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Multiple rifting and alkaline magmatism in southern India during Paleoproterozoic and Neoproterozoic

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ABSTRACT

The Southern Granulite Terrane (SGT) in India preserves the history of tectonothermal events ranging from Paleoarchean to latest Neoproterozoic–Cambrian. Here we investigate alkaline magmatism possibly associated with rifting events in Paleoproterozoic and Neoproterozoic based on petrological, geochemical and zircon U–Pb and Lu–Hf isotopic studies on the alkaline complexes of Korangani (KGAC) and Kambamettu (KAC) in the Madurai Block of SGT. The mica pyroxenite which represents the first intrusive phase at KGAC crystallized from a mildly alkaline hydrous magma derived from a metasomatized mantle. The younger shoshonitic syenite was emplaced at 2533 ± 16 Ma, carries mafic microgranular enclaves, and shows trace-elements ratios consistent with magma mixing trend, and zircon $\varepsilon_{Hf}(t)$ values display mixed positive and negative values −2.6 to 3.6 suggesting the mixing of adakite-like felsic crustal melt and non-adakitic mantle derived melt. In KAC, four distinct magmatic intrusions are identified: i) quartz-monzonite (emplaced at 2498 ± 16 Ma), an ultrapotassic adakitic rock derived from a carbonated alkali-rich lower crustal source with negative zircons $\varepsilon_{Hf}(t)$ values in zircon (−8.0 to −0.8); Y/Nb (>1.2) and Th/Ce (0.03–0.8) ratios; lower Ni (<30 ppm) and Cr (<14 ppm) contents; ii) phlogopite-rich pyroxenite, crystallized from an alkali-rich basaltic parental magma derived from carbonate metasomatized mantle; iii) mantle derived high Ba–Sr carbonatite (emplaced at 2470 ± 15 Ma); and iv) shoshonitic peralkaline syenite rock (emplaced at 608 ± 6 Ma) with strong adakitic signature, low MgO (<1 wt.%), Ni (12–5 ppm) and Cr (49–35 ppm) contents and negative zircon $\varepsilon_{Hf}(t)$ values (−30.3 to −27.3) and trough of Zr–Hf in spidergrams suggesting a carbonated alkali-rich garnet-bearing crustal source.

The geochemical features and petrogenetic considerations of the felsic shoshonitic-ultrapotassic adakite-like rocks (syenite, quartz monzonite), mica-pyroxenites and carbonatite reveal rift-related extensional tectonic settings with magma sources involving both mantle and crustal components during Paleoproterozoic. The late Neoproterozoic shoshonitic adakite-like syenite from KAC also formed in a rift-related setting. In both cases, intracontinental rifting associated with post-collisional extension is proposed.

1. Introduction

Alkaline intrusive complexes, though volumetrically less abundant, are important hosts of a variety of mineral deposits (e.g., Bowden, 1985; Pirajno, 1994) and also offer insights into the evolution of subcontinental lithospheric mantle (SCLM) (e.g., Marks et al., 2008), crust–mantle interaction (e.g., Liu et al., 2008; Li et al., 2010; Lan et al., 2011a, 2011b), asthenosphere–lithospheric interaction (e.g., Ying et al., 2007) and plate tectonic reconstruction (e.g., Yoshida and Santosh, 2011; Pirajno, 2015). Alkaline complexes and associated rocks are mainly found in three tectonic settings (Bonin, 1986; Kinnaird and Bowden, 1991; Pirajno, 2015) such as: i) doming of the crust, followed by rifting; ii) "hot spot" traces with time–space migrating magmatism; and iii) crustal-scale shear zones. There are many alkaline ring complexes reported from the Indian subcontinent especially from the Southern Granulite Terrane (SGT) of southern India where all of them are associated with crustal-scale shear zones (Santosh et al., 2014; Renjith et al., 2016 and the references therein). Some shear zones are suture zones along which various micro-terranes were amalgamated at various times through progressively changing subduction–accretion-collision tectonic setting or represent major aborted rift zones. Understanding the geodynamic conditions that leads to the emplacement of alkaline complexes along such zones is vital to unravel the complex tectonic evolution of a region like SGT carrying a multiple

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collage or continental blocks. Most of intrusive alkaline complexes in SGT are spatially restricted towards the northern part such as the Salem block and these Cryogenian plutons were emplaced in an aborted-rift setting developed along the pre-existing shear/suture zones (Santosh et al., 2014; Renjith et al., 2016). Towards south of Palghat–Cauvery Suture Zone (PCSZ), felsic (A-type granitoids) intrusions dominate as against the alkaline ring complexes to the north. However, there are exceptions such as the alkaline plutons at Kambamettu and Korangani that occur in the central part of Madurai block (Fig. 1a). The Kambamettu alkaline complex (KAC) has been studied by a few works (see Balakrishnan et al., 1985; Catlos et al., 2008; Burtseva et al., 2013) whereas the Korangani alkaline complex is reported here for the first time. Some of the previous workers (e.g., Leelanandam et al., 2006; Catlos et al., 2008) have correlated the KAC and other ~800 Ma plutons within the alkaline complexes from eastern part of the Salem block (Dharmapuri Rift Zone, see Renjith et al., 2016) and suggested a tectonic link across the PCSZ. Recently on similar lines, Brandt et al. (2014) argued a mid-Neoproterozoic extensional rifting on both sides of PCSZ (i.e., Salem block and Madurai block) and correlated with the break-up of Rodinia supercontinent.

In this study, we present petrography, whole-rock geochemistry, U–Pb age and Lu–Hf isotopic composition from the Kambamettu and Korangani plutons and evaluate their petrogenesis and tectonic significance.

2. Geological setting

Southern Granulite Terrain (SGT) of southern India is composed of several major crustal blocks including Coorg, Nilgiri, Salem, Madras, Madurai, Trivandrum and Nagercoil with basement rocks ranging in age from Mesoarchaean to Neoproterozoic and the southernmost blocks at south of the PCSZ subjected to high grade metamorphism during latest Neoproterozoic–Cambrian associated with the final amalgamation of the Gondwana supercontinent (Fig. 1a) (Santosh et al., 2009a, b; Collins et al., 2014; Santosh et al., 2015). The crustal blocks to the north of the PCSZ were accreted along the southern margin of Dharwar

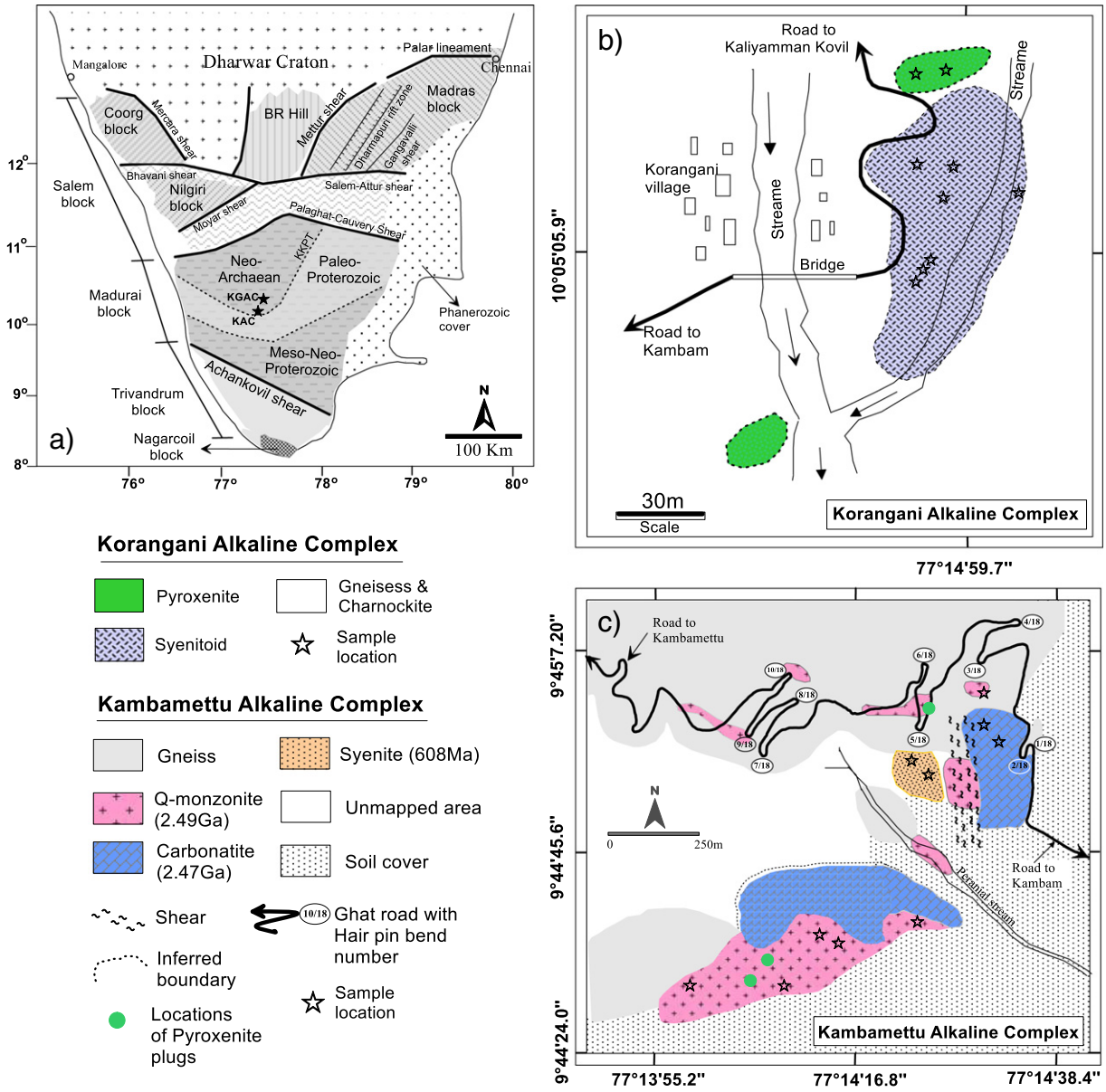

Fig. 1. (a) Schematic map of Southern Granulite Terrain (SGT) of southern India show major tectonic divisions. (KKPT: Karur-Kambam-Painavu-Trichur shear zone). Geological maps of Korangani alkaline complex (KGAC) (b) and Kambamettu alkaline complex (KAC) (c) are from the present study.