Zinc isotope evidence for sulphate-rich fluid transfer across subduction zones

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Subduction zones modulate the chemical evolution of the Earth's mantle. Water and volatile elements in the subducting lithosphere are released as fluids into the mantle wedge and this process is widely considered to result in the oxidation of the sub-arc mantle [1]. However, the chemical composition and speciation of the fluids released from the subducting slab remains poorly constrained. In particular, it is unclear what the role of slab fluids is with respect to sulphur or the economically-important transition metals and chalcophile elements. Here we used zinc stable isotopes ($\delta^{66}Zn$) in subducted Alpine serpentinites to decipher the chemical properties of slab-derived fluids. We showed that the progressive decrease in serpentinite $\delta^{66}Zn$ with increasing prograde metamorphic grade is correlated with a decrease in sulphur content. As theory predicts that $Zn\text{-}SO_4^{2-}$ complexes preferentially incorporate isotopically heavy Zn [2], our $\delta^{66}Zn$ serpentinite record provides direct evidence for the release of SO_4^{2-}-rich fluids during subduction-related serpentinite dehydration. As one mole of SO_4^{2-} can oxidize 8 moles of Fe^{2+}, sulphate-rich fluids are a powerful mantle wedge oxidizing agent [3]. We further demonstrate that these sulphate-rich fluids constitute efficient vectors for transition metal and chalcophile element transfer to the sub-arc mantle [4]. Zinc isotopes are thus a powerful tool that can be used to trace the release of oxidised sulphate-rich slab-derived fluids into to the mantle wedge and to identify their pathways.

[1] Evans *et al.* (2012) *Geology* **40**, 783-786. [2] Black *et al.* (2011) *Geochimica et Cosmochimica Acta* **75**, 769-783. [3] Kelley and Cottrell (2009) *Science* **325**, 605. [4] Bouilhol *et al.* (2012) *The Canadian Mineralogist* **50**, 1291-1304.