Modeling the long-term stability of multi-barrier systems for radioactive waste disposal in geological clay formations

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Large amounts of radioactive waste await final disposal worldwide. Repository facilities that will host this waste must be capable of ensuring very long-term isolation to protect the environment and ensure the safety of the future generations. Because of this need, the concept of geological disposal of radioactive waste emerged in the late 1950s and is now considered, in many countries, to be the best option to ensure safe, long-term containment of radioactive waste. A combination of waste overpacks (e.g. metal canisters, concrete), engineered barriers such as bentonite, and natural barriers such as clay rocks, constitutes the elements of the so-called “multiple-barrier system” between the waste matrix and the biosphere. These barrier properties will evolve with time in response to the physical and chemical interactions between the various constituents of the barriers and the surrounding environment. Consequently, predicting how these properties evolve is important for performance evaluations of the repository concepts. In recent decades, reactive transport modeling codes have become more and more efficient and are used as a bridge between current process knowledge and predictive capabilities. After describing the basic principles that have guided how these reactive transport models are constructed, their usefulness will be exampled on the modelling of clay-concrete interaction. The complexity of the multispace and temporal-scale issues will be tackled by modelling a ten years in-situ experiment and reviewing predictive modelling that have been carried out for time-scales that are not accessible to experimentation.