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Computer modeling of mineral dendrite growth

Dawid Woś[1] and Piotr Szymczak[2]
[1]Insititute of Theoretical Physics, University of Warsaw, Warsaw, Poland (dd.wos@student.uw.edu.pl)
[2]Insititute of Theoretical Physics, University of Warsaw, Warsaw, Poland (piotr.szymczak@fuw.edu.pl)

Mineral dendrites are an example of a pattern which forms in rocks when they are infiltrated by the hydrothermal, manganese-rich fluids. As these fluids mix with other oxygenated fluids within the fractured rock, manganese oxide is formed. The oxide then precipitates, forming intricate, branched patterns. Several models of this process have been proposed, which vary in complexity. One model assumes crystallization of manganese oxides directly on the surface of the growing dendrite, causing it to elongate. Another model involves an initial growth of small nanoparticles of manganese oxide, which then aggregate into larger structures. The evolution of the system in both models is described by the system of reaction-diffusion equations.

We study this process using lattice-Boltzmann method to track the evolving concentrations of the species involved in reaction. Next, we analyze the dependence of the morphology of the resulting patterns on the physical parameters characterizing the reaction and growth, such as initial concentrations of manganese ions and oxygen molecules, reaction rates, nucleation thresholds or surface energy of the dendrites. Our study has been focused on planar structures, growing along fractures or bedding planes. We have investigated the impact of multiple infiltrations of manganese-bearing fluid on the morphology of the dendrites. We compare the numerical results to the morphologies of the real systems with the aim of reconstructing the hydrochemical conditions prevailing during their growth