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GR letter

Preliminary report on the paleomagnetism of 1.88 Ga dykes from the Bastar and Dharwar cratons, Peninsular India

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ABSTRACT

We report the results of a preliminary paleomagnetic study on well-dated 1.9 Ga dykes from the Bastar craton, India. This suite of NW–SE trending dykes was linked to similarly-aged magmatic activity in the Dharwar craton and Cuddapah basin in India as part of a large igneous province. This igneous activity may have extended across many cratons in the "Columbia" supercontinent including the North China craton, Laurentia, Baltica, Australia, Siberia and the Kaapvaal and Zimbabwe cratons (southern Africa). The Bastar dykes along with the Cuddapah traps and dyke yield a dual-polarity magnetization with D = 126°, I = +15.2° (k = 27, α_{95} = 11.9°) and a corresponding paleomagnetic pole at 31° N, 330° E (dp = 6.3°, dm = 12.2°). The relatively robust paleomagnetic and geochronologic database at 1.85–1.90 Ga allow us to test one of the configurations of the supercontinent "Columbia". There are some critical differences between our paleomagnetically-based reconstruction and the archetypal and geologically-based "Columbia" configuration of Zhao et al. (2004). Most notably, Siberia, India and Australia cannot be linked to Laurentia in the archetypal Columbia fit. Proposed links between western Australia and the Kaapvaal and Zimbabwe cratons are possible as is the fit between Baltica and Laurentia. The robust paleomagnetic data reported in this paper require that either the Columbia supercontinent did not exist at 1.9 Ga or requires major modification. Given that our data provide only a snapshot on the Paleoproterozoic, we conclude that the Columbia supercontinent remains a viable possibility although relationships between individual elements should be re-evaluated as more data become available.

1. Introduction

Dykes are useful igneous bodies for deciphering the geological evolution of cratonic blocks, extensional tectonics, mantle chemistry and magma transport history. In addition, dykes are ideal recorders of the Earth's magnetic field due to their quick cooling history and the ability to obtain precise U–Pb emplacement ages. Numerous dyke swarms intrude all the major cratonic blocks within Peninsular India (Fig. 1a). Although there are numerous paleomagnetic studies on many of the Indian dykes, it is only recently that the dykes received detailed attention in terms of establishing a strong geochronologic framework for their emplacement in conjunction with paleomagnetic studies (for examples see Pradhan et al., 2008, 2010; Halls et al., 2007; French et al., 2008; French and Heaman, 2010; Lubnina et al., 2010a,b; Piispa et al., in press; Pradhan et al., in review).

Peninsular India (the Indian Shield) can be subdivided into five major cratonic nuclei, namely the Aravalli in the northwest, the Bundelkhand in the north, the Dharwar in the south, the Singhbhum in the east and the Bastar in southeast (Fig. 1a; Meert et al., 2010). The Bastar craton, where part of our study was carried out, is one of the least studied due to inadequate infrastructure, insurgency and security concerns in the area. We have carried out a preliminary paleomagnetic study in the region and hoped to return for more detailed sampling; however due to the hostilities in the region additional sampling cannot take place in the foreseeable future. Therefore, we present our preliminary results in this paper because we feel that, although limited, they provide useful information on the paleogeographic position of India at ~1.9 Ga.

2. Geological setting

The Bastar craton is an almost a square (500 km^2) crustal block in SE India, bounded to the north by the Central Indian Tectonic Zone (CITZ) and to the south by the Eastern Ghats Mobile Belt. The eastern and western boundaries are defined by two Phanerozoic rift systems, the Mahanadi Rift to the east and Godavari Rift to the west (Fig. 1a). The oldest rock units in the Bastar craton are undifferentiated tonalite–trondjhemite gneisses, exposed in the southern and western parts and popularly known as the Gneissic Complex (Ghosh, 1941; Crookshank, 1963 and see also Ramakrishnan and Vaidyanadhan, 2008). The 3509 + 14/−7 (Sarkar et al., 1993) and 3561 ± 11 Ma (Ghosh, 2004) U–Pb zircon ages attest to the early Archaean status of

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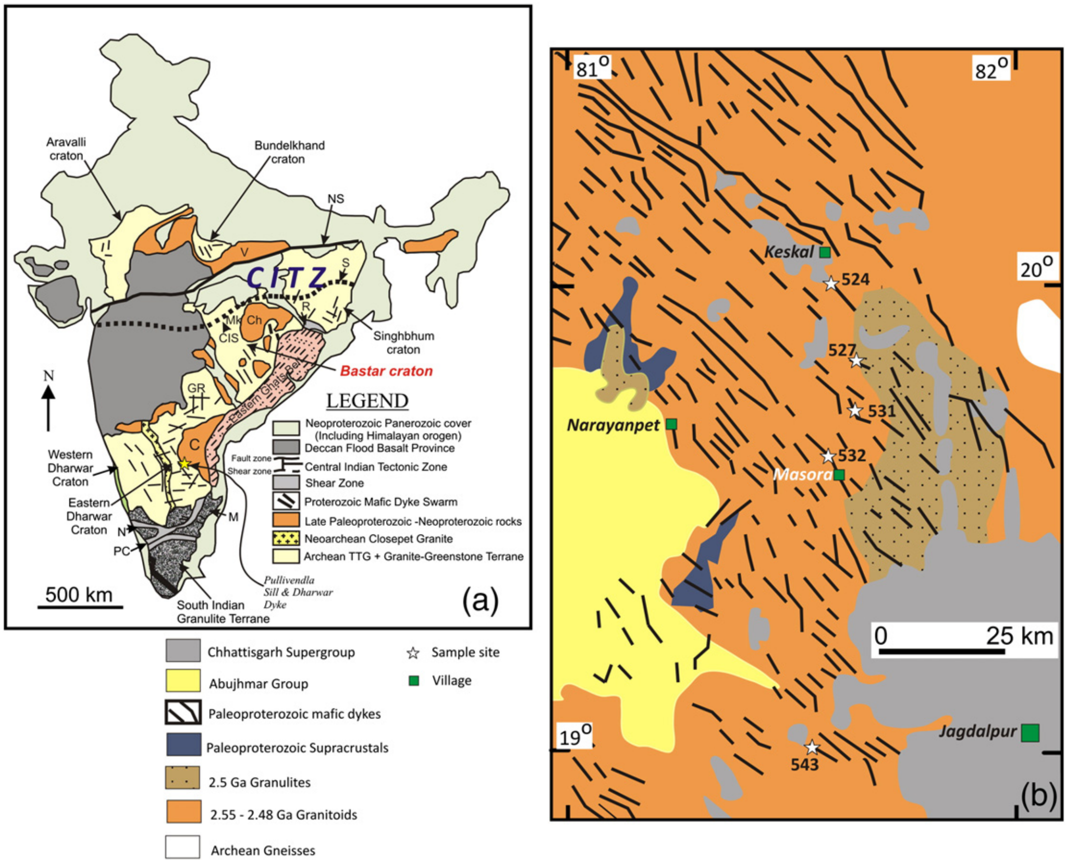

Fig. 1. (a) Generalized geologic map of Peninsular India showing the major cratons and various dyke swarms intruding those cratons. The Bastar craton (focus of this study) is located in east-central region (adapted from French et al., 2008). The Pullivendla sill, Cuddapah traps and Dharwar dyke are represented by the yellow star (b) field area for the present study of Bastar dykes near Keskal. Paleomagnetically sampled dykes are indicated by white stars. The reversely magnetized dyke at Site 543 was dated by French et al. (2008) to 1883.5 ± 4.4 Ma.

the basement gneisses. This high-grade gneissic terrane forms the basement for supracrustals represented by phyllite, schist, quartzite and meta-carbonate interbedded with meta-basalts. Stratigraphic relationships of these supracrustal sequences remain debated on account of two contrasting views. Crookshank (1963) subdivided into an older Sukma Series and younger Bengpal Series, which was in contradiction to the proposal of Ghosh (1941) who considered all the supracrustal rocks as simple facies variants and grouped them under Bengpal Series. Ramakrishnan (1990) reported an angular unconformity between Sukma and Bengpal rocks and observed differences in the grade of metamorphism to call them as two separate stratigraphic entities. However, most studies, including the present one, have followed the classification scheme of Ghosh (1941). The basement gneisses and 'older' supracrustals are intruded by a number of Proterozoic granitoids (Malanjkhand Granite, Kanker Granite, and Dongargarh Granite) that are conspicuous in the southern part of the craton and dated to 2480 ± 3 Ma (zircon U–Pb) by Sarkar et al. (1993). This end Archaean/earliest Paleoproterozoic granitic magmatism is thought to mark a significant accretionary event in the region and overlaps with the widespread end-Archaean granite plutonism recorded in other cratonic blocks in the Indian shield, such as 2.56–2.44 Ma Berach Granite in the Aravalli craton (Wiedenbeck et al., 1996) and 2.51 Ga Closepet Granite in Dharwar craton (Jayananda et al., 2000). Meert et al. (2010) considered that the terminal Archaean marked a major stabilization phase in Peninsular India that could have resulted from either reworking of the older crust or collisional tectonism.

The overlying metasedimentary sequence comprising slate, phyllite, schist and banded iron formations (BIF) is named as the Bailadila Group. The Bailadila Group represents an Early Proterozoic sedimentary ensemble. Mafic dykes represent the youngest magmatic event in the region as they cross-cut all the older rock units. The dykes are concentrated in the southern sector of the Bastar craton and show a dominant NW–SE trend (Fig. 1b). In addition to the mafic dykes, mafic volcanics were reported in previous studies (Ramakrishnan, 1990; Srivastava et al., 1996; Hussain et al., 2008). Several Proterozoic-age intracratonic basins were developed over the granite–gneiss terrane in the Bastar craton including the extensive Chhattisgarh basin in the north and Indravati basin in the south (Fig. 1a and b). Sedimentation in the Chhattisgarh and other "Purana" basins closed near the end of the Mesoproterozoic (Patranabis-Deb et al., 2007; Basu et al., 2008; Malone et al., 2008). The generalized stratigraphy of the Bastar craton is summarized in Table 1 (compiled from French et al., 2008; Ramchandra et al., 1995; Ramakrishnan and Vaidyanadhan, 2008).

Table 1
Generalized stratigraphy of the Bastar craton.

Unclassified mafic dykes	
Younger dolerite dykes (~1.88 Ga)	
Mafic volcanics	Abujhmar Group
Conglomerate, sandstone, shale	
Older meta-basic dykes (~2.1 Ga)	
BIF	Bailadila Group
Slate, phyllite, schist	
~2.5 Ga granites	
Schist, gneisses, conglomerate, quartzite	Bengpal Group
TTG gneisses, undifferentiated crystalline basement (>3000 Ma)	