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Dissolution in Porous Media: Upscaling, Instabilities and Heterogeneity Effects

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Dissolution mechanisms in porous media are of paramount importance in many practical situations. This is the case, for instance, when considering acid injection in reservoirs, or NAPL (Non-Aqueous Phase Liquid) pollutant dissolution in aquifers, salt formation dissolution, ... When trying to model those phenomena, several important theoretical questions must be answered. The major question concerns the possibility of representing by macro-scale equations mass and momentum transfer in such systems. Because dissolution patterns are greatly affected by heterogeneity effects at all scales (pore-scale and small-scale heterogeneities leading to wormholing, large-scale heterogeneities, ...), and because the dissolution process itself leads to transient evolution of the geometrical characteristics of the system, there is a great potential for non-local behavior in space and time. These questions are reviewed on the basis of recent theoretical, experimental, and numerical evidence. The status of Darcy-Scale and Core-Scale models is discussed based on: – theoretical arguments using averaging techniques, – direct numerical simulation of pore-scale and Darcy-scale problems, – experimental evidence (acid injection, salt dissolution, NAPL dissolution). It is shown that Darcy-Scale models have a sufficient potential for reproducing even unstable dissolution patterns in porous media, as well as some quantitative characteristics such as the optimum flow rate leading to the longest wormhole for a minimum acid consumption. Based on numerical results, the possible features of large-scale models is investigated. Finally, a weak solution to the problem of the impact of large-scale heterogeneities on dissolution models is presented in the case of NAPL dissolution.

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