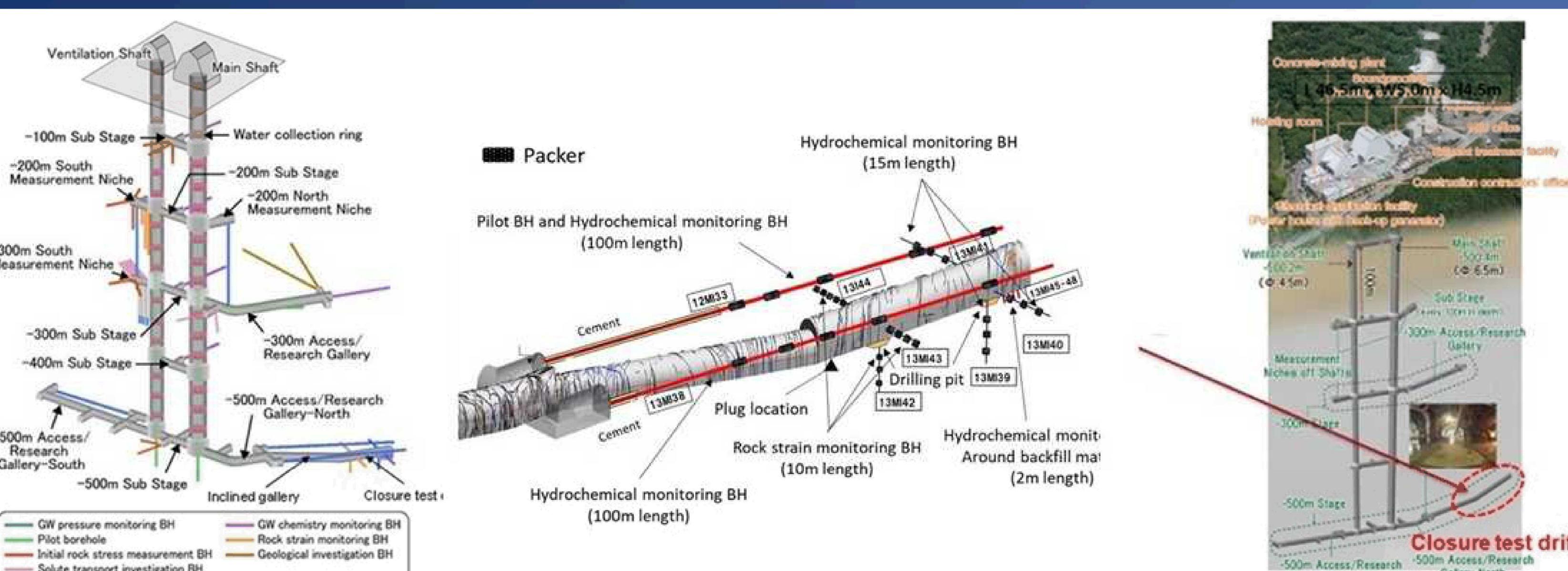


DECOVALEX19 Task C: GREET (Groundwater Recovery Experiment in Tunnel): Fracture Characterization, Modeling of Hydrology, Geochemistry and Reactive Transport at the Mizunami Underground Research Laboratory, Japan

Teklu Hadgu, Elena Kalinina, Carlos F. Jové Colón, and Yifeng Wang

Sandia National Laboratories, P.O. Box 5800, Albuquerque, New Mexico 87185
thadgu@sandia.gov; ekalin@sandia.gov; cfjovec@sandia.gov; ywang@sandia.gov

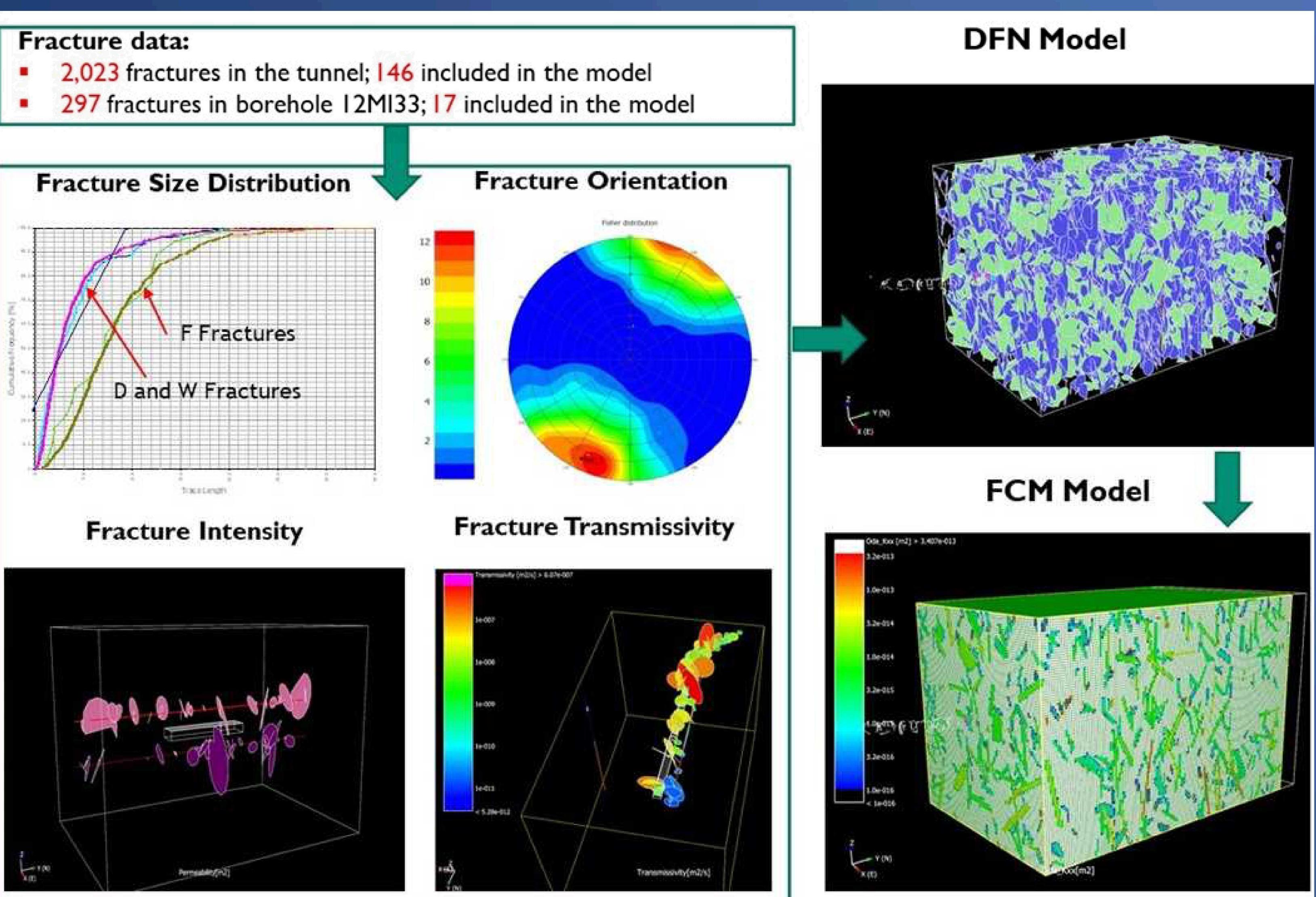
Experimental data from the Mizunami Underground Research Laboratory in Central Japan have been used to develop a fracture model, a hydrology model and a geochemical model for the study area. Details of the study are given below. The study is part of DECOVALEX19, Task C.



The Mizunami Underground Research Laboratory

Development of a Fracture Model

A discrete fracture network model was developed using project experimental data. The major input data were fracture traces measured on the tunnel walls and fractures observed in boreholes. These data were used to derive fracture orientation and fracture intensity distributions and to generate stochastic fractures within the modeling domain. The fracture model was upscaled to an orthogonal continuum mesh with $2 \times 2 \times 2 \text{ m}^3$ cell size using Oda's method.



Steps in Fracture Model Development

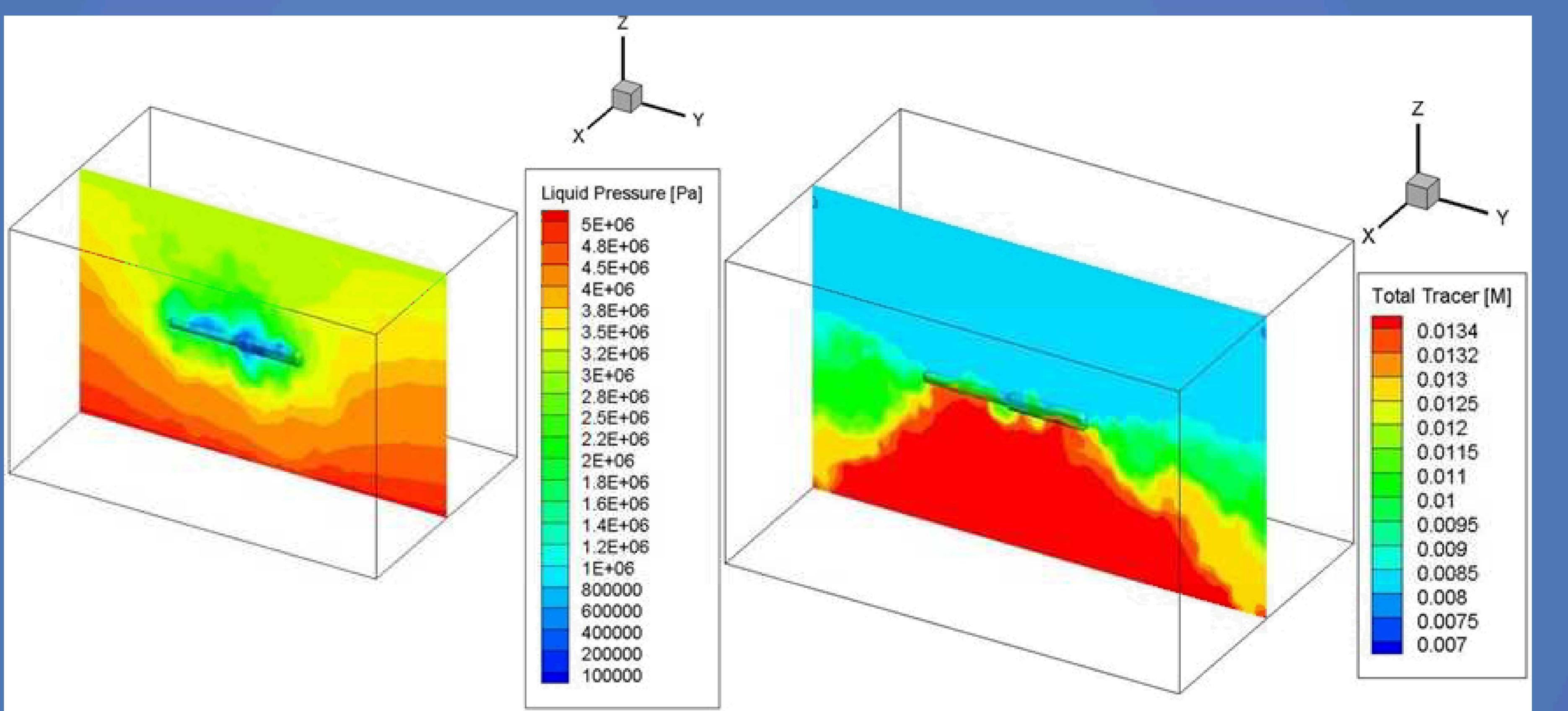
Developed Fracture Data

Fracture Set	Trend ($^{\circ}$)	Plunge ($^{\circ}$)	Fisher Dispersion κ	Volumetric Intensity P_{32} (1/m)
Set 1	208	8	7	0.22
Set 2	303	1.3	3.6	0.086

Modeling Hydrology During Tunnel Excavation

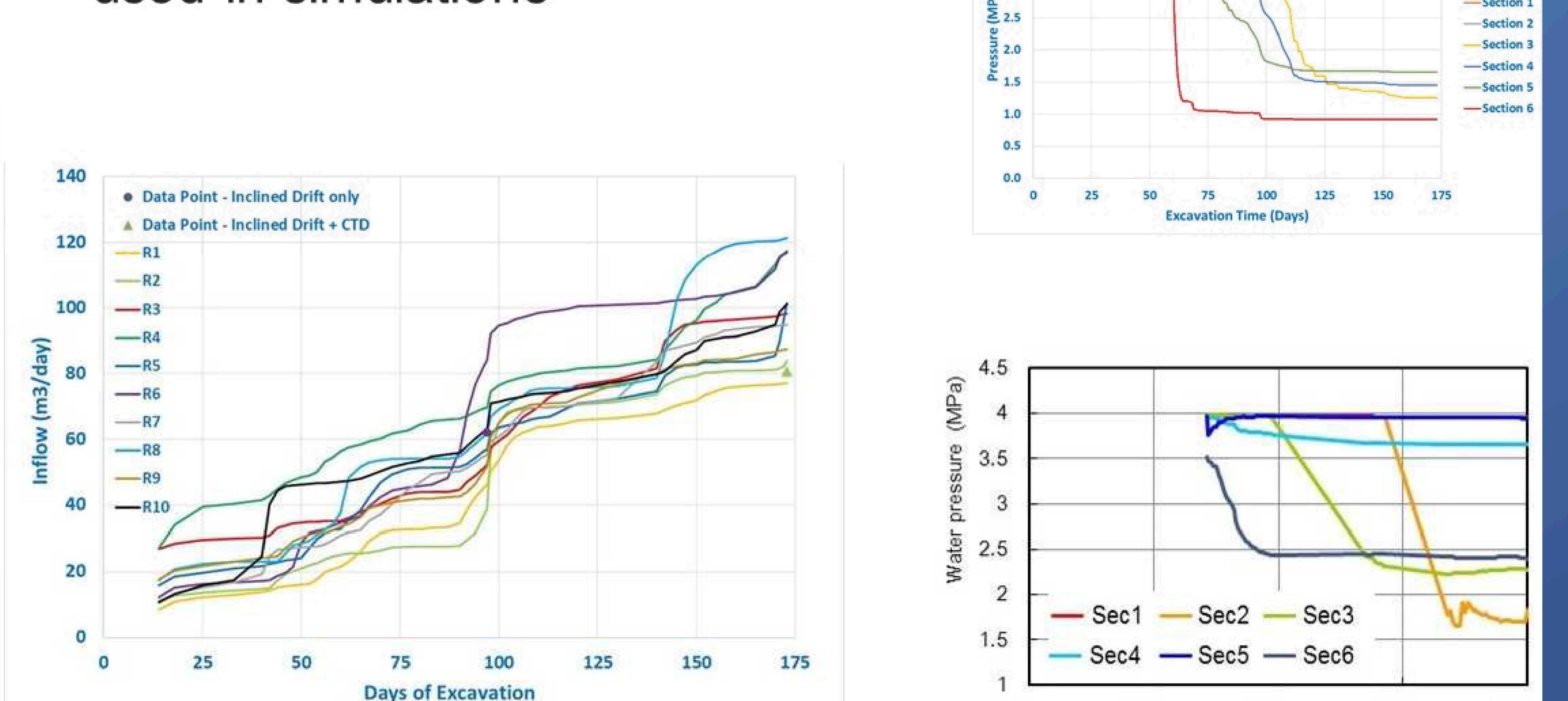
Numerical modeling of flow and transport through fractured crystalline rock was conducted in support of the study of migration of radionuclides from a high-level nuclear waste repository. The modeling involved prediction of inflow, pressure and chloride history at observation points based on experimental data of tunnel excavation progress. Upscaled permeability and porosity fields for 10 realizations were used. The PFLOTRAN numerical code was used for the simulations. Simulation results were compared with experimental data and with results from other teams.

- Domain size: 200 m x 300 m x 200m (1,500,000 grid blocks)
- Initial Condition: Hydrostatic pressure and Cl concentration gradient
- Boundary Conditions: specified pressure and chloride concentration at domain boundary.



Simulation results of distributions of pressure and chloride concentration at end of excavation (173 days of simulation time)

- Tunnel Excavation progress data and location of observation points used in simulations

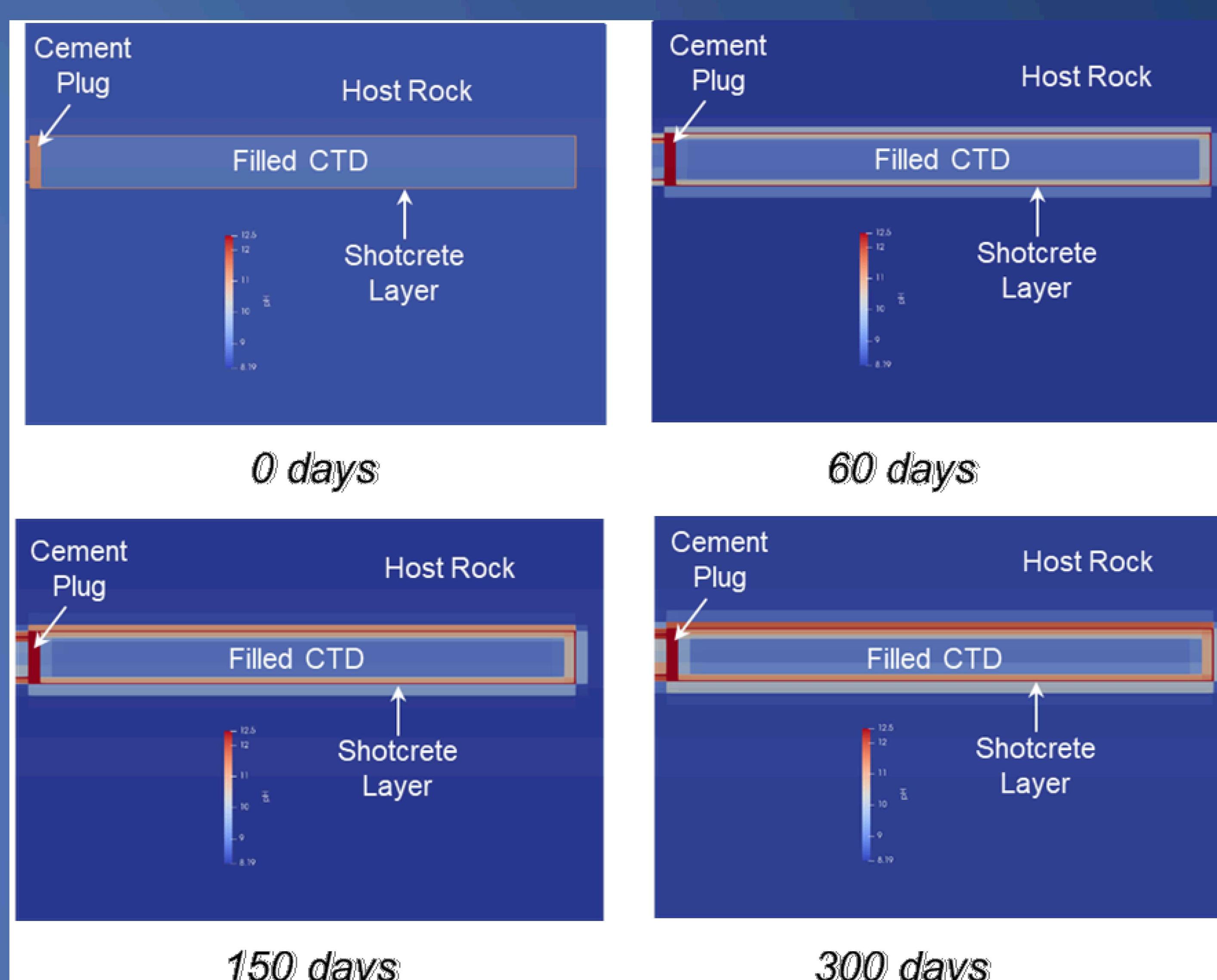


Predictions of Inflow and pressure history at Observation points in a monitoring borehole (12MI33) as a result of tunnel excavation

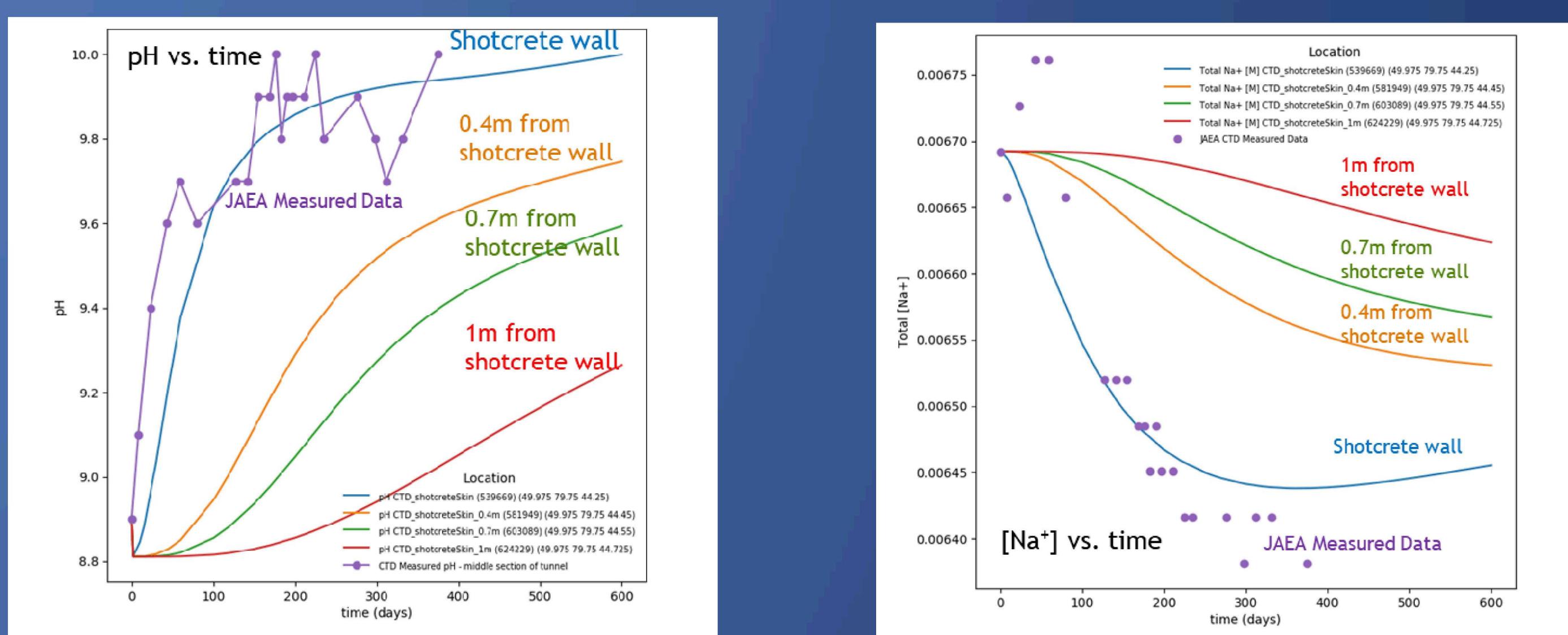
Geochemistry & Reactive Transport Modeling with PFLOTRAN

Preliminary predictions of filled Closure Test Drift (CTD) water chemistry resulting from interactions with cementitious materials under saturation conditions using transition state theory (TST) mineral kinetics expressions for portlandite and brucite.

- Starting pH 8.9
- Shotcrete: generic OPC (with brucite)
- Diffusion only problem



Reactive Transport Model: Preliminary Results



Prediction of pH and $[\text{Na}^+]$ temporal evolution

Summary

GREET provided field experimental data on fractures, hydrology and transport supporting the study of nuclear waste disposal in crystalline rock. The modeling analysis supported by field data resulted in better fracture characterization and prediction of flow and transport. Comparison of modeling results with other DECOVALEX19 Task C teams also helped refine prediction methods.

REFERENCES:

Evaluation of Spent Fuel Disposition in Crystalline Rocks: FY18 Progress report.. M2SF-18SN010302051 by Y. Wang, T. Hadgu, E. Kalinina, J. Jorden, V. K. Gattu, W. Ebert, H. Viswanathan, H. Boukhalfa, S. Chu, J. Hyman, S. Karra, N. Makendonska, P. Reimus, K. Telfeyan, L. Zheng, H. Deng, S. Nakagawa, K. Kim, T. Kneafsey, P. Dobson, S. Borglin, C. Doughty, M. Voltolini, M. Zavarin, E. Balboni, C. Atkins-Duffin.