Mobility of Chromium in Aqueous Fluids as a Function of Temperature, Pressure and Fluid Composition

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Recent studies detected abundant Cr in geological environments that experienced fluid metasomatism, e.g., chromitite with hydrous silicate inclusions in ophiolites [1]; Cr-rich eclogite-facies veins cutting metagabbros [2]; and Cr-rich garnet associated with diamond [3]. However, the mechanism for the mobility of chromium in the deep Earth fluids is poorly understood.

To investigate the mobility of Cr in deep Earth fluids we developed a thermodynamic characterization of eskolaite (Cr_2O_3) and picrochromite ($MgCr_2O_4$) integrated with the thermodynamic properties of numerous aqueous Cr(II), Cr(III), Cr(VI) species. We used experimental measurements of the solubility of Cr_2O_3 in HCl fluids at 500°C – 700 °C and 0.1 – 1.0 GPa and the result of ab initio calculations [4] to retrieve equilibrium constants of a $CrCl(OH)^0$ complex. The Deep Earth Water Model was used to develop a thermodynamic equation of state of this complex. Together with other predicted aqueous Cr-species we calculated the solubility of Cr_2O_3 at 650°C and 10 kbar at QFM to QFM-2 in fluids in equilibrium with pelitic schist. We found a range from 6 ppm to 340 ppm with Cl from 0.5 to 5 molal. However, at less than about 500°C at 10 kbar and low pressures, the solubility of Cr is less than 1 ppm. At 350°C and 2 kbar, it is less than 0.001 ppm. Mass transfer modelling of the pelitic fluid at 650 °C and 10 kbar reacting with dunite, harzburgite and lherzolite resulted in the formation of picrochromite. Our results provide an explanation for the transport of Cr by high temperature fluids, for example in subduction zones, and potentially the formation of Cr-rich minerals.

[1] Arai & Miura (2016) Lithos, 264**, 277-295. [2] Spandler** et al. **(2011)** J. Petrol 52.6, **1207-1236. [3] Klemme** et al. **(2009)** Lithos, 112S**, 986-991. [4] Watenphul** et al. **(2014)** Geochim. Cosmochim. Acta 126, **212-227.**