

Experimental Determination of the Solubility of Diaspore in Pure H₂O at 0.5-2 GPa and 350-450 Degrees C

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The solubility of diaspore in pure H₂O has been determined from 0.5-2 GPa. at 350-500 degrees C. This provides for the first time constraints on the mobility of aluminium in aqueous fluids at high pressures and low to moderate temperatures. Aluminium is the third most abundant element in the earth's crust and is a component of most of the major rock-forming minerals. If we are to understand the major element content of the aqueous fluids that interact and react with crustal materials, we must understand the solubility of aluminium in these fluids. Although the properties of aqueous aluminium species have been extensively examined under vapor saturated conditions through solubility measurements of aluminium hydroxides and oxyhydroxides in non-neutral solutions, experimental work at high pressure is much more limited. Experimental work in the Al₂O₃-H₂O system at high pressure and is largely restricted to corundum solubility experiments conducted at pressures of under 0.6 GPa. Many of these studies differ by roughly an order of magnitude under the same conditions, probably due to equilibration problems. Only the work of Becker et al. (1983) extends to pressures greater than 0.6 GPa. and while this work explored pressures up to 2.0 GPa., it was limited to the 700 degrees C isotherm. This lack of experimental data at high pressures must be addressed if we are to understand the fluid flow interactions that occur at depth. Evidence for the high mobility of aluminium at depth can be seen in aluminosilicate mineral veins (e.g. Ague, 1995). In subduction zone environments, exhumed blocks containing jadeite and albite veins (Coleman, 1961) illustrate the mobility of aluminium in high pressure and low to moderate temperature environments. It is observations such as these that motivated these experiments.

The experiments were conducted using both natural diaspore from Chester, MA and microcrystalline diaspore. This diaspore was synthesized by bringing Al₂O₃ powder and nanopure H₂O to 15 kbar and 400 degrees C for ~90 hours. For these solubility experiments, the capsule design was modified from Manning

and Boettcher (1994) and were placed in a 2.54 cm. diameter NaCl-graphite furnace assembly and brought to pressure and temperature in an end-loaded piston-cylinder apparatus as described in Manning and Boettcher (1994) where they remained for >80 hrs. Equilibrium was obtained in under 70 hours. Solutions were extracted in 10 ml 5% HNO₃ and analyzed by Inductively-Coupled-Plasma spectroscopy (ICP). In some cases solubilities were also measured by weight loss, which showed close agreement to the ICP results.

The results of these experiments show that diaspore solubility in pure water under the conditions of this study results in aluminium concentrations that range from log molality of -3.7 at 0.5 GPa. and 350 degrees C to -1.9 at 1.0 GPa., 500 degrees C (outside or on the boundary of the devolatilization of diaspore to form corundum and H₂O). Solubility increases with increasing temperature and with increasing pressure. Solubilities are one to two orders of magnitude below that predicted for Si but orders of magnitude higher than predicted using the Helgeson-Kirkham-Flowers equation of state and the data for the aluminium species of Pokrovskii and Helgeson (1995). Solubilities are comparable to corundum solubilities measured by Walther (1997) extrapolated to higher pressures, although slightly higher than the solubilities measured by Becker (1983) at the higher temperature of 700 degrees C.

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