Geochemical modelling challenges in the siting of deep (and not so deep) repositories for spent fuel disposal

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The siting and safety assessment of spent fuel repositories is a challenging multidisciplinary endeavour. A sustainable approximation to nuclear waste management requires that the problems posed by the use of nuclear technology are solved within the generations that have mostly been enjoying the benefits of it and that have acquired the specific knowledge to solve them. In this context deep geological disposal remains the only option within our generations for the long term safe isolation of the waste.

Geochemical process understanding and quantification is at the heart of the siting and safety assessment of geological repositories. In the recent years major advances have been done within the geochemical scientific community in order to achieve a proper integration of the various disciplines involved: geology, hydrology, chemistry and microbiology. There is now a clear understanding of the key geochemical processes that control the release and fate of most of the radionuclides in the geosphere. This is from the processes that govern the stability and alteration of the UO_2 spent fuel matrix and the contained radionuclides up to the key processes that control the radionuclide transfer at the critical geosphere-biosphere interface. However, there is still a resistance to include well known processes in the safety assessment due to some limitations in the quantification and modelling of these key processes and on the grounds of some peculiar conservatism.

In my presentation I will discuss the following issues:

1) Realistic vs conservative spent fuel stability and alteration models. The chemical implications of temporary surface storage of spent fuel.

2) Trace metal retention processes in the geosphere and the myth of matrix diffusion.

3) The quantification and modelling of key transfer processes at the geosphere-biosphere interface.

I will illustrate these issues with current examples arising from our work in the siting and PA processes in Sweden, Spain, France and the EU.

Hydrogeochemical-hydrogeological modeling in the Swedish nuclear waste programme – Principles used and examples of application

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SKB is conducting site investigations for a high-level nuclear waste repository in fractured crystalline rocks on two coastal sites at Forsmark and Oskarshamn in Sweden. These investigations started in 2002 and have been planned since the late 1990's. Since hydrogeology and hydrogeochemistry deal with the same geological and hydrodynamic properties, these two disciplines should be able to complement each other while describing/modelling the bedrock groundwater system.

The advantages with an integrated modeling approach are numerous. Hydrogeochemical models generally focus on the effects from reactions on the obtained groundwater rather than on the effects from flow and transport. An integrated modelling approach can describe flow directions and hence help to understand the origin of the groundwater. The turnover time of the groundwater system can indicate the age of the groundwater and, knowing the flow rate, can be used to indicate the reaction rate. Converesely, hydrogeological models will be constrained by a new data set. If the chosen hydrodynamic model parameters values and/or processes cannot reproduce the hydrogeochemical observations then the assumptions need to be revised.

Hydrogeological Discrete Fracture Network (DFN) models are fully three dimensional and transient processes such as variable-density flow and shoreline displacement can be treated, which means that the spatial variability of flow related hydrogeochemical processes important for the characterization of coastal flow in fractured crystalline rocks in the Batic Sea region during Holocene can be modeled, visualised and communicated. The hydrogeological model can independently from hydrogeochemistry, predict the salinity at any point of the modelled rock volume, and the predictions can be checked by direct hydrogeochemical measurements or calculations.

In conclusion, by comparing two independent modelling approaches a consistency check can be made. The comparison will increase the understanding of transport, mixing and reactions and will also provide a tool for predicting future chemical changes due to climate changes, which is an essential component in the saftey assessment of nuclear waste repository. As a result greater confidence can be gained.