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Research paper

Magnetic fabrics in characterization of magma emplacement and tectonic evolution of the Moyar Shear Zone, South India

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ABSTRACT

The Moyar Shear Zone (MSZ) of the South Indian granulite terrain hosts a prominent syenite pluton (∼560 Ma) and associated NW-SE to NE-SW trending mafic dyke swarm (∼65 Ma and 95 Ma). Preliminary magnetic fabric studies in the mafic dykes, using Anisotropy of Magnetic Susceptibly (AMS) studies at low-field, indicate successive emplacement and variable magma flow direction. Magnetic lineation and foliation in these dykes are identical to the mesoscopic fabrics in MSZ mylonites, indicating shear zone guided emplacement. Spatial distribution of magnetic lineation in the dykes suggests a common conduit from which the source magma has been migrated. The magnetic foliation trajectories have a sigmoidal shape to the north of the pluton and curve into the MSZ suggesting dextral sense of shear. Identical fabric conditions for magnetic fabrics in the syenite pluton and measured field fabrics in mylonite indicate syntectonic emplacement along the Proterozoic crustal scale dextral shear zone with repeated reactivation history.

1. Introduction

Magmatic fabrics in intrusive bodies that result from accumulated strain during final crystallization are sensitive indicators of the evolving interactions between magmatic and tectonic processes in the Earth's crust (Žák et al., 2008). Hence, timing of magma emplacement and fabric geometry are critical factors in understanding the tectonic evolution of the host rock and for the regional correlations of igneous activity (Gudmundsson, 1995; Groome et al., 2003; Horsman et al., 2005).

The South Indian shield, considered to be a composite continental segment with diverse petrological, geochemical, structural and metamorphic characteristics, has witnessed several phases of ultra-basic, basic, acidic and alkaline magmatism, mainly in the Proterozoic (Murthy, 1987; Ernst et al., 1995; Bhattacharya et al., 2010) and Late Palaeozoic eras (Radhakrishna, 2003; Radhakrishna et al., 2004). These intrusive bodies have been generally considered as post-tectonic (Rajesh, 2000), especially due to the absence of mesoscopic fabrics, obscured contact relations and multiphase reactivation history of the associated shear zones. Therefore, systematic evaluation of the spatio-temporal relationships of solid-state fabrics becomes crucial in deciphering whether these intrusive bodies are syn- or post-orogenic.

The Moyar Shear Zone (MSZ), forming the north-western part of the Palghat Cauvery Shear System (PCSS) in South India, also hosts an elongated leucocratic syenitic pluton dated to be ∼560 Ma (Miller et al., 1996) and NW-SE to NE-SW trending mafic dykes ranging from dolerite to leucogabbro (∼65 Ma and 90 Ma, Radhakrishna et al., 2003) in composition. Detailed analysis of a part of the MSZ and associated magmatic units is attempted with special reference to structure and Anisotropy of Magnetic Susceptibility (AMS) in order to unravel the magmatic emplacement history and its relation to the shear zone kinematics.

2. Geologic setting

The Moyar Shear Zone (Fig. 1) is one of the prominent Proterozoic tectonic zones in the South Indian granulite terrain (Santosh et al., 2009, 2012; Chetty et al., 2011; Naganjaneyulu and Santosh, 2011; Plavsa et al., 2012; Yellappa et al., 2012) and hence attains importance in the study of crustal evolution of South India. This

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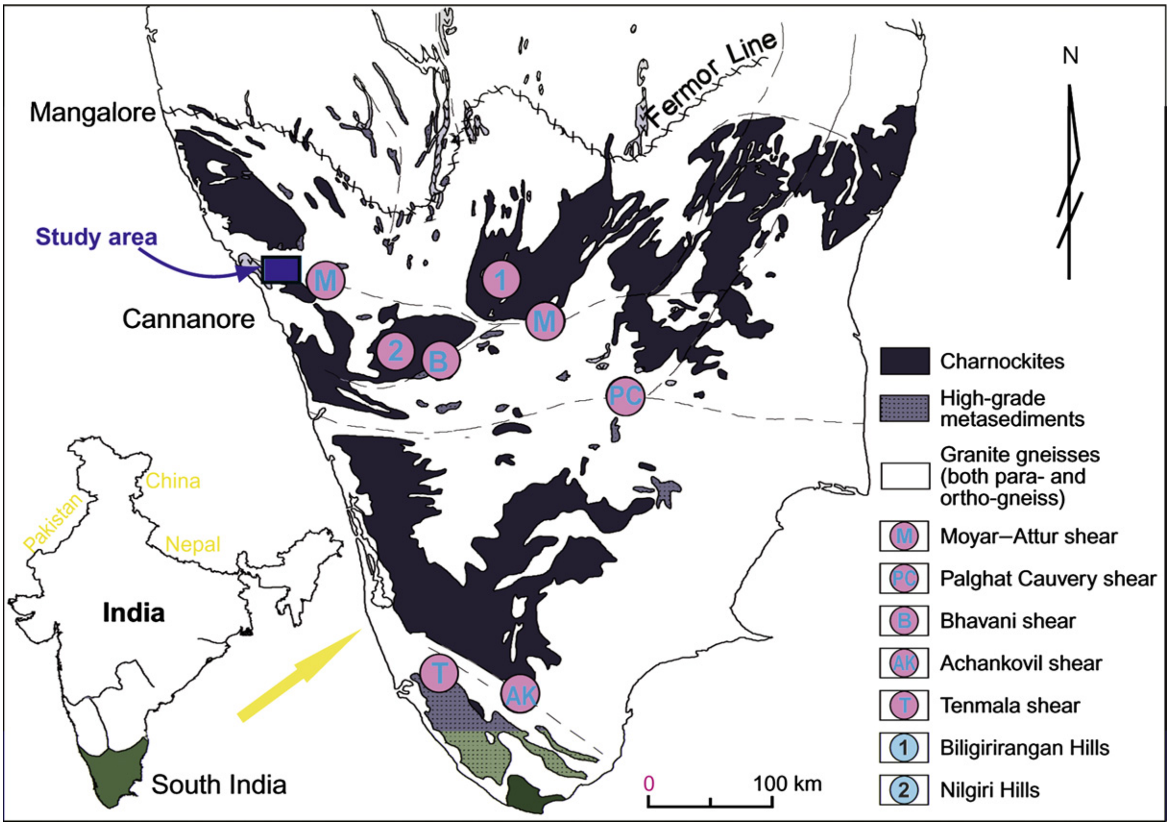

Figure 1. Tectonic map of South India with location of major shear zones (modified after Ghosh et al., 2004).

shear zone, which has been variously considered as a ductile shear zone (Meissner et al., 2002) or as a suture zone (Srikantappa, 1993; Santosh et al., 2009; Chetty et al., 2011) is 20 km wide and trends east-west for a strike length of about 200 km. This shear zone is more or less parallel to the roughly east-west trending gravity contours separating the gravity high and low between Cannanore and Mangalore (Krishna Brahmam, 1993). The acid to basic intrusives and associated amphibolites, gneiss and mylonite form a part of the WNW-ESE trending MSZ, which extends along the northern fringes of the Nilgiri massif and joins the Palghat Cauvery Shear System.

Precambrian crystalline rocks in the area, comprising hornblende-biotite gneiss, mylonitic augen gneiss, garnetiferous hornblende-biotite gneiss and amphibolites, are cut across by magmatic activity (Fig. 2). The rocks, except the syenite, gabbro and mafic dykes, are characterized by polyphase deformation fabrics. The most widely developed planar fabric is a penetrative foliation (S_1), subparallel to the rarely preserved primary bedding/compositional layering (S_0). The foliation, defined mainly by flakes of biotite, crystals of hornblende and flattened and elongated grains of quartz and feldspar, is closely spaced in sheared rocks. Structural analysis indicates formation of folds of different tectonic styles and orientations (Praveen et al., 2009). Thin mylonite zones are common in the gneiss. Mylonitic augen gneiss, characterized by feldspar augens (Fig. 3a), occur along the southern part of the shear zones.

Mafic dykes cross cut the gneisses and mylonites, the syenitic pluton and the younger leucogabbros (Fig. 3b and c). The dykes are widespread, vary in thickness from 30 cm to 10 m (Fig. 3d) and strike NE-SW, NW-SE, NNW-SSE and ENE-WSW. There are also small dykes less than 30 cm in thickness occurring within the major dykes as dyke-in-dyke structures (Fig. 3e).

The syenite pluton, which shows compositional variation from quartz-syenite to leucogranite, occurs as an elongate body of about 20 km length and an average width of about 4 km. The syenite is composed predominantly of sodic plagioclase, microcline, quartz and hornblende. Though it is difficult to delineate different facies within the pluton, grain size variation is prominent with coarse grained (Fig. 3f) central part and porphyritic margins.

3. Materials and methods

Detailed field studies were carried out in an area selected with the help of GIS and remote sensing techniques. The area exposes variously deformed Precambrian crystalline rocks along with younger syenite pluton and mafic dykes. Samples of all these rocks were subjected to detailed field and laboratory analyses. Anisotropy of Magnetic Susceptibility (AMS) analysis was performed to determine the magmatic fabrics of both shear zone rocks and magmatic rocks. In the present study, oriented core samples from charnockite, gabbro, gneiss, mylonite, syenite and mafic dykes were used for AMS analysis, following the oriented block method of sampling. Each block was cored and cut into specimens of 2.5 cm diameter and 2.2 cm height. A high-sensitivity Spinner version of the latest AGICO (Czech) MFK-1A Kappa bridge anisotropy meter at the Structural Geology Laboratory of the Department of Geology, University of Kerala, was used to measure the AMS.

3.1. Anisotropy of Magnetic Susceptibility (AMS)

Magnetic anisotropy is one of the most widely used tool in the determination of magmatic fabrics. Magnetic anisotropies, also called magnetic fabrics, can be determined using low-field Anisotropy of Magnetic Susceptibility (AMS). AMS is the tensor