

Large iron isotope fractionation during mantle wedge serpentinization

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Arc magmas are usually more oxidized than lavas from intraplate settings and spreading ridges. However, iron isotopes of arc magmas are generally lighter, and the mechanism is still controversial. The mantle wedge serpentinite provides new insights to resolve this issue. Here we show that mantle wedge serpentinites/serpentinized peridotites from the Mariana forearc mantle wedge have both heavy Fe isotopes ($\delta^{56}\text{Fe} = -0.01 - 0.15\text{‰}$) and high $\text{Fe}^{3+}/\text{SFe}$ values ($0.50 - 0.88$), which are positively correlated [1]. This indicates coupled iron oxidation and iron isotope fractionation induced by serpentinization in the mantle wedge. The high $\text{Fe}^{3+}/\text{SFe}$ values and high SO_3 contents of the mature serpentinites further suggest that the forearc mantle wedge is highly oxidized. Here we present a new mechanism for iron isotope fractionation and iron oxidation during mantle wedge serpentinization. Because iron solubility is low in the resultant high-pH fluids at the early stage of serpentinization, ferrous iron liberated during olivine serpentinization preferentially precipitates as serpentine, Fe-rich brucite, and magnetite in the serpentinite. After the full consumption of olivine during the late-stage serpentinization, ferrous iron becomes soluble and mobile in low-pH chlorine/sulfate-rich penetrating fluids, and is therefore released to the fluid with light Fe isotopes during progressive serpentinization, leaving the residual serpentinite with heavy iron isotopes. This suggests that mature serpentinites at the base of mantle wedge can act as a filter that sequesters ferric iron with heavy iron isotopes and liberates ferrous iron with light iron isotopes to the penetrating slab fluid, which migrate up to the above mantle wedge and even the mantle melting zone. The highly oxidized forearc mantle wedge serpentinites can also be dragged down to the subarc depth, releasing oxidizing fluids by dehydration. These processes may oxidize the arc mantle wedge coupled with light Fe isotopes, the fluxed partial melting of which consequently produces oxidized arc magmas with light Fe isotopes [1].

[1] Deng et al. (2022) *Earth Planet. Sci. Lett.* 583, 117423.