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Nickel isotope fractionation during magmatic differentiation

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There are two important magmatic differentiation series on Earth, the iron-enriching tholeiitic series and the iron-depleting calc-alkaline series. Magmatic differentiation at convergent margins leads to the formation of the primary building blocks of the continental crust, playing an important role in generating the distinctive calc-alkaline compositions of the continental crust. An increasing number of Ni stable isotopic data of terrestrial rocks and meteorites are now available and are applied to planetary formation and differentiation [1-6], while the behaviour of Ni isotopes during igneous differentiation remains poorly known.

Here, we investigate how Ni isotopes fractionate during differentiation processes along the tholeiitic and calc-alkaline series. The Ni isotopic compositions of a suite of well-characterized tholeiitic samples from the Kīlauea Iki (KI) lava lake, Hawai'i, formed during low-pressure differentiation at extremely low sulfur contents, show progressively lighter Ni isotopes with differentiation. By contrast, the Ni isotopic compositions of calc-alkaline volcanic rocks from the thick Kamchatka arc and a wide range of post-Eoarchean intermediate-felsic igneous rocks that are common constituents of continental crust are enriched in heavy Ni isotopes, significantly deviating from the low-pressure fractionation trend seen in the KI lavas.

We find that differentiation pressure and oxygen fugacity may have placed a major control on the stability of crystallizing phases as magmas differentiate (e.g., magnetite vs sulfide) which could significantly fractionate Ni isotopes, higher pressure may have suppressed magnetite crystallization while stabilized sulfide relative to low-pressure differentiation. Eoarchean TTGs have light Ni isotopes, comparable to the evolved KI lavas, implying a potentially low-pressure differentiation environment comparable to that of the KI lavas.

Thus, Ni isotopes may offer a new means of studying magmatic differentiation and processes of continent formation and differentiation.

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