Estimating The Effect Of Fracture Connectivity On Waste Isolation Using A High-Performance Reactive Transport Simulator, PFLOTRAN

sdsevou@sandia.gov, Sandia National Laboratories, Albuquerque, NM

How does uncertainty in fracture inter-connectivity affect predictions of waste isolation, i.e., predictions of the rate of radionuclide transport from a high-level nuclear waste repository in a fractured host rock?

- Fracture connectivity is determined by temperature and stress fields at the time of rock deposition/formation
- Natural system heterogeneity will always have uncertainty associated with it
- Two end-member simulations using GDSA Framework, an open-source performance assessment tool for deep geologic disposal of nuclear waste:
  - Inter-connectivity to the surface: transport controlled by advection
  - No fracture connectivity to the surface: transport controlled by diffusion

Problem

- Estimating the effect of multiple input uncertainties (spatial variability combined with multiple property uncertainties) will be examined through multi-realization simulations and sensitivity analyses
- Uncertainties in fracture connectivity and thermophysical properties will be accounted for in a probabilistic manner
- Confidence in the operation of the waste isolation safety function will be increased by considering both the deterministic features and of the probability of a percolating fracture network

System Heterogeneity

- Natural system heterogeneity will always have uncertainty associated with it

GDSA Framework

- GDSA Framework (Geologic Disposal Safety Assessment) Framework, an open-source computational and modeling framework (pa.sandia.gov) provides the open-source computational and modeling capability to investigate coupled processes of heat flow, buoyant two-phase fluid flow, and radionuclide transport in a large 3-D spatially heterogeneous permeable rock domain

References


Conclusions & Future Work

- For deep geologic repositories in fractured host rock, sufficient site-specific understanding of deterministic features and of the probability of a percolating fracture network will provide confidence in the operation of the waste isolation safety function
- GDSA Framework (pa.sandia.gov) provides the open-source computational and modeling capability to investigate coupled processes of heat flow, buoyant two-phase fluid flow, and radionuclide transport in a large 3-D spatially heterogeneous permeable rock domain
- The effect of multiple input uncertainties (spatial variability combined with multiple property uncertainties) will be examined through multi-realization simulations and sensitivity analyses

3-D Spatial Profiles of $^{129}$I – connected vs. unconnected

Inventory, Decay Heat, Waste Form Degradation

- Simulation Outputs

Realization with fracture network connectivity
- Realizations without fracture network connectivity
- Observation points are within the 15 m thick engineered barrier system
- The repository is about 600 m below the solid surface
- Breakthrough at the Surface
- Time Histories of $^{129}$I