

Fracturing-assisted reactive transport

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Fluid migration in the Earth's crust is strongly linked to deformation. Fracturing is probably *the* most important porosity and permeability producing mechanism in the lithosphere. Large-scale fracturing is often linked to tectonic stresses, but large-scale fluid flow may also be strongly affected by small-scale forces and small scale fractures. Local fracturing is in some cases a response to locally generated stresses rather than external forces. Such stresses may be related to high fluid pressure gradients, stress perturbations caused by geochemical reactions, or -near the Earth's surface – even to microbial activity.

We present field observations and computer simulations (Fig.1) which illustrate how fluids may propagate into initially more or less impermeable rocks driven by reaction-enhanced porosity generation. The velocity and geometry of the reaction fronts are discussed, as well as the effects of anisotropic external stresses and other boundary conditions on the fluid migration patterns.

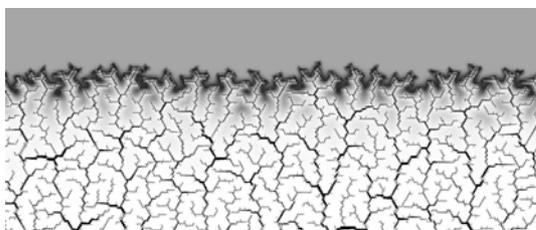


Figure 1. Simulation of a fracture-propagated reaction front in the limit of diffusion control. Gray-scale indicates reaction progress. The front is sharp with a small-scale structure characterized by a block size, $L = (K_c/E\nu)$, where E is Young's modulus, K_c is the critical stress intensity factor, and ν is the volume reduction ratio for the reaction. The front moves with a constant velocity $v = D/L$ (Jamtveit et al., 2000), where D is the effective diffusion constant. On a scale much larger than L the front has a self-affine scaling structure which is characteristic for the front propagation process.

Reference

Jamtveit, B, Austrheim, H., and Malthe-Sørensen, A., (2000), *Nature*, **408**, 75-79

Mineral reaction interfaces and associated porosity generation

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Chemical processes commonly encountered in nature, including hydration-dehydration, cation exchange and oxidation-reduction reactions involving complex fluids containing electrolytes and mixed-volatiles can lead to either passivated mineral surfaces or the formation of reaction rims. Further exchange requires advection and/or diffusion of matter across the zone to the interface between the transformed and unreacted parent phase. Structures within the reaction zone and at the reaction interface, as well as reaction mechanisms and reaction rates, are still poorly constrained for most important rock-forming mineral. This study focused on two aspects of the replacement process, the geometry of the reaction front and the generation of nano- and/or microscopic porosity at or near the interface. Using transmission electron microscopy (TEM) and secondary ion mass spectrometry (SIMS), we interrogated the reaction interface domains in two types of feldspar systems: (a) replacement of plagioclase (~An₃₀) by albite ± muscovite in the Rico, CO paleo-hydrothermal system, and (b) Amelia albite replaced by K-feldspar in experiments (up to 600°C and 200 MPa) employing 1-2 molal KCl enriched in ¹⁸O. In the case of the natural system, the typical reaction interface appears as a curvilinear, somewhat diffuse zone where crystallographic control is not particularly pronounced. Micropores occur infrequently along the interface, but are commonly observed within fine albite-filled fractures and dislocations that either crosscut or are truncated by the reaction interface. In contrast, the nature of the reaction interface in the experimental sample depends strongly on crystallographic control with an overall jagged appearance, exhibits limited microporosity, and has an unusual corrugated or stitch-like nano-texture right at interface. NanoSIMS images and line scans indicate the interface is sharp in the distribution of ¹⁸O and ¹⁶O.