How fluids mobilize rare earth elements: An in-situ XAS study of REE hydrothermal speciation

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The role of hydrothermal fluids in the formation of REE (+Sc,Y) ore deposits has proven particularly difficult to assess from field observations. Fluid inclusions studies and petrological reconstructions indeed suggest that, depending on primary source and evolution of the magmatic-hydrothermal system, the poorly soluble REEs may be mobilized by highly acidic to alkaline fluids containing high amounts of F, Cl, sulfates, carbonates and/or phosphates [1,2].

The role of theses different ligands is itself a matter of debate, as early studies invoked the formation of REE-fluoride complexes [3], while more recent thermodynamic model suggests that chloride and sulphate complexes may play an important role at T > 200 °C [4]. However, the extrapolation of these models towards magmatic-hydrothermal temperatures at which the first mineralizing fluids may be released from carbonatic or alkaline intrusions (450 - 600 °C) suffers from large uncertainties as the experimental database on which they are build is limited to T < 300 °C.

In order to provide a stronger basis for the development of reactive transport models applicable to REE ore genesis, we have conducted a serie of *in-situ* X-ray absorption measurements (XAS) at the ESRF synchrotron (Grenoble, France) to investigate the aqueous solubility and speciation of La, Sm, Nd, Eu, Gd, Er, Yb and Y up to ~ 500 °C and 50 - 80 MPa [5,6]. These experiments provide us with an updated molecular-level understanding of rare earth complexing in Cl^-, F^-, PO_4^{3-}, CO_3^{2-} and SO_4^{2-}-bearing fluids with 1 < pH < 14 and enable us to discuss how pressure, temperature and different ligands may control REE hydrothermal mobilization and fractionation in different environnements.

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