Ensuring CO_2 Storage and Groundwater Protection through Water Monitoring: Applying Geochemical and Statistical Tools

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Background/Objectives. The success of carbon storage relies on injected carbon dioxide (CO_2) permanently staying in the target formation. Ensuring that CO_2 does not migrate to overlying formations will require multiple monitoring tools. In this abstract, we outline the National Energy Technology Laboratory's efforts to develop geochemical monitoring tools that ensure injected CO_2 does not negatively impact the target formation or proximal groundwaters. These efforts provide critical insight into managing carbon storage's effects on the water-energy nexus.

Approach/Activities. The National Energy Technology Laboratory conducted periodic field work from June 2013 through April 2018 at a CO_2 enhanced oil recovery field in the Permian Basin. Researchers collected produced waters from the injection formation and groundwaters from shallow and intermediate formations. The sample set includes one collection event prior to the initiation of CO_2 injection (October 2013) and seven events that occurred during CO_2 injection. Waters were analyzed for pH, alkalinity, and conductivity in the field. Samples were also analyzed for inorganic geochemical parameters (Ca^{2+}, Na^+, Cl^-, SO_4^{2-}, etc.) and stable isotopes (δ^7Li, $^{87}Sr/^{86}Sr$) in order to understand: 1) the effects of injected CO_2 on water-rock-interactions on the target formation and 2) identify potential geochemical tools that would indicate fluid intrusion into groundwater formations. Based on sample measurements, a geochemical reaction path model was created that simulates CO_2-water-rock reactions in the intermediate groundwater formation. This model output was then integrated into a Bayesian belief network, a statistical model. This integrated geostatistical model, aptly named Geochemically Informed Leakage Detection (GILD), was created to determine CO_2 leakage probabilities based on groundwater measurements.

Results/Lessons Learned. General geochemical parameters (Ca^{2+}, Na^+, Cl^-, SO_4^{2-}, etc.), stable isotopes (δ^7Li, $^{87}Sr/^{86}Sr$), and our integrated geochemical statistical model all provide evidence that geochemical monitoring is a crucial tool for carbon storage management. General geochemistry results indicate that although CO_2 injection was associated with significant increases in certain geochemical parameters [alkalinity, TDS, Na^+, Cl^-, SO_4^{2-}], CO_2 injection did not negatively affect the integrity of the target formation. During the sampling period, there was no evidence observed to suggest that produced water had migrated into overlying groundwaters. If this did occur, certain parameters [Na^+, Ca^{2+}, K^+, Cl^-, alkalinity] were identified as sensitive indicators of produced water intrusion into overlying groundwaters. Lithium (δ^7Li) and strontium ($^{87}Sr/^{86}Sr$) isotope results indicate that both could be used as natural tracers for water-rock reactions and tracking CO_2-induced mixing of produced water and overlying intermediate groundwaters. Our integrated geochemistry statistical model, GILD, has demonstrated the ability to predict the probability of CO_2 leakage into overlying groundwaters based primarily on two sensitive parameters (alkalinity and SO_4^{2-}). GILD is currently a framework based on privately licensed software. The project goal is to develop an open-source version for the general public.