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EPMA monazite geochronology of the basement and supracrustal rocks within the Pur-Banera basin, Rajasthan: Evidence of Columbia breakup in Northwestern India

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ABSTRACT

We deduce the timing of the rift-induced collisional event between two orogenies in the central Aravalli–Delhi Fold Belt using monazite chemical dating and metamorphic *P–T* estimates from metapelites of the Mangalwar Complex (MC), and the overlying Pur-Banera (PB) supracrustals. The MC rocks preserve evidence of three regional metamorphic events, while the PB rocks record the last event. The M_1 metamorphism attained its peak *P–T* at ~5.5 kbar and 520–550 °C in the MC rocks at ~1.82 Ga, followed by the M_2 event with peak *P–T* of ~7.5 kbar and 580–660 °C at ~1.35 Ga. The youngest high-pressure M_3 metamorphism attained a peak *P–T* of ~8.0 kbar and 590–640 °C at ~0.99 Ga. Thermobarometry coupled with ages of included monazites in chemically zoned garnet from the MC metapelites indicate preservation of ages spanning between ~1.82 Ga and ~0.99 Ga from different zones (i.e., core to rim), implying episodic garnet growth during supercontinent cycle. The PB metapelites constitute two prominent ages of ~1.37 Ga and ~1.05 Ga. The youngest high-pressure metamorphism (M_3) in the PB rocks with maximum *P–T* of ~8.0 kbar, and 580–670 °C during the Neoproterozoic has overprinted their earlier metamorphic records. Based on monazite geochronology, we assign the ~1.82 Ga and ~1.37–1.35 Ga ages to the amalgamation and breakup of the Columbia supercontinent respectively. The youngest age record of ~1.05–0.99 Ga indicates evidence of Rodinia formation in and around the Pur-Banera basin.

1. Introduction

The Indian Shield is divided into two proto-continental blocks, namely the Southern Indian Block (SIB, the Dharwar–Bastar–Singhbhum craton) and the Northern Indian Block (NIB, the Aravalli–Bundelkhand craton) (Fig. 1a). These blocks evolved into one single landmass during the ~1.9–1.6 Ga Columbia amalgamation event along the E–W trending >700 km long trans-crustal suture of Central Indian Tectonic zone (CITZ) (Acharyya, 2003; Roy and Prasad, 2003; Mohanty, 2010; Naganjaneyulu and Santosh, 2010). This was followed by opening of smaller ensialic basins within the blocks and their subsequent closure during the ~1.1–0.9 Ga Grenvillian orogeny, which eventually formed the amalgamated crust of Rodinia (Chatterjee and Ghose, 2011; Bhowmik et al., 2012; Dasgupta et al., 2013), forming the Greater Indian landmass. However, Bhowmik et al. (2010, 2012) suggested that the pre-1.0 Ga Indian landmass consisted of at least three micro-continental blocks, namely the NIB, the SIB and the Marwar Block (MB), which amalgamated together along Aravalli–Delhi Fold Belt (ADFB) and CITZ at ~1.0 Ga (Fig. 1a). These studies demonstrate the involvement of various micro/proto-continents at two different periods to form the Columbia and Rodinia supercontinents. The ~700 km long, NNE–SSW trending ADFB is the largest tectonic segment in NW India, surrounded by the Bundelkhand Craton and the CITZ in the eastern and the southern parts, respectively (Fig. 1a). The ADFB in the central part host the polymetamorphic terrain of Banded Gneissic Complex (BGC; Gupta, 1934; Heron, 1953; Fig. 1b), which preserves records of a protracted history of crustal evolution for a period of >2.0 Ga spanning from ~3.3 Ga to ~1.0 Ga (Wiedenbeck and Goswami, 1994; Roy and Kröner, 1996; Wiedenbeck et al., 1996a,b; Buick et al., 2006, 2010; Bhowmik et al., 2010). The BGC is further divided into two tectonic domains, on the basis of contrasting geochronology, wherein the southern part (BGC-I of Gupta, 1934) exclusively preserves the Archean ages (Fig. 1b). On the contrary, the northern

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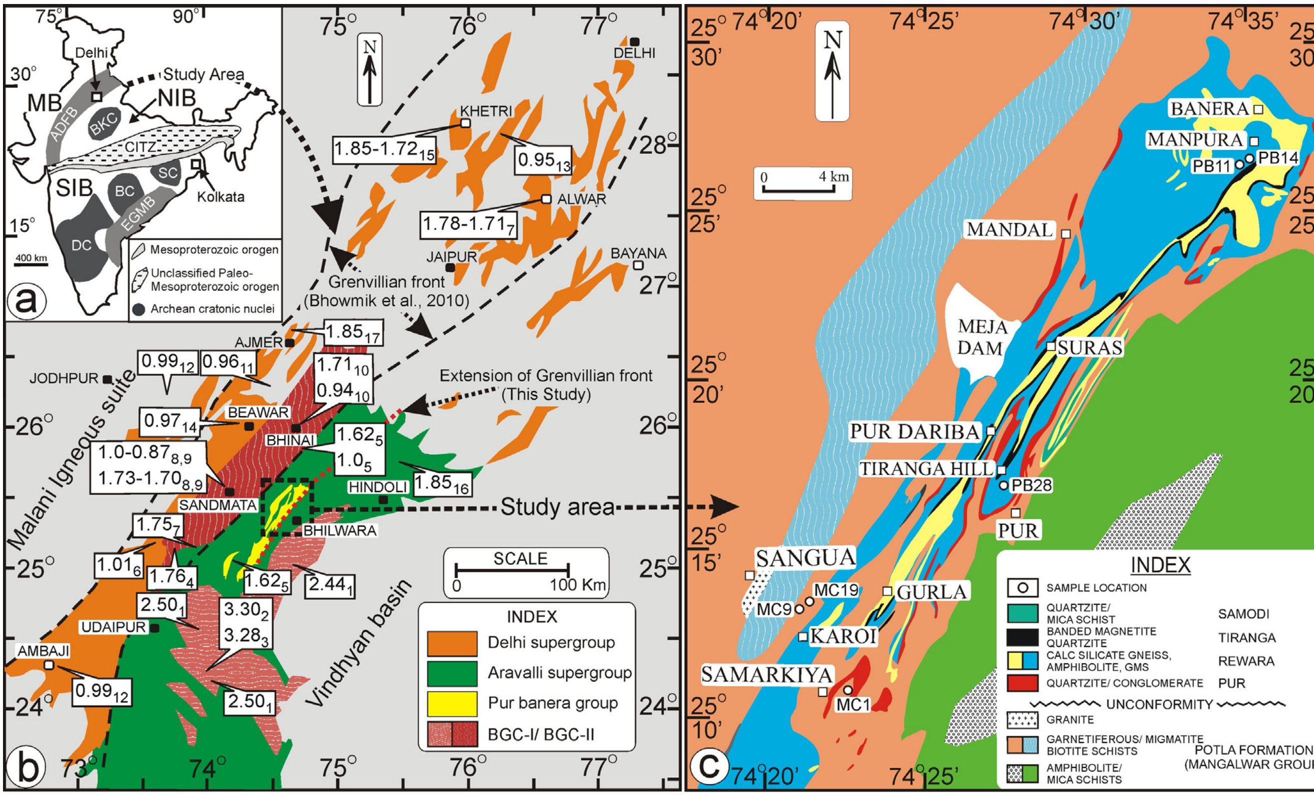

Fig. 1. Tectonic framework of the Aravalli–Delhi Fold Belt (ADFB) in the Peninsular India (modified after Naganjaneyulu and Santosh, 2010 and Bhowmik et al., 2012 (a). The South, the North Indian Block (SIB and NIB) and the Marwar Block (MB) altogether forms the Greater landmass of India. The major cratonic blocks of Dharwar (DC), Bastar (BC), Singhbhum (SC), Central Indian Tectonic Zone (CITZ), and Bundelkhand (BKC) are also shown. Regional geological map of the ADFB, showing the distribution of different lithological components (modified after Heron, 1953; Gupta et al., 1997; Bhowmik et al., 2010) (b). Chronology of the major geological events are after (1) Wiedenbeck et al. (1996a); (2) Gopalan et al. (1990); (3) Wiedenbeck and Goswami (1994); (4) Wiedenbeck et al. (1996b); (5) Hazarika et al. (2013); (6) Volpe and Macdaugall (1990); (7) Biju-Sekhar et al. (2003); (8) Bhowmik et al. (2010); (9) Sarkar et al. (1989); (10) Buick et al. (2006, 2010); (11) Tobisch et al. (1994); (12) Deb et al. (2001); (13) Pant et al. (2008); (14) Pandit et al. (2003); (15) Kaur et al. (2009, 2011a, 2013); (16) Deb et al. (2002); (17) Mukhopadhyay et al. (2000). The black dashed line represents the proposed Grenvillian front by Bhowmik et al. (2010), which is extended towards further east (present study) as shown by the red dotted line (see text for details). All the ages shown (in Ga) are lithology specific rather than their location. Geological map of the BGC-II in central Rajasthan (modified from Gupta et al., 1997), showing the Pur-Banera basin and the surrounding Mangalwar Complex (c). The open circles represent sample locations in the present study. GMS stands for garnetiferous mica schist.

counterpart (BGC-II of Gupta, 1934) dominantly has Paleo- to Neoproterozoic ages (Fig. 1b), while Archean components were also reported (Dharma Rao et al., 2011b; Roy et al., 2012). Thus, the available database created diverse opinions regarding the geochronological status of the BGC-II. For more details see Bhowmik and Dasgupta (2012).

The present study area is a part of the BGC-II, which includes the Mangalwar Complex (MC) and the overlain supracrustal metasediments of the Pur-Banera (PB) Group that evolved as a pull-apart basin (Sinha-Roy, 1989; Sinha-Roy et al., 1998). Recent studies from the western most part of the MC suggest that the rocks were polymetamorphosed to an early amphibolite facies at ~1.82 Ga; followed by a high pressure amphibolite facies event at ~0.95 Ga (Buick et al., 2006, 2010; Bhowmik et al., 2010), implying polyorogenic nature of the ADFB. The earlier age (~1.82 Ga) in the ADFB, represents the onset of Aravalli orogeny (Kaur et al., 2009; Meert et al., 2010), followed by regrouping of disrupted crustal blocks at ~1.0 Ga (Kaur et al., 2011a; Bhowmik and Dasgupta, 2012). This indicates the participation of various micro-blocks at two different periods clubbing together to form the ADFB, which is further linked with the amalgamation of Columbia and Rodinia Supercontinents (Kaur et al., 2009, 2011a, 2013; Bhowmik et al., 2010). Although, the region preserves important records of Proterozoic continental tectonics, in such polymetamorphic terrains it is not always possible to decipher all the earlier tectono-metamorphic events, because later overprinting consequentially erase obscured structural information (e.g., Holdsworth et al., 2001; Dutch et al., 2005). In addition, the current data base does not show any existing geochronological record from the BGC-II between the period 1.7 Ga and 1.0 Ga. Thus, there are fundamental questions regarding the timing of tectonic events, which create hindrance in complete understanding of the ADFB geodynamics. In this context, the study of zoned minerals can be more informative for interpreting various earlier events. Garnet is one of the best known mineral that preserves evidence of multiple metamorphic events in polymetamorphic terrains (Baxter and Scherer, 2013; and reference therein). A single garnet grain can record distinct geological events including the *P–T* path of its evolution (Spear and Pyle, 2002; Likhanov et al., 2013). Further, dating different chronometers (e.g., zircon and monazite) included within the growth zones of garnet can provide age constraints pertaining to discrete garnet growth events (e.g., Hermann and Rubatto, 2003; Foster et al., 2004; Cutts et al., 2010).

The present study places new constraints on the timing of various metamorphic events by EPMA dating of monazite aided by metamorphic *P–T* estimates. Further, discrete monazite ages from garnet growth zones together with the deduced *P–T* values suggest intermittent garnet growth spanning a period of ~0.84 Ga. Since, the ~1.82 Ga and ~0.99 Ga metamorphic events of the MC rocks are well constrained by previous studies (Bhowmik et al., 2010; Buick et al., 2010), we attempt rigorous phase petrology for the