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Research paper

Geochemical constraints on komatiite volcanism from Sargur Group Nagamangala greenstone belt, western Dharwar craton, southern India: Implications for Mesoarchean mantle evolution and continental growth

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A B S T R A C T

We present field, petrographic, major and trace element data for komatiites and komatiite basalts from Sargur Group Nagamangala greenstone belt, western Dharwar craton. Field evidences such as crude pillow structure indicate their eruption in a marine environment whilst spinifex texture reveals their komatiite nature. Petrographic data suggest that the primary mineralogy has been completely altered during post-magmatic processes associated with metamorphism corresponding to greenschist to lower amphibolite facies conditions. The studied komatiites contain serpentine, talc, tremolite, actinolite and chlorite whilst tremolite, actinolite with minor plagioclase in komatiitic basalts. Based on the published Sm-Nd whole rock isochron ages of adjoining Banasandra komatiites (northern extension of Nagamangala belt) and further northwest in Nuggihalli belt and Kalyadi belt we speculate ca. 3.2–3.15 Ga for komatiite eruption in Nagamangala belt. Trace element characteristics particularly HFSE and REE patterns suggest that most of the primary geochemical characteristics are preserved with minor influence of post-magmatic alteration and/or contamination. About 1/3 of studied komatiites show Al-depletion whilst remaining komatiites and komatiite basalts are Al-undepleted. Several samples despite high MgO, $(Gd/Yb)_N$ ratios show low CaO/Al_2O_3 ratios. Such anomalous values could be related to removal of CaO from komatiites during fluid-driven hydrothermal alteration, thus lowering CaO/Al_2O_3 ratios. The elemental characteristics of Al-depleted komatiites such as higher $(Gd/Yb)_N$ (>1.0), CaO/Al_2O_3 (>1.0), Al_2O_3/TiO_2 (<18) together with lower HREE, Y, Zr and Hf indicate their derivation from deeper upper mantle with minor garnet (majorite?) involvement in residue whereas lower $(Gd/Yb)_N$ (<1.0), CaO/Al_2O_3 (<0.9), higher Al_2O_3/TiO_2 (>18) together with higher HREE, Y, Zr suggest their derivation from shallower upper mantle without garnet involvement in residue. The observed chemical characteristics (CaO/Al_2O_3, Al_2O_3/TiO_2, MgO, Ni, Cr, Nb, Zr, Y, Hf, and REE) indicate derivation of the komatiite and komatiite basalt magmas from heterogeneous mantle (depleted to primitive mantle) at different depths in hot spot environments possibly with a rising plume. The low content of incompatible elements in studied komatiites suggest existence of depleted mantle during ca. 3.2 Ga which in turn imply an earlier episode of mantle differentiation, greenstone volcanism and continental growth probably during ca. 3.6–3.3 Ga which is substantiated by Nd and Pb isotope data of gneisses and komatiites in western Dharwar craton (WDC).

1. Introduction

Archaean greenstone belts are dominated by ultramafic-mafic volcanic sequences with minor intermediate to felsic associations. High-Mg volcanic rocks particularly komatiites and komatiitic basalts are more abundant in oldest greenstone sequences and considered to be windows to the Archaean mantle. Komatiites are rare or absent in the Proterozoic and Phanerozoic terrains. Geochemical and isotope signatures of these rocks provide much

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insight in understanding the chemical and thermal evolution of Archaean mantle, continental growth rates, secondary processes such as metamorphism and fluid induced alteration. They also provide important constraints on the tectonic context of greenstone volcanism and, degree and depth of melting of mantle. During the last three decades komatiites and komatiite basalts have been extensively studied from the Archaean greenstone belts of southern Africa, Canada, Australia, Brazil, Finland, North China, and India (e.g. Jahn et al., 1982; Gruau et al., 1987; Wilson and Carlson, 1989; Xie et al., 1993, 2012; Arndt, 1994, 2008; Lesher and Arndt, 1995; Fan and Kerrich, 1997; Grove et al., 1997; Parman et al., 1997; Kerrich et al., 1999; Polat et al., 1999; Chavagnac, 2004; Raul Minas and Jost, 2006; Jayananda et al., 2008; Zhai and Santosh, 2011; Dostal and Mueller, 2012; Furnes et al., 2012). The geodynamic context of komatiite magma generation and eruption are still subjects of discussion, whether komatiite magmas are generated by anhydrous melting of deep mantle or wet melting of shallow mantle (Grove et al., 1997; Parman et al., 1997, 2001; Polat et al., 1999; Arndt, 2003; Chavagnac, 2004). Recently, based on $Fe^{3+}/\Sigma Fe$ ratios of melt inclusions in olivine of komatiites, Berry et al. (2008) have shown anhydrous dry melting of deep mantle generates komatiite magmas during Archaean. Several geodynamic models including oceanic plateaus associated with rising plume, arc setting or combined plume-arc setting have been proposed for the origin of komatiites and komatiitic basalts (De-Witt et al., 1987; Grove et al., 1997; Parman et al., 1997; Polat et al., 1999; Puchtel et al., 1999; Arndt, 2008; Jayananda et al., 2008).

In the Dharwar craton volcano-sedimentary sequences are well preserved in older Sargur Group and younger Dharwar Supergroup (Swaminath and Ramakrishnan, 1981). Several petrologic, geochronologic and geochemical studies focused on the volcanic sequences of Dharwar Supergroup (Balakrishnan et al., 1990, 1999; Zachariah et al., 1995; Anil Kumar et al., 1996; Nutman et al., 1996; Sarma et al., 2008; Anand and Balakrishnan, 2010; Manikyamba

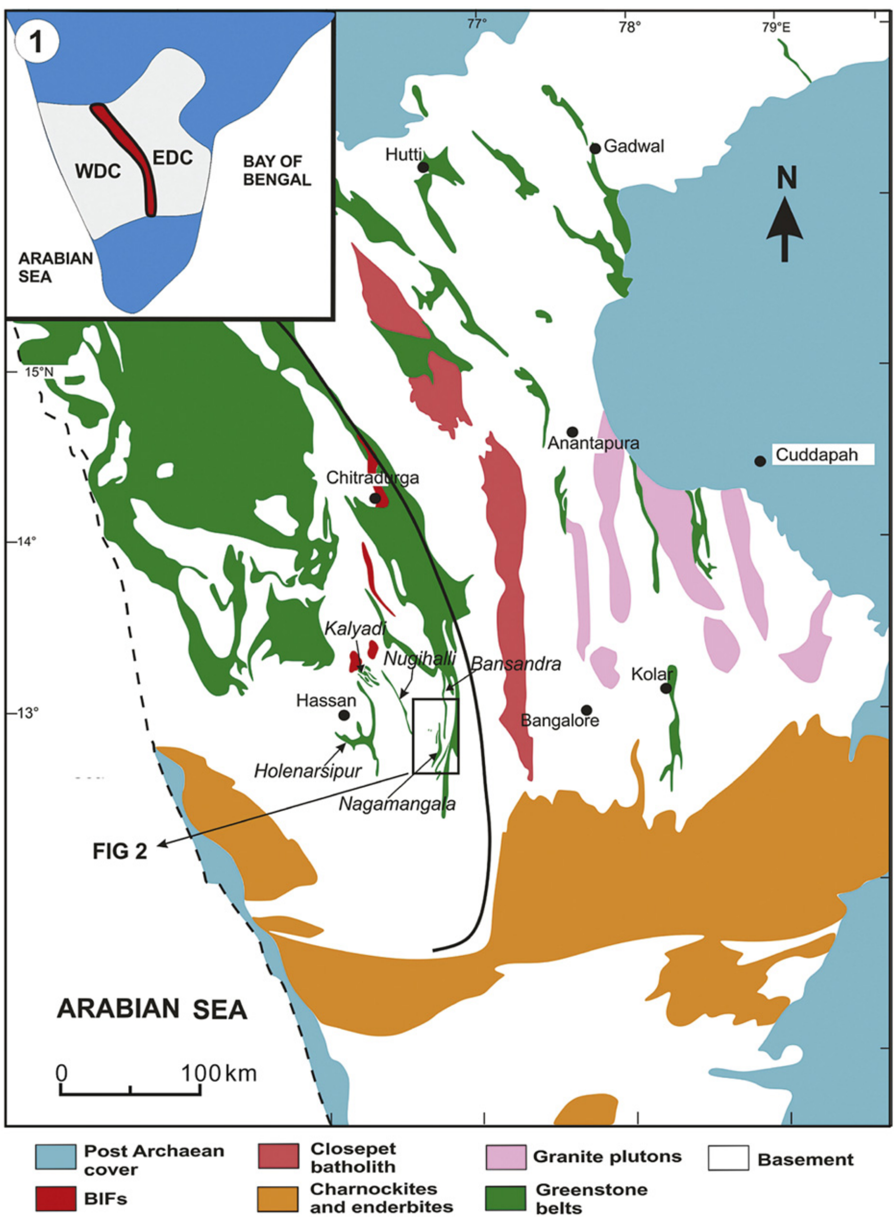

Figure 1. Geological sketch map of the Dharwar craton showing the study area (modified after Chardon et al., 2008).