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A nickel-isotope perspective on planetary differentiation

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Nickel isotopes have been increasingly applied to the study of planetary formation and differentiation. Experimental and theoretical studies [1-3] predict that core-mantle differentiation-induced Ni isotope fractionation is limited for large planetary bodies, such as the Earth, but it can be considerably large in small bodies, as recorded in achondrite samples. So far, global mafic lithologies show relatively larger Ni isotopic variations and are systematically lighter relative to their mantle sources [3,4]. While both natural observations and theoretical calculations [5] suggest that mantle silicate melting would produce melts that are slightly enriched in heavier Ni isotopes, the light Ni isotopic signature observed in many basaltic rocks is best explained by an enhanced dissolution of sulfides, the major light-Ni host in the mantle, during mantle melting [6]. The Ni isotopic systematics in mantle-derived melts is a combined function of source sulfur fertility, melting degree, and sulfur concentration at sulfide saturation. Once extracted from the mantle, magmatic differentiation plays an important role in changing the chemistry of mafic melts towards a more felsic composition. Our comparative Ni isotopic study of a tholeiitic differentiation series from Kilauea Iki lava and a calc-alkaline differentiation series from the Kamchatka arcs found large Ni isotope fractionations. The degree and direction of isotope fractionation are mainly controlled by the tempo of onsets of magnetite crystallization vs. sulfide formation, which in turn, is a function of differentiation pressure and oxygen fugacity. Thus, Ni isotopes may offer a new means of studying planetary formation and differentiation.

[1] Lazar et al. (2012), *ChemGeol*, 86, 276-295; [2] Guignard et al. (2020), *GCA*, 269, 238-256; [3] Wang et al. (2021), *Nat Comms*, 12, 294; [4] Saunders et al. (2022), *GCA*, 317, 349-364; [5] Klaver et al. (2022), *ChemGeol*, 610, 121070; [6] Sheng et al. (2022), *JGR-Solid Earth*, 127, e2022JB02455