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Equilibrium process dominated Si isotope fractionations in the oceanic basalts

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Isotope systems of major elements provide unique insight into the formation and evolution process of planetary bodies [1][2]. They have also been explored for tracing mantle source compositions [3]. However, the recent discovery of kinetically dominated Mg and Fe isotope fractionations in mid-ocean ridge basalt (MORB) has questioned the reliability of melts in determining the composition of planetary interiors for these isotope systems [4]. To re-examine the Si isotope variations in the terrestrial mantle and investigate whether Si isotopes are susceptible to diffusive fractionation during melt transport, we employed critical mixture double spike Si isotope analyses, achieving an analytical precision of ±0.03‰ (2s.d.) [5].

We determined high-precision isotope fractionations between mantle phases, $D^{30/28}Si_{Ol/Cpx}$ = 0.075±0.037‰, $D^{30/28}Si_{Ol/Opx}$ = 0.056±0.028‰, and $D^{30/28}Si_{Ol/Gar}$ of 0.123±0.075‰, and between melt and olivine, $D^{30/28}Si_{Ol/Melt}$ of −0.001±0.029‰. We also re-affirmed the homogeneous Si isotopic composition for accessible mantle of −0.308±0.013‰. Twenty-one MORB analyses, from fast to ultra-slow spreading ridges, have consistent Si isotope compositions and yield a mean value of −0.280±0.009‰ [6].

Our equilibrium partial melting calculations show peridotite melt exhibits $d^{30/28}Si$ value of ~ -0.28‰, which shows pleasing agreement with our empirical MORB measurements of −0.280±0.009‰ [6]. Unlike Mg and Fe isotopes, the absence of systematic $d^{30/28}Si$ variability in MORB from ridges of variable spreading rate, and the consistency between $d^{30/28}Si$ values empirically measured in MORB and those predicted by equilibrium partial melting modelling for peridotite melt, argue against kinetic fractionation of Si isotopes during melt transport [5]. The equilibrium process-controlled Si isotope fractionation makes the Si isotope system a reliable tool to reflect the information on the composition of the mantle both on Earth and other planetary bodies

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