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Upscaling porosity-permeability relation in porous media; reactive pore-scale modeling

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The main objective of this research is to gain a better understanding of the relation between porosity-permeability evolution at the local scale and its manifestation at larger (REV) scales. Continuum pore space changes during the progress of chemical reactions in porous media. Such phenomena takes place in reservoir rock in which CO_2 is to be stored.
In the present approach, the microscopic pore space is modeled using a Multi-Directional Pore Network (MDPN), which allows for a distribution of pore coordination number ranging between one and 26. This topological property, together with geometrical distributions of pore sizes are used to mimic the microstructure of real porous media at the REV scale.
In order to simulate transport of multi-component chemical species, mass balance equations are solved within each element of the network (i.e. pore body and pore throat). We have considered both advective and diffusive transport processes within the pore spaces and have used a Reaction Network Simulator to model multi-component chemical reactions, allowing for both equilibrium and kinetic calculations.
By averaging over the network domain, we calculate the evolution of porosity and permeability as well as of flux-averaged concentration breakthrough curves. We have obtained constitutive relations linking porosity and permeability as the pore space involve during dissolution of calcium carbonate within calcite-cemented sandstone, under conditions relevant to geological storage of CO_2. Results show that transition between advection- and diffusion- dominated transport, along with the distribution of reactive sites between pore bodies and pore throats, play a key role in determining evolution of porosity and permeability.