Synthetic fluid inclusions in olivine: An experimental technique for fluid-melt trace element partitioning in basaltic systems

A. ZEMLITSKAYA[1], R.E. BOTCHARNIKOV[1,2], I.T. DERREY[2], M.V.PORTNYAGIN[3,4], R. MERTZ-KRAUS[1], S. BUHRE[1], S.WEYER[2], F. HOLTZ[2]

[1]Inst. Geosc., Mainz Univ., 55128 Mainz, Germany
[2]Inst. Miner, Hannover Univ., 30167 Hannover, Germany
[3]GEOMAR, 24148 Kiel, Germany
[4]Vernadsky Institute, 119991 Moscow, Russia

The synthetic fluid inclusion approach is widely used in expeimental studies on trace element partitioning between magmatic or hydrothermal phases. Traditionally, fluid inclusions are trapped in quartz which has a simple composition, contains low level of trace elements and is relatively inert to chemical reactions in quartz-saturated systems. The disadvantage of this technique is that it is restricted to the conditions where quartz is stable, limiting its applicability to felsic magmatic/hydrothermal systems. We present a method utilising synthetic fluid inclusions in olivine at conditions suitable for basaltic magmas. This novel experimental technique enabled us to derive partition coefficients between Cl- and S-bearing aqueous fluids and basaltic melts ($D_{fluid/melt}$) for a number of trace elements.

In this approach we used pre-cracked San Carlos olivine as a trap for fluid inclusions and natural basaltic melt representative for Mutnovsky volcano. Fluid was added as an aqueous solution with different NaCl and S concentrations. All solutions were dopped with Rb, Sr and Cs to provide internal references for LA-ICP-MS analyses of trace elements after experiments.

A series of experiments at T = 1030 °C, P = 300 MPa, log fO_2 close to NNO+1 and fluid-saturated conditions was conducted in an internally heated pressure vessel. Kinetic runs were used to test the efficiency of inclusion entrapment and attainment of equilibrium. The basaltic glasses were analyzed by EMPA and LA-ICP-MS, whereas fluid inclusions were analyzed by microthermometry and LA-ICP-MS using UV-femtosecond-laser and freezing cell.

Although the analytical approach for fluid inclusions in olivine is more challenging than that in quartz, the first results demonstrate an affinity for the fluid phases ($D_{fluid/melt}$>1) for a number of studied elements (e.g., B, Na, Cu, Zn, Rb, Cs, Hf, Au, Pb) and relatively low ($D_{fluid/melt}$ <1) values for others (e.g., Al, Ca, Sr, Ba). Furthermore, the data show a significant difference to the fluid-melt partitioning of elements in rhyolitic systems.