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Partitioning of Ba, La, and Y between haplogranitic melts and aqueous fluids: in-situ vs. ex-situ analysis

Manuela Borchert (1), Max Wilke (2), Christian Schmidt (2), and Jean Cauzid (3)

(1) Deutsches Elektronen Synchrotron, Hamburg, Germany (manuela.borchert@desy.de), (2) Helmholtzzentrum Potsdam, Deutsches GeoForschungsZentrum (GFZ), Potsdam, Germany, (3) G2R, Nancy-Université, Vandœuvre-lés-Nancy, France

Barium, lanthanum, and yttrium partitioning experiments between fluid-saturated haplogranitic melts and aqueous solutions were performed at 750 to 950°C and 0.2 to 1 GPa to investigate the effects of melt and fluid composition, pressure and temperature. Partition coefficients were determined using different experimental and analytical approaches. On the one hand quenched experiments were performed, and on the other hand, trace element contents in the aqueous fluid were determined directly at elevated temperatures and pressures using a hydrothermal diamond-anvil cell and synchrotron radiation X-ray fluorescence microanalysis of K-lines. The latter required a high excitation energy of 50 keV due to the high energies necessary to excite K-lines of these elements. Furthermore, a small spot size is of advantage to avoid mixed analyses of fluid and melt. Both, a high excitation energy and a small beam size, were achieved for the first time via application of a new Kirkpatrick-Baez mirror at beamline ID 22 (ESRF, France).

The data from these two techniques showed good agreement for chloridic solutions, whereas quenching had a significant effect on results of the experiments with only water in the case of Ba. In Cl-free experiments, lanthanum and yttrium, trace element contents were even below detection limit in the quenched fluids, whereas small concentrations were detected in comparable in-situ experiments. This distinct difference is likely due to back reactions between fluid and melt upon cooling.

The partitioning data of all elements show no dependence on the temperature and only small dependence on pressure. In contrast, the partitioning are strongly influenced by the composition of the starting fluid and melt. For chloridic fluids, there was a sharp increase in the Ba, La, and Y partition coefficients with the alumina saturation index (ASI). The Ba partition coefficient increased from 0.002 at an ASI of 0.8 to 0.55 at an ASI of 1.07. At higher ASI, it decreased slightly to 0.2 at an ASI of $\sim$1.3. Likewise, it was one to two orders of magnitude higher in chloridic fluids compared to those found in H2O experiments. Fluid-melt partition coefficients of La and Y increased from 0.002 at an ASI of $\sim$0.8 to $\sim$0.1 at an ASI of 1.2. Even at high salinities all elements fractionate into the melt. The compositional dependence of the partitioning data imply that both melt composition and fluid composition have a strong influence on trace element behavior and that complexation of Ba, La, and Y in the fluid is not only controlled by the presence of Cl^- in the fluid. Instead, interaction of these elements with major melt components dissolved in the fluid is very likely.

Reference:

Borchert et al. (2010). Partitioning of Ba, La, Yb, and Y between haplogranitic melts and aqueous solutions: an experimental study. Chem. Geol. 276, 225-240.