SKB Task Force GWFTS: Lessons Learned from Modeling Field Tracer Experiments in Finland and Sweden

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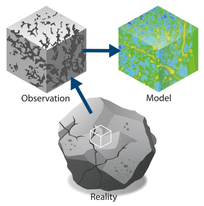
1. Introduction – Task 9

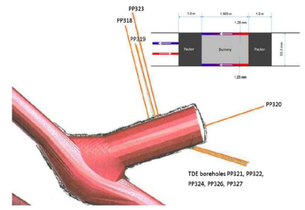


- The international **SKB Task Force on Modeling of Groundwater Flow and Transport of Solutes (TF GWFTS)** was established to support and interpret field experiments (www.skb.se/taskforce).
- Further objectives: To develop, test and improve tools for conceptual understanding and simulating groundwater flow and transport of solutes in fractured rocks.
- Work is organized in **collaborative modeling tasks**.
- Task 9 focuses on **realistic modeling** of coupled **matrix diffusion** and **sorption** in heterogeneous and fractured crystalline rock at depth.

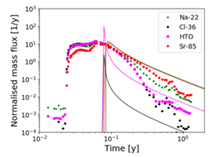
- The participating organizations in Task 9 are:
- **BMWi** (Germany)**, DOE** (USA)**, JAEA/NUMO** (Japan)**, KAERI** (Korea)**, Posiva** (Finland)**, SKB** (Sweden) and **SURAO** (Czech Republic)
- The Modeling Teams are:
- BMWi: **GRS**; DOE: **LANL**; NUMO: **JAEA**; KAERI: **KAERI**; Posiva: **HYRL, VTT**; SKB: **Amphos21, CFE, KTH**; SURAO: **FJFI ČVUT, PROGEO**, **TUL, ÚJV Řež**

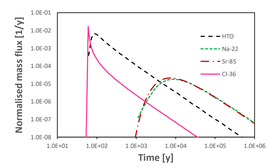
2. Task 9A and 9D

- **Task 9A**: Modeling of the **REPRO WPDE** performed at depth in the underground facility **ONKALO in Finland**.
- The **Water Phase Diffusion Experiment** gave **valuable data** for **modeling** of experiment and **Safety Assessment (SA)**.
- Task 9A was intended to be an easy predictive warm-up exercise, but the experiment gave some unexpected results.
- **Task 9D**: **Possible benefits** of **detailed modeling** of experiments in **safety assessment** calculations.
- Done by **upscaling** of Task 9A (Soler et al., 2019. SKB R-17-10) to conditions applicable for SA of nuclear waste repositories.

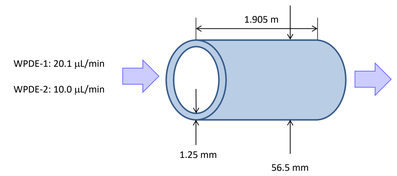


The REPRO niche



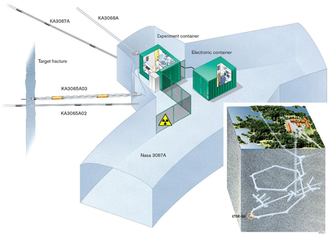


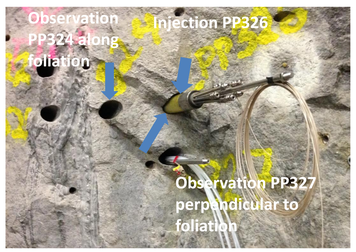
Example: Task 9A (WPDE) upscaled to Task 9D (SA) by Amphos21.



Schematic view of WPDE setup

3. Task 9B and 9C





• **Task 9B**: Modeling of LTDE-SD performed at about 410 m depth in the **Äspö HRL**, which is operated by **SKB (Sweden).**

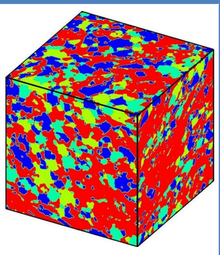
• The in-situ experiment comprised of **injection and seven months monitoring** and sampling of **22 trace elements** representing a variety of **chemical species** and **sorption behavior**. Again, unexpected results. The goal of the modeling was to **interpret** and **explain** the experimental results.

•**Task 9C:** Predictive and inverse modelling of tracer breakthrough curves of the in-situ Through Diffusion Experiment (TDE) performed at about 400 m depth at the ONKALO underground rock characterisation facility in Olkiluoto, Finland, by Posiva.

•TDE was carried out between three parallel boreholes arranged in right-angled triangle. Borehole ONK-PP326 was used for injections and ONK-PP324 and ONK-PP327 as observation boreholes. This facilitated tracer migration along, and across, the rock foliation. The experiment was carried out in 1 m long packed-off intervals, at about 12 m from the tunnel wall.

4. Outcome and Lessons Learned

- **Outcome**: Development of a range of codes and methodologies for modelling diffusion and sorption in the rock matrix
- Development of rich datasets to support modelling (LTDE-SD and REPRO)
- Development of micro-DFN/heterogeneity models
- Better understanding of issues around contamination and anomalous tailing in LTDE-SD
- Useful work on links to SA in Task 9D



- **Conclusions**: In-situ, there will probably be surprises and experimental artefacts.
- Useful with blank samples i.e. not exposed to tracers and radionuclides.
- Predictions can be useful for building conceptual models, aid for planning of experiments, and to create a foundation for further modeling.
- Combined predictive modeling and back-analysis can give clearer identification of uncertainties and gaps in knowledge of processes and importance of various factors and conditions.
- Task 9 pointed out the influence of heterogeneity of crystalline rock e.g., uneven mica distribution.
- Task 9 was a **Team Effort** and all involved learned from each other.

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