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The dynamics of perthite formation: a potential geo-speedometer for high grade metamorphic rocks

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Exsolution by spinodal decomposition is a common phenomenon in a number of mineral systems**.** We investigate perthite formation in anatectic gneisses from Nghorongoro, Tanzania. There alkali feldspar of intermediary composition (XOr=0.56, XAb=0.43, XAn=0.01) shows two generations of exsolution features: The first generation is represented by lens-shaped exsolutions of albite rich (XOr=0.02, XAb=0.95, XAn=0.03) feldspar in an orthoclase rich (XOr=0.90, XAb=0.10) host. The albite rich precipitates are about 10μm wide and zoned with respect to their anorthite component with highest anorthite contents in the centre and discontinuous and locally variable decrease of anorthite component towards the rims. A second generation of about 0.4μm wide sodium rich exsolution lamellae is present in the orthoclase rich host. Whereas coherency of crystal lattices was lost for the first generation exsolution phases, the interfaces between the thin albite rich lamellae and orthoclase rich host are fully coherent. The spatial arrangement, shape and chemical zoning of the exsolved phases suggest exsolution by a spinodal process. We employ an anisotropic version of the Cahn-Hilliard equation to model the dynamics of phase separation in the alkali feldspar system in two dimensions. Our model suggests that both generations of exsolution features can be produced along a monotonous cooling path only for a narrow range of cooling scenarios. The size distribution, shape, and the spatial arrangement of the exsolved phases are reproduced very well in our model when an anisotropic interface energy is considered so that the interface energy varies by a factor of five between the energetically most and least favourable interface orientation. Parameterization of the model with published experimental data on alkali feldspar exsolution suggests that growth of the first generation exsolution phases took about one million years.