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Evaluating Montmorillonite Dissolution Modeling for High-Level Waste Repositories: A Benchmarking Approach

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Engineered barriers in high-level waste (HLW) repositories primarily consist of host rock, backfill, buffer, and disposal canisters. Montmorillonite, a key component of the buffer material, plays a crucial role in retarding radionuclide migration and providing chemical buffering capacity. In deep geological disposal environments, montmorillonite dissolution can occur due to interactions with groundwater, potentially influencing the long-term stability of the repository system. Therefore, accurately modeling the dissolution mechanism is essential for simulating realistic repository conditions and assessing long-term performance.

In this study, a benchmarking analysis of montmorillonite dissolution experiments is conducted using PFLOTRAN, a state-of-the-art reactive transport modeling code. The Thermochimie database, developed by ANDRA, is employed to provide thermodynamic parameters for the simulations. By comparing simulation results with experimental data, the applicability of the database and the reliability of the reaction rate constants will be assessed. The study will also explore how well the model can reproduce experimental trends and identify potential areas for refinement.

The goal of this study is to develop a robust and reliable montmorillonite dissolution model that can effectively represent experimental observations. By improving the accuracy of geochemical modeling approaches for HLW disposal environments, this study will contribute to a better understanding of long-term groundwater–mineral interactions and enhance confidence in the predictive capabilities of numerical models for geological repository performance assessments. The findings of this study will also provide valuable insights for refining thermodynamic databases and kinetic parameters, thereby supporting the development of more reliable safety assessments for deep geological disposal systems.

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