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Peralkaline fluid composition in equilibrium with K-feldspar, muscovite and quartz at 10 kbar and 700°C: Al transport in crustal fluids

A. Wohlers (1) and C.E. Manning (2)

(1) GFZ German Research Centre for Geosciences, Section 3.3, Potsdam, Germany (Anke.Wohlers@gfz-potsdam.de), (2) Department of Earth and Space Scienes, University of California at Los Angeles (UCLA), Los Angeles, CA, USA

Aluminum is commonly regarded as one of the least soluble elements during metamorphic and metasomatic processes. However, abundant field evidence suggests that aluminum transport can occur in natural hydrothermal processes. For example, late formed aluminumsilicate-bearing and muscovite-bearing veins are widely observed in high-grade metamorphic rocks, and provide a persuasive argument for considerable mobility of aluminum in aqueous fluid. The present study explores the fluid composition coexisting with K-feldspar (K-fsp), muscovite (ms), corundum (co) and quartz (qz) at deep crustal metamorphic conditions, using a piston cylinder device at 10 kbar and 700°C. Starting materials of natural microcline, quartz, synthetic corundum, reagent Al_2O_3 and $KSi_3O_6.5$ glass was used.

Ms and K-fsp dissolve incongruently to co + fluid and ms + fluid, respectively. Fluid composition in equilibrium with co + ms and ms + K-fsp were located in experiments with and without qz. In quartz-absent experiments fluid composition with co+ms (I1) is m_{Al} = 0.11, m_K = 0.15, m_{Si} = 0.44, and with K-fsp + ms (I2) m_{Al} = 0.18, m_K = 0.28 and m_{Si} = 0.81, where m_i is molality of the subscripted element. Fluid compositions with qz are: m_{Al} = 0.08, m_K = 0.11 and m_{Si} = 1.18 (co + ms + qtz; II1) and m_{Al} = 0.18, m_K = 0.29 and m_{Si} = 1.58 for (K-fsp + ms +qtz; II2). Measured fluid compositions are peralkaline (K/Al < 1.4). Bulk solubility of Al in pure H_2O at this P and T is reported to be ∼0.3 wt% [1], and increase to ∼1.9 wt % Al in the presence of SiO_2 [2]. This study shows that Al solubility is further enhanced by the presence of K and Si, increasing from ∼4.07 wt% for (I1) to ∼ 7.14 wt% at (I2). Presence of quartz enhances the bulk solubility from ∼ 7.63 wt% (II1) to ∼ 12.05 wt % at (II2).

Results indicate that substantial aluminum transfer may occur at deep-crust metamorphic conditions in aqueous solutions equilibrated with common crustal bulk compositions such as metapelites and granites. Such high Al mobility is promoted by K and Si. Large-scale Al transfer may explain the formation of aluminumsilicate- and muscovite-bearing veins by replacement of K-feldspar in metamorphic rocks, without appealing to either strongly acid or basic solutions.

[1] Tropper and Manning (2007) Chem. Geol. 240, 54-60. [2] Manning (2007) Geofluids 7, 258-269.