

# Critical Reactive Interfaces in Heterogeneous Biogeochemical Systems

**Li Li, Hang Wen, Pam Sullivan, and Sue Brantley**

Natural systems are ubiquitously heterogeneous with sharp interfaces connecting compartments of differing physical, ecohydrological, and biogeochemical properties. These interfaces are often at the convergence of different flow paths, occupy small area / volume fractions of the system domains, and yet have orders of magnitude higher biogeochemical transformation rates than the rest of the domains. The dynamics of these critical reactive interfaces (CRI) therefore often dominate the rates and extent of biogeochemical transformation at large scales. In this talk, I will illustrate the concepts and the drivers of CRI through three examples. In a heterogeneous porous medium with carbonate embedded in largely non-reactive quartz zones, carbonate dissolves only at the very interface of the two mineral zones (Wen and Li 2017). The CRI forms and is driven by the fast approach to carbonate dissolution equilibrium compared to the much slower mass transport to export the reaction products. Long correlation length and large permeability variance minimize the thickness of CRI however maximize the importance of the CRI. That is, the very thin CRIs (~ 1 mm thick and < 1% area extent) are responsible for more than 90% of the dissolution in the whole domain. In a heterogeneous aquifer with amended organic carbon for engineered bioremediation, microbe-mediated iron reduction primarily occurs at the very interfaces of the high permeability preferentially flow zones with organic-containing water and the low permeability clay-rich zones with abundant iron oxides (Bao et al. 2014, Li et al. 2011). The size of the biogeochemical interfaces depends on the permeability contrast of the two zones and control the rates of iron-reduction and the efficiency of bioremediation at the domain scale. At the watershed scale (e.g., Susquehanna Shale Hills in PA and Coal Creek in CO), the CRI is shaped by the stream-land boundaries and the topography, where the convergence of water paths brings together different reacting components (Li et al. 2017).

## References:

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