Stimulation of Carbonate Mineralization During Carbon Sequestration Through Excess Alkalinity Aquired from Algal Production Pond (APP) Supernatant

CHRISTOPHER PAOLINI

SAN DIEGO STATE UNIVERSITY

Algal Production Ponds (APP) used for algae biofuel generation require a source of CO2 for photosynthesis, a process that produces hydroxide ions (OH-) during carbohydrate reactions. The abundance of hydroxide ions can increase pond water pH to 10 or greater and provides a source of alkalinity, in addition to a mechanism for both CO2 disposal and biofuel generation. Approximately 900 billion gallons of formation water are produced each year during Enhanced Oil Recovery (EOR) operations in the United States. Produced water is typically injected back into disposal wells at a significant cost to the oil and gas producer. A synergistic process is presented that uses produced water and recovered CO2 for algae growth in APPs, and the high-pH, high-saline supernatant as a source of excess alkalinity for enhanced carbonate mineralization in deep geologic formations. We present a 3D Thermal-Hydrologic-Mechanical-Chemical ("THMC") application for modeling geologic CO2 sequestration and waste water injection in brine saturated sandstone-shale reservoirs, and investigate the effects of alkaline waste water injection, following CO2 injection, on carbonate mineral saturation and precipitation, under variable injection temperatures and pressures. A nine-mineral kinetic mechanism governing the dissolution of quartz, potassium-feldspar ("K-spar"), anorthite, albite, calcite, kaolinite, smectite, illite, and halite in a porous medium is used, with the aqueous phase pore water temperature modeled using a transient heat advection-diffusion transport model with non-constant thermal coefficients. Water-rock interaction is coupled with a transient mixed finite element method for fluid pressure and velocity, and a Galerkin method for poroelastic mechanics. Thermal coefficients (specific heat and specific enthalpy) are temperature and pressure dependent and computed using the revised Helgeson-Kirkham-Flowers ("HKF") model for approximating the thermodynamic properties of aqueous electrolytic solutions under high temperature and high-pressure. The HKF derived heat capacity and enthalpy of charged aqueous species arising from the interaction of CO2-rich brine with sandstone are used in a heat transfer model source term for computing the aqueous phase volumetric energy generation rate. The poroelastic and pressure-velocity fields are solved in parallel with MPI using domain decomposition. Numerical simulations demonstrate the feasibility of inducing carbonate mineral formation through alkaline waste injection following CO2 injection.