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Evidence for Proterozoic Collision from Airborne Magnetic and Gravity Studies in Southern Granulite Terrain, India and Signatures of Recent Tectonic Activity in the Palghat Gap

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Abstract

The composite airborne total intensity map of the Southern Granulite Terrain (SGT) at an average elevation of 7000' (≈ 2100 m) shows bands of bipolar regional magnetic anomalies parallel to the structural trends suggesting the distribution of mafic/ultramafic rocks that are controlled by regional structures/shear zones and thrusts in this region. The spectrum and the apparent susceptibility map computed from the observed airborne magnetic anomalies provide bands of high susceptibility zones in the upper crust associated with known shear zones/thrusts such as Transition Zone, Moyar-Bhavani and Palghat-Cauvery Shear Zones (MBSZ and PCSZ). The quantitative modelling of magnetic anomalies across Transition Zone, MBSZ and PCSZ suggest the presence of mafic rocks of susceptibility (1.5–4.0 x 10^{-3} CGS units) in upper crust from 8–10 km extending up to about 21–22 km, which may represent the level of Curie point geotherm as indicated by high upper mantle heat flow in this section.

Two sets of paired gravity anomalies in SGT and their modelling with seismic constraints suggest gravity highs and lows to be caused by high density mafic rocks along Transition Zone and Cauvery Shear Zone (CSZ) in the upper crust at depth of 6–8 km and crustal thickening of 45–46 km south of them, respectively. High susceptibility and high density rocks (2.8 g/cm^3) along these shear zones supported by high velocity, high conductivity and tectonic settings suggest lower crustal mafic/ultramafic granulite rocks thrusted along them. These signatures with lower crustal rocks of metamorphic ages of 2.6–2.5 Ga north of PCSZ and Neoproterozoic period (0.6–0.5 Ga) south of it suggest that the SGT represents mosaic of accreted crust due to compression and thrusting. These observations along with N-verging thrusts and dipping reflectors from Dharwar Craton to SGT suggest two stages of N-S directed compression: (i) between Dharwar Craton and northern block of SGT during 2.6–2.5 Ga with Transition Zone and Moyar Shear towards the west as thrust, and (ii) between northern and southern blocks of SGT with CSZ as collision zone and PCSZ as thrust during Neoproterozoic period (0.6–0.5 Ga). The latter event may even represent just a compressive phase without any collision related to Pan-African event. The proposed sutures in both these cases separate gravity highs and lows of paired gravity anomalies towards north and south, respectively. The magnetic anomalies and causative sources related to Moyar Shear, MBSZ and PCSZ join with those due to Transition Zone, Mettur and Gangavalli Shears in their eastern parts, respectively to form an arcuate-shaped diffused collision zone during 2.6–2.5 Ga.

Most of the Proterozoic collision zones are highlands/plateaus but the CSZ also known as the Palghat Gap represents a low lying strip of 80–100 km width, which however, appears to be related to recent tectonic activities as indicated by high upper mantle heat flow and thin crust in this section. It is supported by low density, low velocity and high conductive layer under CSZ and seismic activity in this region as observed in case of passive rift valleys. They may be caused by asthenospheric upwarping along pre-existing faults/thrusts (MBSZ and PCSZ) due to plate tectonic forces after the collision of Indian and Eurasian plates since Miocene time.

Key words: Collision, Proterozoic, Southern Granulite Terrain, Palghat Gap, airborne magnetic and gravity anomalies.

Introduction

Archean-Proterozoic fold belts and exposed lower crustal rocks are of special significance in the quest to unravel the mystery of tectonic processes that operated during those periods. Southern Granulite Terrain (SGT) in India is one such large block of exposed lower crustal rocks and deep-seated intrusives, where different geophysical and geological explorations may help in understanding the evolution of these rocks in general, and SGT in particular (Fig. 1). The high-grade lower crustal rocks of SGT are separated from low- intermediate-grade rocks of the Dharwar Craton towards the north by Transition Zone (Fig. 1) and are characterized by several thrusts/shear zones such as MBSZ, PCSZ and AKSZ, etc. (Fig. 1). The Moyar-Bhavani Shear Zone (MBSZ) is the

northern most shear zone south of Transition Zone (Fig. 1). The region between the MBSZ and PCSZ is known as Cauvery Shear Zone (CSZ) or Palghat Gap, which represents a low land (200–300 m) bordering highland on either sides rising to 2000–2500 m at some places. The PCSZ also marks a geochronological boundary with exposed lower crustal rocks north and south of it showing dominant metamorphic ages of 2.6–2.5 Ga and 0.60–0.55 Ga (Bhasker Rao et al., 2003; Ghosh et al., 1998), respectively referred to as northern and southern blocks (Fig. 1). However, CSZ and southern block are characterized by some intrusives and other tectonothermal events during Meso-Neoproterozoic periods (1.8 Ga and 0.8–0.6 Ga) (Bhasker Rao et al., 2003; Santosh et al., 2003). Further south, the Achankovil Shear Zone (AKSZ) separates the Kerala Khondalite Block towards the south, which primarily shows ages corresponding to the Pan-African event (0.60–0.55 Ga; Bartlett et al., 1995).

Based on increase in the facies of exposed rocks from Dharwar Craton to the SGT, Drury et al. (1984) considered late Archean crustal shortening, which took place through northward subduction and large vertical displacements associated with the MBSZ and the PCSZ exposing lower crustal rocks. However Srinagesh and Rai (1996) based

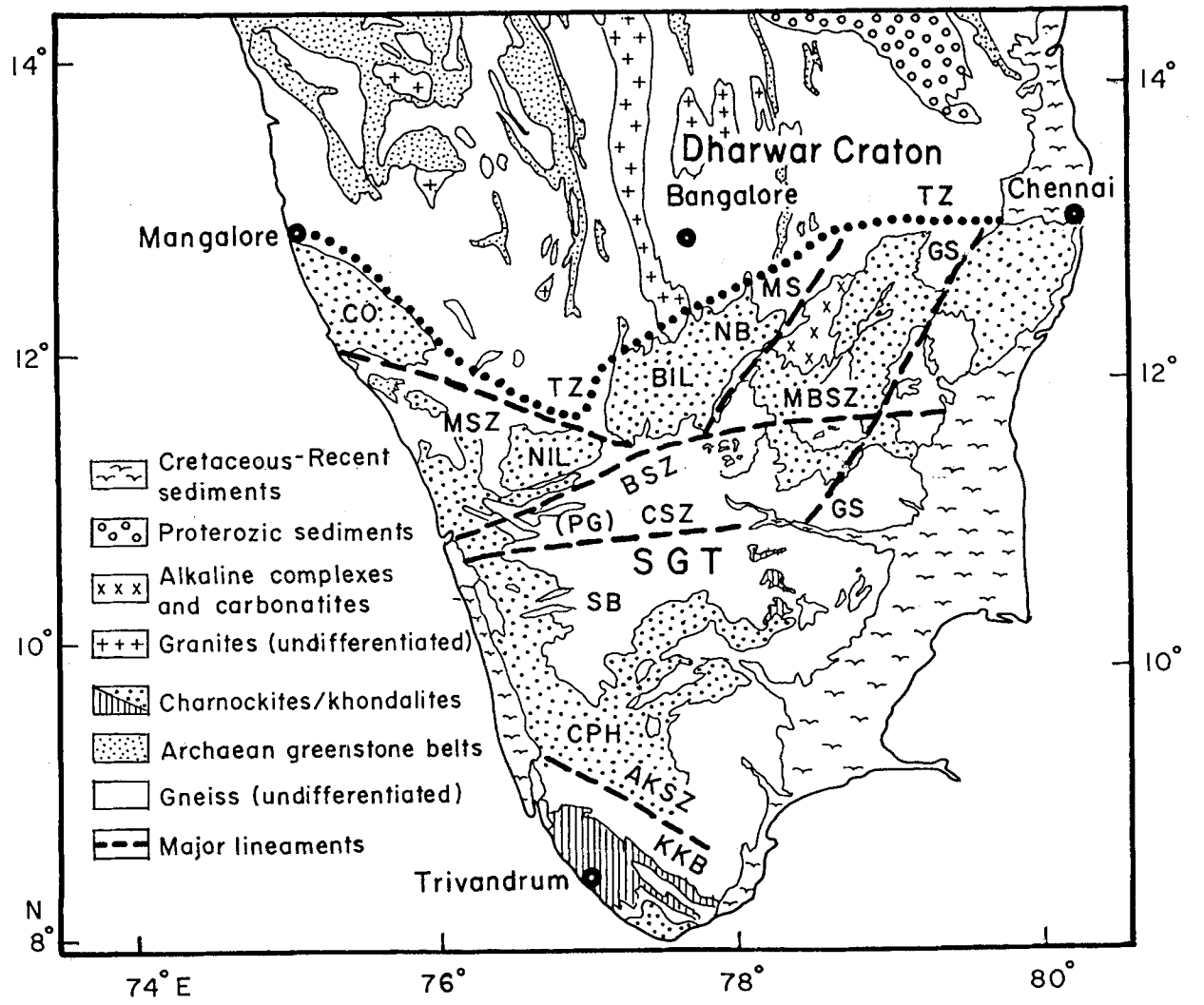

Fig. 1. Simplified geological map of a part of southern India (Ray et al., 2003; Modified after GSI, 1998; Drury et al., 1984) showing the Dharwar Craton and the Southern Granulite Terrain (SGT), which is to the south of the Transition Zone (TZ). The section between E-W striking Moyar Bhavani and Palghat-Cauvery Shear Zones (MBSZ and PCSZ) known as Cauvery Shear Zones (CSZ) or Palghat Gap (PG) separates the Northern Block (NB) and the Southern Block (SB) of predominant metamorphic ages of 2.6–2.5 Ga and 0.6–0.5 Ga, respectively. Achankovil Shear Zone (AKSZ) separates the Kerala Khondalite Block (KKB) to the south of the AKSZ. MSZ and BSZ respectively refer to Moyar and Bhavani Shear Zones. CO–Coorg Hills, BIL–Biligiri Rangan Hills, NIL–Nilgiri Hills belong to Northern block, north of MBSZ while CPH–Cardoman-Palani Hills belong to Southern block, south of PCSZ. MS and GS represent Mettur Shear and Gangavalli Shear connected to the eastern parts of MBSZ and PCSZ. The Palghat Gap represents a low-lying land with average elevation of 200–250 m with hills on either sides rising to 2000–2500 m.