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Moho structure beneath the Eastern Ghat Mobile Belt and adjacent Bastar Craton as deduced from gravity anomalies

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ABSTRACT
A typical gravity profile across Eastern Ghat Mobile Belt (EGMB) and adjacent Bastar Craton was selected from the available Bouguer Gravity Map (NGRI 1975) of India. The Bouguer anomaly map is deceptive as it revealed a low over a background rise of gravity anomaly from the west to the coast. A careful regional-residual separation brought out two prominent highs in place of the frequently quoted low. These highs could be explained by structures at the Moho.

INTRODUCTION

The Eastern Ghat Mobile Belt (EGMB) is an incomplete mobile belt and constitutes the most metamorphosed sector of the Precambrian rocks in the Indian shield. It is bounded by the Archean Dharwar, Bastar and Singhbhum Cratons. Interpretation of gravity profiles across the Eastern Ghats by different workers brought out divergent results which varied from 34 km thick Eastern Ghat rocks lying on the Moho (Nayak, Choudhury & Sarkar 1998) to faulted and layered crust (Niraj Kumar et al. 2004). A careful analysis of the gravity profile across the Bastar Craton and the EGMB in the northern districts of Andhra Pradesh revealed the presence of structures on the Moho both below the Bastar Craton and the EGMB. This type of interpretation is entirely new and differs from those presented by other workers.

EARLIER GEOPHYSICAL STUDIES

Fig.1 shows the gravity anomaly over a part of the Eastern Ghats taken from the map published by NGRI (NGRI 1975). The anomalies are generally aligned parallel to the coast, save those on the Godavari Graben. They are negative on the north-west, but tend to rise towards the south-east to reach a positive value of about +20 mgal near the coast. In between, the gravity anomaly falls to as low as –70 mgal, developing into a gravity low. Interestingly, this gravity low occurs over the boundary of the EGMB and the Bastar Craton. Fig.2 shows a typical gravity profile AB constructed across the trend of the anomalies. The general increase of gravity anomaly from the NW on the Bastar Craton towards the SE on the Eastern Ghats is easily discernable. This profile brings out two gravity lows, the dominant one of –70 mgal occurring over the boundary of EGMB and Bastar Craton, and the other over the EGMB.

This steady increase in the gravity anomaly and the apparent gravity low(s) have been explained differently by several workers. Subrahmanyam & Verma (1986) considered the average of four gravity profiles, which also brought out the general increase of anomaly, towards and over the EGMB, with an intervening low sitting over the boundary of the Bastar Craton and the EGMB. They attributed the general increase in the anomaly to the higher density of the Eastern Ghat rocks compared to that of the Bastar Craton and the intervening low to sudden deepening of the Moho from 34 km below the Bastar Craton to 38 km below the Eastern Ghats. They further assumed that the density in the EGMB has a lateral variation, but is uniform vertically until they encounter the mantle. The interpretation of Subrahmanyam & Verma (1986) was, however, disputed on the detection of a few density interfaces through DSS work (Kaila et al. 1979).

Nayak, Choudhury & Sarkar (1998), therefore, to interpret their gravity profile over the EGMB, assumed a multilayered crust below the EGMB, and invoked a low angle thrust in the crust, emplacement of mantle material into the lower crust, and presence of granites and syenites along the vertically faulted margins. Niraj Kumar et al. (2004), on the other hand, assumed an eastward dipping crustal column and a thrust fault across which the 38-40 km thick crust under craton warps up to 35 km under the younger EGMB.

In all these interpretations, the cause of the gravity anomaly is assumed to lie underneath the profile. The fact that the anomalies can also be caused by sources lying out side the profile is ignored. Further, the profile

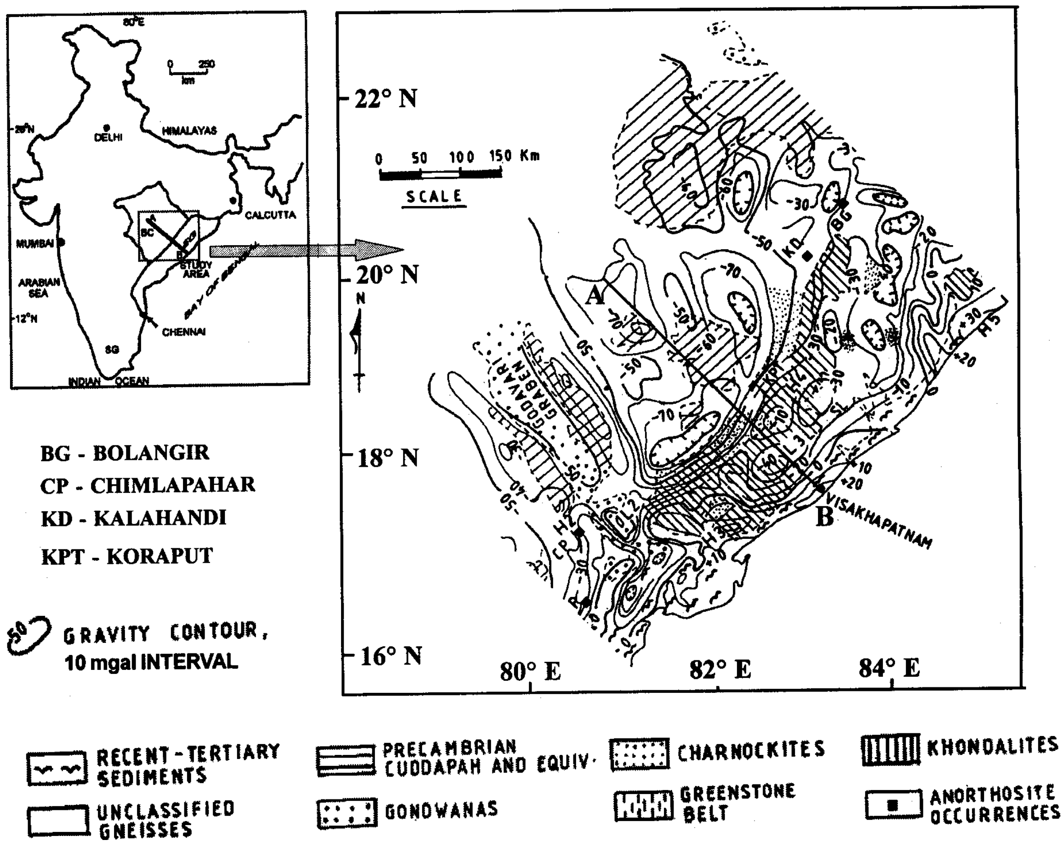

Figure 1. Bouguer anomaly map (after NGRI, 1975) and the profile AB considered for interpretation.

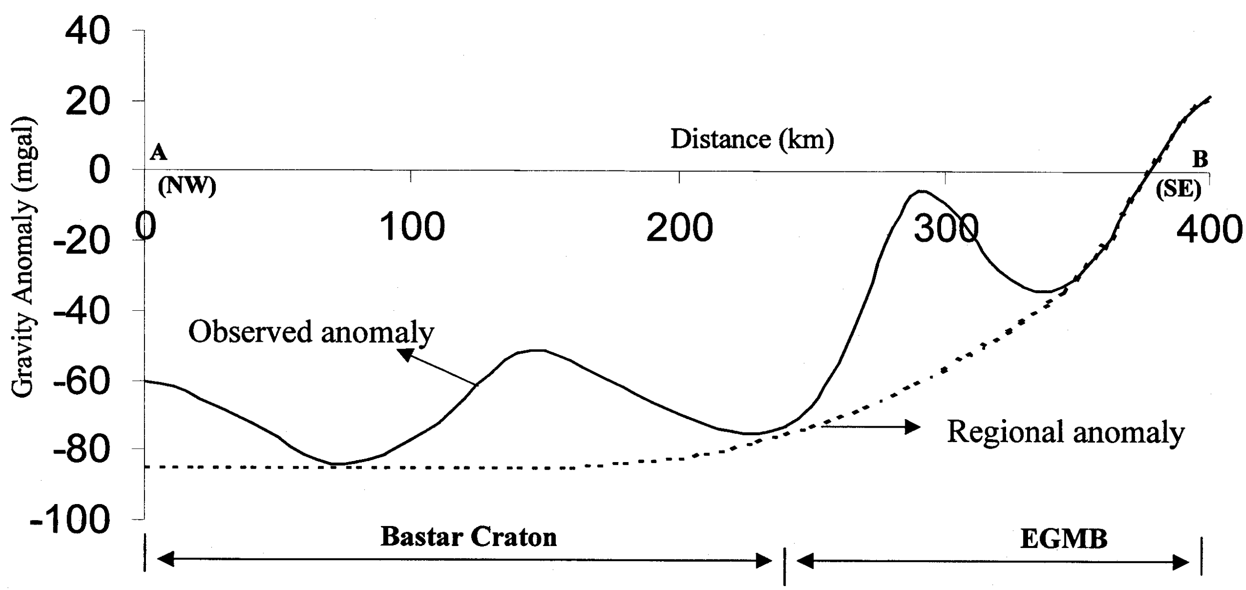

Figure 2. Bouguer gravity anomaly profile (AB) across Bastar Craton and EGMB.

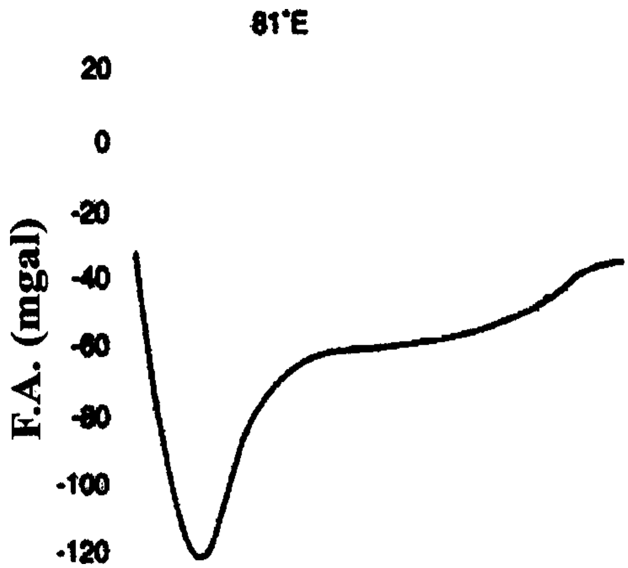

Figure 3. Free-Air gravity anomaly profile in Bay of Bengal. Note the abrupt fall of the anomaly from -30 mgal to –120 mgal, and its tendency to flatten to a normal value.

in Fig.2 actually brings out two gravity highs and two gravity lows, which were consistently ignored by the earlier workers, probably as a consequence of averaging, and being influenced by their typical invisibility on the contour map. More interestingly, the profile shows a regional trend with a consistent and sharp increase from NW to SE, over which the gravity highs are superposed. In other words, the gravity lows appearing on the profile are only deceptive, and one needs to explain the gravity highs, rather than the deceptive low between them.

PRESENT STUDY

The abrupt rise in the magnitude of anomalies and the consequent cluster of linear anomalies near and parallel to the coast (Fig.1) can be due to a faulted Moho near the coast, but in the Bay of Bengal. If so, the Moho on the SE near the coast should be shallower than in the NW. Alternatively, or in addition, the increase in the gravity anomaly can be (fully or partly) the portion of the anomaly that is normally associated with continental shelf and the COB exhibiting a bipolar anomaly, wherein the gravity anomaly rises

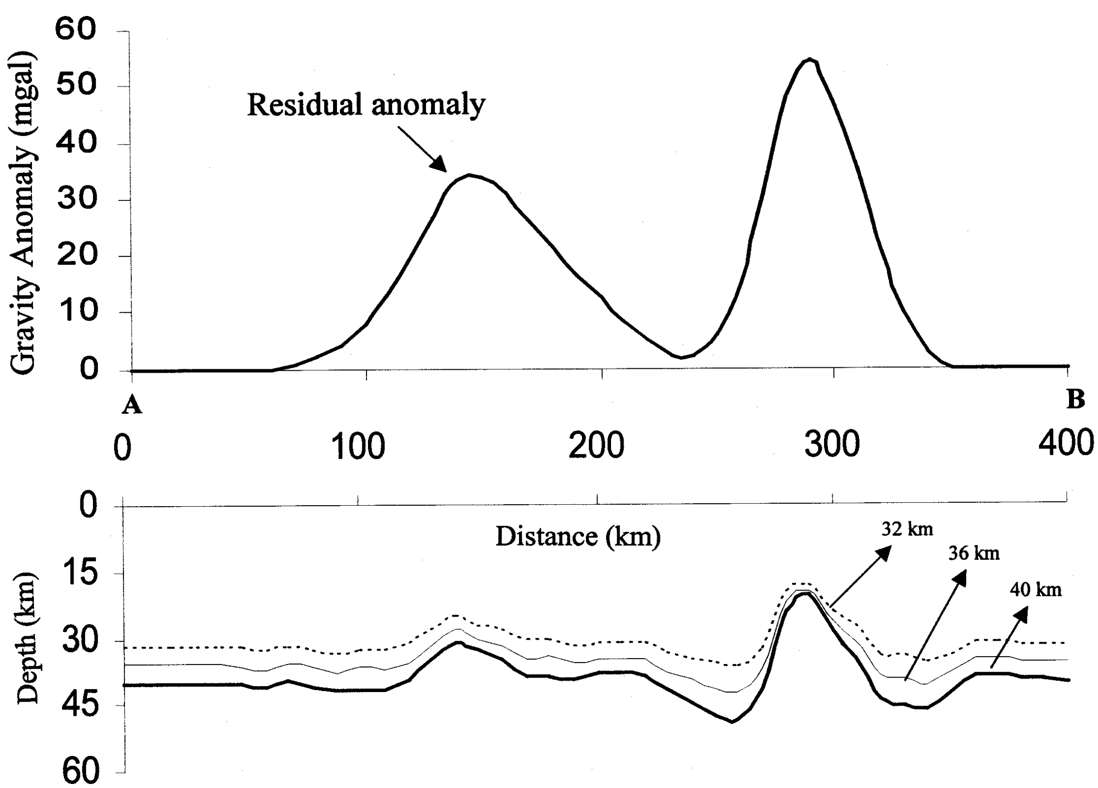

Figure 4. Interpreted structure by varying the Moho depth

sharply over the coast to reach a maximum at the shelf boundary and then to fall sharply to a low near the COB, before it tends to recover over the deep sea. Such a bipolar nature is obviously due to the fact that the low density water column in the oceans is juxtaposed to the upper crust under the continents; and the mantle under the oceans is juxtaposed to the lower crust under the continents. A typical gravity profile in the Bay of Bengal is shown in Fig.3 (Subrahmanyam et al., 2001), wherein the anomaly falls sharply from -30 mgal to as low as -120 mgal near the shelf. Unless the anomaly increases on the continent to reach a maximum, it cannot fall. In the present case, the regional trend of the anomaly showing a rise towards SE can be the portion of the limb of such a bipolar anomaly. If so, the residual anomaly simply consists of two highs, instead of the oft-spoken single low. These gravity highs could be explained by structures at depth on the Moho (Figure 4). Inversion was tried for several depths of the Moho viz., 32, 36 and 40 km. Irrespective of the depth, the structures on the Moho are conspicuous and the interpretation brings into focus that both the Bastar Craton and the EGMB rocks are underlain by a highly faulted Moho with graben/ graben-horst like structures. The presence of such structures below the Bastar Craton and the EGMB are not unjustified, although they are not possibly related to each other in space and time.

The Bastar Craton is bordered by supra crustal rocks, Bengpal Group (including the Sukma Group) and Bailadila Iron Ore Group formed subsequent to the Bastar Cratonic genesis. On the western side of the craton, some ultra-mafic rocks and obducted ophiolites of the mantle occur amidst the supra crustal rocks. These should have been formed in a trench adjacent to the craton, and later obducted into the crust (Misra, Singh & Dutta 1988). Thus, the rise in the Moho below the craton might have been formed at the time of obduction of the ophiolites and emplacement of ultramafic rocks.

The EGMB adjacent to the Bastar Cratonic area is marked by a 'Transition Zone' which may represent the cratonic basement. This zone is followed eastward by a longitudinal zone of 'Western Charnockite Zone' (WCZ) (Ramakrishnan, Nanda & Augustine 1998). The EGMB probably developed along a rifted continent. The composition of the rocks such as ultramafic rocks, mafic rocks and the protoliths of the mafic granulites in WCZ suggest their affinity and derivation from the mantle magma. These could have formed in the initial stages of rift/ trench and were probably obducted later. These along with the protoliths of tonalite charnockites were subsequently metamorphosed to granulite facies. Thus the rise of Moho in the western part of EGMB could have been caused.

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