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Tracing mantle heterogeneity using Mg and K isotopes

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Basalts provide a direct record of mantle composition, yet the origin of their chemical heterogeneity remains debated. Variations may reflect different degrees of partial melting, melt extraction, incorporation of recycled crustal materials, or preserved primordial domains. Non-traditional stable isotopes, particularly Mg and K, offer new tools to distinguish among these processes. Magnesium isotopes are sensitive to mantle lithology and melting processes due to their sensitivity to modal mineralogy and the presence of recycled mafic and sedimentary components. Systematic variations in oceanic basalts indicate that deviations from canonical mantle Mg isotope compositions can reflect contributions from recycled oceanic crust, sediment-derived melts, and lithological heterogeneity in plume and ridge sources. Potassium isotopes, by contrast, are strongly influenced by fluid–rock interaction, and low-temperature surface processes, providing a unique window into the cycling of incompatible elements and volatile-rich materials through subduction and back into the mantle. In this talk, I synthesize recent high-precision Mg and K isotope measurements in oceanic basalts and mantle-derived materials to evaluate how these systems jointly constrain mantle heterogeneity. Coupled Mg–K isotope systematics help assess the role of sediment recycling, metasomatism, and melt extraction, and provide constraints on source characteristics and melting conditions. Case studies from oceanic basalt and arc settings demonstrate that combined Mg and K isotopes can quantify mantle mixing, track volatile and incompatible element cycling, and better resolve the scale and origin of chemical heterogeneity in Earth's mantle.