Near-solidus solubility of alkali feldspar-mica-quartz in H_2O at 1 GPa: Implications for crustal fluids

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At temperatures just below the quartz-saturated wet solidi of albite (Ab) and K-feldspar (Ksp) in the middle and lower crust, quartz (Qz) solubility in H_2O is high [1] and there is strong complexing between aqueous Al and Si [2,3] and possibly alkalis. These observations suggest that near-solidus fluids may be quite concentrated solutions which are capable of substantial mass transfer. We carried out experiments on the solubility of Ab+Qz (580-630°C) and Ksp+Qz (700°C) in H_2O at 1 GPa. Experiments were conducted in a piston-cylinder apparatus using 2.5-cm NaCl-graphite furnaces and a double-capsule method [4]. In both systems, mica (paragonite, Pg, or muscovite, Mu) was present in all run products, indicating that Ab+Qz and Ksp+Qz dissolve incongruently in H_2O. The bulk solubility of Ab+Pg+Qz doubles from 4 to 8 wt% as the solidus (640°C) is approached, with corresponding increases in Si, Al, and Na molalities. Over the same T range, molar Na/Al and Na/Si respectively decrease (2.1 to 1.5) and increase (0.15 to 0.18), indicating that fluids are Na- and Si-rich peralkaline solutions far from Ab stoichiometry. The bulk solubility of Ksp+Mu+Qz at 700°C is even greater (25 wt%), and molar K/Al=15 at K/Si=0.33. Measured Ab+Pg+Qz solubility at 580°C is in fair agreement with predictions from extrapolated thermodynamic data [5], but becomes much greater than predicted as T increases to the solidus. Ksp+Mu+Qz solubility at 700°C is also much greater than predicted. The observations point to strong, pre-melting increases in the extent of polymerization of aqueous species in the narrow 50°C interval immediately below the solidi in these model granitic systems. Polymeric aqueous species involving Na and/or K, along with Al and Si, predominate in model near-solidus and melt-saturated fluids, and provide a simple mechanism for metasomatic mass transfer in deep magmatic systems and Barrovian metamorphism [6].

[1] Manning (1994) *GCA* **58**, 4831-4839. [2] Manning (2007) *Geofluids* **7**, 258-269. [3] Newton & Manning (2003) *GCA* **71**, 5191-5202. [4] Manning & Boettcher (1994) *Am. Min.* **79**, 1153-1158. [5] Manning (1998) *Swiss Bull. Min. Pet.* **78**, 225-242. [6] Ague (1994) *AJS* **294**, 1061-1134.

Relationships between µm-scale melt inclusions and oscillatory trace element zoning in olivine

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Oscillatory zoning of trace elements P, Cr and Al in otherwise unzoned magmatic olivines may preserve information on early crystallisation histories [1, 2], because the higher diffusivities of Mg, Fe, Mn, Ca and Ni inhibit preservation of such clues in the major and minor elements. Concentrations of P in trace-element-rich bands exceed expected equilibrium values, and similar enrichment bands are observed in olivines grown experimentally at constant cooling rate [2]; thus, it seems likely that this phenomenon in natural olivine reflects local kinetic processes during crystal growth rather than oscillations in magma temperature or bulk composition.

Olivines from a subaerial Hawaiian basalt contain P-rich bands, some of which contain 1-5µm melt inclusions. The geometry of these inclusion-bearing bands suggest that they represent “stratigraphic markers” formed during crystal growth, outlining euhedral crystal shapes visible in 3-d. The melt inclusions appear to have nucleated on 1-2 µm Cr-spinels and all share the same orientation regardless of the P-zonation planes (bands) in which they occur. We hope to determine whether disequilibrium growth effects or transcrystalline melt transport (driven by thermal [3] or chemical gradients) control this peculiar melt inclusion distribution, and to what extent melt inclusions and trace element zoning are causally linked.

We used a nanoSIMS 50L ion microprobe to examine the relationship between µm-scale trace element zonation of olivine surrounding linear arrays of melt inclusions within P-rich bands. Initial imaging at 200nm resolution indicates that such bands are 3µm wide. As with meso-scale X-ray mapping [1], Cr and Al are positively correlated with P variations, although they exhibit broader (0.7-1.5µm compared with 0.3-0.8µm for P) compositional gradients at the edges of each band, consistent with diffusive broadening of an initially sharp gradient over a timescale of weeks to months.

[1] Milman-Barris *et al.* (2008, in press) *CMP.* [2] McCanta *et al.* (2008) *LPSC* abstract [3] Schiano *et al.* (2006) *Science* **314**, 970-974.