

Spent Fuel and Waste Science and Technology

Field Data Synthesis and Upscaling for Fractured Rocks

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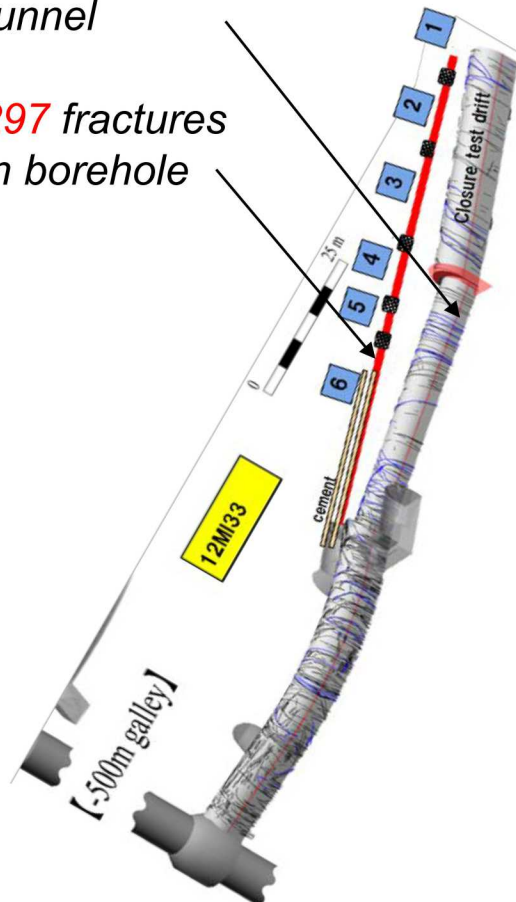
Field Data



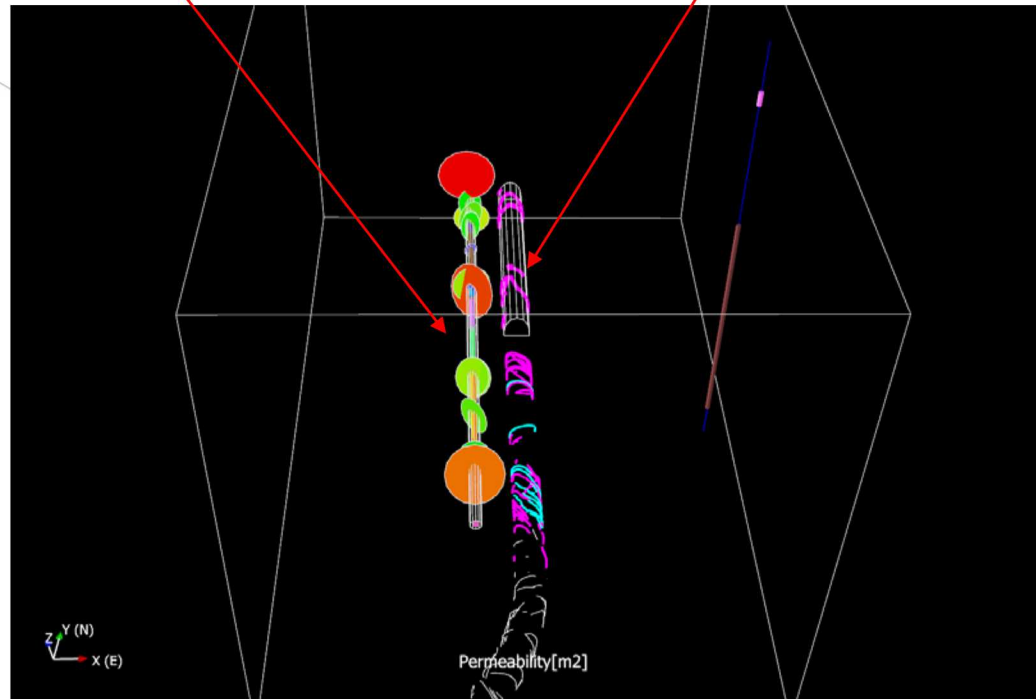
Model

2,023 fractures in the
tunnel

297 fractures in
borehole

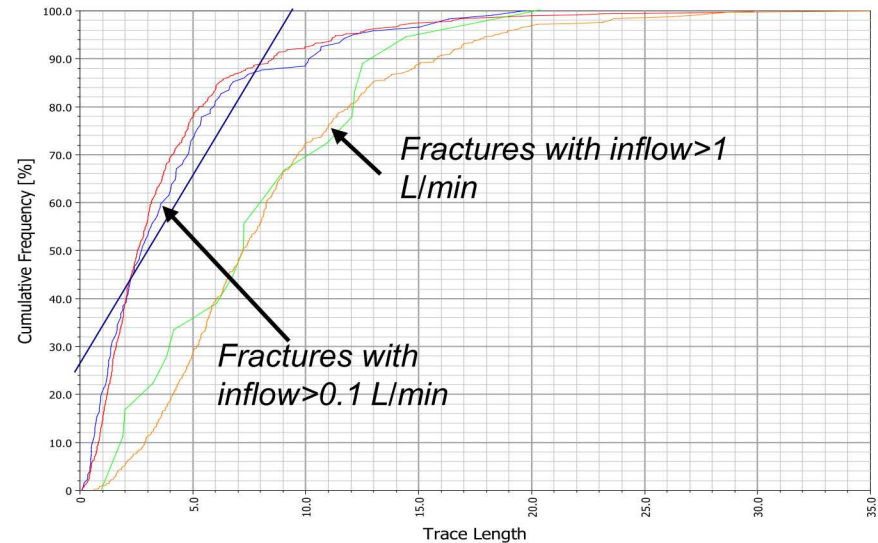
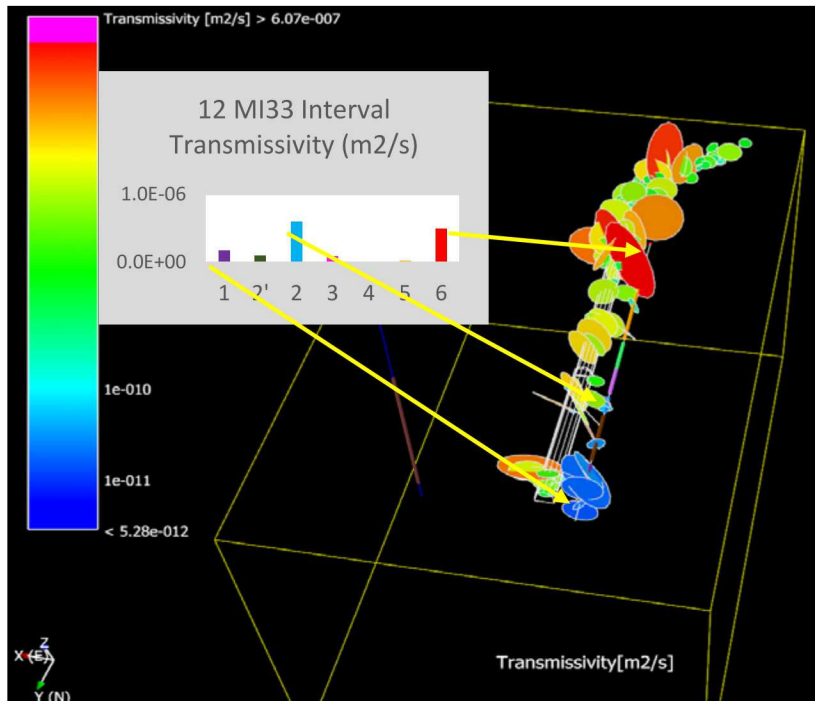


146 fractures in the tunnel
17 fractures in the borehole



- Fractures in the tunnel and borehole have deterministic locations and stochastic sizes and properties.

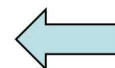
- *Fracture Size distributions from trace length analysis.*



- *Fracture transmissivity from the observed fracture discharge (analytical solution).*



- *Correlations between fracture radius (R), fracture aperture (b) and permeability (k):*



$$k = \gamma_1 \cdot R^\omega \quad b = \gamma_2 \cdot R$$

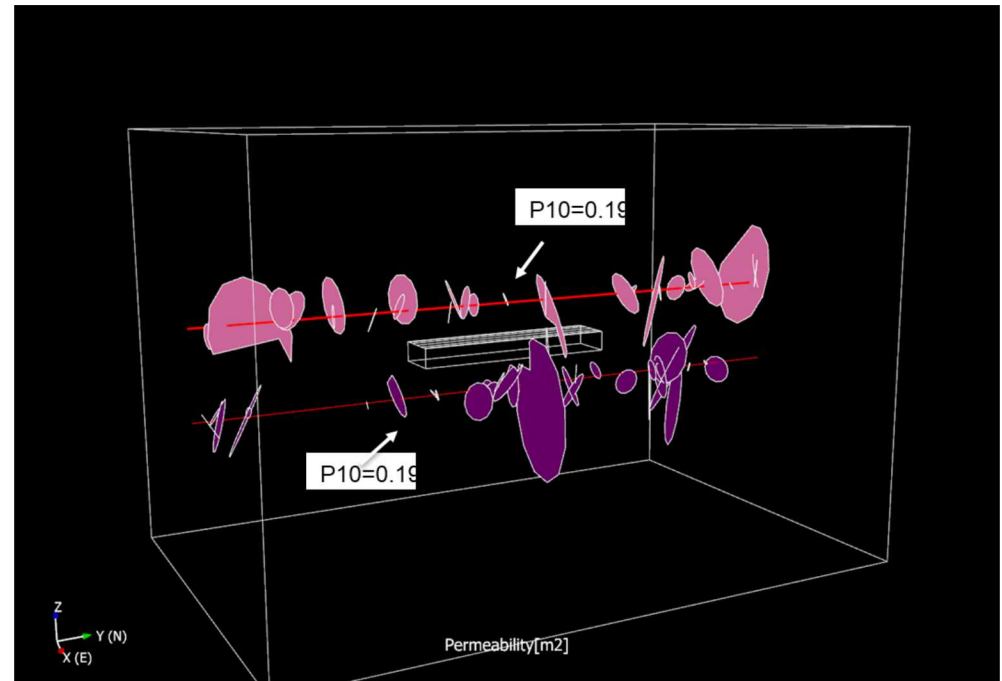
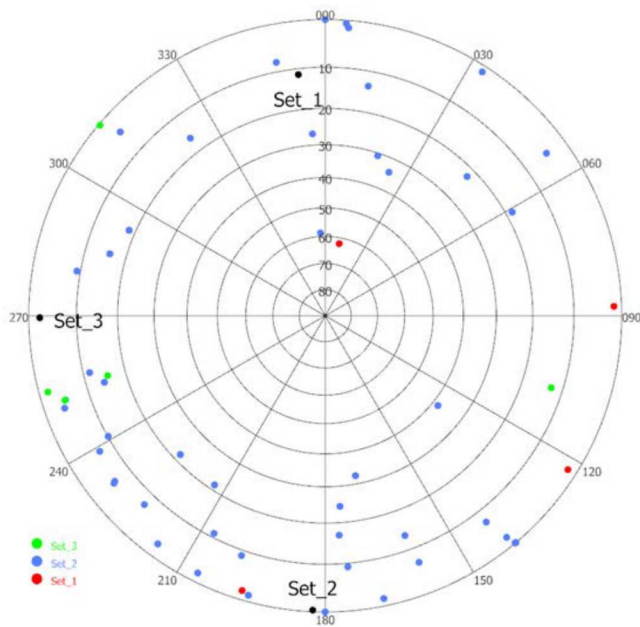
- *Transmissivity from Packer Tests Compared to Transmissivity of Generated Fractures*

Additional Information Required to Generate Stochastic Fractures

- *Number of fracture sets.*
- *Orientation distribution for each fracture set.*

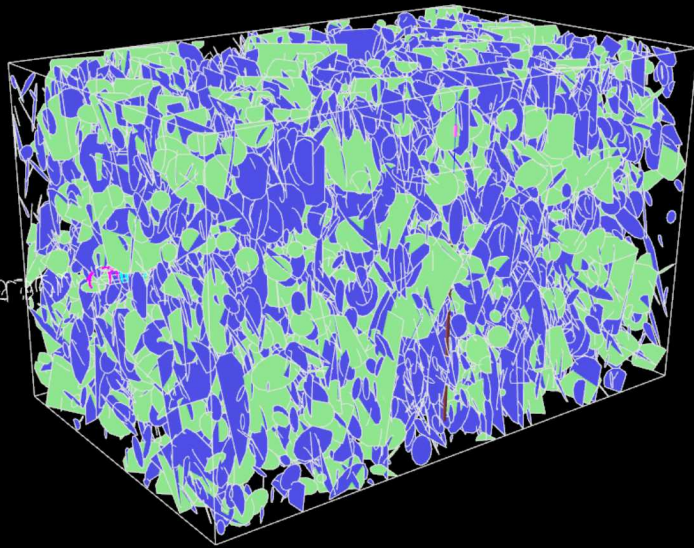
- *Fracture intensity for each set.*

Stochastic Fractures Intersecting Arbitrary Horizontal Boreholes



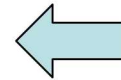
- *Identifying fracture sets from tunnel fracture orientation and plunge*

- *Calculating volumetric intensity (P_{32}) by matching linear intensity (P_{10}) of generated fractures with the P_{10} of observed fracture.*



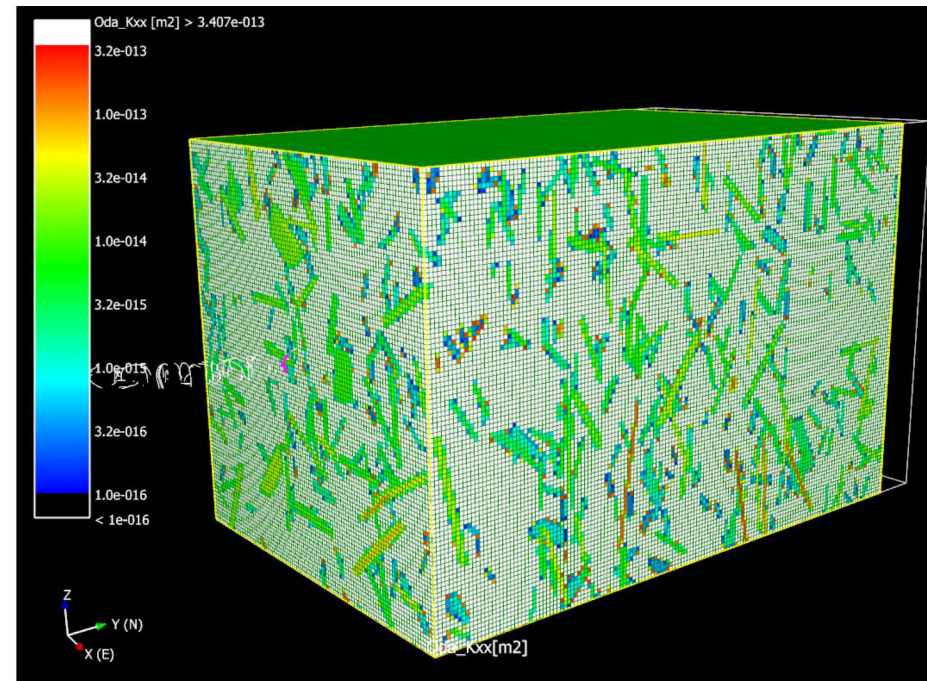
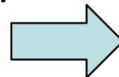
➤ Discrete Fracture Network Model (DFN)

- Total number of fractures: 7,758
- Deterministic fractures in the tunnel and borehole.
- Two sets of stochastic fractures

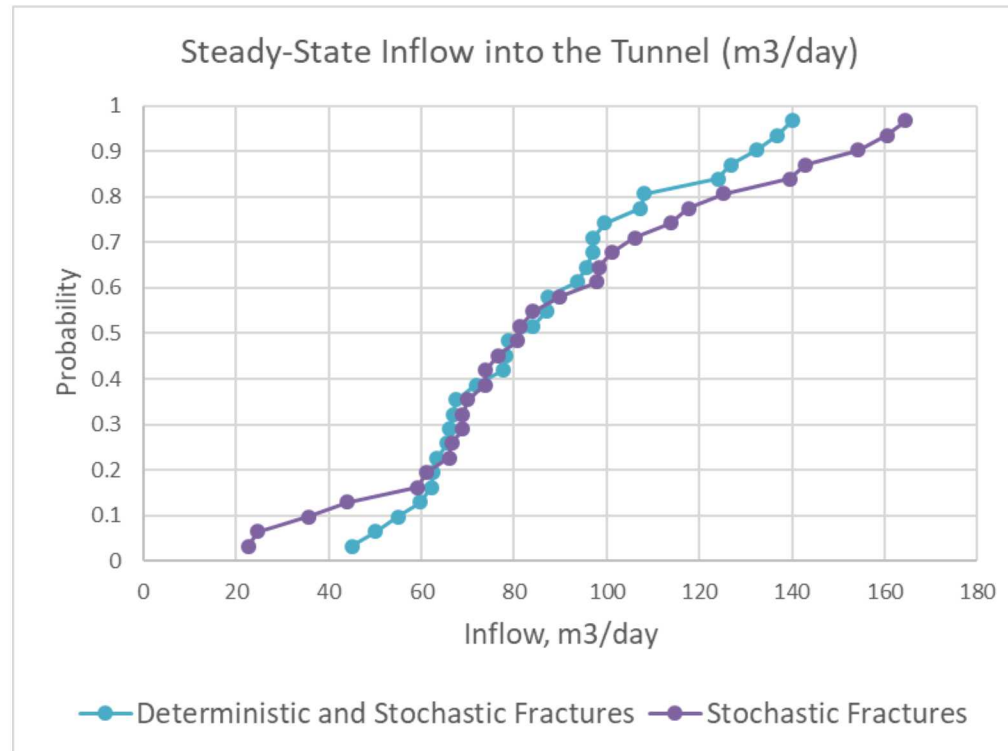


➤ Effective Continuum Model (ECM)

- DFN was upscaled to 1m x 1m x 1m ECM
- Upscaling with Oda's method.
- Oda calculates permeability tensors in three dimensions for each cell.



Total Inflow into the Tunnel Calculated Using Two Different DFNs



➤ ***The uncertainty is reduced when DFN includes the observed fractures in the tunnel and borehole.***

- ❑ ***DFN1, Deterministic and stochastic fractures: $Q = 45 \text{ m}^3/\text{day} - 140 \text{ m}^3/\text{day}$ ($\Delta=95$)***
- ❑ ***DFN2, Stochastic fractures only: $Q = 22 \text{ m}^3/\text{day} - 165 \text{ m}^3/\text{day}$ ($\Delta=143$)***