



## Na/K-interdiffusion in alkali feldspar: new data on diffusion anisotropy and composition dependence

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Exchange experiments between gem-quality alkali feldspar with an initial  $X_{Or}$  of 0.85 or 0.72 and Na/K-salt melts have been conducted at temperatures between 800° and 1000°C. The crystals were prepared as crystallographically oriented plates, the polished surfaces corresponding to the (010) or (001) plane of the feldspar. The composition of the melts was varied systematically to induce a controlled shift of the feldspar towards more Na-rich or K-rich compositions ( $X_{Or}$  0.5 to 1). A molar excess of cations by a factor of 40 in the melt ensured constant concentration boundary conditions for cation exchange.

Different geometries of diffusion profiles can be observed depending on the direction of the composition shift. For a shift towards more K-rich compositions the diffusion profile exhibits two plateaus corresponding to an exchanged rim in equilibrium with the melt and a completely unexchanged core, respectively. Between these plateaus an exchange front develops with an inflection point that progresses into the crystal with  $t^{1/2}$ . The width of this diffusion front varies greatly with the extent of chemical shift and crystallographic direction. The narrowest profiles are always found in the direction normal to (010), i.e. b, marking the slowest direction of interdiffusion.

A shift towards more Na-rich composition leads to the development of a crack system due to the composition strain associated with the substitution of the larger  $K^+$  ion with the smaller  $Na^+$  ion. The exchange front developing in this case lacks the inflection point observed for shifts towards more K-rich compositions.

The observed geometry of the diffusion fronts can be explained by a composition dependence of the interdiffusion coefficient. We used the Boltzmann transformation to calculate the interdiffusion coefficient in dependence of composition from our data in a range between  $X_{Or}$  0.5 and 1 for profiles normal to both (010) and (001) and for different temperatures. As indicated by the different widths of the front a marked anisotropy in interdiffusion is apparent; it is about 10 times faster perpendicular to (001) than normal to (010). This is in good accordance with results of earlier studies.

However, the composition dependence deviates from what is expected from theoretical calculations using the Manning relation for interdiffusion. For profiles normal to (001) the interdiffusion coefficient is nearly constant at  $0.3 \times 10^{-15} m^2 s^{-1}$  over the composition range  $X_{Or}$  0.50 to 0.95 and then rises steeply to values of  $2.5 \times 10^{-15} m^2 s^{-1}$ . Normal to (010) the interdiffusion coefficient is nearly constant at  $0.03 \times 10^{-15} m^2 s^{-1}$  over the composition range  $X_{Or}$  0.50 to 0.97 before, too, rising steeply at higher  $X_{Or}$ .

Interdiffusion coefficients calculated by Christoffersen et al. (1983) for this composition range also showed this rise but much less localized and steep.

The activation energy also shows an anisotropy and slight composition dependence. Normal to (001) it is about 340 kJ/mole while it is 250 kJ/mole normal to (010). In the range between  $X_{Or}$  0.94 to 1 it shows a slight rise by about 20 kJ/mole for both directions.

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### References

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