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Geochemical and Sm–Nd isotopic characteristics of the Late Archaean-Palaeoproterozoic Dhanjori and Chaibasa metasedimentary rocks, Singhbhum craton, E. India: Implications for provenance, and contemporary basin tectonics

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ABSTRACT

In significant contrast to other cratonic blocks of India, the Singhbhum cratonic successions record continuous depositional record from the Palaeoarchaean to Mesoproterozoic. Although the sedimentary facies characteristics and mode of stratigraphic sequence building of the Dhanjori and Chaibasa Formations are well known, sedimentary geochemistry, provenance and tectonic milieu of deposition of these two formations are hitherto unknown. The current manuscript presents geochemical and Sm–Nd isotopic data from the Dhanjori and Chaibasa Formations for the first time and combine previous sedimentological data with the goal to expand the framework for understanding the depositional and tectonic setting of these two formations. The Sm–Nd isotopic data for the Chaibasa clastics is unambiguous with respect to provenance. Average ε_{Nd} (t = 2.2 Ga) = −0.8 ± 1.0 and average Nd model age (TDM) = 2.51 ± 0.08 Ga with average $^{147}Sm/^{144}Nd$ ratios = 0.1114 ± 0.0041 for phyllites and quartzites indicate an extremely homogeneous source signature consistent with a late Archaean "juvenile" crustal provenance, possibly a dominantly upper crustal provenance. The Sm–Nd isotopic data from the older Dhanjori Formation also indicate broadly similar provenance as comparable lithologies in the younger Chaibasa Formation. Our Sm–Nd isotopic data is entirely consistent with the previous sedimentological data and confirms a terrestrial, rift-dominated tectonic setting for the Dhanjori Formation (proximal sources, poorly mixed provenance) and a marginal marine to offshore setting for the more homogeneous Nd isotopic signature of the Chaibasa Formation (distal sources, well mixed provenance).

1. Introduction

The Singhbhum craton, eastern India (Fig. 1) is among one of the few Precambrian terrains in the world that reportedly records sedimentation and volcanism in a changing tectonic scenario ranging from Palaeo-archaean to Mesoproterozoic (Saha, 1994; Mazumder et al., 2000, 2012a,b; Mukhopadhyay, 2001; Mazumder, 2005; Eriksson et al., 2006; Prabhakar and Bhattacharya, 2013;

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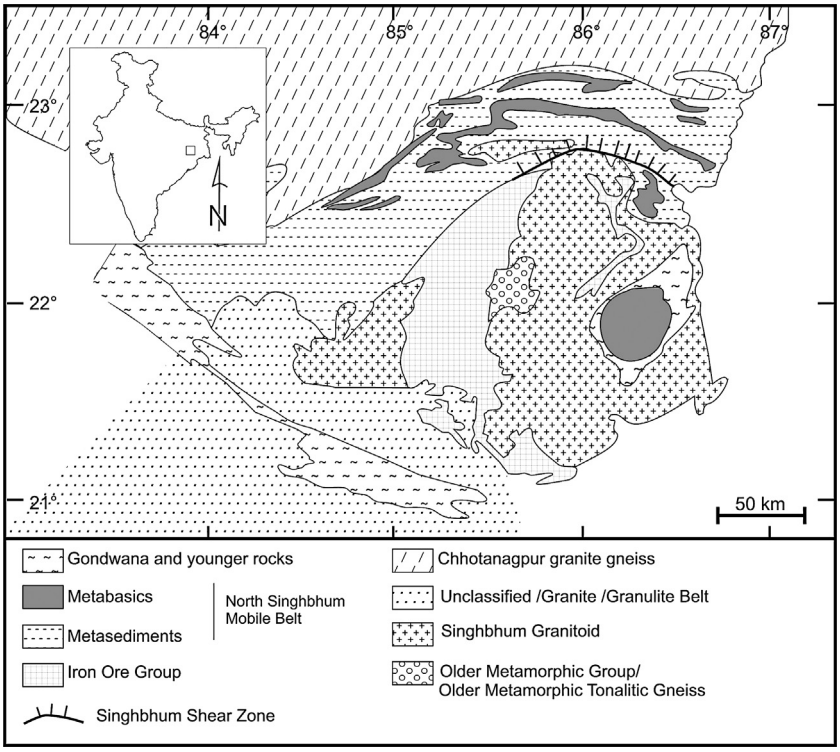

Fig. 1. Geological map of the Singhbhum craton (modified after Mukhopadhyay, 2001). The Singhbhum granitoid and the eastern (E), western (W) and southern (S) Iron Ore Group of rocks constitute the Archaean Singhbhum nucleus (see Mukhopadhyay, 2001 and Mazumder et al., 2012 for details).

Mukhopadhyay et al., 2014; Nelson et al., 2014). The volcano-sedimentary succession occurring to the north of the Archaean Singhbhum nucleus has been inferred to constitute the Singhbhum mobile belt or North Singhbhum Mobile Belt (Saha, 1994; Gupta and Basu, 2000; Sengupta and Chattopadhyay, 2004; Dasgupta, 2004). The Dhanjori Formation represents the lower part of the Late-Archaean to Palaeoproterozoic volcano-sedimentary succession and unconformably overlies the Archaean nucleus. It is entirely siliciclastic and incorporates mostly mafic – and minor felsic volcanics and volcaniclastic rocks (Gupta and Basu, 2000; Mazumder and Sarkar, 2004; Mazumder, 2005). The Dhanjori Formation is conformably overlain by the thicker, and entirely siliciclastic Chaibasa Formation (Mazumder, 2005; Mazumder et al., 2012a,b, 2014).

Determining the depositional and paleotectonic settings of the Dhanjori and Chaibasa Formations is important for understanding the early post-Archaean evolution of the Singhbhum craton. Although earlier researchers studied the sedimentary facies, mode of sedimentary sequence building and stratigraphic relationship between the Dhanjori (Mazumder, 2002; Mazumder and Sarkar, 2004; Mazumder, 2005; Bhattacharya and Mahapatra, 2008; Mazumder and Arima, 2009) and Chaibasa Formation (Bose et al., 1997; Bhattacharya and Bandyopadhyay, 1998; Mazumder, 2002, 2004, 2005; Mallik et al., 2012), issues related to the sediment geochemistry, provenance and tectonic milieu of deposition of these two formations are hitherto unknown (cf. Mazumder et al., 2012a). Chemical and modal composition of the clastic sedimentary rocks provides valuable information for palaeoclimate reconstruction, tectonic setting determination, and provenance analysis (Taylor and McLennan, 1985; Nesbitt and Young, 2004; Saha et al., 2004; Ohta, 2008; Sugitani et al., 2006; Clark et al., 2012). Such information can be extracted by examination of lithology, chemical and isotopic composition of sediments and/or associated volcanic and volcaniclastic rocks (Taylor and McLennan, 1985; McLennan et al., 1993, 2006 and references therein). Efforts have been made to constrain the provenance and tectonic settings of Archaean and Palaeoproterozoic metasedimentary rocks (McLennan et al., 1983a,b, 1984; Taylor and McLennan, 1995; Fedo et al., 1996, 1997; Saha et al., 2004; Sugitani et al., 2006; Clark et al., 2012). This paper presents geochemical and Sm–Nd isotopic data from the Dhanjori and Chaibasa Formations for the first time to further our knowledge and understanding of the geologic history of the Singhbhum craton with respect to crustal evolution and basin evolution across the Archaean-Palaeoproterozoic transition.

2. Geological setting and geochronology

2.1. Geological setting

The Singhbhum crustal province, encompassing the Singhbhum district Jharkhand and a part of north Orissa, exposes a vast tract of Precambrian rocks occupying an area of approximately 50,000 km^2 (Figs. 1 and 2). Three distinct petrotectonic zones in the Singhbhum crustal province have been identified. From south to north, these are: (1) the southern Archaean nucleus encompassing various granitoids, Iron Ore Group of rocks, and Late Archaean siliciclastics (cf. Mukhopadhyay, 2001; Mazumder et al., 2012b) (2) the almost 200 km long North Singhbhum Fold Belt comprising the Dhanjori, Chaibasa, Dhalbhum, Dalma and Chandil Formations (cf. Sarkar and Saha, 1962; Gupta and Basu, 1991, 2000; Acharyya, 2003), and (3) the extensive granite-gneiss and migmatite terrain in the north, known as the Chottonagpur Gneissic complex (Figs. 1 and 2).

The Singhbhum Shear Zone (SSZ) occurs close to the northern and eastern margins of the Archaean nucleus and passes very close to the stratigraphic contact between the Dhanjori and Chaibasa Formations (Figs. 1 and 2; see Mukhopadhyay, 1976, 1984; Saha, 1994 and references therein). The Dhanjori Formation has been affected by shearing, and shows an excellent development of strong L–S tectonites in the quartzites, grits and metabasic rocks (Joy and Saha, 1998,2000). Rocks within the SSZ show the same paragenesis as the Dhanjori Formation except for the presence of kyanite