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ScienceDirect
Precambrian Research 160 (2008) 308–322
Precambrian Research
www.elsevier.com/locate/precamres

1891–1883 Ma Southern Bastar–Cuddapah mafic igneous events, India: A newly recognized large igneous province

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Received 29 June 2007; accepted 16 August 2007

Abstract

A newly recognized remnant of a Paleoproterozoic Large Igneous Province has been identified in the southern Bastar craton and nearby Cuddapah basin from the adjacent Dharwar craton, India. High precision U–Pb dates of 1891.1 ± 0.9 Ma (baddeleyite) and 1883.0 ± 1.4 Ma (baddeleyite and zircon) for two SE-trending mafic dykes from the BD2 dyke swarm, southern Bastar craton, and 1885.4 ± 3.1 Ma (baddeleyite) for a mafic sill from the Cuddapah basin, indicate the existence of 1891–1883 Ma mafic magmatism that spans an area of at least ~90,000 km^2 in the south Indian shield.

This record of ~1.9 Ga mafic/ultramafic magmatism associated with concomitant intracontinental rifting and basin development preserved along much of the south-eastern margin of the south Indian shield is a widespread geologic phenomenon on Earth. Similar periods of intraplate mafic/ultramafic magmatism occur along the margin of the Superior craton in North America (1.88 Ga Molson large igneous province) and in southern Africa along the northern margin of the Kaapvaal craton (1.88–1.87 Ga dolerite sills intruding the Waterberg Group). Existing paleomagnetic data for the Molson and Waterberg 1.88 Ga large igneous provinces indicate that the Superior and Kalahari cratons were at similar paleolatitudes at 1.88 Ga but a paleocontinental reconstruction at this time involving these cratons is impeded by the lack of a robust geological pin such as a Limpopo-like 2.0 Ga deformation zone in the Superior Province. The widespread occurrence of 1.88 Ga intraplate and plate margin mafic magmatism and basin development in numerous Archean cratons worldwide likely reflects a period of global-scale mantle upwelling or enhanced mantle plume activity at this time.

Keywords: Bastar craton; Mafic dykes; Cuddapah sill; U–Pb baddeleyite; Geochronology

1. Introduction

Giant mafic dyke swarms are preserved in many Archean cratons worldwide and are often interpreted to represent the erosional remnants of continental large igneous provinces. They may represent feeders to continental flood basalts temporally linked to mantle plume activity and may be associated with major episodes of crustal extension that can lead to continental rifting and supercontinent break-up (Fahrig, 1987; LeCheminant and Heaman, 1989; Ernst and Buchan, 2001). Establishing the exact timing of emplacement of mafic dyke swarms is critical to unravelling crustal evolution because they represent excellent regional time markers (Fahrig, 1987; LeCheminant and Heaman, 1989; Harlan et al., 2003). Mafic dykes can also be used to constrain apparent polar wander paths (e.g. Buchan et al., 2000; Wingate and Giddings, 2000), and can provide robust piercing points that enhance the veracity of paleocontinental reconstructions (e.g. Heaman, 1997; Wingate et al., 1998; Mertanen et al., 1999; Harlan et al., 2003; Hanson et al., 2004a).

The Indian Shield is transected by numerous, cross-cutting Proterozoic mafic dyke swarms (Fig. 1; Drury, 1984; Murthy, 1987, 1995; Ramachandra et al., 1995). The southern part of the Bastar (Bhandara) craton alone is transected by a minimum of three geochemically and petrographically distinct mafic dyke swarms (Srivastava et al., 1996; Srivastava and Singh, 2003, 2004). Currently there is a general lack of robust geochronological information available for the emplacement age of any mafic dyke swarm in the Bastar craton but some are considered to be Paleoproterozoic (Srivastava et al., 2000). There is also compelling geochronological evidence for Paleoproterozoic (~1.9 Ga) extension and prolific

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0301-9268/$ – see front matter.
doi:10.1016/j.precamres.2007.08.005

mafic magmatic activity in the Cuddapah basin of the adjacent Dharwar craton (Bhaskar Rao et al., 1995; Anand et al., 2003).

The Dharwar and Bastar cratons of peninsular India are central to many proposed reconstructions of ancient Precambrian supercontinents including Ur at ~3.0 Ga (Rogers, 1996), Capricornia at ~1.7 Ga (Krapez, 1999), Columbia at ~1.5 Ga (Rogers and Santosh, 2002; Zhao et al., 2002), and possible juxtaposition of the southern block of the Indian Shield with the eastern block of the North China craton at ~2.5 Ga (Zhao et al., 2003). Obtaining precise and accurate U–Pb ages for southern Bastar and Cuddapah mafic igneous rocks is critical for establishing temporal correlation of large igneous provinces worldwide and evaluating these Paleoproterozoic continental reconstructions. In this paper, we present the results of a U–Pb zircon and baddeleyite geochronological investigation of the BD2 mafic dyke swarm from the southern Bastar craton, and the differentiated Pulivendla sill from the Cuddapah basin. These new ages for mafic/ultramafic magmatism in the southern Bastar craton and Cuddapah basin document the remnants of an extensive ~1.9 Ga large igneous province in south-central India. We consider this magmatism in the context of other reported occurrences of ~1.9 Ga intraplate mafic magmatism and discuss the possible origins of this global-scale magmatism.

2. Geological setting

The Precambrian Shield of southern India is transected by a >200 km × ~1600 km long, ENE–WSW trending mobile belt known as the Central Indian Tectonic Zone that divides the shield into two major crustal blocks (Fig. 1), both of which are transected by Proterozoic mafic dyke swarms (Drury, 1984; Murthy, 1987, 1995; Ramachandra et al., 1995; Stein et al., 2004). The northern block is known as the Aravalli protocontinent and includes the Aravalli-Delhi belt, Bundelkhand massif, and Vindhyan basin (Naqvi et al., 1974). The southern block is referred to as the Dharwar protocontinent and includes the Dharwar, Bastar and Singhbhum cratons and the South Indian Granulite Terrane (Naqvi et al., 1974; Rogers, 1986; Rao and Reddy, 2002; Zhao et al., 2003; Stein et al., 2004).

2.1. Bastar craton

The Bastar craton is a ~500 km × 500 km, four-sided crustal block that is bounded by two mobile belts, the Central Indian

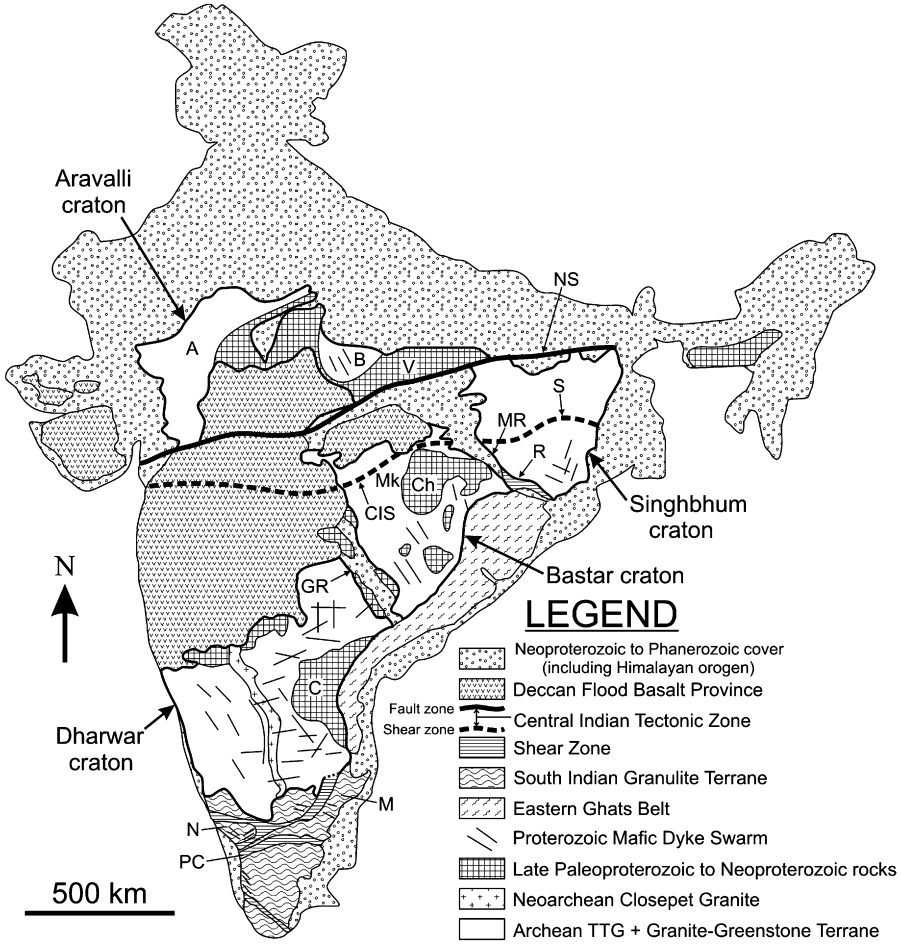

Fig. 1. Overview map of the principle geologic and tectonic elements of the Indian Shield. Geology modified from: Crowe et al. (2003), Geological Survey of India (1998), Mishra et al. (2000), Murthy (1995), Naqvi and Rogers (1987). Abbreviations: A, Aravalli-Delhi Belt; B, Bundelkhand Massif; C, Cuddapah Basin; Ch, Chattisgarth Basin; CIS, Central Indian Shear Zone; GR, Godavari Rift; M, Madras Block; Mk, Malanjkhand; MR, Mahanadi Rift; N, Nilgiri Block; NS, Narmada-Son Fault Zone; PC, Palghat-Cauvery Shear Zone; R, Rengali Province and Kerajang Shear Zone; S, Singhbhum Shear Zone; V, Vindhyan Basin.