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Early crystallizing magmatic olivines as probe into magma evolution processes: Insights from the 2.37 Ga and 2.21 Ga giant radiating mafic dyke swarms of the Dharwar Craton, India

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Major and trace element composition of olivine grains are used to characterize magma crystallization, mantle sources and metasomatic processes within eleven distinct mafic dykes of the Dharwar Craton, representing the 2.37 Ga and 2.21 Ga large igneous provinces (LIPs). These dykes comprise of olivine, clinopyroxene (augite, pigeonite), plagioclase (labradorite, bytownite) and minor orthopyroxene (enstatite) in association with oxides (titano-magnetite, ilmenite, spinel) and sulphide (chalcopyrite). Olivine grains vary from being unzoned (Ol-I, Mg# 84–63) to zoned (Ol-II, Mg# 78–38), and represent primary and secondary growth during magmatic crystallization. Continuously zoned grains show decrease in Ni, Cr, Al, Ca contents and an increase in Mn, Co and Ti concentrations, from core to rim. Fractional crystallization modelling suggests that the olivines crystallized first, followed by clinopyroxenes and later by plagioclases within both the dyke swarms however, the two swarms exhibit diverse magmatic processes: 2.37 Ga dykes essentially reflect fractional crystallization and magma mixing processes while, the 2.21 Ga dykes, reflect multiple episodes of magma fractionation and recharge. Increase in Ni/(Mg/Fe)/1000 ratios (0.7 to 3.0) and a decrease in 100Mn/Fe ratios (1.5 to 1.0) in olivines from the 2.37 Ga dykes to the 2.21 Ga dykes may be interpreted as a transition of the subcontinental lithospheric mantle (SCLM) from a peridotite-dominated composition with lower proportions of recycled oceanic crust (X_{ROC}=0.2–0.3) at 2.37 Ga, to pyroxenite composition having higher proportions of recycled oceanic crust (X_{ROC}>0.3), at 2.21 Ga. Calculated NiO/MnO ratios in Fo_{89} olivines of the dykes show gradual increase from the eastern (1.16–1.36) through central (1.69–1.81), to the western parts (1.88–2.92) of the craton irrespective of their ages, indicating a thicker lithosphere for the Western Dharwar Craton. Al-in-olivine geothermometer registers high olivine crystallization temperatures of 1294–1466°C (±25°), compatible with the olivine crystallization temperatures of several worldwide LIPs (NAIP, Emeishan, Karoo) and suggests involvement of mantle plume. However, olivine compositions along with negative Nb-Ta anomalies, fractionated LREE with flat HREE patterns, variable $(Dy/Yb)_N$ values (0.94–1.69), and largely negative ƐNd(t) values independent of SiO_2, indicate essential role of SCLM in the genesis, suggesting generation of 2.37 Ga and 2.21 Ga mafic dyke swarms through plume-lithosphere interaction.