A MULTISCALE APPROACH TO UPSCALING MULTI-SPECIES REACTIVE TRANSPORT FROM PORE TO MACRO SCALE WITH APPLICATIONS TO CO2 SEQUESTRATION

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In order to safely store CO2 in depleted reservoirs and deep saline aquifers, a better understanding of the storage mechanisms of CO2 is needed. Reaction of CO2 with minerals to form precipitate in the subsurface helps to securely store CO2 over geologic time periods, but a concern is the formation of localized channels through which CO2 could travel at large, localized rates. Pore-scale network modeling is an attractive option for modeling and understanding this inherently pore-level process, but the relatively small domains of network models may prevent accurate upscaling and capturing of any such “emergent phenomena”.

Here, we develop a transient, single-phase, reactive pore-network model that includes reduction of pore-throat conductivity as a result of precipitation. Multiscale modeling is performed by using a mixture of finite-element mortars adapted for pore-scale models, to ensure continuity of the bulk flux and pressure across interface boundaries, and a novel way of transporting species between boundary-throats. Coupled sub-domains are solved separately in parallel and information is effectively communicated between them via the coupling process.

The multiscale approach presented, allows for modeling at larger scales leading to more accurate upscaling methods, by including the effects of the surrounding media on the small-scale; which is oftentimes ignored by treating each small-scale model as a stand-alone tool to extract macroscale information. The multiscale method can be applied to modeling of multi-species and multiphase phenomena such as transport of acid, reactive polymer/surfactant, CO2 and more. The domain may have severe heterogeneous features such as impermeable layers, fracture and sudden changes in permeability. Moreover the method easily allows for creating hybrid models with different physics and solution algorithms in each sub-domain. This allows for the integration of pore-scale models with continuum scale simulators, at parts of the domain where higher resolution is desired e.g. around wellbore regions.