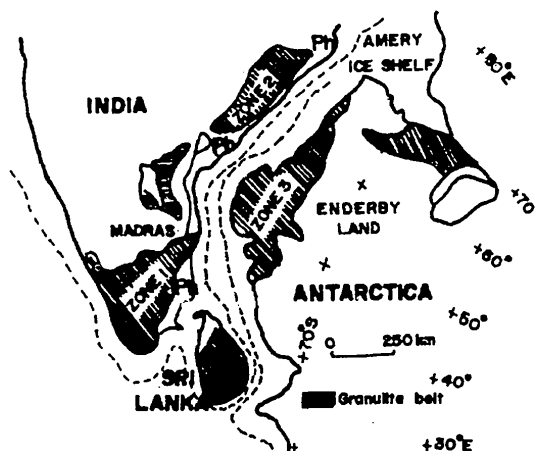


Fig.1. Granulite belts (Zones 1 to 3) of east coast of India and East Antarctica (modified from Crawford, 1974) Ph:Phanerozoic Rocks.

Chilka lake appears to be the northern limit of zone 2.

In this paper, a qualitative and preliminary attempt has been made to correlate the magnetic anomalies over the eastern continental margin of India (ECMI) and the distribution of the granulite facies over the east coast of India and the Enderby Land of Antarctica.

DATA

The Regional Centre of National Institute of Oceanography (NIO) at Visakhapatnam has made an extensive coverage over the ECMI (from 30 m to 3000 m water depth) with bathymetry, magnetic gravity (partly) and shallow seismic surveys (Fig 2). Major structural lineaments were inferred from the magnetic anomaly map of ECMI drawn at 50 nT contour interval (Fig 3) by Murthy *et al.* (1993). Subrahmanyam *et al.* (1994, 1995) and Murthy *et al.* (1995) analyzed the magnetic data of the Cauvery (C-B) Krishna-Godavari (K-G) and Mahanadi (M-B) offshore basins (Fig 3) in detail. Based on these results, a preliminary tectonic lineament map was drawn (Murthy and Rao, 1993). These two maps (Fig 3 and 4) and the geomorphic and tectonic map (Fig 1) are used in the following qualitative study.

ANALYSIS AND DISCUSSION

Based on anomaly signature, the magnetic contour map (Fig 3) can be broadly divided into two parts. The northern part between Kakinada and Chilka lake represents a highly complex anomalous zone with short wavelength and high amplitude negative anomalies (reaching at places nearly -1600 nT). There is, however, a linear (W-E) trend of low amplitude (<100 nT) positive anomalies off Visakhapatnam. This might be due to offshore extension of a coastal lineament into the sea. Murthy *et al.* (1987) reported offshore extension of Tuni - Visakhapatnam basement fold axis, reported earlier from coastal geological studies

by Sriramdas and Rao (1979). The southern part between Kakinada and Nizampatnam in contrast is a subdued region with anomaly amplitudes not more than 200 nT. This region with the exception of Madras - Pondicherry shelf comprises of mostly positive anomalies. The Madras - Pondicherry shelf is associated with high amplitude negative anomalies. Murthy *et al.* (1993, 1995) reported rift related dyke intrusions beneath the innershelf off Madras to Pondicherry, Nizampatnam and Kalingapatnam to Gopalpur.

Three major structural lineaments were delineated from the magnetic data of eastern continental margin of India and Bengal Fan using the data along tracks shown in fig 2 (Murthy *et al.* 1993). They are (Fig 3 and 4); the Ocean - Continent Boundary (OCB, Trend I), the N-S trending 85°E ridge (Trend II) and the series of NE-SW ridges and depressions (Trend III) beneath the Visakhapatnam - Chilka lake margin (Fig 3). In addition, high resolution magnetic anomaly maps (drawn at 20 nT interval) of the Cauvery, K-G and Mahanadi basin revealed the offshore extension of the three Gondwana grabens and the associated NW-SE and W-E coastal cross trends. (Murthy *et al.* 1995 and Subrahmanyam *et al.* 1995). An isolated magnetic anomaly of high amplitude (peak to peak 450 nT) located near the OCB off K-G basin (Fig 3 and 4) is however an exception in an otherwise subdued anomaly field of this basin. This anomaly (marked as Hotspot in Fig 4) was interpreted as a hot spot trace (Murthy *et al.* 1995) originated during the breakup of India and Antarctica.

Correlation between the magnetic anomaly map (Fig 3), the preliminary tectonic lineament map (Fig 4) with the granulite facies distribution map (Fig 1) reveals some interesting features.

1. There is a similarity in the magnetic anomaly pattern over ECMI and the distribution of granulite belt on the east coast, thereby indicating the offshore extension of the coastal geology.

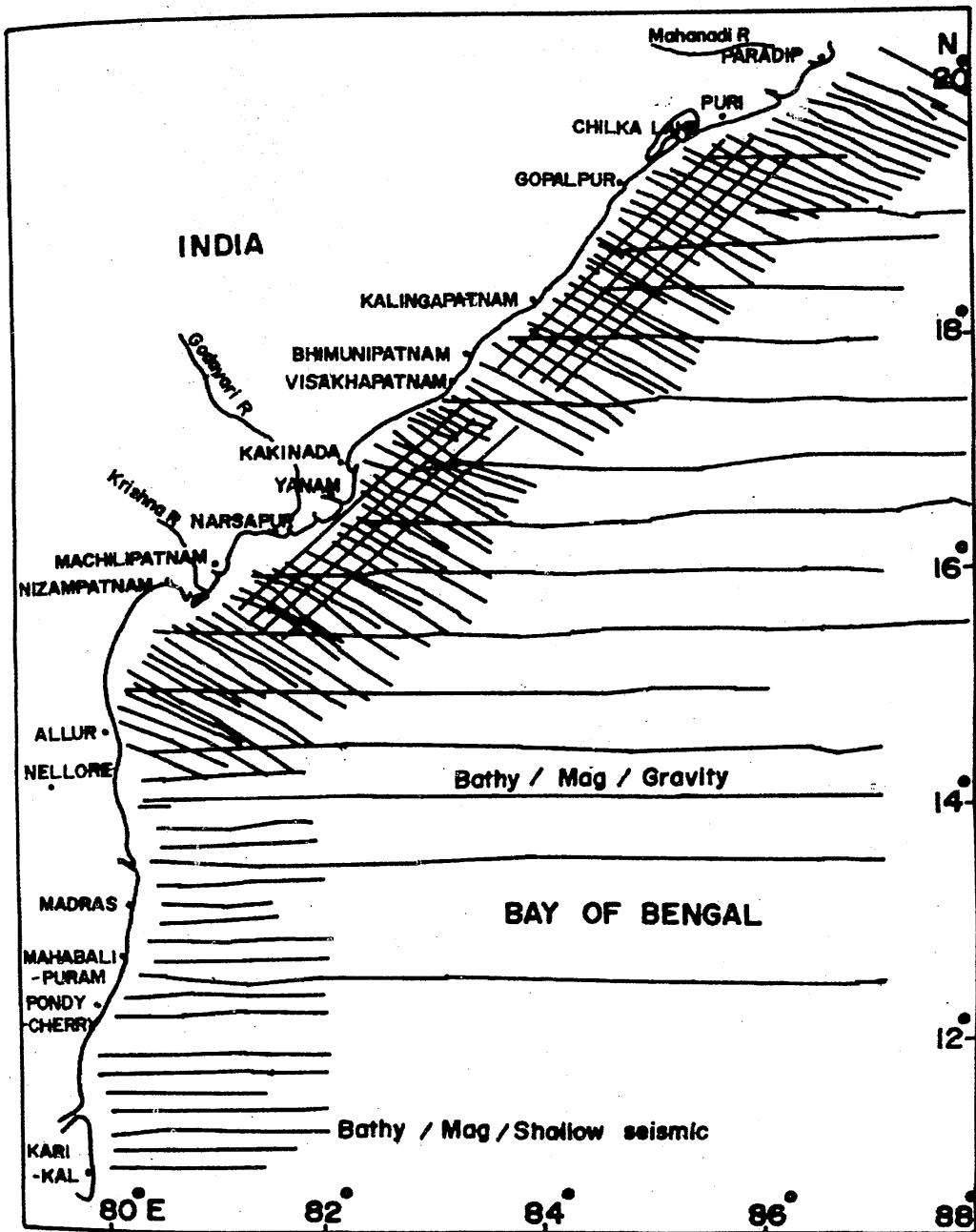


Fig 2. Geophysical coverage over the ECMI (Bathymetry, magnetic and shallow seismic).

The coastal granulite belt between Visakhapatnam and Chilka lake (Fig 1) appears to extend offshore as indicated by the

complex anomalous zone over this part of ECMI (Fig 3). Beyond Chilka lake, we find subdued magnetic anomalies, indicating the

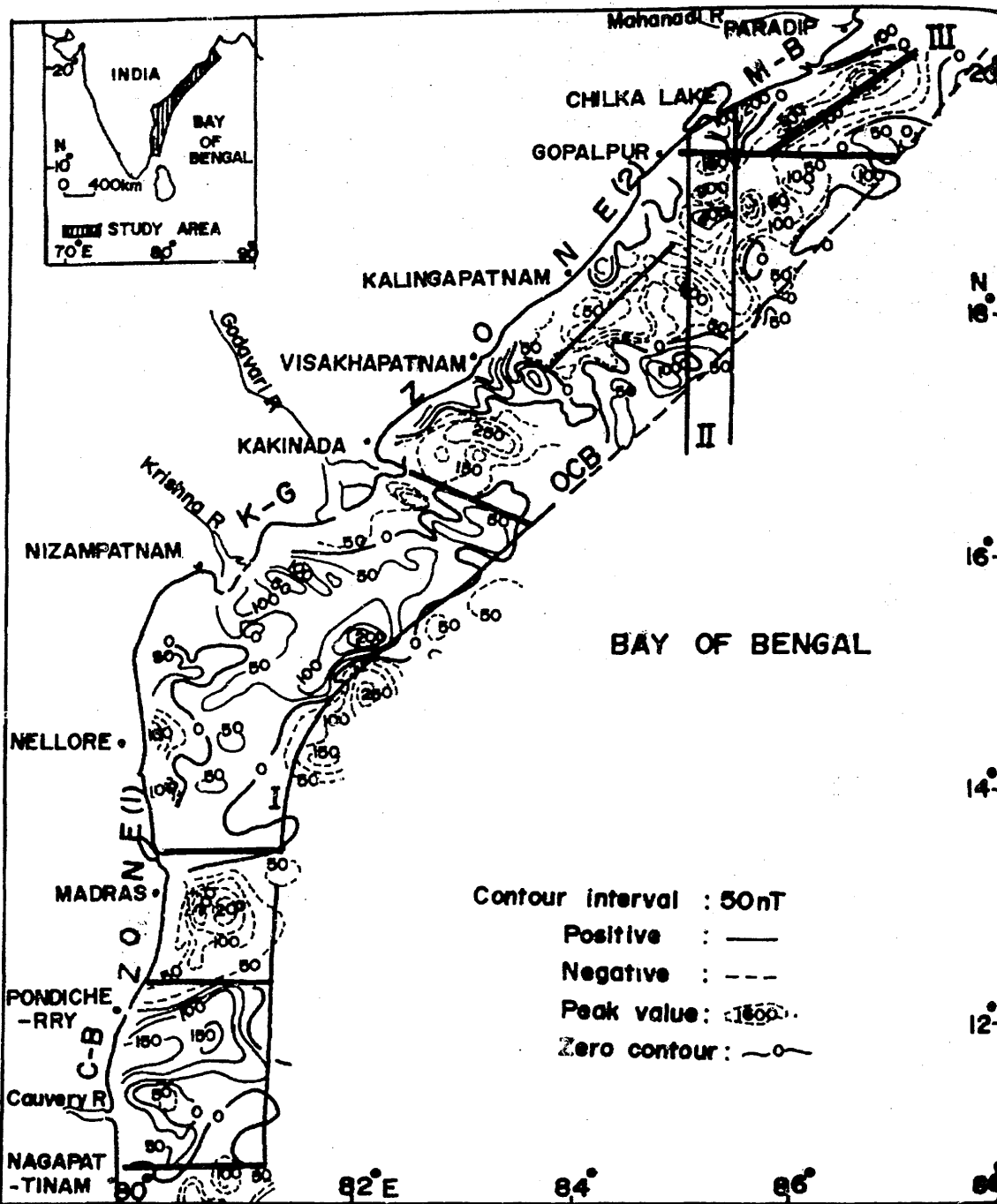


Fig 3. Magnetic anomaly map of ECMI: Contour interval: 50 nT; Trends I,II and III and zones 1 and 2 explained in the text. C-B: Cauvery Basin; K-G: Krishna - Godavari Basin; M-B: Mahanadi Basin; OCB: Ocean - Continent Boundary. Heavy horizontal lines on the map demarcate significant changes in the anomaly signature.

influence of Mahanadi offshore basin. In the southern part which comprises of mostly the Cauvery and K-G basin, the magnetic map

represents a subdued field. The coastal region over this part is occupied by Phanerozoic sedimentary rocks (Subramanian, 1967 and

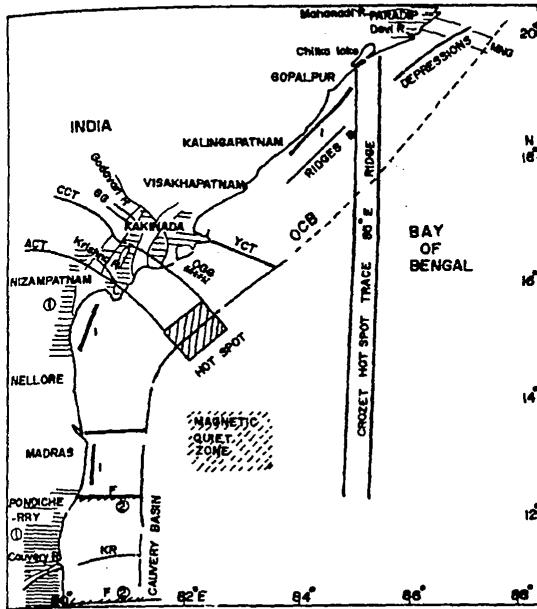


Fig 4. Major tectonic lineaments of ECMI and part of Bengal Fan inferred from magnetic data.

I: Rift related volcanism; ACT: Avanigedda cross trends; CCT: Chintalapudi Cross trend; YCT: Yanam Cross trend; KR: Kumbakonam Ridge; OGG: Offshore Godavari Graben; MNG: Mahanadi Graben; 1: Onshore basin; 2: Faulted boundary

Crawford 1974), with the exception of Madras - Pondicherry coast where high amplitude magnetic anomalies are observed in the offshore, corresponding to the granulite exposures reported on this coastal belt. The subdued nature of magnetic anomalies over the offshore basins might be due to subsidence caused by heavy load of Phanerozoic/Young shelf sediments.

2. The Ocean Continent Boundary (OCB, Fig 4) appears to be the seaward limit of the granulite belt, since earlier studies made by Murthy *et al.* (1995) and Subrahmanyam *et al.* (1995) indicated truncation of several coastal trends near the OCB.

3. While the offshore basins are associated with NW-SE or W-E cross trends, the non-basinal areas like the Kakinada-Chilka lake and the Madras shelf are associated with NE-SW basement trends (Fig 4).

4. Magnetic anomaly map of ECMI can be used to link the granulite facies belt of India

and east Antarctica. The convex bulge of the granulite belt of Enderby Land of East Antarctica (zone 3, Fig 1) appears to be detached from the granulite belts of zone 1 and 2 on the east coast of India as also evident from the nature of the subdued magnetic anomalies over the concave portion of east coast of India represented by the K-G basin and Nizampatnam Bay. Magnetic data over ECMI therefore supports that prior to fragmentation, the entire region of Gondwanaland covering Peninsular India and East Antarctica (between 35°E and 90°E) comprises of a single and stable block of granulite rocks as also suggested earlier by Crawford (1974) and Fedorov *et al.* (1982).

5. Fedorov *et al.* (1992) and Mishra (1984) correlated Mahanadi graben with the rift zone occupied by Lambert glacier and Amery Ice shelf. Fedorov *et al.* (1982) indicated a similar continuation of Godavari graben based on a rift zone identified from limited aeromagnetic data over the Enderby Land of East Antarctica. Murthy *et al.* (1995) and Subrahmanyam *et al.* (1995) reported the offshore extension of the Cauvery, K-G and Mahanadi graben trends thereby suggesting a link between these graben trends and the Antarctic margin. However not much data is available about the continuation of Cauvery basin into the East Antarctica.

6. The eastern margin between Kakinada and Chilka lake is structurally a complex zone (Fig 3 and 4) with predominant NE-SW trends (Ridges and Depressions). A similar complex basement structure is expected off the East Antarctica margin. This part of the Indian and Antarctic might have been affected by maximum tensile stress during the fragmentation.

7. The linear trends of the 85°E ridge (Fig 4), the Ninety east Ridge and the isolated source of high magnetization (marked as hotspot in Fig 4) are relatively younger events unrelated to the pre-breakup tectonics and as reported by several earlier studies, they might represent the traces of the hotspots

over which the Indian plate has passed during its northward flight from Antarctica.

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