The sanidine–'sanidine hydrate' reaction boundary

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Potassium feldspar has been found, experimentally, to be stable at mantle pressures and temperatures. However, in the presence of water, Seki and Kennedy (1964) synthesised a hydrate phase of comparable structure to the 'barium feldspar hydrate', cymrite. A series of reversal experiments has been done on the reaction:

$$KAlSi_3O_8 + nH_2O \rightleftharpoons KAlSi_3O_8.nH_2O$$

in the pressure range 2–3 GPa and temperature range 450–68°C

Experimental techniques

Reversals were carried out in the piston cylinder apparatus using a charge assembly consisting of boron nitride pieces within a furnace surrounded by a salt outer sleeve. The temperature was read with a $Pt/Pt_{87}Rh_{13}$ thermocouple. The pressure was calibrated using the quartz-coesite transformation and no pressure correction was found to be necessary. The starting material used for the reversals was a mixture of 40% 'sanidine hydrate' (synthesised at 3 GPa and 550°C in the piston cylinder apparatus) and 60% sanidine (synthesised at 0.1 GPa and 750°C in the cold seal apparatus) both of which were initially synthesised from a $KAlSi_3O_8$ gel. The products were analysed using X-ray powder diffraction. A change in the relative peak intensities implying a reaction of >15% was taken as a reasonable indication of stability. Some samples that contained only one phase were run with an internal standard to correct for systematic errors so that the cell parameters could be refined.

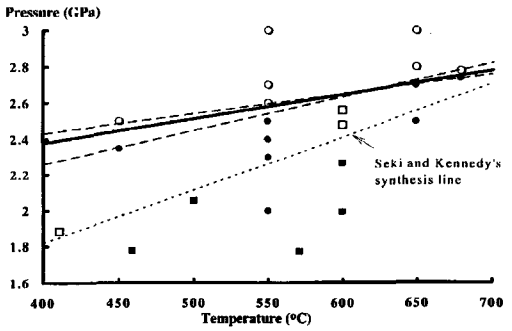

FIG. 1. Results of reversal experiments in comparison with the synthesis line as determined by Seki and Kennedy (1964). ○ = 'sanidine hydrate', ● = sanidine, ——— = best fit line for reversed reaction, – – – = max/min gradient of possible reaction lines, □ = S + K's 'sanidine hydrate', ■ = S + K's sanidine.

Results

The reversal results are plotted in figure 1. The equilibrium line is at a higher pressure than the synthesis line determined by Seki and Kennedy. A preliminary investigation of the X-ray powder diffraction trace gave cell parameters for a hexagonal primitive cell of: a = 0.5319 nm, c = 0.7629 nm, volume = 0.18691 nm^3 c/a = 1.434. If the formula of 'sanidine hydrate' has one H_2O molecule per formula unit (i.e. $KAlSi_3O_8{\cdot}H_2O$) and this composition does not vary with pressure and temperature, simple thermodynamic calculations show that $\Delta_{Hf,298} = -3717.25 \pm 3$ $kJmol^{-1}$ $\Delta S_{f,298} = 0.397 \pm 0.006$ $kJK^{-1}mol^{-1}$. However, in the light of what is known about cymrite (Graham *et al*, 1992), the assumption of constant composition may be incorrect. The water content and the structural character of the water still needs to be determined from thermogravimetric analysis and infrared spectroscopy. These should reveal how the water content varies with pressure and temperature of formation. Pressure (GPa)

The wet melting curve of sanidine (Goldsmith and Peterson 1990) would intersect this reversed reaction at approximately 700°C. Very little evidence has been found so far for the existence of a field containing the 'Granular Incoherent Brownish Isotropic Substance' (GIBIS) found by these authors. 'Sanidine hydrate' can exist only at high pressures equivalent to depths in excess of 60 km i.e. in the lower crust or upper mantle,in regions of low geothermal gradient.

References

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