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Provenance of sediments in the Marwar Supergroup, Rajasthan, India: Implications for basin evolution and Neoproterozoic global events

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ABSTRACT

The Marwar Supergroup of NW India is one of the largest Neoproterozoic sedimentary successions of India. Deposited in an intracratonic sag basin, the Supergroup contains largely unmetamorphosed and undeformed fluvial and marginal marine siliciclastics, marine carbonates, and minor volcaniclastics which hold clues to the geotectonic evolution of India subsequent to the disintegration of the Rodinia and during the formation of the Gondwanaland. Here, we present age constraints for the initiation of sedimentation and evolution of the basin. The Rb-Sr whole rock isochron of a felsic tuff from the lower part of the Supergroup, yields an age of 703 ± 40 Ma, which suggests that the sedimentation in the Marwar basin started in the Cryogenian period. The result of Sr isotope stratigraphy suggests a depositional age of ~570 Ma (Late Ediacaran) for the carbonate sequences in the middle part of the Supergroup, indicating a depositional hiatus of ~100 Ma between the lower and middle Marwars. We speculate that this relapse in the sedimentation could be related to the widespread Pan-African event (Malagasy Orogeny). Provenance analysis using Neodymium (Nd) isotopes and trace elements shows that sediments in the lower Marwars were contributed by the Delhi Supergroup (~1.6 Ga), Banded Gneissic Complex-2 (> 1.8 Ga) and possibly the Erinpura Granites (~850 Ma), whereas the siliciclastics deposited in the middle and upper Marwars were predominantly sourced from the Delhi Supergroup. Interestingly, the contribution from the Malani Igneous Suite (MIS) to the sedimentation is limited only to the basal formation near the basin margin.

1. Introduction

The Neoproterozoic Era (1000–541 Ma) had witnessed dynamic changes in climate (Hoffman et al., 1998; Och and Shields-Zhou, 2012), life (Canfield et al., 2007; McFadden et al., 2008), and tectonics in terms of continental configurations (Collins and Pisarevsky, 2005; Meert, 2003). The supercontinent Rodinia broke apart and the stage was set for the amalgamation of Gondwanaland (Li et al., 2008). Deposition of the Marwar Supergroup of Rajasthan, western India took place during this Era. Sedimentation in the basin possibly started subsequent to the break-up of Rodinia (Roy and Jakhar, 2002) and believed to have continued through the period that saw the formation of Gondwanaland (McKenzie et al., 2011), thus making it contemporaneous with the Huqf Supergroup of Oman, Salt Range of Pakistan, Krol-Tal Groups of the Himalaya and Molo Group of Madagascar (Cozzi et al., 2012; Davis et al., 2014; Turner et al., 2014). Paleomagnetic studies within the Marwar Supergroup suggests an equatorial paleogeographic position for the Indian shield during basin development alongside the Arabian-Nubian shield, Eastern Antarctica and Australia in the Ediacaran-early Cambrian Period (Davis et al., 2014). However, an intermediate northerly latitude is also proposed for the basement of the basin; the ~750 Ma old Malani Igneous Suite (MIS), which suggests that the Indian shield along with Laurentia, Baltica, South China and Seychelles formed the western margin of the Rodinia (Gregory et al., 2009; Meert et al., 2013; Torsvik et al., 2001). Furthermore, there have been growing support for the view, from various microbially induced sedimentary structures (MISS) (Kumar and Ahmad, 2014; Sarkar et al., 2008) and Edicaran type fossils (Kumar et al., 2009) within the lower part of the Marwar Supergroup, that the sedimentation in the basin started well before the Ediacaran Period. Deposited in a shallow intracratonic sag basin, the Marwar Supergroup consists of largely unmetamorphosed and undeformed fluvial and marginal marine siliciclastics, marine carbonates and minor volcaniclastics (Paliwal, 1998; Pareek, 1981; Roy and Jakhar, 2002).

Because of its temporal occurrence and likely spatial configuration, the basin and its sedimentary record hold keys to our understanding of the post-Rodinian tectono-climatic evolution of the Indian shield. In this study, we attempt to unravel the sedimentary history of the basin

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by constraining the provenance of the siliciclastic formations and siliciclastics within the carbonate formations of the Supergroup using variations in trace element contents and radiogenic isotopic (Sr-Nd) compositions as proxies. To establish the chronology of the events, we provide age constraints on deposition of various formations using Rb-Sr isochron dating of a tuff layer and $^{87}Sr/^{86}Sr$ stratigraphy of the carbonate sequences.

2. Geologic setting

2.1. Regional geology

The Aravalli Craton is generally considered to be represented by the 3.3–2.5 Ga Banded Gneissic Complex (BGC-1) in southern Rajasthan which forms the basement of subsequent magmatic activities and sedimentary deposits (Fig. 1) (Gopalan et al., 1990; Roy and Kröner, 1996; Wiedenbeck and Goswami, 1994). It consists dominantly of amphibolite to granulite grade tonalitic and granodioritic gneisses, with associated lenticular masses of amphibolite. The ancestry of BGC of central Rajasthan (BGC-2), however, remains equivocal (Fig. 1) (Bhowmik and Dasgupta, 2012; Buick et al., 2006; Tobisch et al., 1994). This slightly younger basement is exposed to the north of BGC-1. It is subdivided into (1) the Sandmata Complex consisting of granulites and (2) the Mangalwar Complex; a spatially more extensive assemblage of gneisses, meta-granitoids and minor amphibolites. The stabilization of the Aravalli Craton at ~2.5 Ga (Wiedenbeck et al., 1996) was followed by sedimentation of the Aravalli Supergroup (2.3–1.6 Ga ?) and the Delhi Supergroup (1.8–0.8 Ga ?) (Ahmad et al., 2008; Biju-Sekhar et al., 2003; Kaur et al., 2011b; McKenzie et al., 2013; Van Lente et al., 2009). A major thermal event is believed to have occurred in the Aravalli Craton at ~1.7 Ga and is manifested in most of the geochronological data reported from the region (Buick et al., 2006; Roy et al., 2005; Tobisch et al., 1994). The Delhi Supergroup is intruded by numerous granitic plutons that largely fall into two categories; (1) the older 1.7–1.8 Ga group, which is exposed mostly in the northeastern part of the Delhi Fold Belt (DFB; Biju-Sekhar et al., 2003; Choudhary, 1984; Kaur et al., 2011a, 2009, 2007) and (2) the younger (0.8–1.0 Ga) and abundant group of rocks known as the Erinpura Granites that are exposed in the southwestern part. (Choudhary, 1984; Pandit et al., 2003; Van Lente et al., 2009) A metasedimentary sequence, known as the Sirohi Group, comprising of shales and carbonates metamorphosed to lower greenschist facies, is exposed within the younger DFB granitoids (Purohit et al., 2012). The Precambrian magmatic activity in the Aravalli Craton ended with the voluminous 770–750 Ma Malani magmatism, which produced a suite of rocks that are dominated by rhyolites with minor basic volcanics and granitoids (Crawford and Compston, 1970; Gregory et al., 2009; Meert et al., 2013; Rathore et al., 1999, 1996).

2.2. Marwar Supergroup

The Marwar Supergroup unconformably overlies the MIS, covering an area of over 100,000 km^2 (Kumar, 1999) (Fig. 1). The Aravalli Mountain range, the Delhi-Lahore subsurface ridge and the Devikot-Nachna subsurface high form the boundaries of the basin in east, north and southwest, respectively (Pareek, 1984, 1981). Most of the north and northeastern parts of the basin are covered by Quaternary sand deposits. The MIS forms the basement of the Marwar basin in central

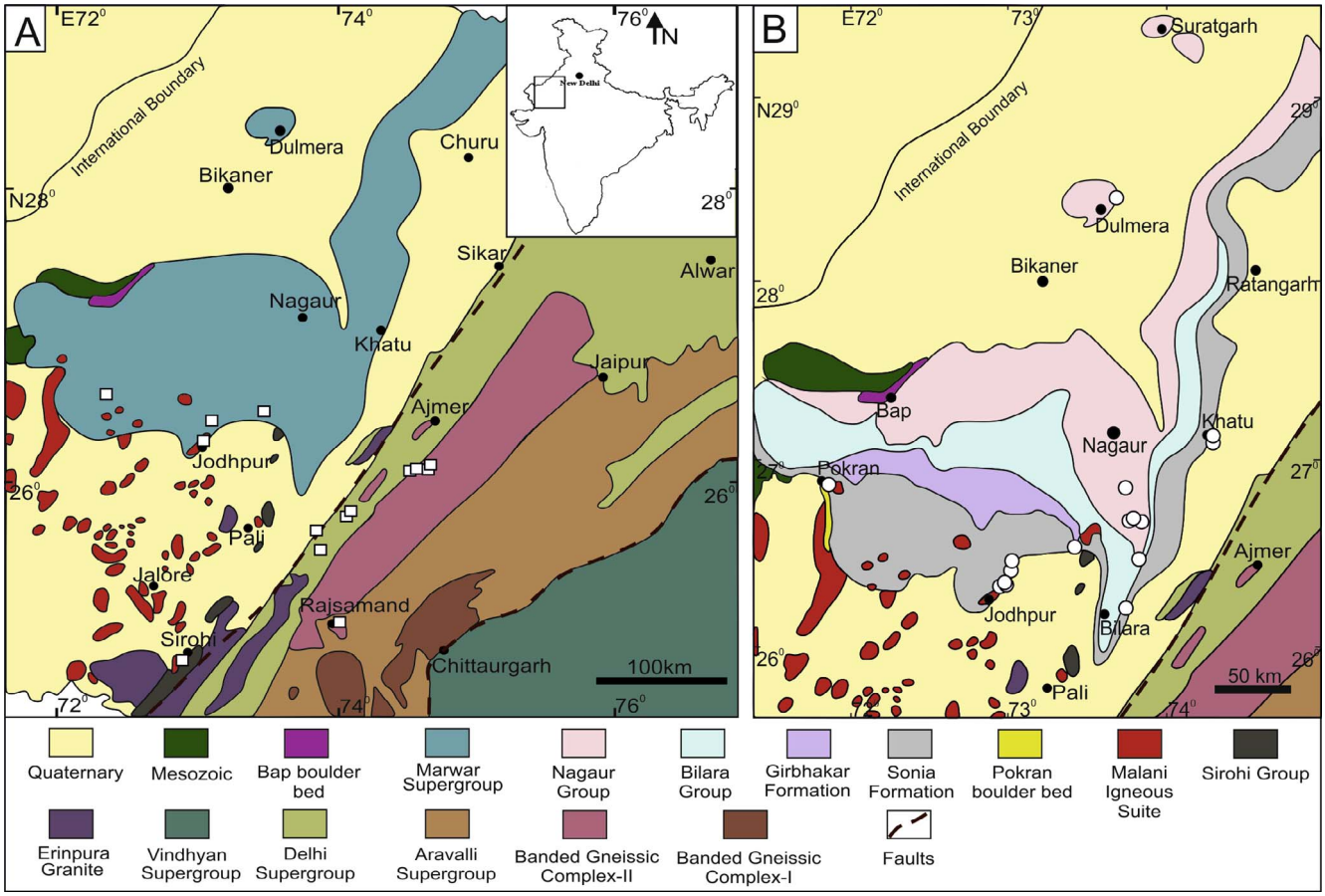

Fig. 1. (A) Geological map of western India showing the Marwar Supergroup and surrounding litho-tectonic units (modified after Roy and Jakhar, 2002). The study area is marked in the inset and sampling locations of the basement rocks are shown as white squares. (B) Geological map of the Marwar Supergroup with stratigraphic subdivisions (modified after Pareek, 1984). Locations of the samples from Marwar Supergroup are shown as white circles.