



Reaction induced fracturing

Rainer Abart (1), Elena Petrishcheva (1), Jozef Predan (2), and Franz-Dieter Fischer (3)

(1) Department of Lithospheric Research, University of Vienna, Vienna, Austria (rainer.abart@univie.ac.at), (2) Faculty of Mechanical Engineering, University of Maribor, Maribor, Slovenia (jozef.predan@um.si), (3) Institute of Mechanics, Mining University Leoben, Leoben, Austria (Mechanik@unileoben.ac.at)

Mineral reactions do, in general, not conserve volume, and, if reaction progress is heterogeneously distributed in solid phase or in a solid phase aggregate, this inevitably induces stress. Typical situations include eigenstrain caused by phase transformations or by the diffusion mediated evolution of composition gradients within a crystal. If the induced stresses exceed the material's mechanical strength, a propagating reaction front leaves behind a wake of fractured material. When only one component of the induced stress is tensile, a system of approximately equi-spaced parallel cracks forms, where the characteristic crack spacing depends on the induced stress state. This situation is encountered, when potassium-rich alkali feldspar or alkali feldspar of intermediate composition is shifted towards more sodium-rich compositions by diffusion mediated cation exchange. Here we present the results from cation exchange experiments, where gem-quality sanidine from Volkesfeld (Eifel, Germany) with $K/(K + Na) = 0.85$, machined to cuboid plates was exposed to an excess amount of NaCl-KCl salt melt at 850°C and ambient pressure. The composition of the salt melt was chosen so that the alkali feldspar was shifted towards more sodium-rich compositions. Due to the associated anisotropic shrinkage of the crystal lattice a system of equi-spaced parallel cracks formed emanating from the crystal surface and extending approximately perpendicular to the direction of maximum shortening. Time series experiments revealed that after an initial delay time the cracks propagate at a nearly constant rate. During the steady state crack propagation stage, the crack walls, which have become wetted by the salt melt, serve as new surfaces for Na-K exchange. Nearly time independent concentration-, eigenstrain-, and stress fields are established around the propagating crack tip reflecting the intimate coupling among Na-K exchange between the feldspar and the salt melt, the chemically induced eigenstrain in the feldspar, and the rearrangement of the stress state towards lower stress levels due to crack propagation. Chemically induced crack formation and diffusion controlled crack propagation appears to play a key role in the transformation of sanidine or orthoclase to sodic plagioclase (Rapakiwi structure), which often accompanies felsic-mafic magma interaction.