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New behavior of Ni in the mantle wedge deduced from high-Ni olivine in a peridotite xenolith from Avacha volcano, the Kamchatka arc

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Nickel is one of the siderophile elements, and is concentrated in deep parts of the Earth, being one of the main elements in the core and mantle. Its concentration in the upper mantle olivine is rather constant, being about 0.4 wt% in NiO at Fo_{90}. The fine-grained harzburgite that contains the nickel-rich olivine comprises olivine, primary/secondary orthopyroxene, chromian spinel, amphiboles (tremolite to magnesiohornblende), and sulfide globules. The sample contains disseminated nickel-rich domains (mostly 300 μm), of which NiO content of olivine decreases gradually from the center (up to 4.8 wt%, equivalent to 4.7 mol.% of liebenbergite component, Ni_2SiO_4) outward to the normal mantle value (0.4 wt%). The nickel-rich olivine occasionally coexists with sulfide globules, which are homogeneous nickel-rich MSS with high (up to 0.9) and variable Ni/(Ni + Fe) ratios. Orthopyroxene also exhibits abnormally high NiO content (up to 1.1 wt%), compared to normal NiO content ($<$ 0.1 wt%). Chromian spinel has relatively high Cr# (= 0.48-0.65) and high ferric iron ratio (ca. 0.1). The spinel coexisting with the nickel-rich MSS is also high in NiO content (1.0 wt%).

The formation of nickel-rich olivine in mantle peridotite is accomplished only if a large amount of nickel sulfide melt are available in the upper mantle. This is possible only in the mantle wedge above subducting slab, which releases sulfur upward on dehydration. The metasomatism by sulfur-rich melt is especially prevalent beneath the volcanic front. This process forms metasomatized peridotites with high-magnesium, low-nickel olivines in addition to the nickel-rich olivine as in the case of Avacha peridotite. The mantle wedge likely has chemical heterogeneity in nickel: some part

is poor in nickel and compensated by nickel enrichment in some other part. Consequently, olivine, in addition to sulfide, can serve as a nickel reservoir, especially beneath the front, where material input is most active from the slab.