

Geophysical Research Abstracts
Vol. 13, EGU2011-12193, 2011
EGU General Assembly 2011
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Modelling Mineral Vein Dynamics - A Phase Field Approach

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January 11, 2011

Abstract

One of the most important indicators for fluid flow and fluid-rock interaction in the geological record are vein networks. Veins are dilatation sites in rocks where minerals precipitated from a solution, which can be stationary (transport by diffusion) or flow with a wide range of velocities (transport by convection). Vein microstructures comprise a wide range of crystal habits from dendrites, fibres, elongate-blocky to blocky crystals, depending on the boundary conditions of the crystal growth. Numerous attempts have been made in the past (Bons, 2001; Urai, 1991) to model the processes involved in the formation of veins. Although existing models can produce rather natural-looking microstructures, but do not incorporate many of the basic thermophysical and continuum mechanics concepts which governs the phase transition dynamics underlying the vein formation process.

In the current work, we present the modelling the vein growth process using the phase-field method. This technique, which is established in the computational materials science community to investigate crystallization process, is shown to be a powerful tool to describe processes during vein formation which also involve crystal growth. The phase-field method has also been utilised to study the crystal growth competition from a supersaturated fluid which is controlled by the crystallographic orientation and growth anisotropy of the crystals. Here we focus on the capability of the phase-field method to correctly describe the inherently coupled transport of dissolved material by convection, the development of facets on the crystals growing in a supersaturated solution in the state of flow, the propagation of grain boundaries and the final stages of sealing the fractures.

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