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New age, geochemical and paleomagnetic data on a 2.21 Ga dyke swarm from south India: Constraints on Paleoproterozoic reconstruction

Anil Kumar[a,*], E. Nagaraju[a], Jean Besse[b], Y.J. Bhaskar Rao[a]

[a] National Geophysical Research Institute, Council of Scientific and Industrial Research, Uppal Road, Hyderabad 500 007, India
[b] Institut de Physique du Globe de Paris, 4 Place Jussieu, 75252 Paris Cedex 05, France

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ABSTRACT

Geochemical, paleomagnetic and Sm–Nd whole rock-mineral isochron age data are presented for a ~450 km-long N-S striking mafic dyke swarm from the Dharwar craton, southern India. Dykes in this swarm are basaltic tholeiite in composition and despite traversing diverse Archean rocks display limited compositional heterogeneity along their entire outcrop. Two whole rock-mineral Sm–Nd isochrons from one of these dykes yield ages of 2173 ± 43 Ma and 2190 ± 51 Ma (2σ) respectively. These ages are consistent with recently reported U–Pb ages of 2209.3 ± 2.8 Ma and 2220.5 ± 4.9 Ma for two other dykes within the craton that show a similar trend and chemical composition (French and Heaman, 2010), suggesting emplacement of this swarm close to 2210 ± 10 Ma. Paleomagnetic directions obtained from fifteen sites along the length of this swarm are all similar within errors despite dissimilar orientation between dykes towards the northern end of the swarm, with a grand mean of $D_m = 239°$ and $I_m = -64°$, corresponding to a paleopole at lat. 32°S; long. 302°E (dp = 8, dm = 10). This Paleoproterozoic pole from the Dharwar has coeval poles from the Slave, Superior and Rae provinces and allows a Paleoproterozoic reconstruction of these cratons. Our reconstruction at ~2210 Ma shows that all these cratons could have been located within about 30° of each other, with Slave and Dharwar being remarkably closer (<10°). However, lack of reliable Neoarchean paleomagnetic data from the Dharwar inhibits tracing its ancestry to either of the Neoarchean Supercratons: Sclavia or Superia.

1. Introduction

Earth's history records numerous periods of accentuated mafic magmatism. Those magmas genetically unrelated to seafloor spreading and subduction are the Large Igneous Provinces (LIPs) and include continental flood basalts. Proterozoic LIPs are generally deeply eroded to expose giant dyke swarms, several of them being of continental dimensions. Recognition of coeval giant dyke swarms on different continents could be extremely useful for continental reconstructions, for deciphering the frequency of mantle perturbation events and also for understanding the chemical evolution of the mantle through Proterozoic.

Like in most Archean cratons, the Dharwar craton was also invaded by a large number of mafic dyke swarms, which are predominantly of Paleoproterozoic age (for recent summaries: Halls et al., 2007; French and Heaman, 2010), apart from those of Cretaceous age (Kumar et al., 1988, 2001; Radhakrishna et al., 1994). Of these, the recently discovered E-W to ENE-WSW trending giant radiating dyke swarm emplaced at 2367 Ma with an areal extent of nearly the entire eastern Dharwar craton appears to be the most dominant (Kumar et al., 2012). Other dyke swarms that have been dated recently using U–Pb baddeleyite geochronology from the eastern Dharwar craton include a N-S oriented swarm at 2220.5 ± 4.9 Ma, a NW-SE striking swarm at 2209.3 ± 3.8 Ma and a radial WNW-ESE to NW-SE swarm at 2180.8 ± 0.9 to 2176.5 ± 3.7 Ma (French and Heaman, 2010). The N-S striking dyke swarm appears to extend for over 450 km and straddle nearly the entire length of the Dharwar craton (Fig. 1). In order to establish the spatial extent of this dyke swarm, lateral variation in composition and study their paleomagnetic signature, a concerted geochemical, paleomagnetic and geochronological study was undertaken. Based on these results, we also attempt here a Paleoproterozoic continental reconstruction involving the Dharwar craton.

2. Regional geology and sampling

The Archean Dharwar craton as summarized by Swami Nath and Ramakrishnan (1981), Drury et al. (1984) and Naqvi and Rogers (1987) consists of four blocks. These are the Southern granulite block, the Eastern Ghats granulite block and the low-grade Northern block that is further divisible into western and eastern blocks based on contrasting metamorphic P–T conditions. The latter two

* Corresponding author. Tel.: +91 40 23434790.
E-mail address: anilkumar@ngri.res.in (A. Kumar).

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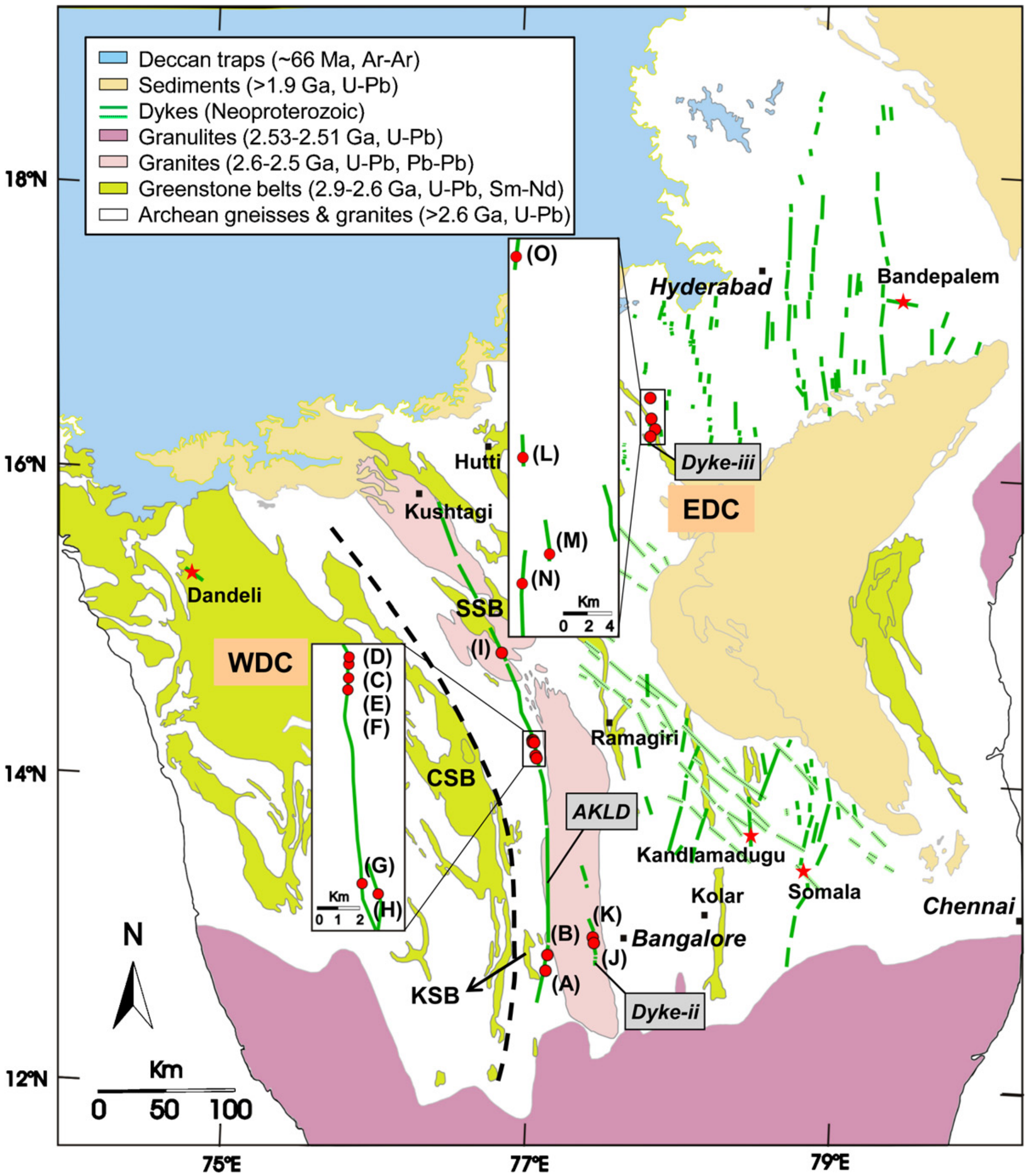

Fig. 1. Simplified geology map (modified after Naqvi and Rogers, 1987, dykes traced from Google earth and French and Heaman, 2010) of a part of the Dharwar craton showing AKLD (Andhra Karnataka long dyke) dykes ii and iii, other ~2210 Ma dykes (after French and Heaman, 2010). Red dots indicate sampled site locations of this study, A–I in parentheses are sites on AKLD, J and K on dyke ii and L–O on dyke iii. Red stars in the map indicate site locations of samples used for U–Pb age determinations on the Kandlamadugu (2220.5 ± 4.9 Ma), Somala (2209.3 ± 2.8 Ma) and 2181–2176 Ma Bandepalam-Dandeli dykes by French and Heaman (2010). EDC and WDC are Eastern Dharwar Craton and Western Dharwar Craton respectively, SSB: Sandur schist belt, CSB: Chitradurga schist belt, KSB: Kunigal schist belt. Black dashed-line demarcates the boundary between the Eastern and Western Dharwar craton.

blocks are separated by a north-south fault zone proximal to the eastern margin of the Chitradurga belt (Fig. 1).

Of the three dykes sampled in this study one of the dykes is unusually long and runs nearly parallel to the eastern margin of the Chitradurga schist belt to its east for well over 350 km, along the western edge of the eastern Dharwar craton. In its southern most part, east of the Kunigal schist belt, the dyke intrudes mid-Archaean amphibolite grade gneisses, while along its middle and northern exposure it cuts late-Archaean K-rich granites, low-grade gneisses and schists such as the Sandur schist belt (Fig. 1). The strike of the dyke is generally NNE in the southern and N-S in the middle parts, but swings ~25° NNW in its northern half, thus broadly following the regional structural grain of the basement rocks. Thickness of the dyke is irregular along its length (shows no systematic variation in thickness along strike), and varies between 40 and 230 m. The dyke preserves a vertical dip along the entire strike length sampled. It is medium to coarse grained and has sharp contacts with the country rock. Two of the sampling sites located along the southern most part of the dyke are in the amphibolite region of the craton whereas the six sites in the middle portion and one site in the northern part of the dyke are located in the greenschist facies regions (Fig. 1). The increasingly deeper exposure level of the crust from north to