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Research paper

Proterozoic orogenic belts and rifting of Indian cratons: Geophysical constraints

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ABSTRACT

The Aravalli–Delhi and Satpura Mobile Belts (ADMB and SMB) and the Eastern Ghat Mobile Belt (EGMB) in India form major Proterozoic mobile belts with adjoining cratons and contemporary basins. The most convincing features of the ADMB and the SMB have been the crustal layers dipping from both sides in opposite directions, crustal thickening (~45 km) and high density and high conductivity rocks in upper/lower crust associated with faults/thrusts. These observations indicate convergence while domal type reflectors in the lower crust suggest an extensional rifting phase. In case of the SMB, even the remnant of the subducting slab characterized by high conductive and low density slab in lithospheric mantle up to ~120 km across the Purna–Godavari river faults has been traced which may be caused by fluids due to metamorphism. Subduction related intrusives of the SMB south of it and the ADMB west of it suggest N–S and E–W directed convergence and subduction during Meso–Neoproterozoic convergence. The simultaneous E–W convergence between the Bundelkhand craton and Marwar craton (Western Rajasthan) across the ADMB and the N–S convergence between the Bundelkhand craton and the Bhandara and Dharwar cratons across the SMB suggest that the forces of convergence might have been in a NE–SW direction with E–W and N–S components in the two cases, respectively. This explains the arcuate shaped collision zone of the ADMB and the SMB which are connected in their western part. The Eastern Ghat Mobile Belt (EGMB) also shows signatures of E–W directed Meso–Neoproterozoic convergence with East Antarctica similar to ADMB in north India. Foreland basins such as Vindhyan (ADMB–SMB), and Kurnool (EGMB) Supergroups of rocks were formed during this convergence. Older rocks such as Aravalli (ADMB), Mahakoshal–Bijawar (SMB), and Cuddapah (EGMB) Supergroups of rocks with several basic/ultrabasic intrusives along these mobile belts, plausibly formed during an earlier episode of rifting during Paleo–Mesoproterozoic period. They are highly disturbed and deformed due to subsequent Meso–Neoproterozoic convergence. As these Paleoproterozoic basins are characterized by large scale basic/ultrabasic intrusives that are considerably wide spread, it is suggested that a plume/superplume might have existed under the Indian cratons at that time which was responsible for the breakup of these cratons. Further, the presence of older intrusives in these mobile belts suggests that there might have been some form of convergence also during Paleoproterozoic period.

1. Introduction

Orogenic belts during Precambrian period formed due to collision of cratons played an important role in growth of continents. Their identification is important to understand the plate tectonics and associated activities at that time. In a Precambrian terrain, if crustal blocks are separated by boundaries across which there is a marked difference in physical properties, stratigraphy or tectonic history or a discontinuity in structural trends, such boundaries represent suture zones, especially if they are highly sheared. Sutures are important to demarcate orogenic belts. Similarly, there

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are several geophysical signatures as described below based on the present day collision zones which may help in delineating old suture zones in the Archean–Proterozoic terrains.

(1) High order of reflectivity in the upper and lower crusts indicates convergence and extensional phases, respectively. Dipping reflectors from either side in the crust whose junction if projected to the surface coincides with a sheared zone indicates a suture where high velocity lower crustal rocks may occur due to thrusting. Near vertical reflections in the crust or dipping reflectors in the upper mantle away from the suture also indicate convergence tectonics.
(2) High gravity anomalies over the Proterozoic terrain representing high density lower crustal rocks and lows over the Archean terrain related to sediments of the foreland basins on one side and subduction related intrusives on the other side suggest collision and subduction (Mishra, 2006).
(3) Magnetotelluric studies often suggest the presence of blocks of different conductivities on either side of the Archean–Proterozoic sutures. They also provide evidence of high conductivity at shallow depth on the obducted side (mobile belts) and along the suture that are related to thrusted blocks and fluids, respectively. High conductivity and low density rocks in the upper mantle dipping away from the mobile belt may indicate remanence of the subducted rocks that are metamorphosed to give rise to fluids causing these anomalies.

A topographic map of the Indian continent is given in Fig. 1 that shows important Proterozoic fold (mobile) belts like the Aravalli–Delhi (ADMB), the Satpura (SMB) and the Eastern Ghat (EGMB) Mobile Belts and Godavari Proterozoic Belt (GPB) and adjoining basins and cratons that are discussed here. It also shows the epicentres of earthquakes of magnitude 4–6 (white stars) and >6 (black stars) (USGS Website) that occurred since 1975. Plate

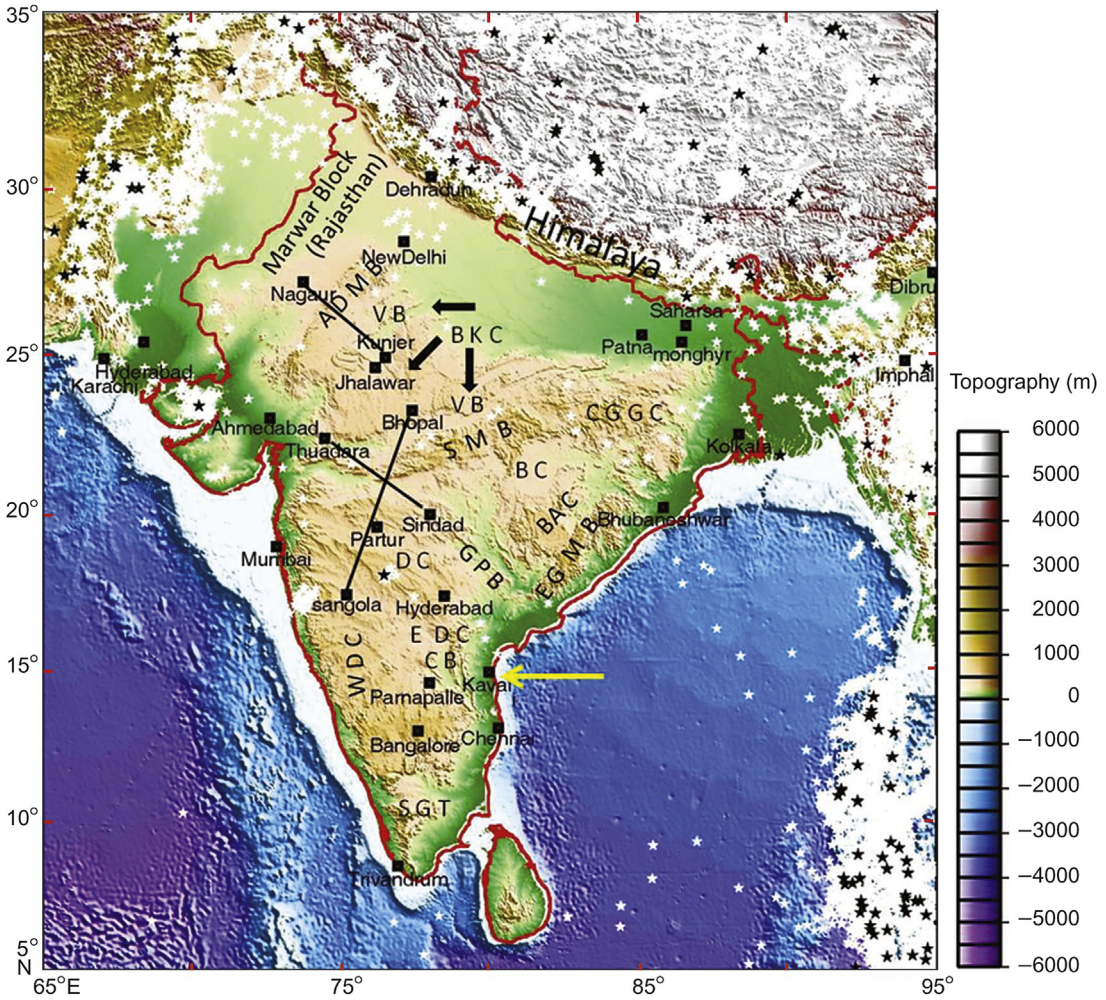

Figure 1. A simplified tectonic map of India showing various cratons and fold (mobile) belts with arrows indicating direction of convergence during Proterozoic convergence based on the present study. The E–W and N–S arrows in north India indicate Meso–Neoproterozoic convergence between the Bundelkhand craton (BKC) and Marwar block across the Aravalli–Delhi Mobile Belt (ADMB) and BKC and Bhandara craton (BC) across the Satpura Mobile Belt (SMB), respectively while the NE–SW arrow is the resultant of these two converging forces during that time. In fact, NE–SW directed force might be the primary force of convergence at that time and N–S and E–W forces may be its component. They are joined together in the western part and formed a curvilinear collision zone along which Vindhyan basin formed as a foreland basin. E–W yellow arrow is the direction of convergence between the East Antarctica and the Dharwar craton (India) across the Eastern Ghat Mobile Belt (EGMB). Stars denote the epicentres of earthquakes of magnitudes 4–6 (white stars) and >6 (black stars), respectively from 1975 onwards (USGS Website). North and NW of Kolkata where the northward extension of the EGMB is likely to interact with the eastward extension of the SMB and Munghyr–Saharsa ridge under the Ganga basin show more seismic activity compared to other parts of these mobile belts. BAC – Bastar craton; CB – Cuddapah Basin; CGGC – Chottanagpur Granite and Gneiss Complex; DC – Dharwar craton; EDC – Eastern Dharwar craton; GPB – Godavari Proterozoic Belt; SGT – Southern Granulite Terrain; VB – Vindhyan basin; WDC – Western Dharwar craton.