

Impact of transport pathways in Radium accumulation under groundwater discharge areas.

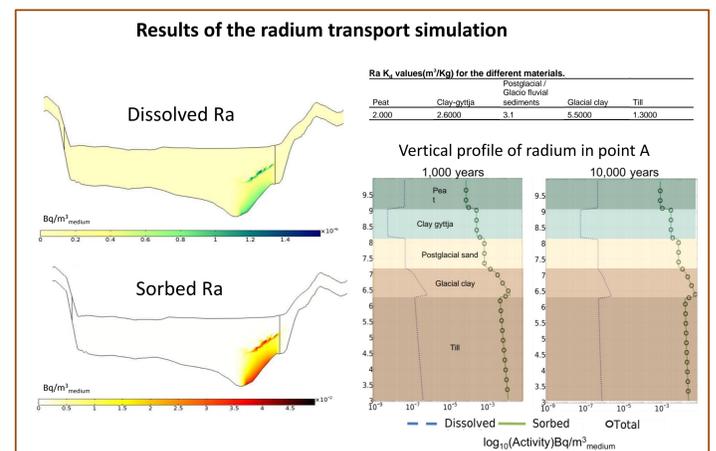
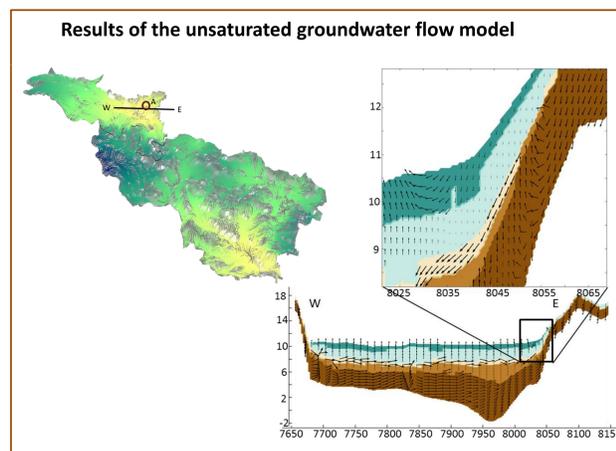
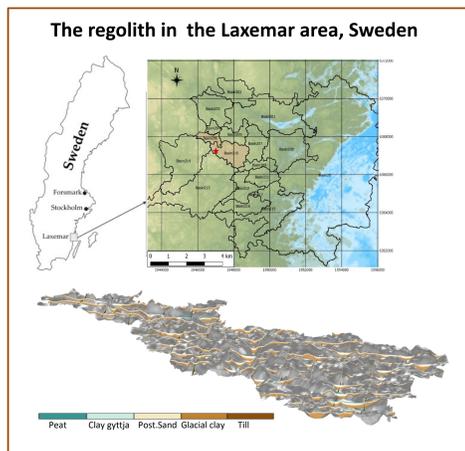
Elena Abarca⁽¹⁾ (elena.abarca@amphos21.com), Alvaro Sainz-Garcia⁽¹⁾, Diego Sampietro⁽¹⁾, David Garcia⁽¹⁾, Jorge Molinero⁽¹⁾, Peter Saetre⁽²⁾, Ulrik Kautsky⁽²⁾
⁽¹⁾ Amphos 21 Consulting S.L. ⁽²⁾ SKB, Swedish Nuclear Fuel and Waste Management Co.

The problem

Radionuclide accumulation patterns in quaternary sediments are key for the safety evaluation of a nuclear waste repository. The retention capacity of the regolith (loose sediments) is evaluated considering that radionuclides would migrate from deep bedrock to the surface and will eventually interact with these sediments. In a studied area in Sweden, quaternary deposits are formed, from oldest to youngest, by till, glacial clay, postglacial sand, clay gyttja and peat. Three modelling approaches lead to different concentration patterns as a result of their underlying simplifications.

3D hydrogeological model and Ra transport with a Kd-based retention approach

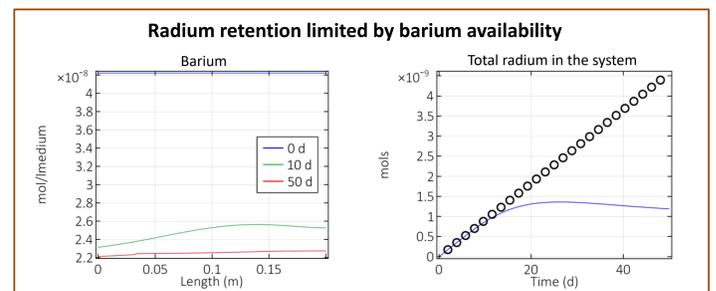
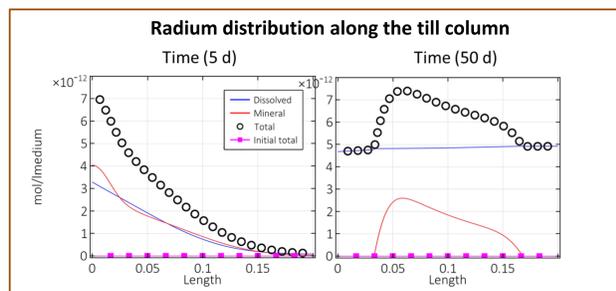
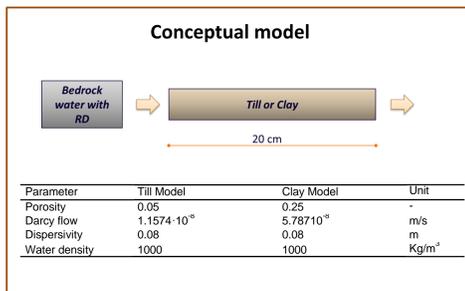
Radium transport is modelled at the catchment scale in 3D with Comsol Multiphysics. Radium sorption is simulated using a lumped parameter, the distribution coefficient (Kd), which relates the mass retained in the solid phase to its aqueous concentration.



Kd-based simulations rely on two key assumptions: Kd depends on soil properties and it is constant in time; Ra accumulation responds to high Kd values of the materials and the proximity to the radionuclide source.

1D mechanistic geochemical model of Ra transport in till and clay

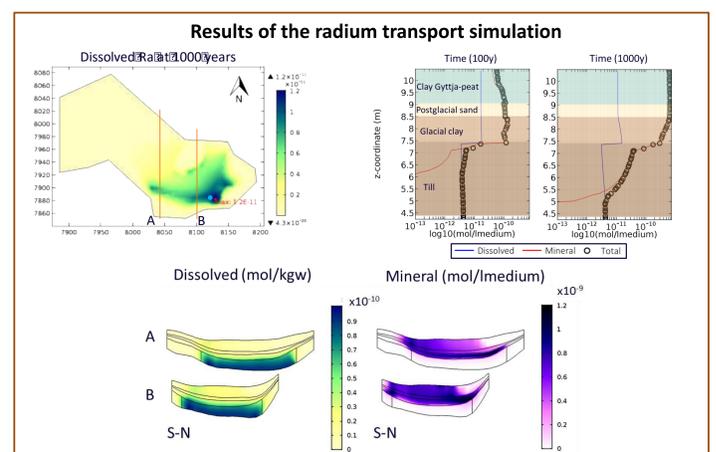
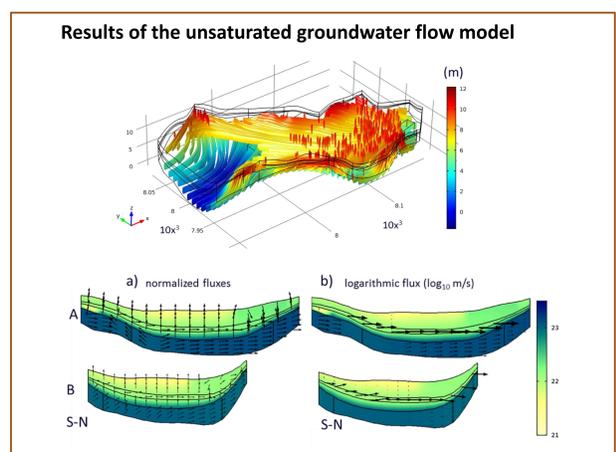
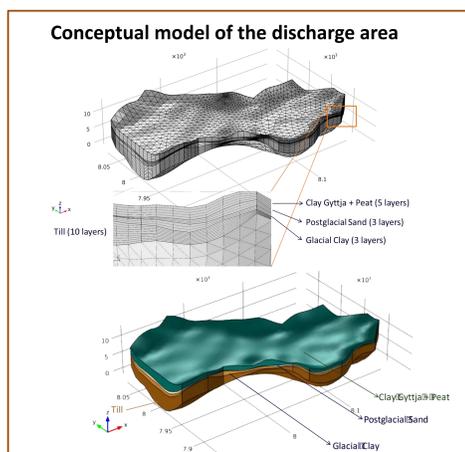
1D reactive transport models of radionuclide bearing granitic water in till and clay sediments were developed in iCP [3] based on existing mechanistic descriptions [2, 3]. They assume that radium immobilization occurs through the precipitation of an ideal solid-solution of barite with trace amounts of radium (Ba,Ra)SO₄.



When the granitic water, enriched in radionuclides, enters the till or clay it mixes with the resident Ba-rich water and the solid-solution precipitates. The maximum accumulation peak moves downstream with time. Ba is depleted after precipitation of (Ba,Ra)SO₄ and Ra is transported downstream by groundwater flow. As a result, (Ba,Ra)SO₄ redissolves and precipitates downstream, displacing the area of maximum Ra accumulation with time.

3D hydrogeological model with a mechanistic geochemical model of Ra transport

The mechanistic geochemical models developed in 1D are integrated in a 3D model with realistic hydrological conditions and an accurate representation of the regolith layers.



The postglacial sand, a 0.5-1 m-thick but very permeable layer interbedded between clays, acquires a critical role. The 3D groundwater flow field fosters mixing between Ra-bearing waters and resident waters across this layer. Mixing promotes chemical reactions and Ra accumulates primarily within this sandy material.

Conclusions

These results evidence the importance of understanding transport pathways to predict accumulation patterns and fluxes of radionuclide bearing groundwater. This information is essential to carry out informed simplifications needed for the purpose of risk assessment.

References

- [1] Nardi et al., 2014. Comput. Geosci., 69, 10–21.
- [2] Piqué et al., 2010. Conceptual and numerical modelling of radionuclide transport in near-surface systems at Forsmark. SR-Site Biosphere. SKB-R-10-30, Svensk Kärnbränslehantering AB.
- [3] Sena et al., 2008. Complementary modelling of radionuclide retention in the near-surface system at Forsmark: Development of a reactive transport model using Forsmark 1.2 data. SKB-R-08-107, Svensk Kärnbränslehantering AB.