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Impact of pore and pore-throat distributions on porosity-permeability evolution in heterogeneous mineral dissolution and precipitation scenarios

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Mineral dissolution and precipitation reactions in porous media can alter formation properties, including porosity and permeability, in complex ways. While porosity increases with mineral dissolution and decreases with mineral precipitation, permeability alterations largely depend on the location of reactions in individual pores and the greater pore network. Pore network models enable simulation of permeability alterations from pore scale variations in dissolution and precipitation reactions. Uniform and non-uniform distributions of mineral reactions have been previously observed, controlled by pore size, PeDa, or mineral distribution, for example. In this work, the evolution of permeability with varying spatial reaction patterns is investigated for uniform, normal, and left and right skewed pore and pore throat size distributions using pore network modeling simulations. Simulated spatial reaction scenarios include uniform, random, channelized, and pore size dependent dissolution and precipitation reactions. Simulated permeability evolution is compared to permeability calculated using common macroscopic porosity-permeability relationships. These relationships are unable to reflect the evolution of permeability resulting from non-uniform structure modifications. For all pore and pore-throat distributions, the largest disagreement between the pore-scale simulations and the macroscopic relationships is for size-dependent reaction scenarios, where reactions initiate in small or large pores. Porosity-permeability evolution in these scenarios is step-like where reactions initiating in small pores have a region with large changes in permeability and little change in porosity and reactions initiating in large pores have a region with large changes in porosity and little change in permeability. These relationships are fundamentally different than the macroscopic relationships examined here. Simulation observations from the four pore and pore-throat size distributions will be leveraged here to develop new porosity-permeability relationships for these scenarios.

References

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