Zinc isotope fractionation at destructive plate margins and potential implications for the global recycling signature

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Our understanding regarding the behaviour of the fluid mobile element Zn at destructive plate margins is limited. In particular the fractionation mechanisms and input-output mass-balance remains to be investigated due to implications for the spatio-temporal cycling of this vital and socio-economically relevant element. In this study, we investigate the Zn isotope systematics of subduction input provided by IODP samples from the SW Pacific in comparison to lavas from the central Tonga arc, addressed as a worldwide endmember in terms of pre-subduction mantle wedge depletion. With an improved analytical precision, we report subtle, yet resolvable Zn isotope variations between the central Tongan islands, with an overall statistically relevant variation of 0.05‰ (at ±0.014‰ 2SD). The signatures are all > 0.1‰ lighter than the subduction input at this site, suggesting a fractionation process during subduction. After careful extraction of the isotopic effect caused by mantle melting processes (using DMM δ66/64Zn provided by Sossi et al. (2018) and Wang et al. (2017) and melt extraction indices such as Sm/La, Zr/Nb, and Zn/La), a pronounced negative correlation is observed between the Zn isotopic composition of the lavas and key fluid indicators such as Ba/Th and Ce/Pb. Together with predictions from ab initio calculations and mixing models performed between Indian DMM and Rayleigh dehydration of the subducting slab, we attribute the remaining, subtle Zn isotope variations to additions by Cl-rich fluids to the individual mantle wedges. A maximum of 5% chlorine-fluid contribution is suggested for the magmatic source of Tofua, whereas smaller proportions are estimated for Kao, Late and Ata. Overall, this study sheds new light on Zn fractionation mechanisms in sediment-poor subduction zones. Implications for the long-term Zn recycling will be addressed in this presentation.

References:

