

A Geochemical Framework for Evaluating Shale-Hydraulic Fracture Fluid Interactions

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The development of shale oil and gas reservoirs has increased dramatically due to the application of hydraulic fracturing techniques. Fracture fluids contain dissolved oxygen and numerous chemical additives [1] that are out of equilibrium with the reducing conditions in shale reservoirs and could react extensively with shale minerals and alter porosity. Yet, the complex dissolution-precipitation reactions in shales along with the poorly constrained characteristics of many fracture fluid additives hinder predictive modeling based on established reaction kinetics and thermodynamic constants [2]. Here, we are developing a reaction framework to better predict reaction progress and porosity evolution upon exposure of shales to hydraulic fracturing fluids. In order to assess the extent of interaction between shale minerals and fracturing fluids, shales of different mineralogical and organic compositions were exposed to simulated fracturing fluid in batch reactors. Fluid samples were collected periodically to monitor reaction rate and progress, whereas solids were characterized post-reaction to evaluate bulk changes in mineralogy and identify secondary precipitates. Experimental conditions were simulated using the reactive transport model CrunchFlow [3] to elucidate the relative reactivity and reaction rate of individual mineral phases. Reaction paths were dependent on the initial mineralogical composition of the shale, with carbonate-rich shales facilitating rapid buffering of the initially low pH fracturing solution, in contrast to clay-rich shales. While selective removal of carbonate minerals created localized porosity in most shales, the presence of secondary Fe(III) and Al-bearing (hydr)oxides phases suggests pore space may also be occluded. The formation of such Fe(III)-bearing precipitates appeared to be accelerated by the organic constituents of fracture fluid. The incorporation of these homogeneous and mineral-fluid reaction rates in our reactive transport model will permit improved prediction of reservoir permeability evolution and metal release during hydraulic fracturing operations as a function of initial reservoir mineralogy.

[1] Stringfellow et al. (2014) *J. Hazard. Mater.* [2] Carroll et al. (2013) *Environ. Sci. Technol.* [3] Steefel and Maher (2009) *Rev. Mineral. Geochem.*