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A qualitative appraisal of geomagnetic manifestations of the geological structures in the Indian equatorial region

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Abstract. From the data of the geomagnetic survey of the Indian equatorial region conducted during 1971, it has been possible to deduce the subsurface magnetic anomalies at each survey station. The vertical magnetic anomaly profiles seem to reflect some of the known geological structures in the region. The association between magnetic anomalies and the deep-seated structures in this area emphasises the importance of future intensive studies.

Keywords. Magnetic anomaly; charnockite-khondalite series; fault; synclinal axis; anticlinal axis; gravity gradients; upper mantle.

1. Introduction

The Indian Institute of Geomagnetism, Bombay, the National Geophysical Research Institute, Hyderabad and the Survey of India, Dehra Dun, in collaboration had conducted a preliminary geomagnetic survey in the Indian equatorial electrojet region during 1971, to locate the line of zero dip (Anon 1972). The three parties starting from Kanyakumari, simultaneously measured, at ten selected stations, the absolute values of the horizontal (H) and vertical (Z) components of the earth's magnetic field at various hours of the day along three approximately parallel S–N (eastern, central and western) profiles (figure 1). The stations occupied along the three profiles, with names of some selected stations and some of the known geological structures are shown in figure 1. However, simultaneous measurements of the vertical field values are available only at 5 stations along the western profile for this study. As a result there are in total, only 26 Z and 31 H measurements including Kanyakumari. Apart from the purpose for which the survey was made, the data can be utilised for studying, on a preliminary basis, the magnetic response of the various regional geological structures known to exist in the region. Such a study would be of great help in planning intensive geophysical surveys in future.

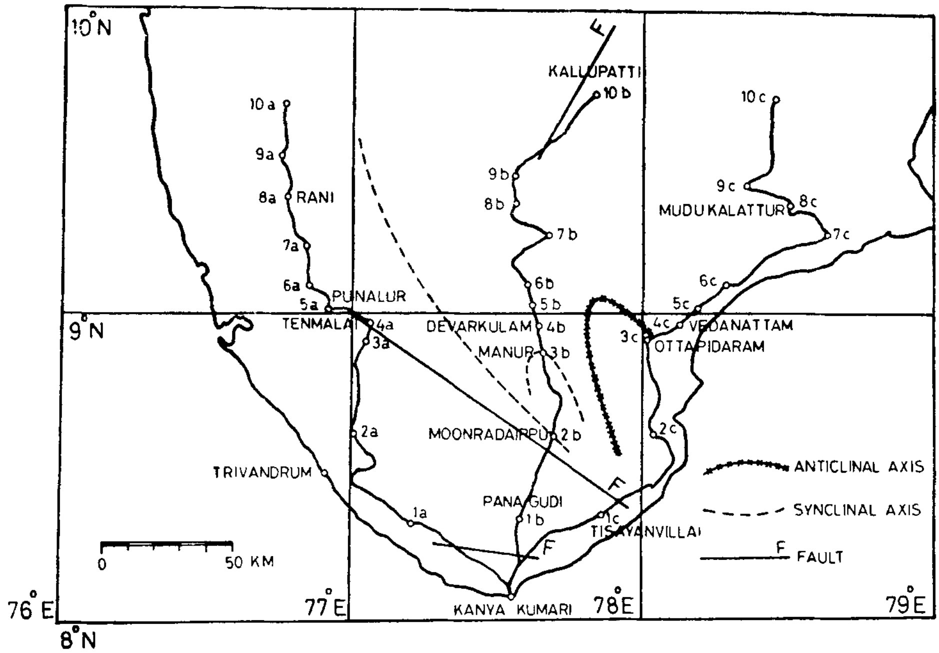

Figure 1. Map showing the location of the stations along (a) western, (b) central and (c) eastern profiles in the Indian equatorial region. Some of the known geological structures are also shown.

2. Data and analysis

The average night-time *H* and *Z* values, distributed between 8·0° N and 9·7° N latitudes and 76·8° E and 78·7° E longitudes, were obtained from the observations made between 19 and 23 hr IST at each of the survey stations. It was ensured that disturbed days were omitted in the survey. Because only night-time average field values are considered for this study, the disturbance effects, if any, would be negligible and there would be little contribution from the sq-dynamo currents. These values, however, comprise, apart from the main field, a component that could be identified with the subsurface geology. Using the coefficients of the International Geomagnetic Reference Field (IGRF) model, 1970, the main field component in *H* and *Z* at each of the stations are computed for the year 1971 and are subtracted from the respective night-time field values at each of the stations and the respective ΔH and ΔZ anomalies are obtained.

The anomalies along the three (western, central and eastern) profiles are shown in figures 2(a), (b) and (c) respectively. To provide an approximate idea on the surface distribution of the anomaly, a vertical anomaly contour map has been prepared. Though the contour map has not been presented here, because of its inherent shortcomings, recourse has been taken to it while discussing certain trends, which are otherwise not entirely discernible from the profiles of figure 2.

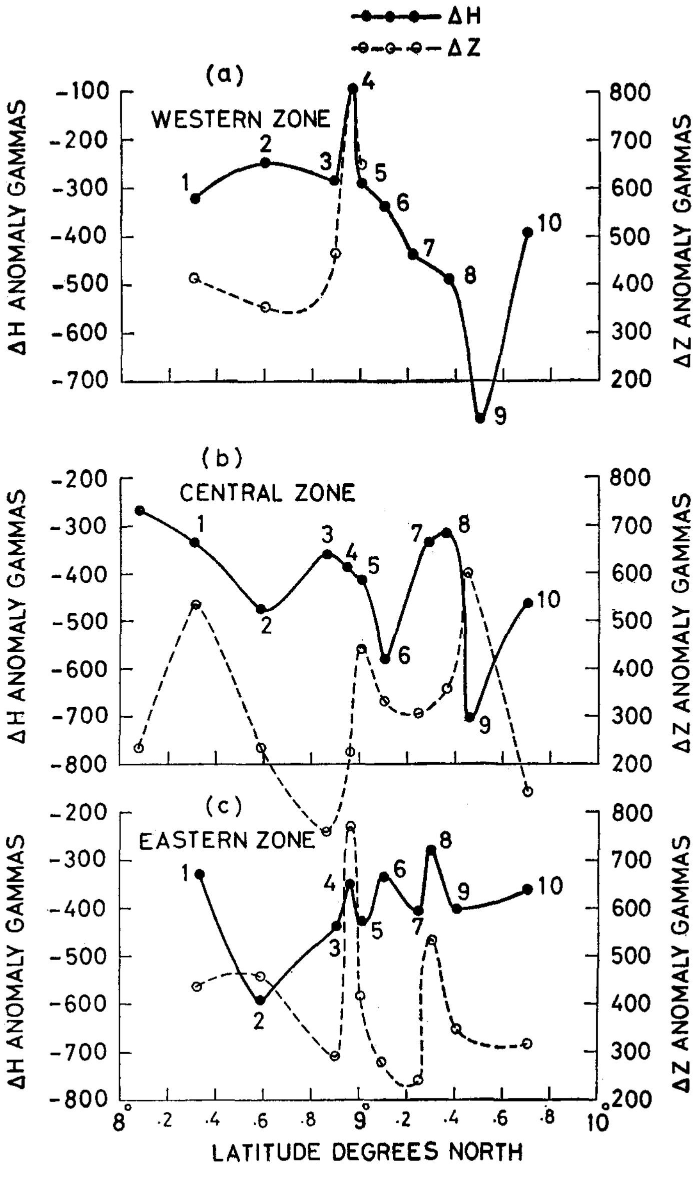

Figure 2. The deduced ΔH and ΔZ magnetic anomalies due to subsurface structures along the (a) western, (b) central and (c) eastern profiles. The numbers indicated are stations which are located as shown in figure 1.

3. Results and discussion

The charnockite-khondalite (Archaean) suites of rocks of the region constitute a part of the Eastern Ghat Complex, whose dominant structural trend is NE–SW. The formations of the region are highly folded and faulted and charnockite hill masses (horsts) had been uplifted along the weak planes. The trend of the various known structures varies from NE–SW to NW–SE (Narayanaswamy 1970; Karunakaran 1970).

A deep-seated fault trending WNW-ESE between Kanyakumari and Panagudi, proposed by the Oil and Natural Gas Commission (ONGC) (Tectonic map of India 1970), the fault in the Tenmalai–Tisayanvillai line, the synclinal axes passing through Manur and Moonradaippu and the anticlinal axis near Ottapidaram (Karunakaran 1970) and the fault to the west of Kallupatti (Valdiya 1973) are some of the known structures in the region.

The manifestations of the complex systems of geological structures of the region can be seen in the ΔH and ΔZ anomaly profiles shown in figure 2. Though it is difficult to completely interpret these profiles, some striking features can be discussed. Vertical anomaly peaks can be seen at the stations 4a (Tenmalai), 1b (Panagudi), 4c (Vedanattam) and 8c (Mudukalattur). The ΔH profiles also show maximum values at these stations, excepting at 1b. Interestingly all these anomaly highs occur along the periphery of the southern part of the Indian subcontinent. These are reflected as high positive anomaly closures in the contour map, that might correspond to the uplifted charnockite masses, which are known to be highly magnetic. Further, they conform to the observed positive gravity gradients towards the coast (Gulatee 1956; Qureshy 1970; Das *et al* 1970), which characterise the decreasing depth to the mantle.

The western zone profile (a) traverses across the Tenmalai–Tisayanvillai fault near Tenmalai. Though the anomaly curves indicate a fault pattern (figure 2a), apparently the effect due to the charnockite massif near Tenmalai is superposed on them. The central zone profile (b) traverses across (i) the deep-seated fault proposed by ONGC between Kanyakumari and Panagudi (ii) the Tenmalai–Tisayanvillai fault and (iii) the synclinal axes near Moonradaippu and Manur. The anomaly curves in the central zone (figure 2b) do not bring out the effect of the abovementioned faults, mainly because of lack of observations in the immediate vicinity of these structures, though high ΔZ has been observed near Panagudi, which could probably be attributed to the charnockite intrusives, as already mentioned. The synclinal structure near Manur (3b) is well brought out as a depression in the anomaly curves. In figure 2c, the anomaly curves show high ΔZ and ΔH values near Vedanattam probably reflecting the effect due to the charnockite instrusives, which can be identified with the anticlinal structure that is known to exist in the vicinity. The contour pattern also conforms to the strike of the Tenmalai–Tisayanvillai fault, the fault near Kallupatti and the proposed deep-seated fault near Panagudi; and it vividly brings out the synclinal structure near Manur and the anticlinal structure near Ottapidaram. Further, the trend of the contours suggests an E–W fault pattern in the Devarkulam–Ottapidaram region, approximately along 9° N parallel. The charnockite suite of rocks evidently have been uplifted and emplaced along the faults and other weak planes, resulting in a valley-like structure near Manur, with a magnetic low, which is encircled by the magnetic highs near Tenmalai, Panagudi and Vedanattam.

Most of the structures of the charnockite-khondalite tracts of South India are known to have a deep tectonic control, probably originating in the upper mantle. It is noteworthy that many of the major structures of the area under study have been reflected in the anomaly curves indicating that the structures are responsive to the magnetic method. The anomaly profiles do not, however, reflect all the structural patterns, mainly due to lack of closely spaced data.

Thus, from this preliminary study with the available equatorial electrojet survey data, it has been possible to establish that magnetic anomalies of the region are well correlated with some of the known geological structures. Detailed systematic study of the region is now being planned to identify and confirm the existence of the other structures as well as to attempt a quantitative interpretation of the various geological structures of the region.

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