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Structural anatomy of a dismembered ophiolite suite from Gondwana: The Manamedu complex, Cauvery suture zone, southern India

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A B S T R A C T

Detailed geological and structural mapping of the Manamedu ophiolite complex (MOC), from the south-eastern part of the Cauvery suture zone (CSZ) within the Gondwana collisional suture in southern India reveals the anatomy of a dismembered ophiolite succession comprising pyroxenite actinolite–hornblendite, hornblendite, gabbro–norite, gabbro, anorthosite, amphibolite, plagiogranite, mafic dykes, and associated pelagic sediments such as chert–magnetite bands and carbonate horizons. The magmatic foliation trajectory map shows inward dipping foliations and a variety of fold structures. Structural cross-sections of the MOC reveal gentle inward dips with repetition and omission of different lithologies often marked by curvilinear hinge lines. The succession displays imbricate thrust sheets and slices of dismembered ophiolite suites distributed along several localities within the CSZ. The MOC can be interpreted as a deformed large duplex structure associated with south-verging back thrust system, consistent with crustal-scale 'flower structure'. The nature and distribution of ophiolitic rocks in the CSZ suggest supra-subduction zone setting associated with the lithospheric subduction of the Neoproterozoic Mozambique Ocean, followed by collision and obduction during the final stage of amalgamation of the Gondwana supercontinent in the end Precambrian.

1. Introduction

Suture zones, the sites of obducted oceanic lithosphere during the processes associated with continental collisional tectonics, are characterized by deformation zones of extraordinary complexity with transform related high strain zones (Dewey, 1977). They provide important record of the remnants of destructed oceanic crust (in the form of ophiolites) and convergent margin processes. The study of suture zones is crucial to understand the end-product of plate collision tectonic processes in time and space. Investigations of suture zones have received major attention since late 1960s particularly after the advent of the concept of plate tectonics encompassing the processes of rifting, subduction, accretion and collision (Dilek and Robinson, 2003; Kusky, 2004 and references there in). Structural analysis of accretionary belts formed within continental collision settings range from outcrop-scale to plate-scale evaluation of multiphase deformation and strain variation (e.g., Braid et al., 2010).

The Cauvery suture zone (CSZ), southern India (Fig. 1), is one of the significant Proterozoic shear zones juxtaposing two discrete crustal blocks viz., the northern granulite block and the Madurai granulite block of Southern Granulite Terrain (SGT) (Drury and Holt, 1980; Chetty, 1996; Chetty et al., 2006). Earlier, some workers regarded the CSZ as a suture zone since it comprises predominantly high grade assemblages intruded by distinctive assemblages of medium to coarse grained dunite–peridotite–websterite–garnet gabbro–anorthosite complexes showing analogy to modern ophiolite sequences (Gopalakrishnan et al., 1990; Viswanathan et al., 1990). The 2.5 Ga high grade supra-crustal assemblages occurring as swaths in the CSZ are interfolded and inter-thrust with sheaths of granulites of allochthanous origin (Drury et al., 1984). The region also consists of large layered mafic-ultra mafic complexes such as the 2.9 Ga old Sittampundi anorthosite complexes (Bhaskar Rao et al., 1996). The mafic, ultra-mafic complexes of Chalk hills to the north of Salem and intrusions of younger granitoids (~550 Ma) probably belonging to post suturing, occur mostly around Sankaridurg and further west along the CSZ (Nathan et al., 2001). The CSZ is widely interpreted to be the product of Archean collision orogeny (Drury et al., 1984; Ramakrishnan, 1993). Constrictive transpressional deformation is also reflected in the central part of the CSZ exposing Perundurai domal structure with radial stretching lineations suggesting exhumation and extrusion phenomena (Chetty and Bhaskar Rao, 2006a). The recent geological

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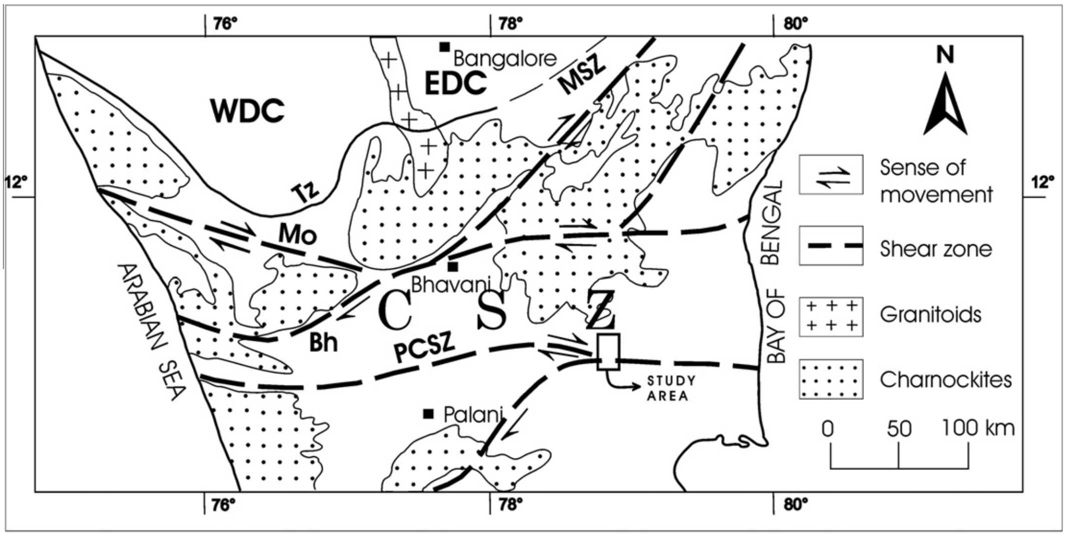

Fig. 1. Regional tectonic framework of the Cauvery suture zone showing the study area. CSZ – Cauvery suture zone; Mo – Moyar shear zone; Bh – Bhavani shear zone; MSZ – Mettur shear zone; PCSZ – Palghat Cauvery Shear Zone; SASZ – Salem Attur Shear Zone; CTSZ – Cauvery Tiruchirapalli Shear Zone; Tz – Transition Zone; WDC – Western Dharwar Craton; EDC – Eastern Dharwar Craton (after Chetty and Bhaskar Rao, 2006a).

and geophysical studies have established that the CSZ is a Precambrian suture zone involving south dipping subduction (Chetty et al., 2006 and the references therein). The CSZ has also been demonstrated as a crustal-scale 'flower structure' that formed during Neoproterozoic dextral transpression resulting from oblique collisional processes (Chetty et al., 2003; Chetty and Bhaskar Rao, 2006b). Recently, it has been regarded as a Neoproterozoic/Cambrian suture zone that extends from the Betsemisaraka suture zone of Madagascar and has been described as the site of Mozambique ocean closure (Collins et al., 2007, in press; Santosh et al., 2009; Raharimahefa and Kusky, 2009).

Ophiolite rocks, the characteristic features of suture zones formed by ocean closure, preserve record of tectonic and magmatic processes from rift–drift through accretionary and collisional stages of continental margin evolution in various tectonic settings. Ophiolites are interpreted to form in a wide variety of plate tectonic settings including oceanic spreading centers, back arc basins, fore arcs, arcs and other extensional magmatic settings including those in association with plumes (Kusky, 2004; Dilek et al., 2007; Ribeiro et al., 2010; Pearce and Robinson, 2010; Ali et al., 2010; Kryza and Pin, 2010). Recent reports and the current models suggest that many ophiolites were generated above subduction zones (suprasubduction ophiolites) or in back arc basins rather than in major oceans. In general, ophiolites represent upper levels of collisional sutures and get easily eroded and the chances of their survival are rare in the cryptic terminal sutures of deeply eroded Precambrian orogens such as CSZ. Further, ophiolites have always been difficult to recognize in Precambrian records because of their fragmental preservations, vast petrological diversity, inconspicuous structures and intense tectonism. However, recently some Paleoproterozoic ophiolites have been reported from Kandra, (Vijaya Kumar et al., 2010) and Kanigiri (Dharma Rao et al., 2010) located in southeastern part of India, which yielded ages of 1.85 Ga and 1.33 Ga respectively. The Manamedu Ophiolitc Complex (MOC) of present study has been described as typical suprasubduction zone ophiolite based on petrographic and geochemical characteristics (Yellappa et al., 2010). Isotopic geochronology of the zircons from the plagiogranite associated with the MOC shows $^{206}Pb/^{238}U$ magmatic crystallization age of 817 ± 16 Ma (Sato et al., 2011). However, detailed structural studies on this complexly fragmented and chaotically distributed lithological sequence have not yet been attempted.

In this paper, we present, for the first time, the results of detailed structural mapping of the dismembered units in the Manamedu ophiolite complex. Based on the results, we construct regional structural cross-sections along with the distribution of other ophiolite complexes in the vicinity, in an attempt to evaluate the structural geometry and emplacement history of ophiolitic rocks within the CSZ. This study also aims at documenting the relationships between the ophiolitic rocks and the basement high grade rocks and offers an opportunity to compare Proterozoic ophiolites with the more common Phanerozoic ones in terms of igneous processes, subsequent disruption and metamorphism during emplacement, and post emplacement tectonics.

2. Regional geological setting

The Cauvery suture zone (CSZ) extends east–west for about 400 km with a width of ~70 km (Fig. 1). Regionally, the eastern part of the CSZ consists of two major shear zones which include: (i) an east–west trending 2–3 km wide zone with steep foliations dipping south along a valley described as Salem–Attur shear zone (SASZ), and (ii) nearly east–west trending 8–10 km wide zone subparallel to the Cauvery river course comprising dominantly, moderately and northerly dipping foliations (CTSZ) (Chetty and Bhaskar Rao, 2006c). Whereas the Salem–Attur Shear Zone (SASZ) represents the northern boundary, the Cauvery–Tiruchirapalle Shear Zone (CTSZ) marks the southern boundary of the CSZ. These two major boundary shear zones are connected by a set of sigmoidal shear belts with an average width of ~1 km and sub-vertical high strain fabrics traversing the interlying central region. These sigmoidal shear belts in the eastern part of the CSZ also delineate zones of less deformed fold dominated domain and zones of high strain domains (Chetty and Bhaskar Rao, 2006c). Whereas the low strain fold dominated domain display multiple events of folding, the high strain zone is characterized by the presence of mylonites, phyllonites, augen gneisses, banded iron formations, highly asymmetric fold structures, and associated well-developed stretching lineations. The SASZ at the northern boundary is marked by the effects of fluid infiltration and retrogression related to mantle derived CO_2 and hydrothermal fluids (Wickham et al., 1994). The MOC occurs as a distinct semicircular body at Manamedu vil-