



Evaluation of Mineral Reactivity in response to CO₂ Perturbation in Natural Conditions

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Fluid-rock interaction controls many environmental and geological processes occurring at the Earth's surface. The quantification of these processes is important to model the global element cycles, notably carbon dynamics, geothermal resource evaluations and CO₂ geological storage. Here, we evaluate the amount of mineral reactive surface area participating to the CO₂ neutralization in the granitic geothermal field of Galicia (Spain). In this low enthalpy thermal field, fluids are characterized by partial pressure of CO₂ ranging from 10⁻¹⁰ to 10⁻⁵ Pa, pH from 10 to 6 and an increasing of major cations as a function of the pCO₂. A field-scale mineral dissolution rate of the main granite minerals has been estimated using as input data the chemical composition of the sampled fluids, assuming the continuum equilibrium condition defined by the overall progress of CO₂ perturbation and a Bootstrap Methodology parametrized by the Metropolis-Hasting algorithm solved independently on time scale. Comparing our field scale mineral dissolution rate to mineral dissolution rates estimated by kinetic rate constant at the observed pH, pCO₂, temperature and reaction affinity, we evaluate also a field-scale reactive surface area of the minerals controlling the CO₂ neutralization.

We found that over the entire CO₂-rich water-rock interaction process, the rate of mineral dissolution remained constant whereas the ratio of Biotite-Albite reactive surface areas changes by 1 – 4 orders of magnitude while the K-feldspar - Albite surface area ratio changes by 1 order of magnitude. We propose that reactive surface areas of the minerals is not a constant parameter as previously assumed in modeling of CO₂ crustal reactive transport. Our results indicate that biotite should play a crucial role in the fluid composition in granite CO₂-hydrothermal interaction as suggested by isotopic consideration. Our field scale reactivity approach offers a reliable geochemical methodology for estimating the evolution of mineral reactive surface area in natural systems where reservoir properties, fluid residence time or timescale of fluid-rock interaction are not sufficiently known.