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Coarsening kinetics of coexisting peristerite and film microperthite over 10^4 to 10^5 years

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Abstract

Alkali feldspar crystals from the Klokken syenite pluton (South Greenland) have a coarse patch perthite exsolution texture, on the scale of hundreds of micrometers, produced by dissolution-reprecipitation reactions at ~500 °C. We have discovered that Ab-rich patches ($Ab_{92}An_7Or_1$) subsequently exsolved by spinodal decomposition to give peristerite, with a periodicity of 17 nm. This is the first time a peristerite has been characterized by TEM within a perthite, and the first peristerite to be found outside regional metamorphic rocks and pegmatites. The coexisting Or-rich patches, $Ab_{16}Or_{84}$ ($An_{0.3}$), unmixed over the same temperature interval to yield coherent film microperthite with periodicities ≤1 µm. Because the peristerite and film perthite from a single hand specimen from the Klokken intrusion have shared exactly the same cooling history, they provide a novel opportunity to test the utility of diffusion coefficients obtained in the laboratory for prediction of coarsening rates over 10^5 yr time scales, in the light of a calculated cooling trajectory for the pluton. We find good agreement between observed and predicted periodicities for the film perthite, which began to exsolve by coherent nucleation at the coherent solvus for ordered feldspars at ~420 °C, ~32 000 yr after crystal growth, and took a further 13 000–39 000 yr to coarsen to a periodicity of 1 µm. Peristerite exsolution began at the conditional spinodal at ~450 °C, but on the basis of the best existing experimental data would have taken ~520 000–4 600 000 yr to coarsen, incompatible with the cooling history. We speculate on changes to these "best" parameter values to describe NaSi-CaAl interdiffusion that would lead to peristerite coarsening rates compatible with the cooling history of the Klokken intrusion. We find that an interdiffusion expression:

$$D_{\text{NaSi-CaAl}} = (9 \times 10^{-12})\exp(-220\,000/RT)$$

(where D and the pre-exponential term, A, are in units of m^2/s and the activation energy, E_a, is in J/mol) leads to coarsening rates compatible with the experimental data, the cooling path of the Klokken intrusion, and the coarsening rate of the coexisting film perthite. The new interdiffusion parameters are consistent with fine-scale peristerite intergrowths in low-grade metamorphic rocks and with the existence of the coarsest known peristerite. In the light of our discovery, it seems likely that peristerite is commonplace in albitic plagioclase in granitic rocks.

Keywords: Peristerite, perthite, diffusion, kinetics, alkali feldspar, Klokken intrusion