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Geochemical study of disseminated nickel sulfides from the late Archean Shankaraghatta ultramafic-mafic complex, Western Dharwar Craton (southern India)

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The Shankaraghatta Complex, part of the Hegdale Gudda Formation of the Shimoga Supracrustal Group (2.8-2.7 Ga) [1] in the Western Dharwar Craton (southern India), is constituted by serpentinized dunites that are surrounded by talc-tremolite-actinolite-chlorite schists. The serpentinized dunites host disseminated sulfide globules (5 modal %) represented by pentlandite-millerite-pyrite with minor chalcopyrite and disseminated magnetites. The serpentinites represent the adcumulate-mesocumulate sheet flow facies of a komatiitic flow, and are flanked by komatiitic basalts, now represented by the schists. The strong LREE enrichment, negative Nb-Ta anomaly and trace element ratios like high La/Sm (1.8-3.5) and low Nb/Th (6.6) in the serpentinites indicate crustal contamination signatures. Trace element modelling suggests 12% Assimilation Fractional Crystallization (AFC) processes were responsible for sulfide-saturation, where the primary contaminant appears to be the Archean basement gneiss. Primary pentlandite composition is not preserved, and is represented by violarite. The presence of millerite and secondary magnetites indicate alteration of the primary magmatic sulfide assemblage, such as pentlandite and pyrrhotite (now exhausted), during the serpentinization process (T ≈ 500 – 300 °C). Pyrites and pentlandites are found to host platinum group minerals (PGMs) like Bi-bearing palladian melonites ($[(Ni, Pd)(Te, Bi)_2]$) and muckeiites($NiCuBiS_3$) , while irarsite (IrAsS), gersdorfite (NiAsS), hollingworthite (RhAsS) are hosted in the millerites. The serpentinization process was perhaps also responsible for remobilizing PGEs and semi-metals (As, Bi, Te, Sb) from the primary sulfides, which later precipitated as PGMs and alloys in a reducing environment. Interestingly, in-situ sulfur isotope studies on the pyrites show a narrow range of $\delta^{34}S$ (0.2-1.9 per mil) and non-zero $\Delta^{33}S$ (-0.01 to -0.14 per mil), which indicate magmatic signatures. This implies that despite the alteration of the primary sulfide and redistribution of PGEs, the sulfur isotope composition remains undisturbed during the serpentinization process. Weathering and oxidation of the sulfides also did not play a role to perturb the sulfur isotopes.

[1] Devaraju, Viljoen, Sawkar & Sudhakara (2009), Journal of Geological Society of India 73, 73–100.