European Mineralogical Conference
Vol. 1, EMC2012-167, 2012
European Mineralogical Conference 2012
© Author(s) 2012

Na/K-interdiffusion in alkali feldspar: new data on diffusion anisotropy and composition dependence from cation exchange experiments

A.-K. Schaeffer (1), D. Rhede (2), G. Habler (1), E. Petrishcheva (1), and R. Abart (1)

(1) University of Vienna, Department of Lithospheric Research, Vienna, Austria (anne-kathrin.schaeffer@univie.ac.at), (2) GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany

Exchange experiments between single crystals of gem-quality alkali feldspar (X_{Or} 0.85) and NaCl/KCl melts were done at 850˚C and close to ambient pressure. The starting material was prepared as crystallographically oriented plates with polished (010) or (001) surfaces. Melt composition was varied systematically between X_{KCl} 0.6 and 1 to shift the feldspars towards more Na-rich as well as more K-rich compositions (X_{Or} 0.70 to 1). A 40-times molar excess of cations in the melt was applied so that the composition of the melt remained essentially unaffected by cation exchange.

Depending on the direction of the composition shift composition profiles with different geometries develop in the feldspar. A shift towards more K-rich compositions produces profiles, which exhibit two plateaus corresponding to an exchanged rim in equilibrium with the melt and an unexchanged core, respectively. The exchange front between these plateaus shows an inflection point and propagates through the crystal with $t^{1/2}$. The widths of the exchange fronts strongly depend on crystallographic direction and on the extent of composition shift applied to the feldspar.

The profiles developing during a shift towards more Na-rich compositions are comparatively smooth and lack an inflection point. If $X_{Or}$is shifted by more than 3 mole-% the composition strain associated with the substitution of the K^+ion by the smaller Na^+ion leads to the development of cracks with (h0l) direction.

While the propagation rate of the fronts is roughly equal in all crystallographic directions, the widths of the exchange fronts from diffusion normal to (010) are always distinctly narrower than the widths of the fronts from diffusion normal to (001).

The geometry of the diffusion fronts can be explained by a composition dependence of the interdiffusion coefficient. Such a dependence was first described by Christoffersen et al. (1983) who used an experimental setup that produced reliable data only for intermediate compositions. From our data we extract the coefficients for Na+/K+ interdiffusion normal to (010) and (001) for the composition range $0.7 \leq X_{Or} \leq 1.0$. We find that interdiffusion is markedly anisotropic, being about ten times faster in the direction perpendicular to (001) than perpendicular to (010), which agrees well with Christoffersen et al. (1983).

However, the composition dependence that we observe deviates from what is expected from theoretical calculations using the Manning relation for interdiffusion. For diffusion normal to (001) the interdiffusion coefficient is 0.3 x $10^{-15} m^2 s^{-1}$without significant composition dependence in the range $0.70 \leq X_{Or} \leq 0.95$. At $X_{Or} > 0.95$ it rises sharply to values of 2.5 x $10^{-15} m^2 s^{-1}$. Normal to (010) the interdiffusion coefficient is 0.03 x $10^{-15} m^2 s^{-1}$for $0.70 \leq X_{Or} \leq 0.97$ and then increases sharply. As a result of the different composition dependences at $X_{Or} >$ 0.95 the diffusion anisotropy is even more pronounced in this composition region. The cause for the pronounced composition dependence of Na^+/K^+ interdiffusion at $X_{Or} > 0.95$ is still enigmatic.

References

Christoffersen et al. (1983): Interdiffusion of K and Na in alkali feldspar: diffusion couple experiments, -American Mineralogist, Vol. 68, pp. 1126-1133