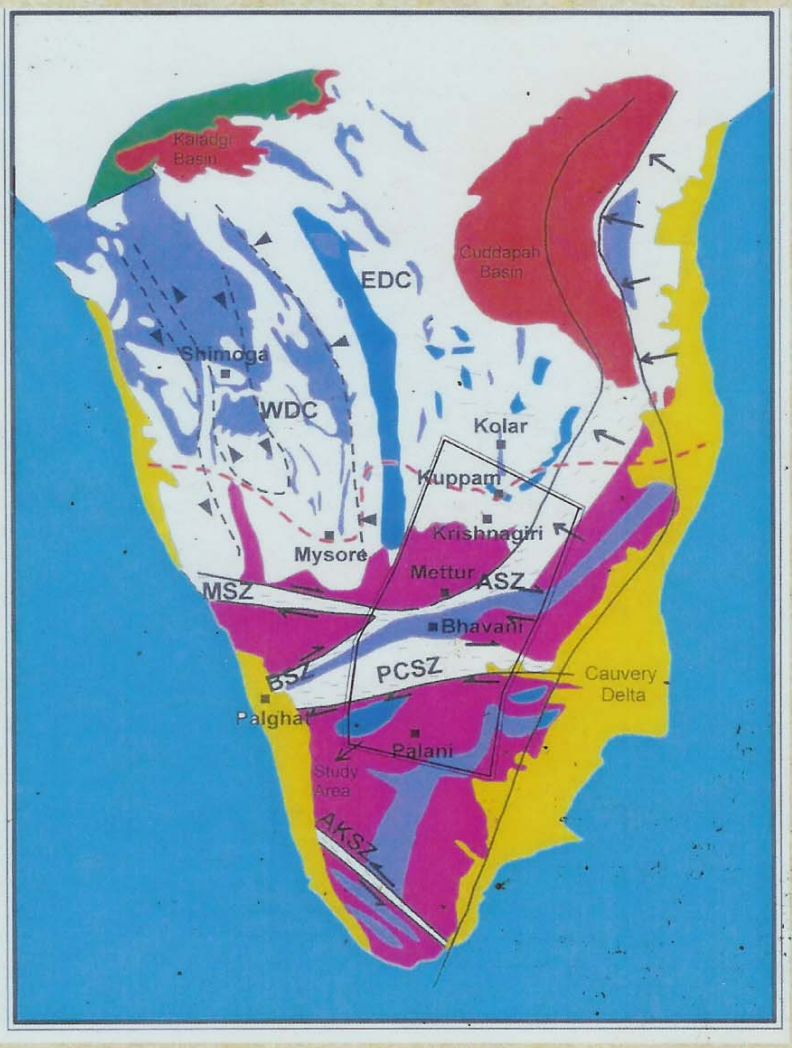
CATEGORY - B

TECHNICAL REPORT NGRI-2001-EXP-317

MODELING THE TECTONIC EVOLUTION OF SOUTHERN GRANULITE BELT OF THE INDIAN SHIELD USING COINCIDENT SEISMIC REFLECTION/REFRACTION, GEOLOGICAL/GEOCHEMICAL, GEOCHRONOLOGICAL, GRAVITY/MAGNETIC, MAGNETOTELLURIC AND DEEP RESISTIVITY STUDIES ALONG THE SOUTHERN GEOTRANSECT



National Geophysical Research Institute
(An ISO 9001 Organisation)
Hyderabad – 500 007, INDIA
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Grant-in-Aid
by
Department of Science and Technology, New Delhi

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SYNTHESIS

The integrated geological and geophysical experiment toward a comprehensive understanding of the deep crustal configuration and evolution of the SGT has contributed a wealth of new information helpful in the characterization of the upper, middle and lower crustal columns of the SGT in terms of various physical properties such as velocity, density and conductivity and the compositional differences between various crustal layers. The study also led to the recognition of new shear zones and a more meaningful geological characterization of important and temporally distinct tectonic domains of the region.

The Kuppam-Palani geotransect presents a crustal section from the Archean low-to high-grade metamorphic transition in the north extending far into the southern granulite terrain further south. Geologically, the region traversed comprises a large part of the Archean granulite domain of the SGT. The region is dissected by a crustal scale Cauvery Shear Zone (CSZ). These shear zones are belts of kinematic partitioning associated with recurrent reworking of the Archean crust. Some of these may also represent boundaries of geologically distinct domains. The traverse intersects the Mettur shear zone at around Nagarasampatti and P-Ca shear zone (CNSZ) at Chennimalai. The Mettur shear zone is an extension of the east-west trending Moyar-Bhavani shear zone (MBSZ) and coincides with the $N45^0E$ fault described by Grady. The nature, location and deep crustal configuration of these shear zones are well defined in the present study.

The Seismic refraction / wide angle reflection studies indicate an essentially four layered crustal velocity structure with a thick mid-crustal low velocity layer (LVL) throughout the region. The overall crustal thickness of the region north of Mettur shear zone (low-grade cratonic domain) is 38 km , while that south of it is ~ 45 km, with subtle local variations. However, significant changes in reflectivity character and velocity structure are observed across the shear zones as exemplified at Nagarasampatti along the Mettur shear zone and around Chennimalai in the Palghat-Cauvery shear zone. Most significantly, the seismic velocity layers define prominent reversals in their regional dip across the shear zones and also indicate striking Moho

upwarp, of the order of 4-5 km at Nagarasampatti and Chennimalai.. A deep penetrating south dipping reflection band from Kuppam reaches Moho depth at Nagarasampatti which is interpreted as a thrust zone. Further south, this shows an uptrend suggesting a distinct crustal block south of Mettur shear zone. The velocity structure between Bhavani and Palani reveals an undulating nature of all the crustal layers consistent with the presence of anastomosing shear zones. The average crustal velocity south of the MBSZ is relatively higher than the region to the north.

Bouger gravity data reveal a bipolar distribution across the Mettur shear zone , characterized by gravity low to the north and a high towards south. Gravity modeling with constraints from the seismic velocity structure indicates a southward deepening of the Moho from ~41km near Kuppam to ~46km, near Nagarasampatti. The crustal block , south of Mettur shear zone also indicates northerly vergence but a relatively shallow section. Over the CSZ, the gravity model consists of a broad Moho upwarp contributing to the regional gravity high. The Mettur shear zone is also associated with a conspicuous magnetic gradient comprising a low magnetic anomaly over the northern Dharwar craton and a high over the SGT, consistent with seismic and gravity data. Such paired magnetic anomalies are typical of fault zones. The magnetotelluric and deep resistivity studies also indicate a southerly dipping high conductive zone at the Mettur shear zone extending deep into the crustal column, which is in agreement with south dipping reflection band observed in the seismic reflection study. The high conductive zone is thus considered to be the geoelectrical expression of the observed seismic reflection band. The geoelectrical signatures of the region for MT studies have exhibited a marked variation of resistivity to deep crustal depths indicating different evolutionary history for different parts of the region. For e.g. the region, north of CNSZ exhibits a high resistive zone (10^4 ohm.m), whereas south of it , the region is marked by lower resistivity (10^3 ohm.m).

The structural trends across the MBSZ are distinctly different and the basement gneisses in these domains show differences in lithological associations and their crust formation ages. Structural studies suggest that the MBSZ represents south dipping frontal thrust while the other shear zones south of it could represent north dipping back thrusts. The regional structure can be modelled as a crustal scale flower structure, typical of transpressional tectonic zones.

In summary, the contrasting geological and geophysical features of crustal blocks across the Moyar-Bhavani-Mettur shear zones, particularly 1) the divergent seismic reflection fabric and variations in crustal velocity structure across shear zones, 2) the bipolar Bouger gravity and magnetic anomalies and 3) close spatial associations of high conductive zones together with the regional scale deeply penetrating southerly dipping reflection band are interpreted in terms of a collision tectonic model. It is envisaged that a Precambrian crustal block is upthrusted on to the Archean Dharwar cratonic block across the Moyar-Bhavani-Mettur shear zone, which is visualized as a Late Archean / Paleo Proterozoic suture associated with kinematic partitioning. Subsequently, the region formed a part of a large transpressional tectonic zone during the Neoproterozoic where crustal reworking associated with magmatism and migmatization was localized mainly along the shear zones. This phase accounts for much of the regional uplift as established by the limited petrological and geothermobarometric data while uplift seems to have continued episodically during the Phanerozoic.

The Kuppam-Palani geotransect studies revealed several fascinating features of the southern granulite terrain, not known hitherto. However, these studies were limited largely to the Archean crustal domains of the SGT. For a more comprehensive analysis, it is essential that the studies may be extended further south across the Madurai Block, the Achankovil Shear Zone and the Kerala Khondalite Belt.