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A giant radiating mafic dyke swarm of the Dharwar Craton depicting 2.21 Ga global LIP event: Insights from Pb-Pb geochronology and geochemistry

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The Dharwar Craton (DC) of the Indian Peninsula represents a classic Archean granite-greenstone terrain, transected by numerous Proterozoic mafic dyke swarms of different orientations and ages. Integrated with precise ages and geochemistry, mafic dykes act as unparalleled source for several key information about early earth processes: identification of Large Igneous Provinces (LIPs), age and location of plume centres, mantle sources and processes, tectonics and prior earth configurations. Precise Pb-Pb baddeleyite ages on four mafic dykes helped in understanding the crustal extension of coeval Anantapur-Kunigal mafic dyke swarm (Figure 1) of the Eastern Dharwar Craton (EDC). Collectively they represent NNW to ENE trending giant radiating dyke swarm, that exhibits a fanning angle of 65º and converges towards the north-western margin, beneath the Deccan Traps where the associated mantle plume was located. This spectacular dyke swarm has an expanse of >1,40,000 km^2, enveloping the entire DC and gives an average weighted mean age of 2210 ± 0.53 Ma. Four precisely dated samples along with twenty-one other similar trending dykes (NNW to NW) from Western Dharwar Craton, were studied for geochemistry (Figure 1). They show basaltic to basaltic-andesitic composition and have sub-alkaline tholeiitic nature. The dykes were classified based on La_N/Lu_N ratios: Group I with values ~2 show relatively flat REE patterns while, Group II with values 4-6 have inclined REE patterns. Both the groups primarily show LREE enrichment and most of the samples exhibit negative Nb-Ta and Ti anomalies, indicating crustal contamination. However, low Th/Nb values (0.14-0.73) and negative Zr-Hf anomaly observed in the samples, inhibits significant crustal inputs. Geochemistry suggests that the dykes fractionated from two distinct mantle melts with slightly different sources, both within the spinel-garnet transition zone. The overall composition of these 2.21 Ga dykes is consistent with a mantle plume induced heterogeneous source, that was previously modified by some ancient subduction event. Coeval dykes from EDC manifests similar geochemical behaviour, mantle source characteristics and tectonic history. Synchronous dykes reported from distant cratons viz. Superior, Slave, Greenland, etc., altogether represents 2.21 Ga LIP event, which is linked with the Sclavia/Superia Supercraton.

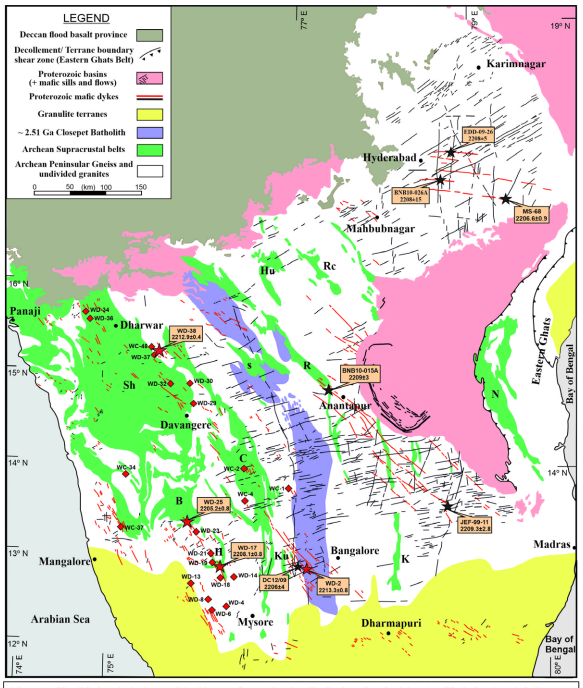

Figure 1: Simplified geological map of the Dharwar Craton showing distribution of mafic dykes (modified after French & Heaman, 2010). Locations of NNW to NW sampled dykes shown in red colour rhombus and stars. Locations of 2.21 Ga previously dated mafic dykes shown in black (French & Heaman, 2010; Nagaraju et al., 2018b; Soderlund et al., 2019; Srivastava et al., 2014) and red stars (Yadav, Sarma, & Parashuramulu, 2020). Greenstone belts: Sh, Shimoga; B, Bababudan; H, Holenarsipur; C, Chitradurga; Ku, Kunigal; S, Sandur; Hu, Hutti; Rc, Raichur; R, Ramagiri; K, Kolar; N, Nellore.