Geophysical Research Abstracts
Vol. 14, EGU2012-9356, 2012
EGU General Assembly 2012

How do the fingers interact: upscaling the description of the emerging structures in fracture dissolution

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A number of experimental and numerical studies of dissolution in fractured and porous rocks have established that the evolving topography of the pore space depends strongly on the fluid flow and mineral dissolution rates. Remarkably, there exists a wide parameter range in which positive feedback between fluid transport and mineral dissolution leads to the instability of the reaction front and spontaneous formation of pronounced finger-like channels. As dissolution proceeds the fingers interact, competing for the available flow, and eventually the growth of the shorter ones cease. Initial phases of the this process are well understood in terms of linear stability analysis, which yields the wavelength of the most unstable
perturbation. However, the later stages of the evolution are no longer linear and hard to tackle analytically.
Here, however, we show that the analysis of the system in the nonlinear regime can be drastically simplified by introducing a higher level description, in which the microscopic details of the medium are neglected and only the channels are tracked. The key element here is a correct characterization of the effective interaction of the fingers, which is obtained in terms of the evolving pressure field around the channels. Due to its simplicity, the reduced model is tractable with conformal mapping techniques. A complex reactive flow problem in the evolving geometry of fractures rock is thus reduced to a much simpler task of tracking evolving shapes in a 2d complex plane.