International H

Management Conference

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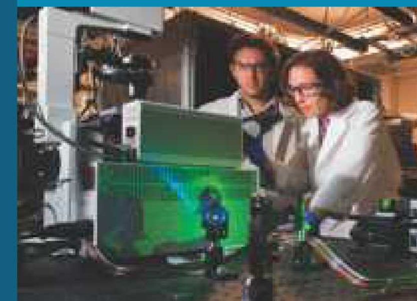
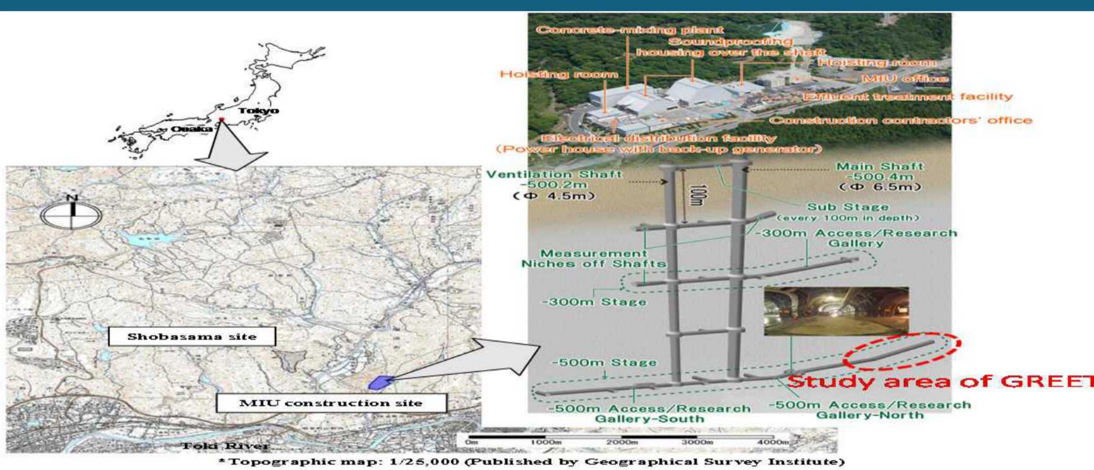
SAND2019-3694C

Determination of Factors Influencing Radionuclide Transport in Fractured Crystalline Rock





PRESENTED BY

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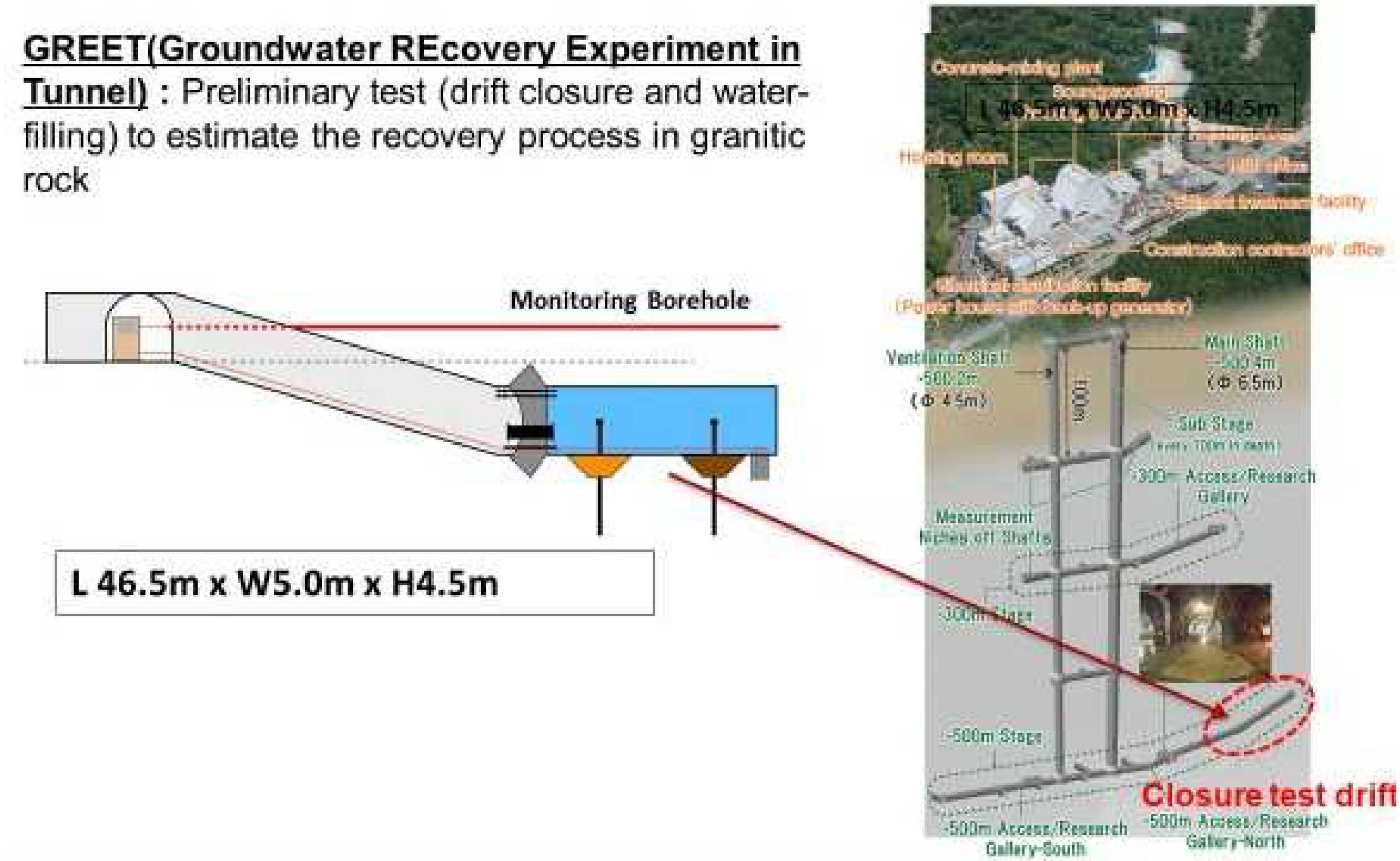
SAND2018-XXXX

Outline of Presentation

- Introduction to DECOVALEX19 Task C: GREET (Groundwater Recovery Experiment in Tunnel).
- Modeling of Hydrology at the Mizunami Underground Research Laboratory, Japan.
- Effect of boundary condition due to domain size
- Upscaling Discrete Fracture Model to a Continuum Model

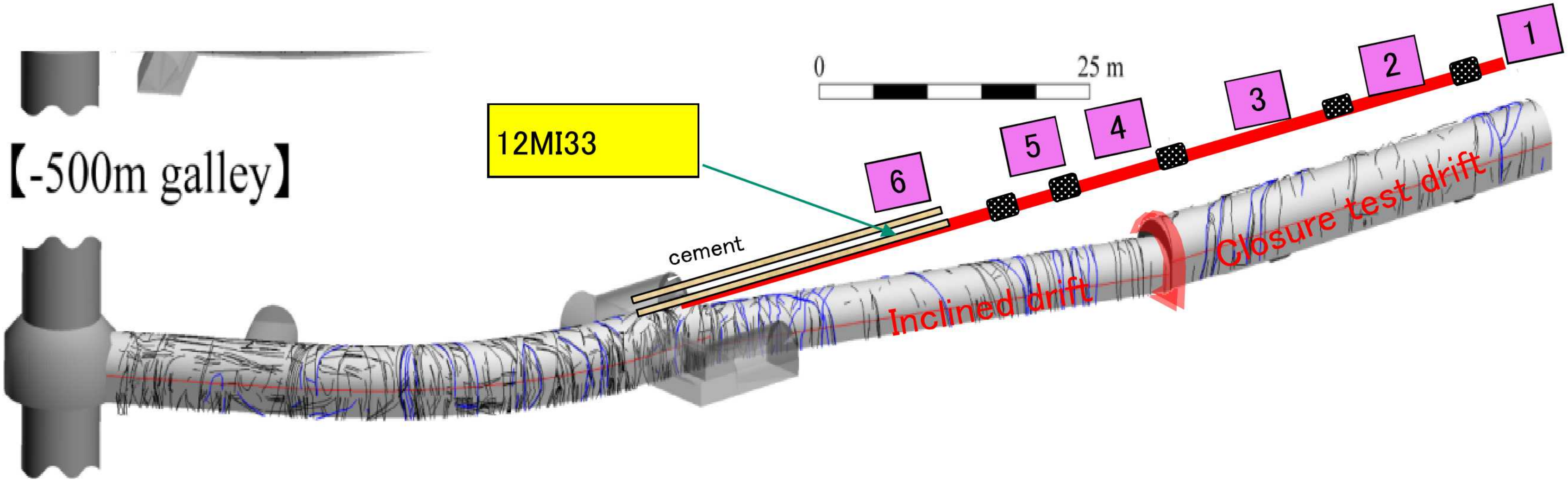
Hydrology and Geochemical Experiments at the Mizunami Underground Research Laboratory

- URL located at Tono area (Central Japan)
- Study is part of DECOVALEX2019 Task C (JAEA experiments)



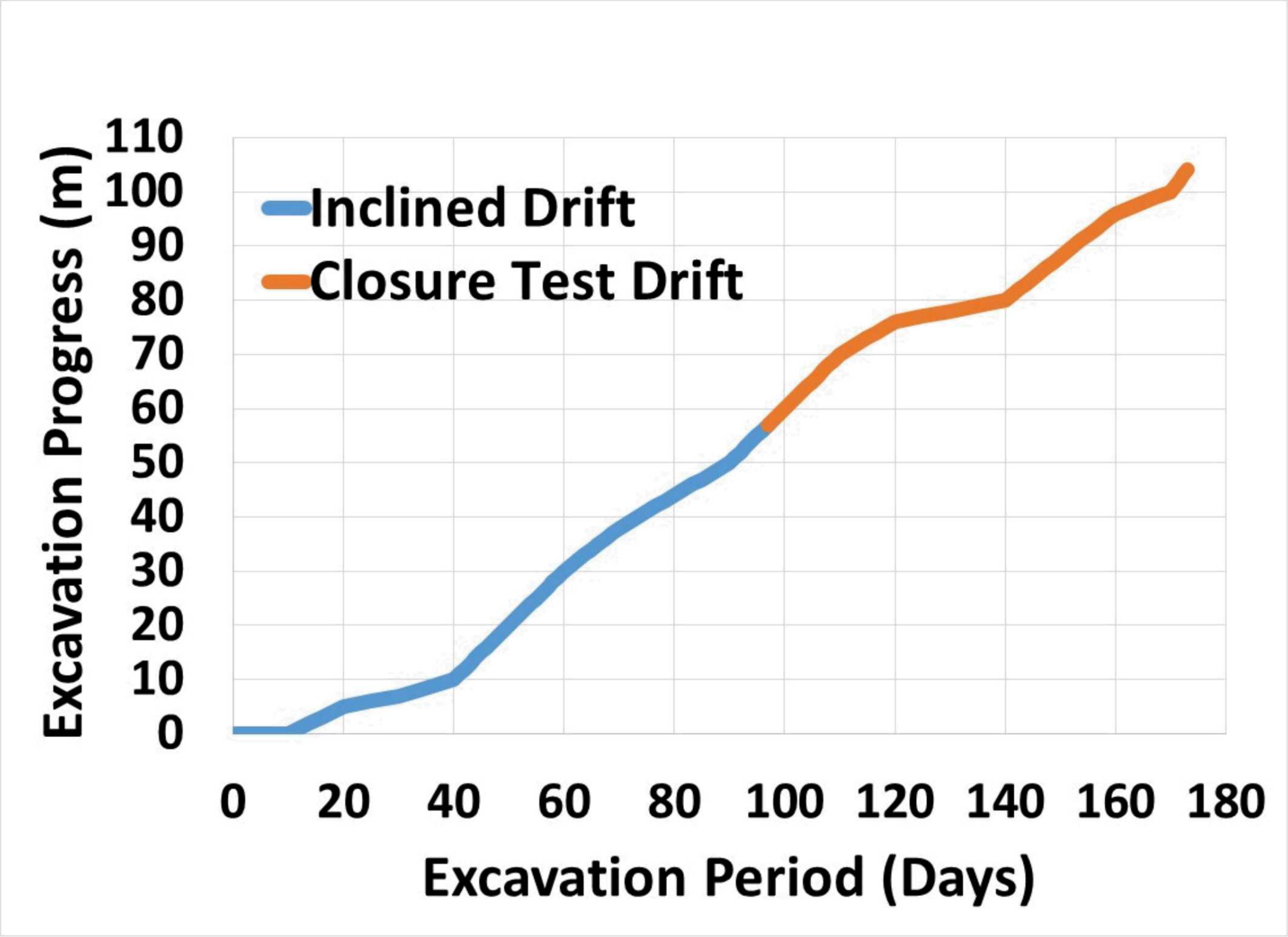
Study Area: Tunnel and an Observation Borehole

- Tunnel sections: Inclined Drift and Closure Test Drift
- Monitoring Sections in Observation Borehole 12MI33



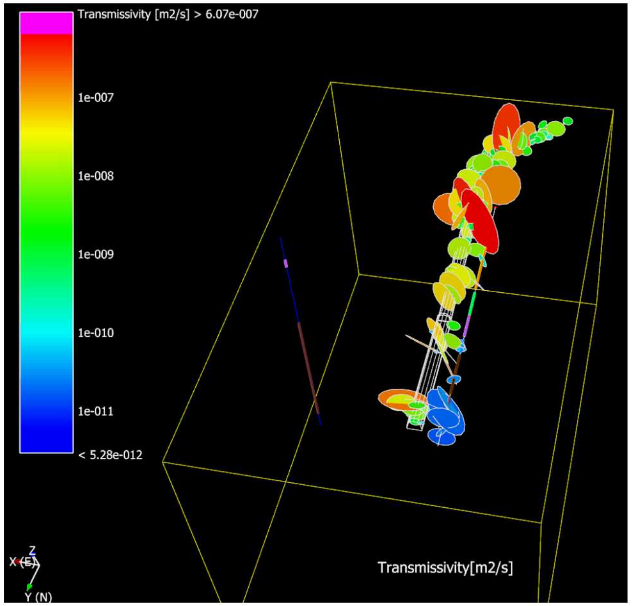
Tunnel Excavation Progress Data

- Progress of excavation of inclined Drift and Closure Test Drift tunnel sections

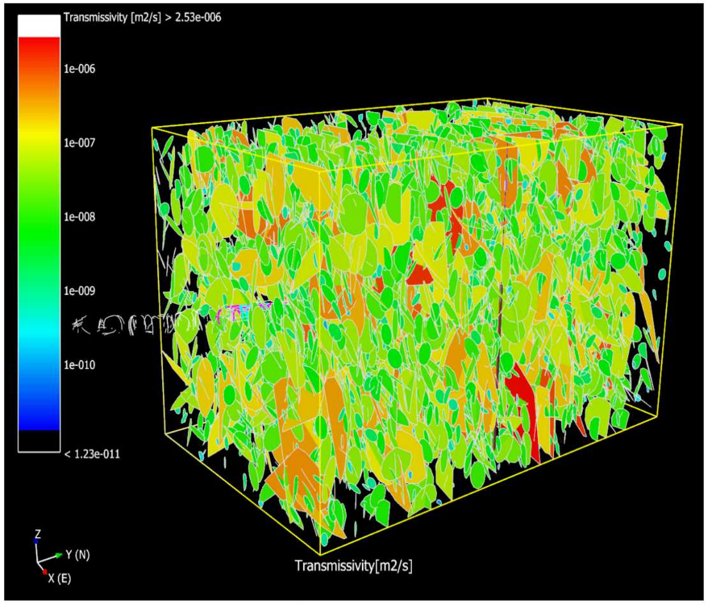


Fracture Model Development

- Measured fractured data from tunnel walls and Borehole 12MI33
- FRACMAN used in model development (Kalinina et al., DFNE 2018)



Fracture transmissivity in tunnel and observation borehole 12MI33



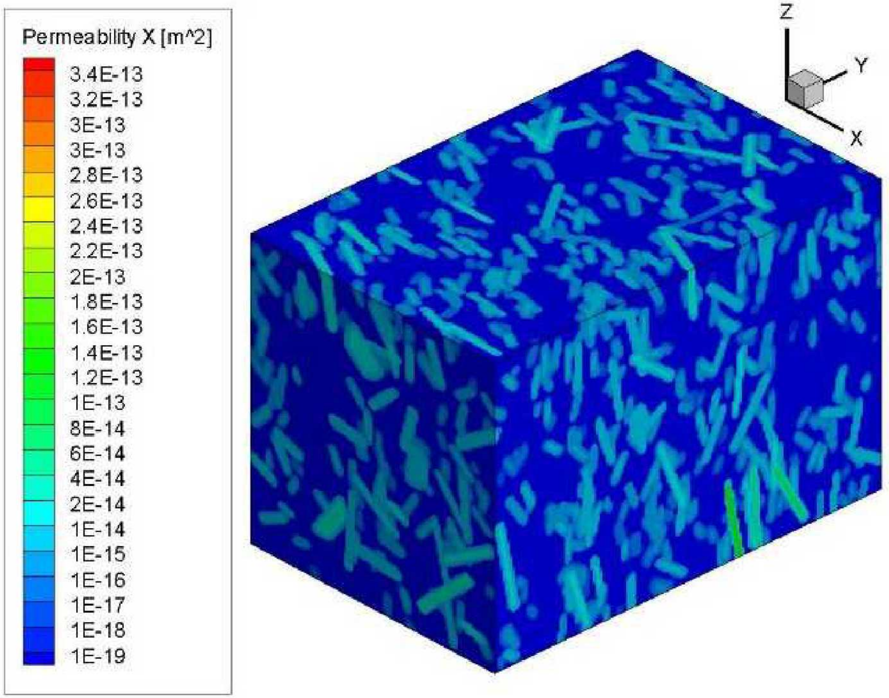
A realization of discrete fracture network

Developed fracture data

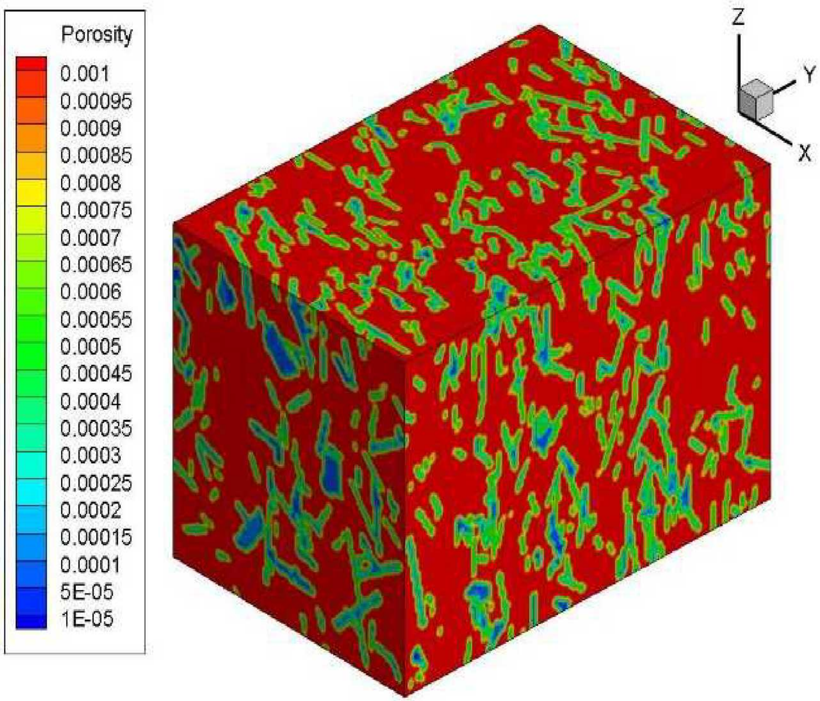
Fracture Set	Trend (^{0})	Plunge (^{0})	Fisher Dispersion κ	Volumetric Intensity P_{32} (1/m)
Set 1	208	8	7	0.22
Set 2	303	1.3	3.6	0.086

Upscaled Permeability and Porosity

- Upscaled permeability and porosity fields for a single realization
- Matrix rock represented by permeability of 10^{-19} m^2 and porosity of 0.001



Upscaled permeability of a realization



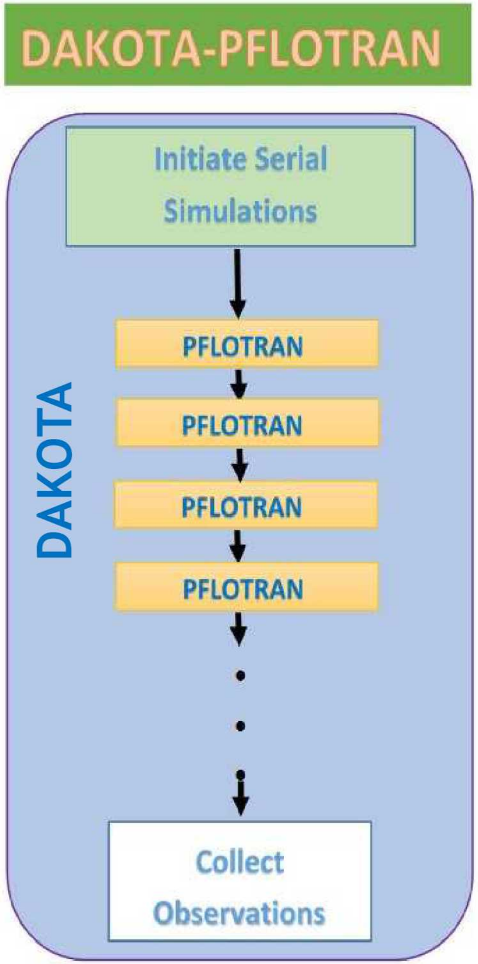
Upscaled porosity of a realization

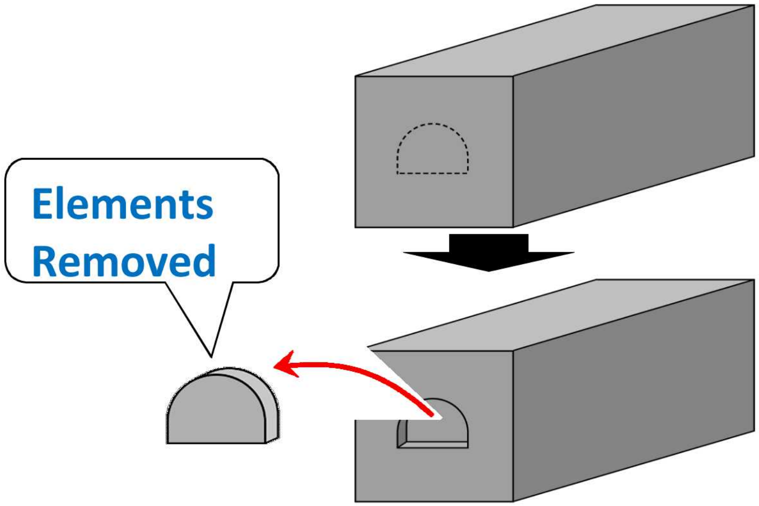
Simulation Model Development

- Simulation was conducted for tunnel excavation, water inflow, pressure drawdown and chloride concentration changes.
- Modeling domain: 200 m x 300 m x 200 m.
  - Regular mesh with grid block size: 2 m x 2 m x 2m.
  - Mesh Size: 1,500,000 grid blocks.
- Fracture model with two fracture sets; 10 DFN realizations used.
- Permeability and porosity upscaled to continuum grid.
- Initial Condition: hydrostatic pressure and chloride conc. gradient
- Boundary Conditions: specified pressure and chloride conc.
- Pressure and chloride prediction at observation points.
- Prediction of inflow rate as a result of tunnel excavation.
- DAKOTA, optimization code and PFLOTRAN massively parallel numerical code used for simulation.

Flow Simulation Approach

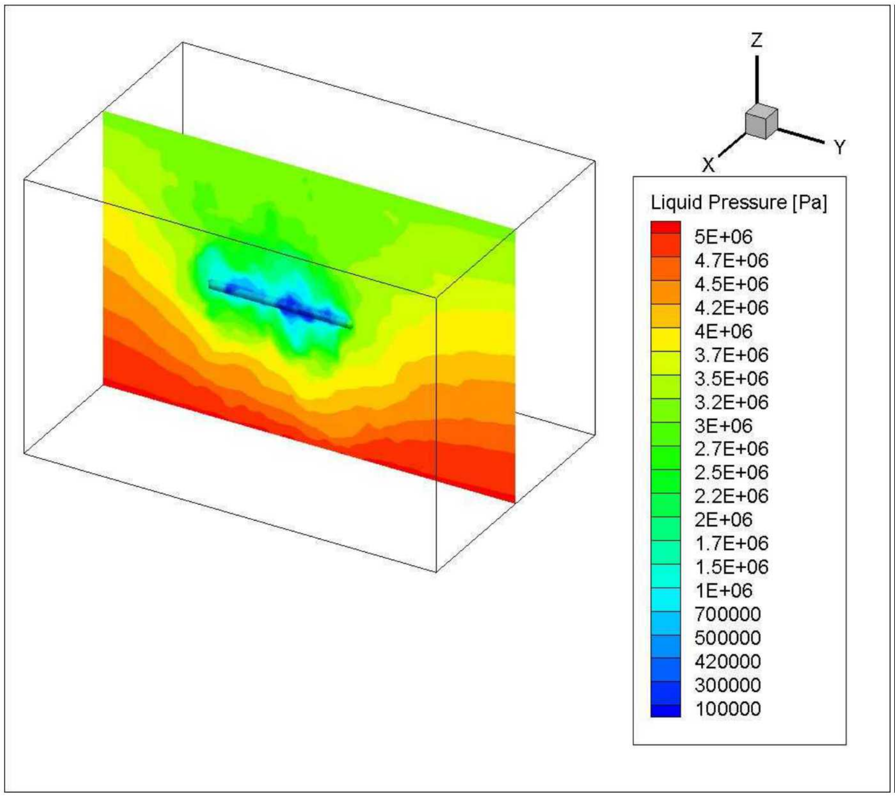
- Progressively removing material.
  - 1 m at a time for a total of 103 m.
- DAKOTA-PFLOTRAN simulation codes used.
  - DAKOTA: Optimization Code.
  - PFLOTRAN massively parallel numerical code.
- Excavated tunnel at atmospheric pressure boundary condition.
- Simulations run for 10 fracture realizations.



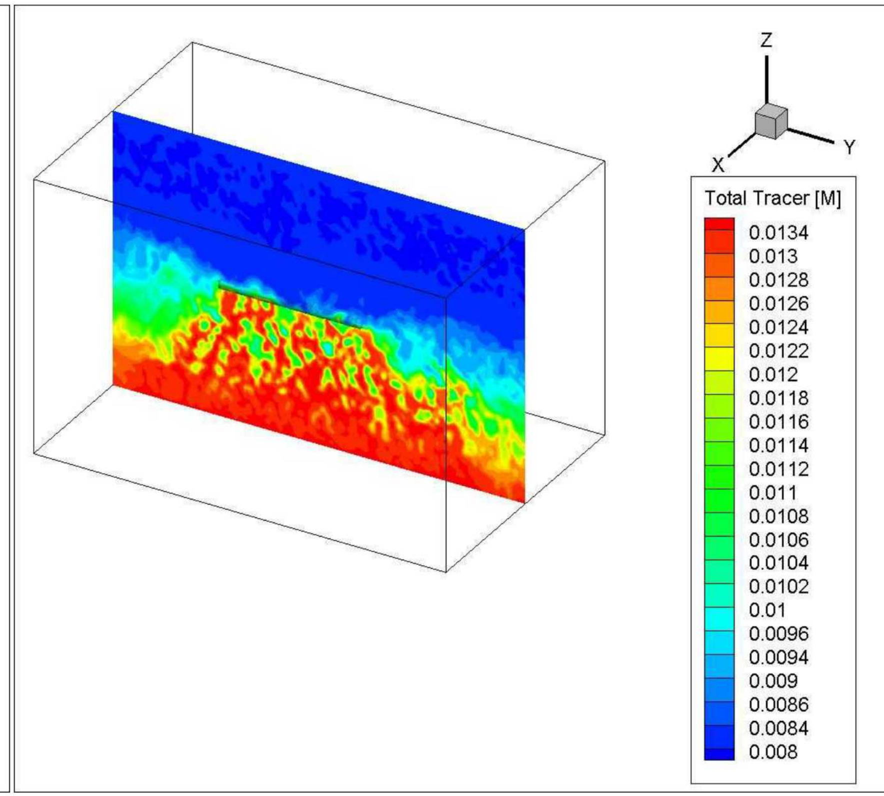


Predicted Pressure Distribution Results

- Pressure and Chloride distributions along tunnel axis, after 173 days simulation time (total excavation time)



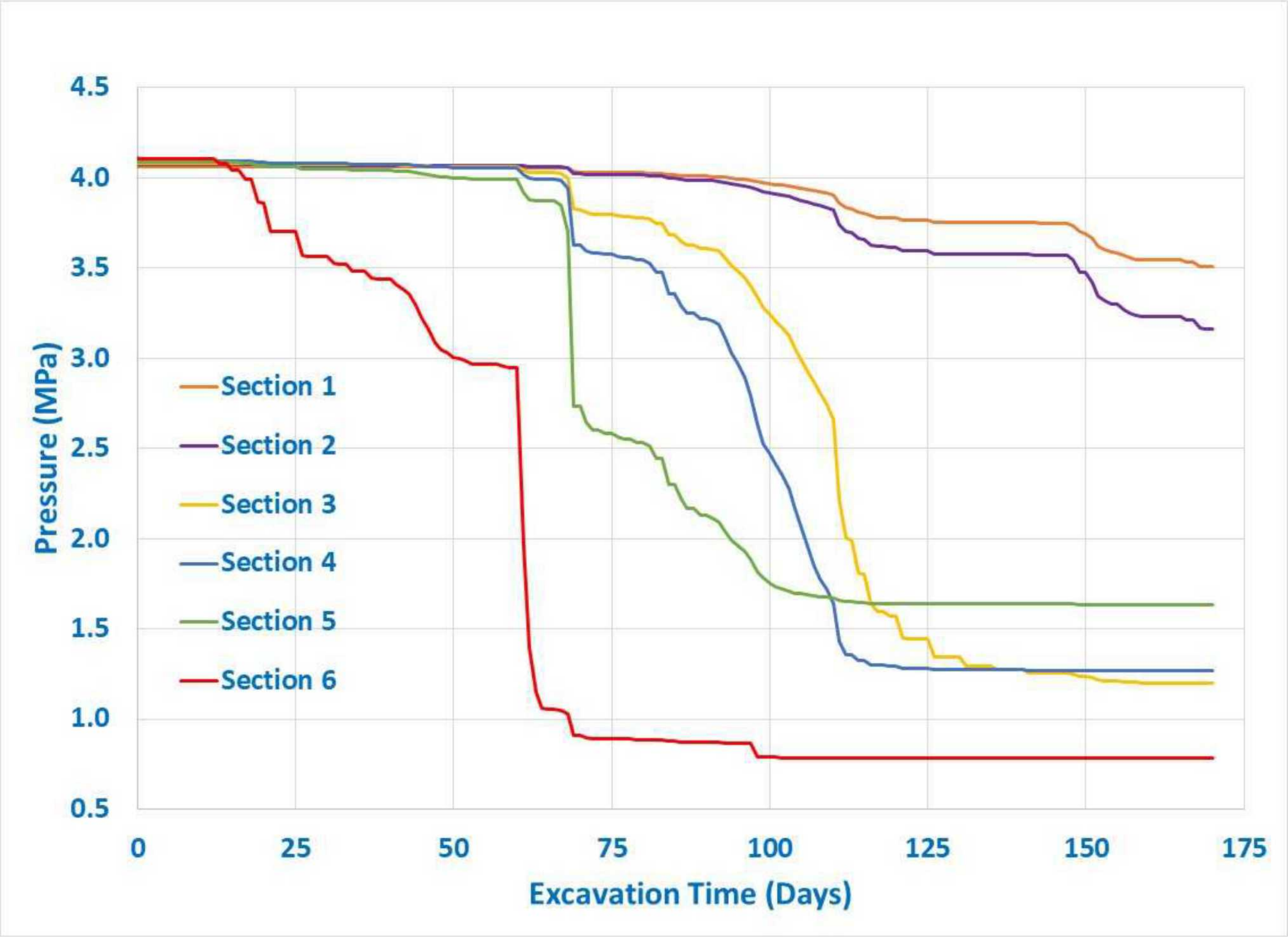
Pressure Distribution



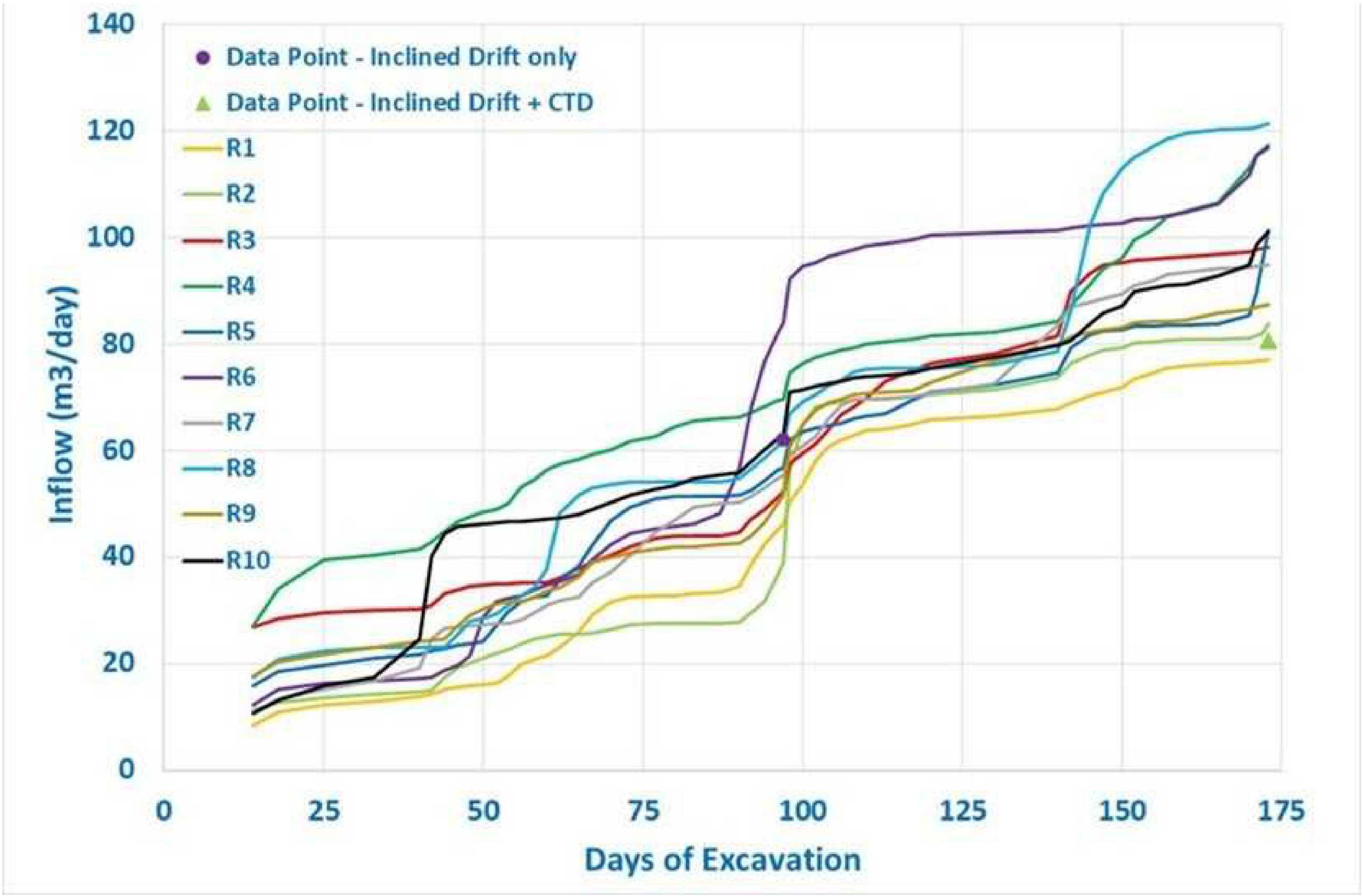
Chloride Distribution

Predicted Pressure History Results

- Predicted pressure history at monitoring points in Observation Borehole 12MI33
- Pressure drawdown due to flow into tunnel as a result of excavation.



Predicted Inflow of Water into Tunnel for Ten Fracture Realizations

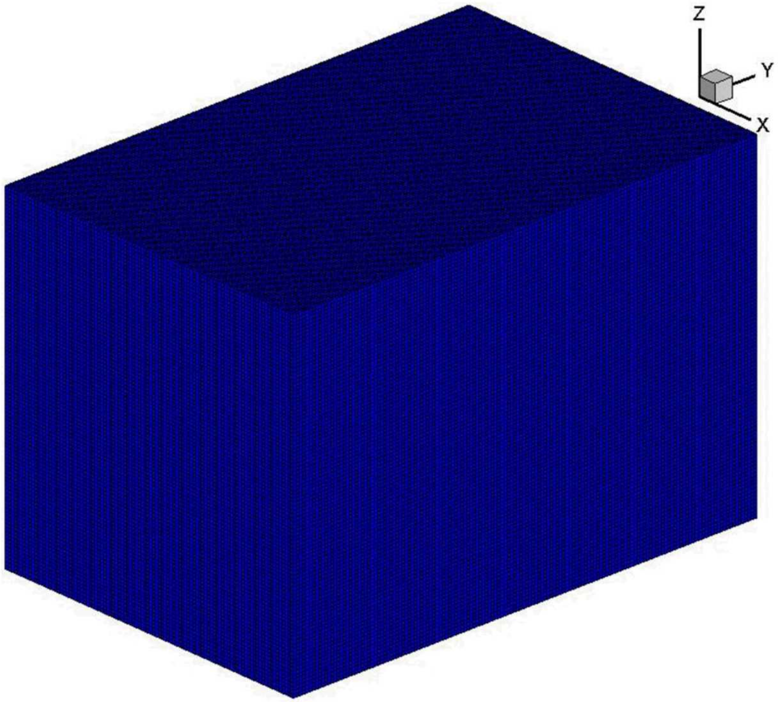


Analysis of Effect of Boundary Condition

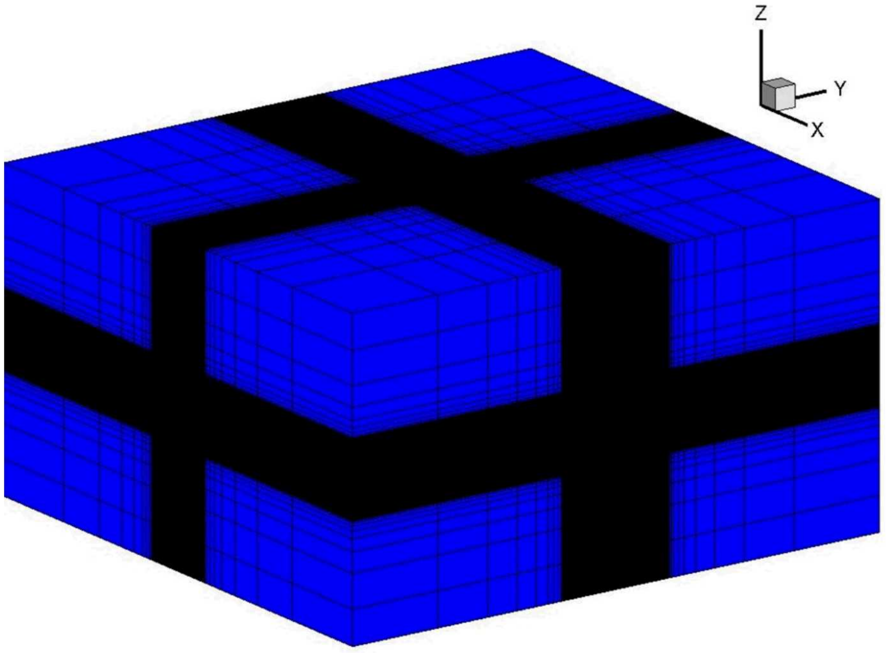
- For the base case specified pressure and chloride concentration boundary conditions were applied at the top, bottom and sides.
- To study the effect of boundary condition, a larger domain was used with no boundary conditions applied.
- Inflow prediction analysis was done for the larger domain size and compared results with those of the base case.
- Permeability and porosity for Realization 2 upscaled to large grid.
- Initial Condition: hydrostatic pressure and chloride conc. gradient.
- The same modeling procedure as for the base case were applied.

Analysis of Effect of Boundary Condition, Contd.

- Base Case domain
  - Domain size: 200 m x 300 m x 200 m in the x, y and z
  - Mesh size: 1,5000,000 grid blocks.
- Larger domain
  - Domain size: 1386 m x 1486 m x 806 m in the x, y and z
  - Mesh size: 2,352,987 grid blocks.

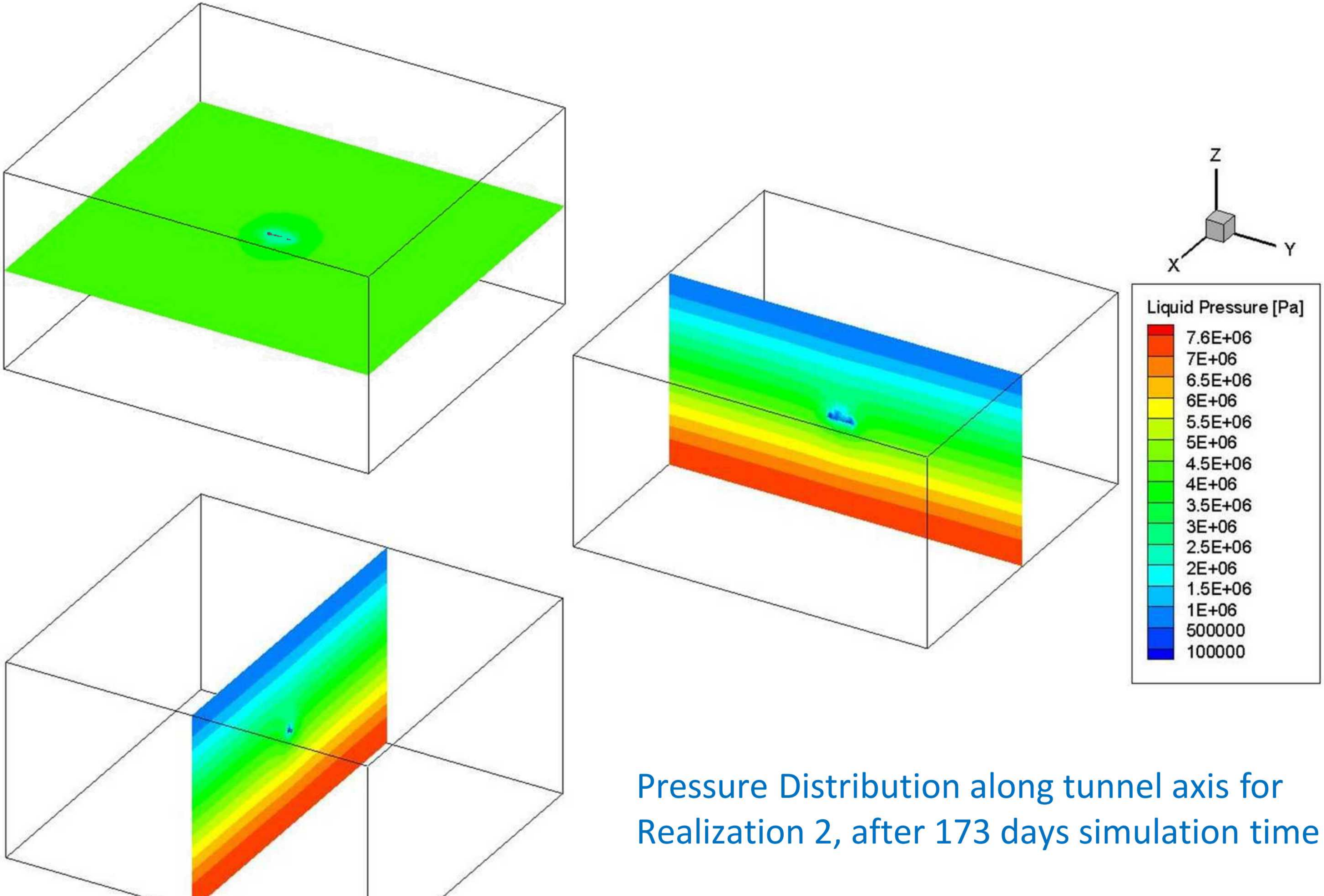


Base Case Domain (Not to Scale)



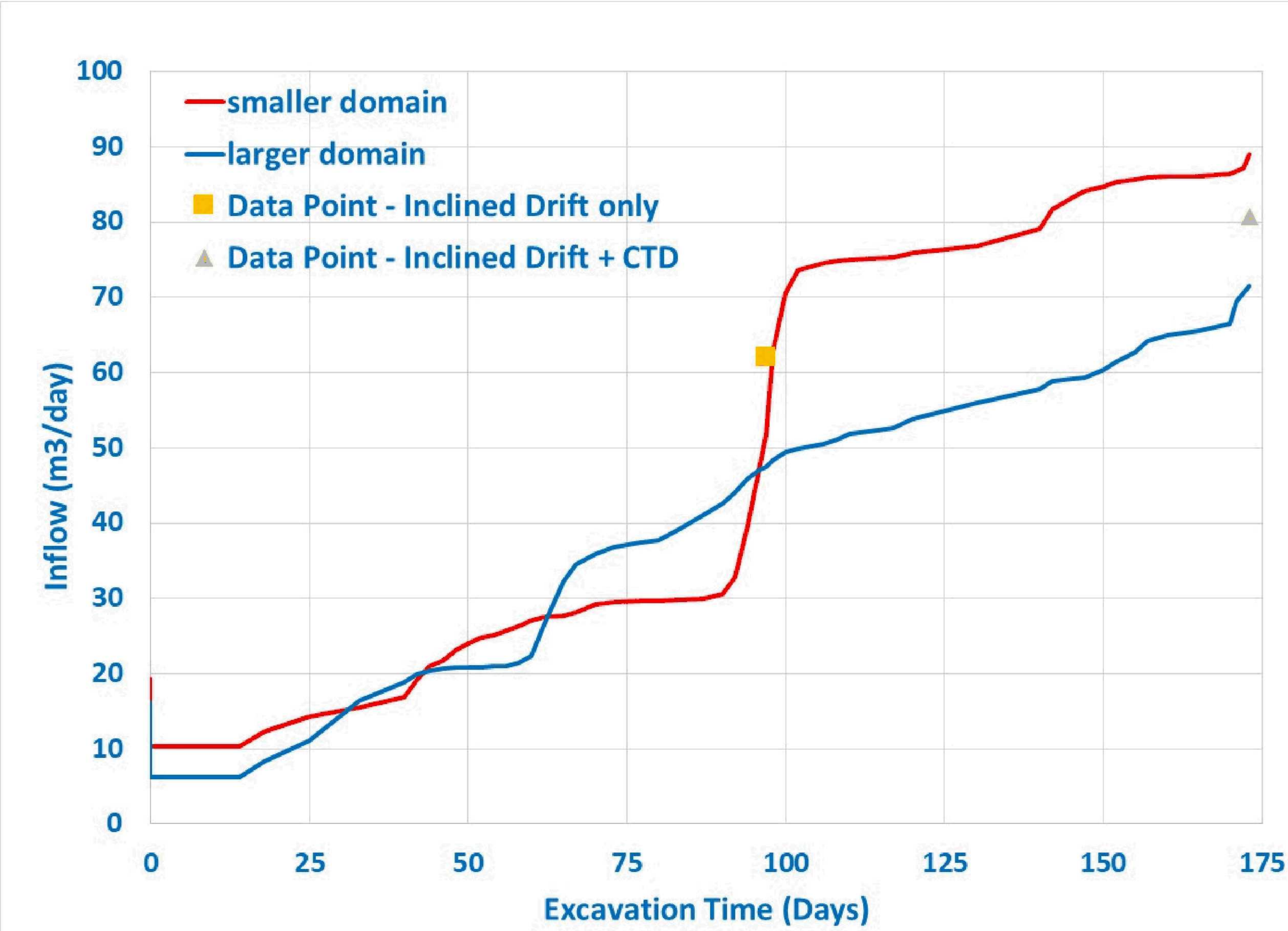
Larger Domain (Not to Scale)

Distribution of Pressure for Large Domain



Pressure Distribution along tunnel axis for Realization 2, after 173 days simulation time

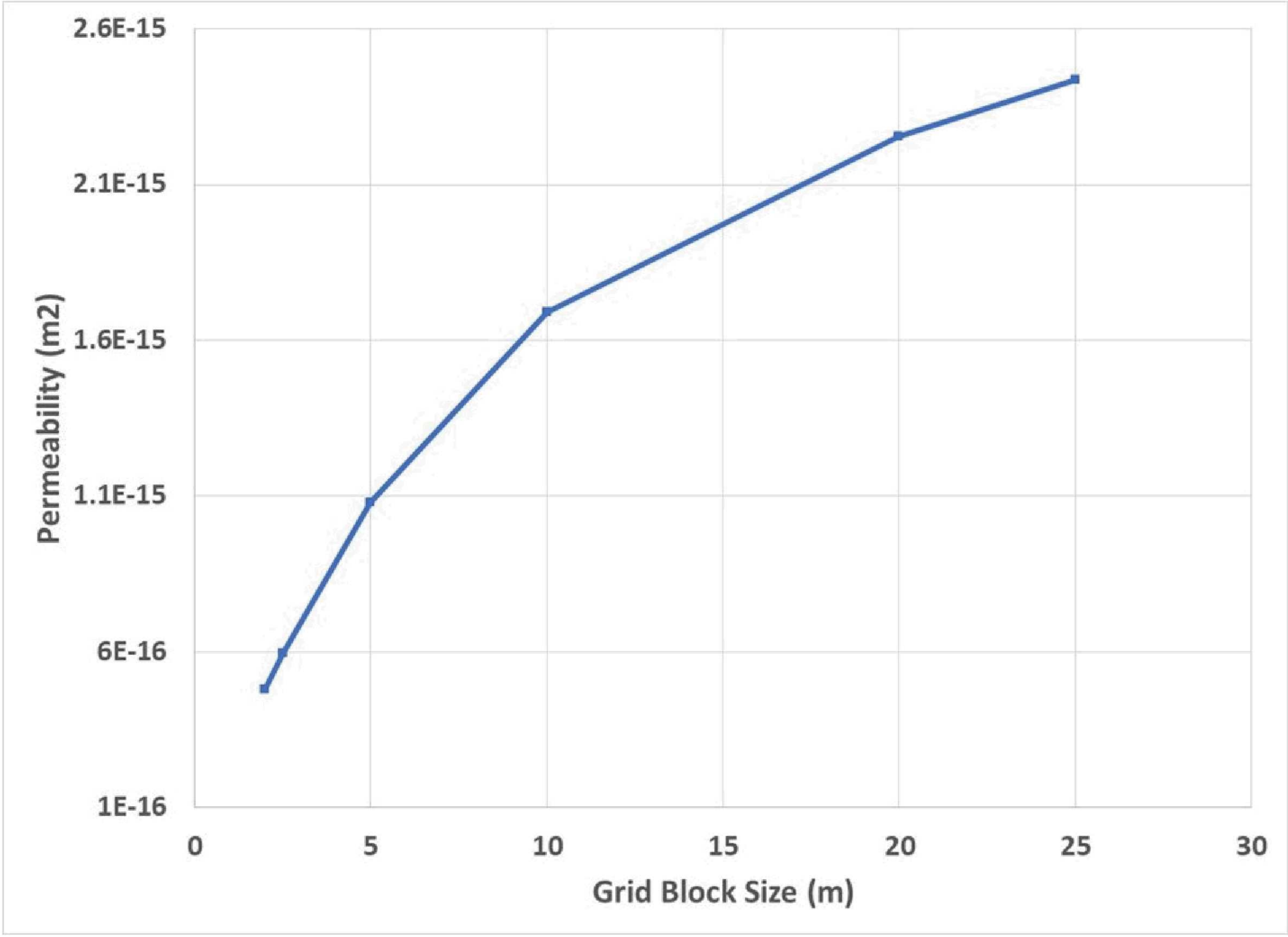
Comparison of Predicted Inflow of Water into Tunnel



Effect of Grid Block Size in Upscaling DFN to Continuum Grid

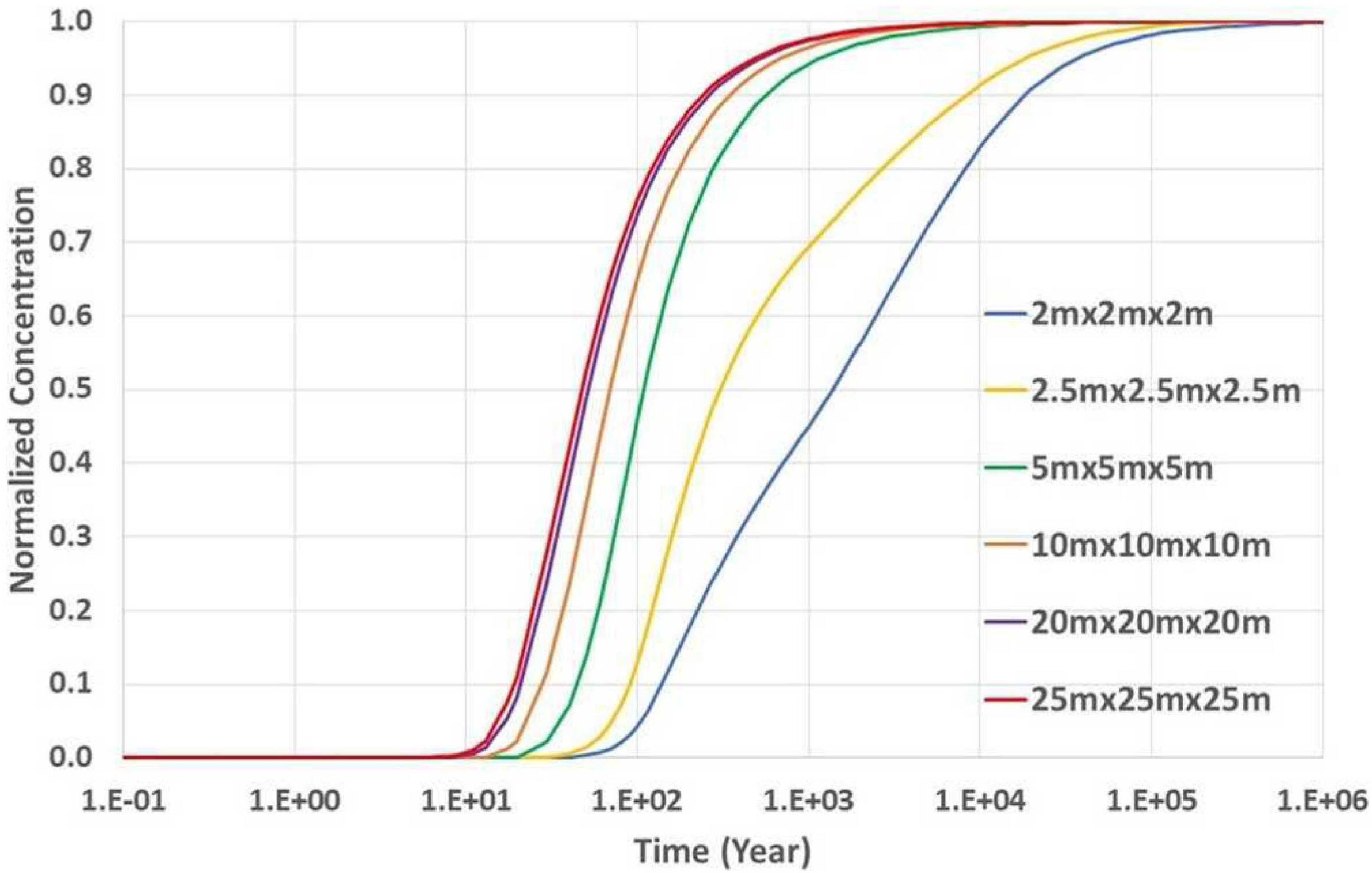
- For the DECOVALEX Task C modeling DFN was upscaled to continuum in FracMan using the Oda method.
- The Oda method is a geometric based upscaling method.
- Modeling analysis conducted to study effect of grid block size.
- Different domain sizes and grid block sizes considered.
- A fracture realization was used for the analysis.
- Effective permeability and tracer breakthrough estimated.
- PFLOTRAN used for flow and transport simulations.
- Results are shown for domain size 200 m x 300 m x 200 m.
  - Pressure and tracer concentration gradient applied.
  - Flow and transport from south to north (300 m length).

Effective Permeability vs Grid Block Size



Tracer Transport Breakthrough Curves for Different Grid Block Sizes

- Simulations showed grid block size limits of 0.5 m to 25 m
- Direct DFN simulations to be used to optimize grid block size



Conclusions

- ◦ Flow modeling was conducted to predict inflow of water during tunnel excavation and pressure drawdown at the Mizunami Underground Research Laboratory.
- ◦ Results show that determination of optimum domain size is important to limit boundary effects.
- Oda upscaling method is grid block size dependent
  - Output shows a power law relationship between permeability and grid block size
  - There is a need to compare upscaled results to DFN simulation results to optimize grid size

Acknowledgements

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