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# Modeling retardation effects by barium and strontium solid solutions on radium cations in the near field of radioactive waste repository

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In the near field of a radioactive waste repository, bentonite is often used as a buffer material to prevent the migration of hazardous radionuclides into the biosphere. Traditionally the retardation mechanisms are simplified into a linear isotherm concept. The corresponding $K_D$ value is thereafter used for safety assessment purposes. Often, due to the lack of experimental data, the retardation based on the formation of solid solutions is ignored and only cation exchange and surface complexation processes are considered in evaluating $K_D$s. In this contribution, we use the newly coupled code GeoSys-GEM to simulate the reactive transport of radium in a bentonite column. In a first step, a chemical model was set up which contained non-ideal radium, barium, and strontium sulfate and carbonate solid solutions. Our reactive transport simulations suggest that the formation of such solid solutions strongly contributes to the retardation of radium. The aqueous $Ra^{2+}$ concentration will be lower by $3 \sim 4$ orders of magnitudes in the presence of sulfate solid solutions. However, its fixation capacity is highly influenced by the sulfate inventory available in the medium. In a second step, the chemical model was further extended to include ion exchange effects, with the clay mineral montmorillonite acting as an ion-exchanger. A sensitivity analysis was conducted to find out to what extent the mechanisms and compounds influence the retardation of radium. With this model, we are able to predict the transport of radionuclides in a more realistic way and reduce the conservatism of the simplified models (linear isotherms) used for performance assessment.