

Putting fluid salinity and solid solution into transport models

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We developed methods that explicitly consider salinity and solid solution in modeling infiltration-driven carbonation and decarbonation reactions produced by 1-D fluid flow along T- and P- gradients relevant to metamorphism. The effect of (A) salinity was evaluated by parameterizing X_{CO_2} of $\text{H}_2\text{O}-\text{CO}_2-\text{NaCl}$ fluid in equilibrium with reactants and products as a function of X_{NaCl} of the input fluid (X_{NaCl}° , in the range 0.0-0.3 or 0-58 wt% NaCl) and distance along the flow path. The effect of (B) solid solution was evaluated by parameterizing X_{CO_2} of $\text{H}_2\text{O}-\text{CO}_2$ fluid in equilibrium with reactants and products as a function of reaction progress (ξ), X_{CO_2} of the input fluid ($X_{\text{CO}_2}^\circ$), and distance along the flow path. The distribution of mineral products along the flow path was then computed as function of X_{NaCl}° , $X_{\text{CO}_2}^\circ$, and time-integrated input fluid flux (TI^2F^2) both analytically and with a finite-difference method.

Principal results are: (A) For mineral-fluid equilibrium at the reaction site, the TI^2F^2 required to displace a mineral reaction front a given distance along the flow path always increases with increasing X_{NaCl}° , by a factor of up to 1.4-7.9 for X_{NaCl}° up to 0.3, depending on the reaction and P-T conditions [1]. Immiscible fluid phase separation and differential loss of the liquid (L) or vapor (V) phase from the reaction site always increases the TI^2F^2 required to advance the reaction front a given distance compared to equilibration of minerals and fluid with no loss of L or V. (B) When reactions involve solid solutions, the slowest moving value of ξ typically corresponds to initial reaction. For input of fluid with disequilibrium $X_{\text{CO}_2}^\circ$ into a single layer, a sharp reaction front develops, and TI^2F^2 can be computed exactly. For layer-parallel flow where multiple layers equilibrate with the same flowing fluid, layer-by-layer variations in ξ with $\xi < \xi_{\text{maximum}}$ can develop depending on the mode, initial mineral compositions, and thickness of each layer. For input of fluid with equilibrium $X_{\text{CO}_2}^\circ$ and reaction driven by flow along P- and T-gradients, TI^2F^2 can be computed to within ~10% simply using a single ξ -averaged value of X_{CO_2} at the reaction site.

[1] Ferry & Gottschalk (2009) *CMP* **158**, 619–636.

Isotope tracing of CO₂ seepage: Results from controlled release experiment in Bozeman, Montana

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The geological storage of carbon dioxide (CO_2) captured from the emissions of combustion of fossil fuels is a promising option to mitigate the increase in atmospheric greenhouse gases. Within the past 10 years, efforts in understanding the storage capacity, chemical and physical alteration, and the leak potential of CO_2 impact to various reservoir types have been researched both at the laboratory and field. State-of-the-art monitoring equipment and models in the areas of geophysics, geochemistry, atmospheric chemistry, and remote sensing are being employed within this research area. Specifically, over the past 4 years, a controlled field experiment has taken place in Bozeman, Montana where pure CO_2 has been released at known rates and depths to quantify the detection limits of various monitoring techniques. A 87 m buried pipe located 2 m below the soil surface is in place and over the past 4 years of experimentation, a range in CO_2 injection rate and time (0.1 ton/day to 0.3 ton/day for 10-30 days depending upon year) has been monitored by a variety of monitoring equipment. The monitoring tool highlighted in this paper, is the use of stable isotope detection of CO_2 seepage into atmospheric, vegetation, and groundwater reservoirs. Results show a distinct isotopic impact to the local groundwater (at 1.2 m depth), surface CO_2 (chamber and canopy) within 24 hours after injection, and vegetation (7 m from CO_2 source). Quantification of seepage CO_2 versus natural CO_2 in these reservoirs is discussed.