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Can mineral precipitation reduce the breakthrough time in dissolving porous medium?

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We investigate the chemical erosion of porous media using a 2D network model in which the system is represented as a series of interconnected pipes. We consider a system with two coupled reactions involving dissolution of a solid component and precipitation of dissolution products, which results in the overall change of pore diameters. Importantly, the topology of the network is allowed to change dynamically during the simulation: as the diameters of the eroding pores become comparable with the interpore distances, the pores are joined together, thus changing the interconnections within the network. With this model, we investigate different growth regimes in an evolving porous medium, identifying the mechanisms responsible for the emergence of specific patterns. We study the change of permeability of the system in time. The crucial parameter here is the ratio of dissolution to precipitation reaction rates. Depending on its value, the permeability either increases, decreases or oscillates in time. Finally, we consider practically important problem of finding an optimum reactions rates that give a maximum increase in permeability for a given amount of dissolving reactant. Somewhat paradoxically, we find that precipitation can, for a particular range of parameters, make the dissolution more efficient by focusing it in localized regions.