WIPP Hydrologic Investigations in the Salado Formation

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Hydrologic investigations of the Salado Formation evaporites at the WIPP site have focused on two primary areas:

- What are the natural properties of the different rock types?
  - permeability
  - pore pressure
  - fracturing
  - hydraulic fracturing pressure
  - brine chemistry
- How will these properties be affected by construction of the repository, emplacement of waste, and repository closure?

Hydraulic properties are pertinent to the following questions:

- Brine inflow—how much brine might enter the repository after it is closed?
- DRZ/EDZ—how extensive will the damaged zone around the excavations be, and how will rock properties be altered?
- Gas threshold pressure—if gas is generated in the repository, what pressure must it reach before it can flow into the rock?
- Fracture pressure—at what pressure will the repository host rocks fracture, and will the fractures be horizontal or vertical?
- Transport—can radionuclides (in brine or gas) be transported away from the repository in the Salado?

A variety of experimental programs were developed to address these issues:

- Permeability testing—straddle-packer testing of 1- to 5-m intervals in boreholes drilled from the repository—addresses brine inflow, DRZ, and transport
- Room Q—2.9-m diameter circular room 109 m long sealed and instrumented to measure brine inflow, deformation, and resistivity changes—addresses brine inflow, DRZ, and transport
- Simulated DHLW heater experiments—470 and 1500 W heaters placed in 0.8-m-diameter vertical boreholes to simulate the heat generation from defense high level waste—addresses brine inflow to HLW boreholes
- Gas threshold pressure testing—*in situ* measurement of pressure at which gas displaces brine and starts to flow into naturally fractured anhydrite interbed—addresses gas generation and dissipation issues
- Coupled permeability testing and hydraulic fracturing—permeability testing before and after hydraulic fracturing of anhydrite interbeds—addresses fracturing pressure and altered hydraulic properties

- Brine sampling—sample brines from different strata and from different locations in individual strata to compare chemistries—addresses flow within and between strata, as well as potential radionuclide transport

The principal findings of these investigations were:

- Anhydrite beds are naturally fractured and have more permeability, which is pressure dependent, than other Salado lithologies
- Argillaceous halite may have some permeability where undisturbed by excavation effects
- Pure halite appears to have no permeability except within the DRZ/EDZ
- Pore pressures are approximately lithostatic where undisturbed by excavations
- Brine inflow to a closed, unheated repository will be minor
- More brine inflow would occur to a repository with heat-generating waste
- Hydraulic fracturing increases anhydrite permeability and makes it more pressure-dependent
- Gas threshold pressure of anhydrite interbeds is below the fracturing pressure
- Gas generated within the repository will be able to dissipate through anhydrite interbeds without fracturing the rock
- Differences in brine chemistry in nearby boreholes show that Salado brine is not mobile—radionuclides will not be transported away from the repository

Questions or issues that would benefit from further research include:

- Issues related to two-phase flow:
  - How can we characterize the undisturbed saturation state in anhydrite interbeds?
    - Fully brine saturated?
    - Partially gas saturated?
  - How can we characterize the saturation state in the DRZ/EDZ?
  - *In situ* measurement of gas threshold pressure needs refinement
- How do we quantify the relationship between repository pressure and fracture dilation and permeability?
- How do we understand/predict gas/brine transport through fractured anhydrite?
- Factors affecting brine flow to heat sources are incompletely understood