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Determining the coherent solvus for alkali feldspar

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Alkali feldspar is one of the most common rock forming minerals in magmatic and metamorphic rocks. It forms a solid-solution between the sodium and potassium end members. At temperatures above about 600°C alkali feldspar shows continuous miscibility. Towards lower temperatures, a miscibility gap exists. When cooled from super-solvus temperatures into the two phase region of the phase diagram, alkali feldspar of intermediate composition exsolves forming coherently intergrown lamellae of Na-rich and K-rich alkali feldspar, a microstructure referred to as perthite. The compositions and the characteristic widths of the exsolution lamellae reflect the cooling history. For a quantitative retrieval of cooling rates the thermodynamics of the solid solution including the effect of coherency strain and Na-K interdiffusion, which determines the coarsening kinetics, must be known.

Four alkali feldspars with different degrees of Al-Si ordering were investigated, namely Madagascar Orthoclase, Volkesfeld Sanidine, Zillertal Adular and Zinggenstock Adular. For each feldspar a ther- modynamic mixing model describing the strain free solvus was derived from feldspar-NaCl-KCl salt Na-K partitioning experiments performed at 800°C, 900°C and 1000°C. The models show increasing non-ideality with increasing degree of Al-Si ordering. The corresponding coherent solvi and spinodes were calculated using the strain energy function of Robin (1974).

The coarsening kinetics was obtained from exsolution experiments. To this end, each alkali feldspar was shifted to intermediate compositions by exchange with NaCl-KCl melt at 900°C for 35 days and subsequently tempered at 440°C, 480°C, 520°C and 560°C for 4, 8, 16, 32, 64, 128 or 256 days. Analyses of the run products by pXRD revealed splitting of reflections of the lattice planes that are subparallel to the lamellae subparallel to (-801), a feature that is diagnostic for coherent exsolution in feldspar. TEM investigation of foils extracted perpendicular to the crystallographic **b**-axis revealed fully coherent lamellae and lamellar widths between 8 and 30 nm. Lamellae growth rates were obtained from the time series experiments. For a given annealing time and temperature Madagascar Orthoclase shows relatively sharp and thick lamellae as compared to the other three feldspars. The coherency strain was derived from a comparison of the lattice parameters determined for the Na-rich and the K-rich lamellae by pXRD measurements

of the experimental products with those of strain free feldspar as given by Kroll et al. (1986). The strain energy density calculated for the coherent intergrowth is by a factor of two smaller than the one given by Robin (1974).

Kroll, H., Schmiemann, I., and Cölln, G. (1986). Feldspar solid solutions. American Mineralogist, 71:1–16.

Robin, P.-Y. F. (1974). Stress and strain in cryptoperthite lamellae and coherent solvus of alkali feldspars. Am Mineral, 59:1299–1318.