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Trace Element Mobility in Subduction Zone Fluids. An Experimental Study.

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Our understanding of fluid transport processes in subduction zones is rather limited. Whilst mid-ocean-ridge basalts show a depletion of incompatible elements, such as Ba, Rb or Th, island-arc basalts display a relative enrichment of these elements, whereas the high field strength elements (HFSE) are depleted. Recent experimental results at very high pressures (corresponding to 120-180 km depths) show strong effects of pressure and temperature on the composition of the fluid phase liberated from the subducting slab (Kessel et al., 2005). However, the aim of our study is to evaluate the influence of fluid composition and residual mineralogy on trace element signature of high-temperature high-pressure (Hp-HT) fluids at moderate pressures between 5 and 20 kbar.

This study presents a modified experimental approach to study trace element composition of HP-HT fluids with LA-ICP-MS (Laser Ablation- Inductively Coupled Plasma- Mass Spectrometry). The experiments were conducted in an end-loaded piston-cylinder apparatus at Münster University. The starting material consists of a synthetic mixture of average altered mid-ocean-ridge basalt (MORB) composition doped with 27 trace elements. We use a 200 ppm Cs standard solution as an internal standard for the measurements with LA-ICP-MS. We employ diamond aggregates in our experiments to capture fluids (Kessel et al., 2005), which are equilibrated with a residual mineral assemblage of basaltic bulk composition. After quenching of the experiments, the capsule was frozen, then sectioned and placed in a home-built freezing stage, designed to fit a 193 nm New Wave Laser system, to ensure constant temperature during the whole duration of the analysis.

The preliminary experiments on trace element mobility in subduction zone fluids show, that element fractionation take place during the dehydration of the oceanic crust in depths of 20-70 km controlled by metamorphic fluids. The composition of the fluids is primarily a function of the temperature and displays no apparent pressure dependence. The fluid mobile trace elements are fractionated from the more less mobile trace elements, such as Th, Nb or Ta by metamorphic fluids. The concentrations of the rare earth elements, primarily the light rare earth elements, increase with increasing temperature. Our data show that U, Ta and Ba are much more mobile in a fluid phase than refractory elements, such as Nb, Th or Yb. Furthermore our data displays a fractionation of HFSE during the interaction with metamorphic fluids, which can be observed in the decrease of Nb/Ta with increasing temperature in the fluid.

Reference:
Kessel, R, Schmidt, MW, Ulmer, P, Pettke, T (2005): Trace element signature of subduction-zone [U+FB02]uids, melts and supercritical liquids at 120–180 km depth. Nature, 437, 724-727