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Proterozoic evolution of Eastern Dharwar and Bastar cratons, India – An overview of the intracratonic basins, craton margins and mobile belts

Dilip Saha *, Sarbani Patranabis-Deb

Geological Studies Unit, Indian Statistical Institute, Kolkata 700108, India

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ABSTRACT

Based on critical analysis of stratigraphic succesions in the Proterozoic intracratonic basins, geochronological data and possible connections or disconnections with adjacent fold belts and craton margin mobile belts, an overview of the Proterozoic evolution of the Eastern Dharwar and Bastar cratons in India is presented. The Chattisgarh and Cuddapah basins in these cratons with Archean nuclei host sedimentary successions ranging in age from the Paleoproterozoic to the Ediacaran period, and representing several silicilastic and carbonate cycles. The Proterozoic successions of the Pranhita–Godavari valley (PGV) basin along the Dharwar–Bastar join, record multiple rifting since late Neoarchean suturing of the two cratons. We postulate a first order stratigraphic correlation across the cratons and their join and discuss how major sea level fluctuations coupled with regional tectonic events shaped the development of unconformity bound successions, adjoining fold belts and the mobile belts with supposed global tectonic connections. The oldest Paleoproterozoic intracratonic sedimentation is preserved in the Cuddapah and PGV basins, while sedimentation in the Bastar craton is largely Mesoproterozoic. The fluviodeltaic to shallow marine Neoproterozoic sedimentation followed emplacement of end-Mesoproterozoic kimberlites and lamproites indicating thermal rejuvenation of the Indian continental crust. The allochthonus Nallamalai fold belt in eastern Cuddapah basin and the early Mesoproterozoic fold belt in PGV basin point to craton margin crustal convergences which punctuated the Paleoproterozoic sedimentation. Widespread development of carbonate bearing sequences in the Mesoproterozoic to Neoproterozoic successions point to peneplanation of the cratons and stable platformal sedimentation. The Neoproterozoic sedimentation was terminated following the docking of the Eastern Ghats belt to the eastern margin of the Dharwar–Bastar ensemble and possible final tectonic hiccups in the Central Indian Tectonic zone bordering the Bastar craton. The available data and their analysis rule out any foreland basin type connection between the Eastern Ghats belt and cratonic sedimentation in Bastar and Eastern Dharwar.

1. Introduction

Built over the four large amalgamated Archean nuclei (Dharwar, Bastar (Bhandara), Singhbhum, Aravalli–Bundelkhand), the Indian shield is a vast repository of the Proterozoic geological record. The Proterozoic sedimentary basins and supracrustal sequences in India are comparable in scale, and perhaps also in development, to those of Africa, Australia, Brazil and North America (Hoffman, 1989; Eriksson et al., 1999; Teixeira and Cordani, 2008, pub. 2010; Saha and Mazumder, 2012). The Bastar and Dharwar cratons constitute two of the four major cratons in the Precambrian shield of India (e.g. Radhakrishna and Naqvi, 1986; Ramakrishna and Vaidyanadhan, 2008; Meert et al., 2010; Saha and Mazumder, 2012). Both the cratons are associated with major accretion of granitic material at around 2500 Ma as exemplified by the Closepet granite, Dongargarh granite and Malanjkhand granite, heralding the major cratonization event in southern cratonic province of India (Jayananda et al., 2013). The two cratons are also circumscribed by supposedly Middle Proterozoic mobile belts, namely the Eastern Ghats belt (EGB) and the Central Indian tectonic zone (CITZ), which hold key to the Proterozoic tectonic development of the Indian shield. The EGB lying to the east of these cratons show multiple deformation and granulite metamorphism recorded during the Proterozoic. In models of supercontinent reconstruction, the EGB is often shown to have links with East Antarctica (Yoshida et al., 2003; Rogers and Santosh, 2004; Dasgupta and Sengupta, 2003) and crustal accretion along the southeastern margin of India is thought to be associated with Columbia/Rodinia/Gondwana amalgamation. On the other hand, the CITZ along the northern

* Corresponding author. Tel.: +91 3325753159.
E-mail address: sahad.geol@gmail.com (D. Saha).

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border of the Bastar craton has been shown to contain possible sites of Proterozoic ocean closure (e.g. Roy et al., 2001; Acharya, 2003). More recently, CITZ is considered as a possible link in alternative models of end-Proterozoic supercontinent reconstruction involving India and Australia (e.g. Bhowmik et al., 2012; Mohanty, 2012).

South of the CITZ, the intracratonic basins in the Bastar (Bhandara) craton are Chattisgarh, Khariar, Indravati, Ampani and Sukma (Sabari) basins (e.g. Chaudhuri et al., 2002; Ramakrishna and Vaidyanadhan, 2008; Chakraborty et al., 2010). The Cuddapah basin is the largest intracratonic basin in the Eastern Dharwar craton while the smaller Bhima and Kaladgi basins occur at the northern margin of the Western Dharwar craton (Nagaraja Rao et al., 1987; Kale, 1991; Saha and Mazumder, 2012; Saha and Tripathy, 2012a; Patranabis-Deb et al., 2012). The NNW–SSE trending Pranhita–Godavari valley (PGV) basin follows the join between the Bastar (Bhandara) craton and the Eastern Dharwar craton (e.g. Chaudhuri and Chanda, 1991; Saha, 1992b; Saha and Chaudhuri, 2003). The flat lying, generally undeformed Proterozoic sedimenatry successions in all these basins share the common aspects of lying above a basal unconformity over Archean granite–gneiss (granitoid) basement, predominantly quartzite–shale–carbonate successions, absence of any body fossils but common occurrence of stromatolitic carbonates with algal or other micro-fossil remains comparable to those in the Russian Rephean sequences (Ramakrishna and Vaidyanadhan, 2008). These inverted basins, traditionally referred to as Purana basins with age similar to the Algonkian (Holland, 1909), are intra-continental in nature and host unconformity bound sequences, some of which are involved in craton margin deformation, thus posing the question of relation between the bordering exhumed orogens and basin development. Of these, the PGV basin records both extensional and contractional reactivation (Saha, 1992b; Ghosh and Saha, 2003, 2005).

The sedimentation in the Cuddapah basin in the Eastern Dharwar craton began prior to 1900 Ma (e.g. Bhaskar Rao et al., 1995) and possibly continued in the Neoproterozoic with two major hiatuses. A major fold belt, the Nallamalai fold belt (NFB), is tectonically juxtaposed against the eastern margin of the generally undeformed outcrops of the western Cuddapah subbasins. Sandwiched between the NFB and the EGB lies the Nellore schist belt (NSB). Although traditionally NSB is considered to be an extension of the Archean greenstone belt of Dharwar (e.g. Ramam and Murty, 1997), some workers consider the NSB as part of the Krishna province of EGB hinting at later accretion to the craton margin (Dobmeier and Raith, 2003). More recent works suggest that dismembered Paleoproterozoic to Mesoproterozoic ophiolites and/or ophiolitic melange occur in the NSB, which provide additional clues to the Proterozoic crustal accretion processes at the margin of the Eastern Dharwar craton (Saha, 2004, 2011; Vijaya Kumar et al., 2010; Dharma Rao et al., 2011).

Prominent in the Bastar craton is the Chattisgarh basin where earliest sedimentation started around 1500 Ma (Bickford et al., 2011a,b; Das et al., 2009). South of the main Chattisgarh outcrop a number of smaller basins, namely Khariar, Abhujhmar, Ampani, Indravati and Sukma (Fig. 1) occur which are lithologically similar to the Chattisgarh rocks. They are often considered as the isolated parts of greater Chattisgarh basin which was fragmented and separated by post lithification faulting or doming up of the basement and erosion of structural highs (Ahmad, 1958; Ramakrishnan, 1987). We review the stratigraphy in the Chattisgarh and its sister-basins, PGV and Cuddapah basins and attempt a stratigraphic correlation across the Godavari join taking into account the more recently published geochronological data.

We also provide a critical summary of the geological development of the fold belts adjoining the above major basins, their relationship with the so called exhumed orogens, vestiges of which possibly occur in the CITZ and EGB, and the reported ophiolite belts along the eastern margin of the Eastern Dharwar craton. A few pertinent issues in this overview and analysis are: Did the EGB orogen result in any flexural loading on the craton? If so, where is the foreland/foredeep sedimentation, as we see in the case of modern collisional orogens: say the coupling of the Himalaya and the Ganga basin? How far did the convergence along plate margin affect the craton interior sedimentation and inversion of the basins? Supercontinent break-up and/or assembly exert influence on the global relative sea-level. How is it reflected in the development of Proterozoic epi-continental sea and associated intracratonic basins in India?

2. Geological overview

2.1. Bastar (Bhandara) craton

The Bastar craton (also known as the Bastar–Bhandara craton) is flanked by two Upper Paleozoic–Mesozoic rifts, namely the Mahanadi graben in the northeast and the Pranhita–Godavari rift in the southwest (Fig. 1). The Satpura mobile (orogenic) belt partly overlapping with the CITZ marks the northern part of the Bastar craton. The Eastern Ghats belt was finally accreted to the southeastern margin of the craton in the late Neoproterozoic–early Paleozoic (e.g. Biswal et al., 2007; Vijaya Kumar and Leelanandam, 2008). A synopsis of the stratigraphic and tectonic development, including deformation and magmatism, of the craton has been given by Saha and Mazumder (2012). The main basement consists of 2600–2500 Ma old TTG gneisses and greenstone belts like the Sonakhan belt. Still older crustal remnants are interpreted from 3650–3500 Ma old tonalitic and gneissic enclaves (Sarkar et al., 1993; Ghosh, 2004).

The Meso- to Neoarchean Bailadila Group host the major BIF bearing succession of the Bastar craton. The end-Archean cratonization event is marked by the emplacement of a number of granitic bodies, notably the Dongargarh granite and Malanjkhand granite (Stein et al., 2004). The Paleoproterozoic supracrustal belts overlying the TTG gneisses and granitoid basement have undergone multiple deformation and metamorphism, some attaining UHT granulite facies (Bhowmik et al., 2005). Of these supracrustal successions, the Dongargarh Supergroup unconformably overlying the basement has been divided into volcanosedimentary successions of the Nandgaon and Khairagarh groups. The latter includes the Bijli rhyolite representing a major volcanic event at around 2180 Ma (Sarkar et al., 1981; Sensarma, 2009; Chalapathi Rao and Srivastava, 2009). The western limit of the Eastern Ghats mobile belt overlying the Bastar craton is demarcated by a shear zone, referred to as a terrain boundary shear zone (Bandyopadhyay et al., 1995; Biswal et al., 2003).

2.1.1. Chattisgarh basin

With an outcrop area over 36000 sq. km the Chattisgarh basin has 2300 m thick preserved succession of clastic and carbonate cycles (Fig. 2, Table 1). The Chattisgarh basin evolved as a N–S trending cratonic rift within the Bastar craton (Das et al., 1992; Patranabis-Deb and Chaudhuri, 2002, 2008b). The Central Indian Tectonic zone (CITZ) marks the northern boundary of the basin. The sedimentary succession unconformably overlies the Archean crystalline basement, the Neoarchean Sonakhan granite–greenstone belt and the Neoarchean to Paleoproterozoic Dongargarh Kotri volcanics (Fig. 1). Murti (1987) subdivided the Chattisgarh succession into the coarse siliciclastic dominated Chandarpur Group and the limestone-shale dominated Raipur Group, separated by a major unconformity. Das et al. (1992) envisaged two sub-basins, the Baradwar sub-basin in the eastern part and Hirri