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An approach for modeling geothermal reservoir behavior using the reactive transport simulator TOUGHREACT

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It is well-known that interactions between hydrothermal fluids and rock alter the primary mineralogy leading to the formation of secondary minerals and potentially significant physical and chemical property changes. Reactive transport simulations are essential for evaluating the coupled processes controlling the geochemical, thermal and hydrological evolution of geothermal reservoirs. However, the many assumptions required by reactive transport models make the application of numerical methods to predicting reservoir behavior challenging. Therefore, continued assessment of numerical codes and modeling approaches is required. The objective of this preliminary investigation is to successfully replicate the observations from a series of laboratory experiments (Morrow et al., JGR, 106, B12, pp. 30551-30560, 2001) using the code TOUGHREACT. The laboratory experiments carried out by Morrow et al. (2001) measure permeability reduction in pre-fractured and intact Westerly granite core samples due to high-temperature fluid flow through the samples. Initial permeability and temperature values used in our simulations reflect the experimental conditions and range from 6.1×10^{-20} to 1.5×10^{-17} m^2 and 150 to 300 °C, respectively. The primary mineralogy of the model rock is plagioclase (40 vol.%), K-feldspar (20 vol.%), quartz (30 vol.%), and biotite (10 vol.%). All initial parameters were selected for consistency with the experimental conditions and to facilitate comparison between the simulations and experiments. The simulations are further constrained by the requirement that permeability, relative mineral abundances, and fluid chemistry agree with experimental observations. A one-dimensional model was chosen to simulate the experiments. There are possible advantages to this approach. Because parameters given by Morrow et al. (2001) are for the bulk media, this approach facilitates the use of their data in our models. Additionally, an approach utilizing bulk-media parameters may prove useful for field problems where fracture distributions or geometries are poorly known. We find that this modeling approach correctly predicts the experimentally observed trends in fracture permeability, solute composition, and mineral precipitation over time only if the mineral reactive surface areas in the model decrease with increasing clay mineral abundance. Importantly, we successfully simulate the observations from the various experiments equally well using this approach. Our results indicate that to some extent geothermal reservoir evolution can be adequately depicted using a relatively straightforward formulation that explicitly considers the temporal evolution of reactive surface areas. These results will be compared to more complex multi-dimensional models to help identify the processes that dominate geothermal reservoir evolution. A better understanding of coupled thermal-chemical-hydrologic phenomena will facilitate future development of models that can be realistically applied to field problems.