Precambrian Research 226 (2013) 91–104

Contents lists available at SciVerse ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Central/Eastern Indian Bundelkhand and Bastar cratons in the Palaeoproterozoic supercontinental reconstructions: A palaeomagnetic perspective

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ARTICLE INFO

Article history:
Received 18 June 2012
Received in revised form
21 November 2012
Accepted 21 November 2012
Available online 29 November 2012

Keywords:
Mafic dykes
Palaeoproterozoic
Bundelkhand craton
Bastar craton
Palaeomagnetism

ABSTRACT

Mafic dykes in the central Indian Bundelkhand and eastern Indian Bastar cratons are potential sources for tracing the location of the Indian shield within Palaeoproterozoic supercontinent reconstructions. A total of 610 oriented core samples were collected from 27 mafic dykes (342 samples) in Bundelkhand craton and 20 dykes (268 samples) in Bastar craton. The characteristic magnetisations identify distinct groups of directions. The derived palaeopoles are integrated with recently reported U–Pb isotopic ages from the Bundelkhand and Bastar cratons and correlated with palaeopoles from the mafic dykes in the Dharwar craton, South India. Characteristic remanence (ChRM) identified in these dykes are classified into (i) steep upward/downward components further sub-grouped as ca. 2.37 Ga steep 1 ($\lambda = 10.2^\circ$S; $\Phi = 75.0^\circ$E; $A_{95} = 18.1^\circ$ in Bundelkhand and $\lambda = 22.3^\circ$N; $\Phi = 71.4^\circ$E; $A_{95} = 21.6^\circ$ in Bastar), component comparable with ca. 2.4–2.45 Ga steep 2 group from one dyke in Bundelkhand ($\lambda = 14^\circ$S; $\Phi = 101^\circ$E; $A_{95} = 26.1^\circ$) and one dyke in Bastar ($\lambda = 6^\circ$N; $\Phi = 113^\circ$E; $A_{95} = 26.5^\circ$). A steep component ($\lambda = 60.4^\circ$N; $\Phi = 45.3^\circ$E; $A_{95} = 9.7^\circ$ in Bundelkhand and a comparable component $\lambda = 49^\circ$N; $\Phi = 129^\circ$E; $A_{95} = 15.1^\circ$ from one dyke in Bastar) is not assigned an age at present. (ii) ca. 2.18 Ga shallow easterly and antipodal shallow westerly components ($\lambda = 0.4^\circ$S; $\Phi = 347^\circ$E; $A_{95} = 21.6^\circ$ in Bundelkhand and $\lambda = 18.0^\circ$N; $\Phi = 344.0^\circ$E; $A_{95} = 8.1^\circ$ in Bastar) and (iii) 1.99 Ga shallow northwest and antipodal shallow southeast ($\lambda = 57.5^\circ$N; $\Phi = 309.0^\circ$E; $A_{95} = 4.7^\circ$ in Bundelkhand and $\lambda = 39^\circ$N; $\Phi = 321^\circ$E; $A_{95} = 28^\circ$ in Bastar). A group (iv) of ~2.2 Ga northeast shallow components ($\lambda = 36.0^\circ$S; $\Phi = 357.0^\circ$E; $A_{95} = 9.4^\circ$) is found only in the Bundelkhand craton. The distinct groups of palaeomagnetic pole determinations from dykes of the Bundelkhand and Bastar craton exhibit a remarkable match with palaeomagnetic poles determined from Precambrian mafic dykes in the Dharwar craton. The close comparison of mafic dyke magnetisations between the cratons suggests close proximity since 2.45–2.5 Ga. Models suggesting amalgamation of crustal blocks along the Central Indian Tectonic Zone at 1.8 Ga or a 1.0 Ga collision along this zone to form Rodinia are untenable. Testing of proposed NeoArchaean-Palaeoproterozoic supercontinent reconstructions showing a north China–India linkage or India's close proximity to Slave craton to form a supercraton 'Sclavia' are not supported. Instead, the data are compatible placing India in close proximity to the Yilgarn block of Western Australia.

1. Introduction

Following Wegener's hypothesis of Pangea and advancement of the plate tectonic hypothesis for evolution of late Phanerozoic distribution of continental fragments, Piper (1982) and Anderson (1982) have visualized the existence of supercontinent as long ago as the Palaeoproterozoic. However, only in 1990s there has been a growing interest on the pre-Pangea continental configurations, but it has been mostly focused on the Neoproterozoic continental assembly described in literature as "Rodinia" (McMenamin and MacMenamin, 1990) and the Rodinia-Gondwana transition. This has generated considerable interest in palaeomagnetic studies of Precambrian rocks particularly because palaeomagnetic studies uniquely provide quantitative information on the spatial proximity of the continental blocks in contrast to geological correlations which are non-unique. Much of the palaeomagnetic record along with high precision geochronological studies has been generated for Neoproterozoic times to test the Rodinia configuration and the Meso- and Palaeoproterozoic configurations remain largely untested quantitatively. Nonetheless, studies by many Precambrian geologists have brought into light the existence of 2.3–1.8 Ga old orogenic belts and accretionary crustal growth across widely dispersed continental blocks (Rogers, 1996; Condie, 1998; Kusky et al., 2007; French and Heaman, 2010; Söderlund et al., 2010 and

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http://dx.doi.org/10.1016/j.precamres.2012.11.013

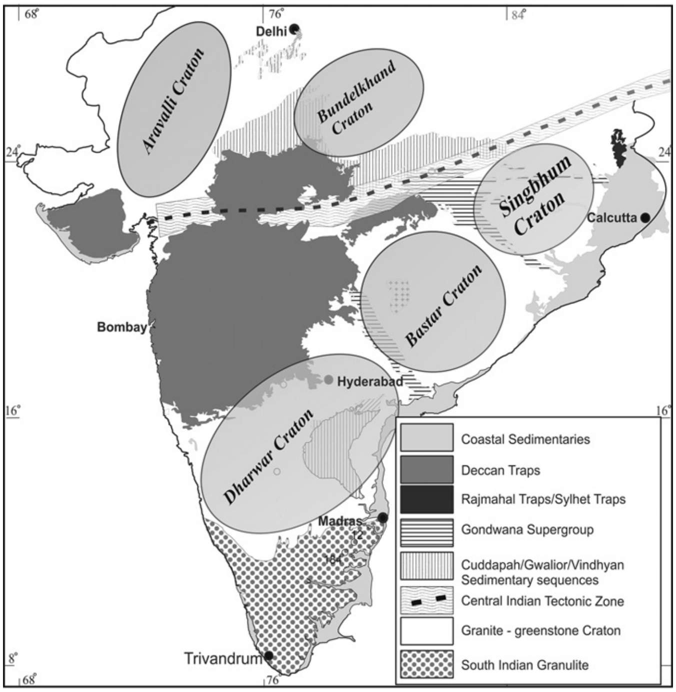

Fig. 1. Broad tectonic sketch of the Indian shield showing the distribution of Archaean cratons and other major geological features.

references therein). These studies contribute towards proposals for a Meso- and Palaeoproterozoic supercontinent configuration, although the history of this proposed supercontinent remains unclear. Recent reviews giving an account of these aspects include Bleeker (2003) and Zhao et al. (2004).

Although a Neoarchaean supercontinent named Kenorland was proposed (Williams et al., 1991), as there are no compelling evidences to support the notion, Bleeker (2003) visualized that many of the Archaean cratons represent fragments of a larger crust–mantle system – a supercraton. The supercratons are postulated to have existed across the Archaean-Proterozoic boundary from the time of amalgamation at ca. 2.6 Ga. Early Proterozoic (2.45–2.10 Ga) is marked by protracted history of diachronous break-up of these cratons, drifting of fragments independently and coalescence along the globally distributed 2.1–1.8 Ga collisional orogens forming a supercontinent that is variably described as Hudsonland, Nuna and Columbia (Condie, 2002; Meert, 2002; Rogers and Santosh, 2002; Rao and Reddy, 2002; Zhao et al., 2004; Wingate et al., 2009; Evans and Mitchell, 2011; Zhang et al., 2012 and references therein). One of the Neoarchaean supercratons proposed is "Sclavia" in which Dharwar craton in India, Zimbabwe and Wyoming are suggested as the nearest neighbours to the Slave craton (Bleeker, 2003). Dyke swarms are considered to provide robust piercing points in palaeocontinental reconstructions although they may be subsequently fragmented and partially destroyed and dispersed globally. French et al. (2008) and French and Heaman (2010) used U–Pb baddeleyite and zircon dating of mafic dykes in the Indian shield to test the juxtaposition of Dharwar and Slave cratons. Similarly, in the Columbia configuration, the Indian shield is shown adjacent to north-China based on correlation of the supposed 1.8 Ga orogens (Zhao et al., 2003). Palaeomagnetic investigations coupled with U–Pb baddeleyite/zircon dating from the Precambrian cratons have recently attained significance to provide better insight into these models.

The Indian shield comprises some of the most ancient cratonic blocks (Fig. 1) and includes the Dharwar craton in the south, the Bastar and Singhbum cratons in the east and the Bundelkhand and Aravalli cratons in the north. Collectively these make the Indian shield an obvious choice for tracing early NeoArchean-Palaeoproterozoic supercontinental history. The Dharwar craton has been central to many geological and palaeomagnetic studies, but similar interest has been lacking for the Bundelkhand and Bastar cratons. Mafic dykes of Proterozoic age occur profoundly in all Precambrian cratons and are potential targets for palaeomagnetic studies. We have carried out such studies on a large number of mafic dykes in India (Radhakrishna and Joseph, 1996a,b; Radhakrishna et al., 2003). Other major studies include studies by Hargraves and Bhalla (1983 and references therein), Venkatesh et al. (1987), Dawson and Hargraves (1994) and Halls et al. (2007). The results of our study on several dykes around the Cuddapah basin in the Dharwar craton are the subject of an accompanying paper (Radhakrishna et al., submitted for publication). This present paper presents results from mafic dykes in Bundelkhand and Bastar cratons. We also note a simultaneous study on the mafic dykes in Bundelkhand (Pradhan et al., 2012) and Bastar (Meert et al., 2011) cratons and combine these results with our study to discuss implications for the geotectonic framework of the Indian shield and supercontinent history during the Palaeoproterozoic.

2. Geological setting

Both the Bundelkhand and Bastar cratons comprise granitic gneiss complexes of Archaean age. The basement of Bundelkhand craton comprises ~3.5 Ga highly deformed gneiss-greenstone assemblages and 2.5 Ga granite plutons (Basu, 1986; Sharma and Rahman, 2000). Numerous quartz veins represent hydrothermal activity that is profusely distributed mainly in NNE–SSW and NE–SW trending tectonically controlled fractures of post cratonic times (Pati et al., 2007, 2008). The Bastar craton also comprises Neoarchaean (~3.5 Ga; U–Pb zircon geochronology of Sarkar et al., 1993; Ghosh, 2004) basement gneissic complex with supracrustal rocks, generally described as the Bengpal and Bailadila Groups and include ~2.5 Ga granitic plutonism (Crookshank, 1963; Ramakrishnan, 1990; Ramchandra et al., 1995; Ramakrishnan and Vaidyanadhan, 2008). The northern boundary of Bastar craton is represented by the Central Indian Tectonic Zone (CITZ; Fig. 1) which is regarded as a major tectonic divide between the northern (Bundelkhand and Aravalli) cratons and southern (Bastar, Singbhum and Dharwar) cratons in the Indian shield (Acharyya, 2003; Zhao et al., 2004). Proterozoic intracontinental sedimentary basins were developed over the basement region of Bundelkhand and Bastar cratons. Mafic dykes constitute major Proterozoic mafic igneous activity in both the cratons and are not seen to cut across the sedimentary basins (Figs. 2 and 3).

The entire Bundelkhand craton is traversed by mafic dykes crossing all Archaean lithologies. The dykes are traced in strike extensions from a few metres up to 20 km and predominantly in a NW–SE direction; ENE–WSW and NE–SW trending dykes also occur but in much smaller numbers. A prominent ENE–WSW dyke is over 50 km long and >20 m wide and passes through the village Mohaba (Fig. 2). The dykes are not metamorphosed or structurally foliated and can be classified as medium to coarse grained dolerites; larger dykes are gabbroic in nature in the central region and fine-grained chilled margins are observed where contact zones are exposed. Typically, dyke samples show ophitic to subophitic textures with occurrence of plagioclase and clinopyroxene phenocrysts/microphenocrysts and are subalkaline tholeiites in composition. Deuteric alteration is common and hydrothermal alteration to chlorite/actinolite is also present. Opaque oxides occur as dispersed grains or skeletal shapes.

Three generations of dykes are proposed based on field dispositions (Basu, 1986) and NW–SE dykes are cut by ENE–WSW and