

Carbonation of hydraulic fracturing flowback and produced water for Carbon Capture, Utilization and Storage

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Mineral carbonation is a negative emissions technology for capturing CO₂ in carbonate minerals. Previous studies have demonstrated that accelerated production and carbonation of brucite [Mg(OH)₂] from synthetic saline water can be used to store atmospheric CO₂ in hydrated Mg-carbonate minerals [1,2]. In this study, we use hydraulic fracturing flowback and produced water (FPW) as a source of alkaline earth cations (Ca and Mg) for mineral carbonation.

Solution pH directly impacts the efficiency of Ca- and Mg- hydroxide precipitation from FPW. For this reason, we adjusted the pH of three representative FPW samples (initial pH of 5.0, 6.0 and 6.1) to 8.5–12 (n=8, in pH increments of 0.5). X-ray diffraction (XRD), Field-Emission Gun Scanning Electron Microscopy (FEG-SEM) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS/MS) results indicate that (1) increasing the pH of FPW removes Ca from solution through the precipitation of calcite (CaCO₃), aragonite (CaCO₃), and portlandite [Ca(OH)₂], and Mg through the precipitation of brucite [Mg(OH)₂]; (2) 30% of the Ca and 100% of the Mg is recovered at pH 12; and (3) the precipitates scavenge Mn and Zn from solution. Our experiments confirm the proposal of Ferrini *et al.* [1] that FPW can be used as a Mg source for mineral carbonation. We show that Ca provides most of the carbonation potential of FPW and that hydroxide precipitation efficiently removes transition metals. Under atmospheric pCO₂, the low DIC concentrations (<10 mg/L) in FPW favour Ca- and Mg-hydroxide precipitation (>50 wt% at pH >9.5) and indicate that mineral precipitation outpaces CO₂ dissolution. Future experiments will supply 10% CO₂ gas [3] to accelerate carbonation and begin to unlock the potential of FPW as a resource for climate change mitigation.

[1] Ferrini *et al.* (2009) *J. Hazard. Mater* **42**, 105–121. [2] Wilson *et al.* (2010) *ES&T* **44**, 9522–9529. [3] Harrison *et al.* (2013) *ES&T* **47**, 126–134.