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Geochemistry of two stratigraphically-related ultramafic (komatiite) layers from the Neoarchean Sigegudda greenstone terrane, Western Dharwar Craton, India: Evidence for compositional diversity in Archean mantle plumes

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ABSTRACT

Two compositionally different ultramafic units are present in the Neoarchean Sigegudda greenstone terrane, Western Dharwar Craton, India. These ultramafic units occur in the same volcano-sedimentary sequence and are separated by a fault-bounded volcanic arc association. Because of deformation and amphibolite facies metamorphism, the primary igneous textures have been extensively modified in both ultramafic units. Given their spatial and temporal association with sedimentary and volcanic rocks and high MgO contents (12–29 wt.%), these ultramafic rocks are interpreted as metamorphosed komatiites and komatiitic basalts. Field relationships and rock types indicate that the lower section of the Sigegudda volcano-sedimentary sequence was deposited in a peri-cratonic, continental rift setting. The lower ultramafic unit is characterized by 12.4–29.6 wt.% MgO, Mg# = 76–91, and 526–1150 ppm Ni. The upper ultramafic unit is overall more magnesian and compositionally restricted: MgO = 21.6–25.9 wt.%, Mg# = 86–89, and Ni = 610–1000 ppm. The lower unit features a combination of relatively elevated TiO_2 (0.40–0.90 wt.%), $Al_2O_3/TiO_2 \leq$ the chondritic ratio of 21, and $(Gd/Yb)_N$ ratios >1; these are Ti-enriched komatiites reported for the first time from greenstone belts in the Dharwar Craton. The upper unit is compositionally comparable to Al-undepleted komatiites and characterized by $Al_2O_3/TiO_2 \geq 21$, LREE-depletion coupled with near-flat chondrite-normalized HREE patterns. Geochemical data indicate that the Sigegudda komatiites and komatiitic basalts were variably contaminated by either continental crust or sub-continental lithospheric mantle, or both. The geochemical differences between the two units are explained by variable depths and degrees of partial melting. The Ti-enriched lower unit appears to have been formed through lower degrees of partial melting at depths ≥90 km, whereas the Al-undepleted upper unit was generated by higher degrees of partial melting at depths ≤90 km. Field relationships and geochemical characteristics of the Sigegudda komatiites can be explained by a geodynamic model in which the stratigraphically lower Ti-enriched komatiites were erupted from a mantle plume onto a rifting continental margin, whereas the stratigraphically upper Al-undepleted komatiites originated from a younger mantle plume and erupted onto a volcanic arc sequence that accreted to the rifted continental margin.

1. Introduction

Komatiites have been reported from both the ca. 2.7 Ga Sandur Superterrane of the Eastern Dharwar Craton as well as the older, ca 3.5 Ga greenstone terranes of the Western Dharwar Craton. Compositionally, these are mostly Al-undepleted komatiites (Jayananda et al., 2008; Manikyamba et al., 2008; Naqvi et al., 2002). Greenstone lithologies of the Western Dharwar Craton have a predominance of komatiites and komatiitic basalts, but so far only few high-precision trace element data have been reported for these rocks (Jayananda et al., 2008). New mapping combined with high-precision elemental data for the Sigegudda terrane, Western Dharwar Craton, reveals two stratigraphically-related but compositionally distinct ultramafic units, here referred to as upper and lower ultramafic units (Figs. 1 and 2). Because of intense deformation and amphibolite facies metamorphism, an unambiguous spinifex texture has not been preserved in these ultramafic rocks. Textures seen on the outcrops are more akin to a "garbenschiefer" texture than a spinifex texture (Fig. 3), implying a metamorphic origin. Nevertheless, their spatial and temporal association with volcanic and sedimentary rocks (Fig. 2) and their high MgO (16–29 wt.%) contents suggest that they are likely to have been emplaced as komatiites and komatiitic basalts.

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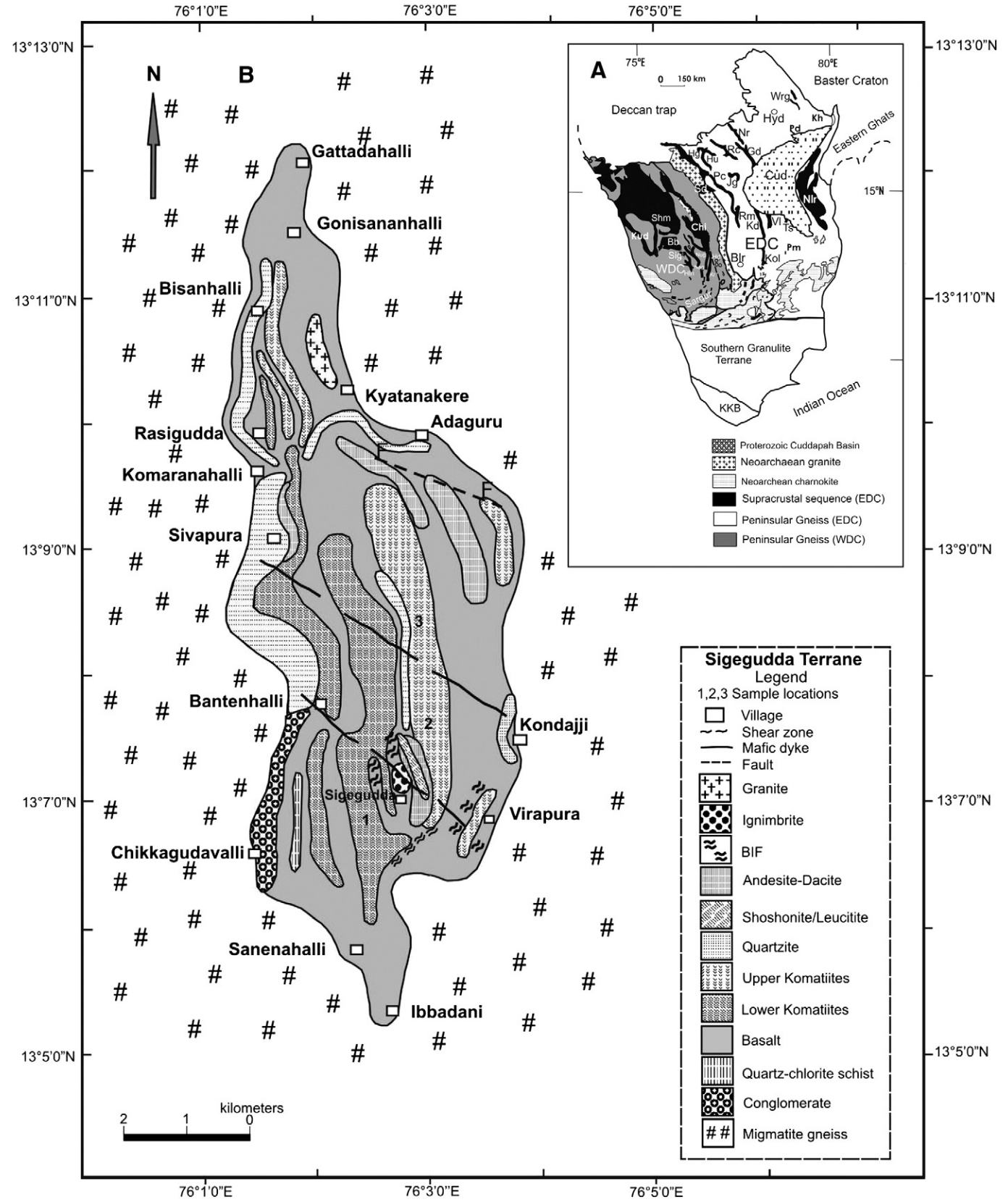

Fig. 1. (A) Simplified geological map of southern Peninsular India showing the Western and Eastern Dharwar Craton, with the intervening belt of Closepet granites, the distribution of greenstone belts, and the study area [modified after Hokada et al. (2013)]. Western and eastern Dharwar greenstone terranes are referred to Ramam and Murty (1997). Cities are in open circles. (B) Simplified geological map of the Sigegudda terrane after Ramakrishnan and Viswanatha (1981), showing sample locations 1. lower komatiites, 2. komatiitic basalts and 3. upper komatiites sampled in this study and keyed to the stratigraphic section of Fig. 2.