

The effect of chlorine on the transport of trace elements in subduction zones

*Greta Rustioni¹, Andreas Audetat¹, Hans Keppler¹

1. Bayerisches Geoinstitut, University of Bayreuth, 95440 Bayreuth, Germany

It is generally accepted that arc magmas are produced by partial melting of the metasomatized mantle wedge overlying the subducting slab. However, the exact nature of the slab-derived mobile phase that triggers mantle melting is still under debate. The standard model (Gill 1981; Arculus and Powell 1986; Tatsumi 1989; Peacock 1990) assumes that the mobile phase is an aqueous fluid released by the breakdown of hydrous minerals contained in the subducting oceanic lithosphere. On the other hand, some studies (e.g. Hermann et al. 2006; Spandler and Pirard 2013) suggested that fluid transport of trace elements is too inefficient to explain the enrichment observed in arc magmas. Hydrous melts produced by direct melting of the subducting slab have therefore sometimes been proposed as the main agents of mantle metasomatism.

However, although the ability of water to dissolve ions is reduced along subduction path, the presence of ligand may enhance the solubility of trace elements as neutral complexes. In subduction zone fluids, chlorine is considered one of the most relevant complexing agents due to its chemical affinity and elevated abundance (Keppler 2017 and references therein).

To evaluate the effect of Cl on trace element partitioning between aqueous fluids and eclogitic minerals at subduction zone conditions, a series of piston cylinder experiments was conducted at 4 GPa and 800 °C, with a MORB glass as solid starting material. Initial fluid salinities ranged from pure water to 10 wt. % NaCl solutions, covering the range of compositions typically observed in subduction zones. The experiments produced an eclogitic mineral assemblage consisting of garnet, omphacite, kyanite and rutile. Quenched fluids were sampled with the diamond trap method. This technique allows to directly obtain the composition of the fluid in equilibrium with the minerals using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) together with a freezing chamber, as both the frozen fluid and the fluid components that precipitate upon quenching can be analyzed together. LA-ICP-MS analyses were also carried out for the solid phases to determine fluid/mineral partition coefficients.

The results indicate that chlorine may increase the fluid/mineral partition coefficient of Large-Ion Lithophile Elements (LILE) by up to two orders of magnitude for salinities typical of natural subduction zone fluids. Enhanced partitioning into the fluid was also observed for the Rare Earth Elements (REE), with the light REE partitioning preferentially into the fluid for high salinities. On the other hand, the behavior of High-Field Strength Elements (HFSE) is less affected by the addition of Cl. The presence of chlorine therefore tends to enhance the characteristic negative Nb-Ta anomaly of arc magmas. Overall, the preliminary data obtained in this study suggest that in most cases, Cl-bearing aqueous fluids are likely the mobile phase responsible for metasomatism and melting in the mantle wedge.

References

Arculus, R., and Powell, R. (1986) Source component mixing in the regions of arc magma generation. *Journal of Geophysical Research*, 91, 5913-5926.

Gill, J. (1981) Orogenic andesite and plate tectonics. Springer Berlin.

Hermann, J., Spandler, C., Hack, A., and Korsakov, A. (2006) Aqueous fluids and hydrous melts in high-pressure and ultra-high pressure rocks: implications for element transfer in subduction zones. *Lithos*, 92, 399-417.

Keppler, H. (2017) Fluids and trace element transport in subduction zones. *American Mineralogist*, 102(1), 5-20.

Spandler, C., and Pirard, C. (2013) Element recycling from subducting slabs to arc crust: A review. *Lithos*, 170, 208-223.

Peacock, S. (1990) Fluid processes in subduction zones. *Science*, 248(4953), 329-337.

Tatsumi, Y. (1989) Migration of fluid phases and genesis of basalt magmas in subduction zones. *Journal of Geophysical Research*, 94(B4), 4697-4707.

Keywords: subduction zone, fluids, chlorine, trace elements, partition coefficients, diamond trap