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Experimental halogen partitioning between earth upper mantle minerals and silicate melt

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Owing to their incompatibility, halogens have similar geochemical properties to noble gases in many systems and may therefore be used as key tracers of volatile transport processes in the earth. Halogen fractionation may occur during partial melting of the upper mantle, fractional crystallization or partitioning between immiscible fluids. Experimental determination of the halogen partitioning behaviour is the basis for the investigation of the concentration and distribution of halogens in the earth´s mantle.

High P-T partition experiments were performed in a piston cylinder apparatus using a model primitive mantle composition proposed by Jagoutz et al. (1979) simplified to the four components CaO, MgO, A_2lO_3 and SiO_2 (CMAS) according to the procedure of O´Hara (1968). Defined small amounts of halogens (0.2 wt%) were added as CaF_2, $CaCl_2$ and $CaBr_2$. All experiments were first heated up to 1720˚C and then cooled slowly to the target temperature to guarantee growth of large homogeneous crystals, following the method of Beyer et al. (2011). Pressures range between 1.0 GPa and 2.5 GPa and final experimental temperatures between 1500˚C and 1600˚C, thus representing partial melting conditions of the earth upper mantle.

Back-scattered electron images of polished samples show euhedral, almost rectangular forsterite grains or a mixture of euhedral forsterite and pyroxene grains with a side length of up to 150 μm, which are embedded in a MORB-like melt.

Electron microprobe analysis reveals a homogeneous major element composition of the forsterite and pyroxene single crystals as well as of the melt. Halogen mapping, measured via Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS), shows no concentration gradients within the minerals or within the melt. These observations suggest that the experiments were performed at equilibrium conditions.

The fact that we were able to produce large pyroxene and forsterite crystals at equilibrium conditions in a halogen doped system, which simulates partial melting and fractional crystallization processes in the earth´s upper mantle, allows us to determine the partitioning behaviour of fluorine, chlorine and bromine between silicate melts and pyroxene as well as forsterite using TOF-SIMS.