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A Neoarchean dismembered ophiolite complex from southern India: Geochemical and geochronological constraints on its suprasubduction origin

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A B S T R A C T

Ophiolites, the remnants of ancient oceanic lithosphere, have been described from collisional sutures of various ages with only few examples from Archean terranes. Here we report the discovery of a Neoarchean ophiolite suite from the southern margin of the Dharwar Craton in India, tectonically intercalated within a Neoproterozoic suture zone. The metamorphosed and variably dismembered ophiolite suite, exposed around Devanur, comprises altered ultramafic units, websterite, gabbros, mafic dykes, amphibolites, trondhjemites and pegmatites associated with ferruginous metachert. Structural and petrographic studies indicate that the rocks represent a highly sheared and metamorphosed suite emplaced as a thrust sheet. The major and trace element geochemistry of the mafic dykes indicate derivation from basaltic–andesitic magmas with tholeiitic to calc-alkaline characteristics. The rocks display negative Nb anomalies with enrichment of LILE (K, Rb, Ba, Th) and depletion in HFSE (Ti, Nb, Hf, Tb). The tectonic discrimination of these rocks based on various geochemical plots suggests that they were generated in a suprasubduction zone setting. We present new SHRIMP zircon U–Pb data for two trondhjemite samples from this complex, which yield ^{238}U–^{206}Pb ages of 2528 ± 61 and 2545 ± 56 Ma. The Neoarchean age from the trondhjemites obtained in our study is closely comparable to similar ages obtained in recent studies from magmatic zircons in charnockites and orthogneisses in the area. The suprasubduction zone assemblages and arc magmas suggest a Neoarchean ocean closure along the southern margin of the Dharwar Craton.

1. Introduction

Ophiolites, the remnants of oceanic lithosphere, provide important information on the evolution of ancient arcs, petrogenetic processes, opening and destruction of ocean basins, and the nature of subduction–accretion–collision tectonics in major orogenic belts (Nicolas, 1989; Şengör, 1990; Searle and Cox, 1999; Dilek and Newcomb, 2003; Beccaluva et al., 2004). Ophiolitic rocks have also been critical in evaluating the structure and petrophysical properties of modern oceanic lithosphere and subduction systems (e.g. Ceuleneer et al., 1988; Vissers and Nicolas, 1995; Parkinson and Pearce, 1998; Godard et al., 2000; Boutelier et al., 2003), which determine the large-scale dynamics of the mantle-lithosphere system (Davies and Richards, 1992; King, 2001). Ophiolitic suites developed in different tectonic settings have generally been classified into mid-ocean ridge (MOR) type and suprasubduction zone-type (SSZ) type (Pearce et al., 1984a). Miyashiro (1973, 1975) proposed that subduction-zone magmatism is manifest in SSZ-type ophiolites before the formation of island-arcs (Pearce et al., 1984a). The origin of SSZ-type tholeiites with back-arc basin affinities, on the other hand, can be attributed to the later intra-oceanic subduction and plate convergence leading to the generation of supra-subduction-type oceanic crust as a consequence of imparting a certain extent of subduction component into the mantle melting region (Dilek and Newcomb, 2003; Hawkins, 2003; Pearce, 2003; Dilek and Furnes, 2011).

The occurrence of ophiolitic rocks has been reported from various terranes of different ages on the globe. Although most of the well-documented examples come from Phanerozoic belts (e.g., Ishikawa et al., 2002; Dilek and Robinson, 2003; Dilek and Newcomb, 2003; Vaughan and Scarrow, 2003; Hara et al., 2009; Braid et al., 2010; Isozaki et al., 2010; Pearce and Robinson, 2010; Zhang et al., 2010), ophiolites of Archean age have also been recorded such as those from the 2.5 Ga ophiolites in the Dongwanzi, Zunhua and Wutaishan areas in the North China Craton (Kusky et al., 2001; Polat et al., 2005, 2006; Kusky, 2010), and the ~3.8 Ga ophiolites from Isua supracrustal belt in

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southwest Greenland (Furnes et al., 2007, 2009). Whereas the ophiolites in younger orogenic belts preserve a complete sequence/ stratigraphy, those from Archean and Proterozoic terranes are highly dismembered, preserving only partial sequences (e.g. Kroner, 1985; Barhe, 1990; Dann, 1991; Kusky, 2004). Some of the world's best examples of Proterozoic ophiolites have been reported from the Arabian–Nubian shield, Kareliean shield, Capesnot Belt of west Africa and the south west USA (St Onge et al., 1989; Abhouchami et al., 1990; Scott et al., 1991, 1992; Boher et al., 1992; Dann, 2004). Some of the well studied examples for ophiolitic assemblages from Proterozoic terranes include the Mesoproterozoic Kandra (Vijayakumar et al., 2010) and Kanigiri ophiolites (Dharma Rao and Reddy, 2009; Dharma Rao et al., 2011) and the Neoproterozoic Manamedu ophiolite complex (Santosh et al., 2009; Yellappa et al., 2010) from Peninsular India.

In this contribution, we report for the first time a Neoarchean suprasubduction zone complex from Devanur, near the southern periphery of the Archean Dharwar Craton in southern India, dismembered and incorporated within the Palghat–Cauvery Suture Zone, a Neoproterozoic collisional suture developed during the closure of the Mozambique Ocean associated with the final assembly of the Gondwana supercontinent (Collins et al., 2006, 2007; Santosh et al., 2009). We present the detailed field observations, petrology, geochemical and SHRIMP zircon U–Pb age data, to evaluate the petrogenetic and tectonic significance of the complex.

2. Geological setting

2.1. Cauvery suture zone

The Cauvery Suture Zone (CSZ), a part of the larger Palghat–Cauvery Suture Zone considered as a trace of the Gondwana-forming suture (Collins et al., 2007; Santosh et al., 2009) is a network of pervasive mega shear zones and is one of the major tectonic features (70 × 350 km) in the Southern Granulite Terrain (SGT) of Peninsular India. The E–W trending CSZ divides the SGT into two distinct crustal domains: the Archean Dharwar craton to the north and the Neoproterozoic granulite blocks to the south (Fig. 1). The CSZ has been variously described as: (1) a collision zone and cryptic suture, with remnants of probable ophiolitic sequence (Gopalakrishnan, 1994), (2) a dextral shear zone as exemplified by the deflection of north–south Archean fabrics to near east–west disposition along the MBSZ (Drury et al., 1984; Chetty et al., 2003), (3) an analog of the central part of the Limpopo mobile belt (Ramakrishnan, 1993), (4) the Archean–Proterozoic Terrane boundary (Harris et al., 1994), (5) a zone of Palaeo- and Neoproterozoic reworking of Archean crust (Bhaskar Rao et al., 1996; Raith et al., 1999), and (6) a Neoproterozoic dextral–ductile transpressive tectonic zone (Meissner et al., 2002; Chetty et al., 2003; Chetty and Bhaskar Rao, 2006) and (7) Neoproterozoic crustal-scale 'flower structure' (Chetty and Bhaskar Rao, 2006). In addition, the CSZ has also been regarded as Ediacaran–Cambrian suture and has been correlated with the Betsimiserka suture zone, Madagascar (Collins et al., 2007; Collins et al., 2008; Raharimahefa and Kusky, 2009). A Pacific-type prolonged Neoproterozoic subduction–accretion history culminating in a Himalayan-style collision during latest Neoproterozoic–Cambrian along this zone, associated with the closure of the Mozambique Ocean and the birth of the Gondwana supercontinent, has also been proposed (Santosh et al., 2009).

In a recent study, Yellappa et al. (2010) reported the petrological and geochemical characteristics of an ophiolitic suite from the Manamedu complex (MOC) (Fig. 2) within the CSZ, based on which a suprasubduction zone tectonic setting was proposed. Sato et al. (2011) presented U–Pb zircon data from this locality which indicates that the MOC was generated in mid Neoproterozoic associated with subduction tectonics, followed by Cambrian metamorphism during the final collisional assembly of Gondwana.

The dominant rock types along the CSZ include supracrustal sequences metamorphosed to granulite facies, migmatized orthogneisses showing varying degree of retrogression, charnockites, granites, banded iron formations, and several dismembered suites of mafic–ultramafic complexes with varying lithological association including dunite, peridotite–websterite and garnet-bearing gabbro–anorthosite complexes some of which have been considered to display features comparable with modern ophiolite sequences (Gopalakrishnan, 1994). These rocks are particularly well exposed in the form of linear belts along the north–south Manamedu–Mahadevi corridor (Fig. 2).

The supracrustal sequences show E–W striking fabrics with predominant northerly dips at moderate angles (Fig. 3). These have been transformed into steepened high strain fabrics along several shear zones. A set of E–W striking parallel shear zones could be mapped with an approximate spacing of ~700 m. The rock types occur in the form of structural ridges comprising lithologies such as garnet-bearing mafic granulites, alternating linear belts of pyroxenites, peridotites, gabbros, amphibolites, all of which are tectonically intercalated within highly deformed cherty bands and elevated strike ridges characterized by more resistant chert-magnetite horizons. These ridges are invariably bound by shear zones on either side. The ophiolitic complexes of Manamedu and Devanur occur within this corridor.

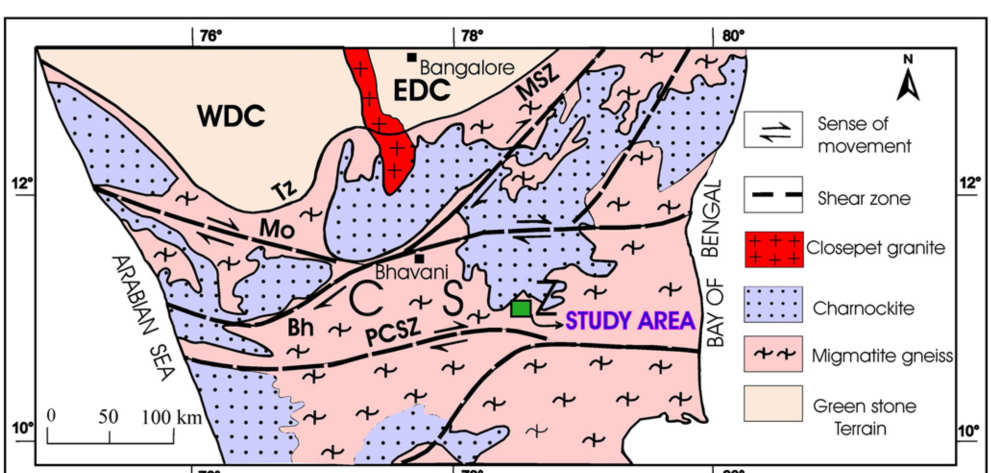

Fig. 1. Geological framework of Cauvery Suture Zone (after Chetty and Bhaskar Rao, 2006).