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Na-K interdiffusion and coherent exsolution in alkali feldspar

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Sanidine is a widespread liquidus phase in K-rich volcanic rocks. At temperatures above about 600°C it forms a continuous solid-solution between $KAlSi_3O_8$ (Ksp) and $NaAlSi_3O_8$ (Ab) with minor admixtures of $CaAl_2Si_2O_8$(An) and $BaAl_2Si_2O_8$ (Cn). Towards lower temperatures a solvus opens leading to lamellar unmixing of alkali-feldspar with intermediary composition during cooling, which gives rise to perthite formation. The necessary chemical segregation occurs by the interdiffusion of Na and K on the alkali sublattice of the feldspar; whereby the diffusion must be uphill concentration gradients for exsolution to occur. Diffusion is time and temperature dependent, and the exsolution microstructures undergo an evolution in terms of the chemical segregation between the Na- and the K-rich lamellae and with respect to coarsening. The dynamics of this evolution can well be described with Cahn-Hilliard (CH) theory, which links the thermodynamics of the alkali-feldspar solid-solution, the energetic contribution of the newly formed interfaces between exsolution lamellae, and Na-K interdiffusion. We present experiments for independent calibration of the empirical parameters entering the CH model. These include the Margules parameters describing the non-ideality of the alkali feldspar solid-solution, the interfacial energy of lamella interfaces, and the Na-K interdiffusion coefficients including their composition and temperature dependence. We use atom probe tomography for the direct observation of the phase relations and coarsening kinetics in nm-scale coherent lamellar intergrowth, which, for the first time, allows for the direct calibration of the exsolution kinetics in cryptoperthite microstructures.