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Sandia National Laboratories

Geomechanics in Development of Nuclear Waste Repository

Public Engagement Commission On Spent Fuel Management

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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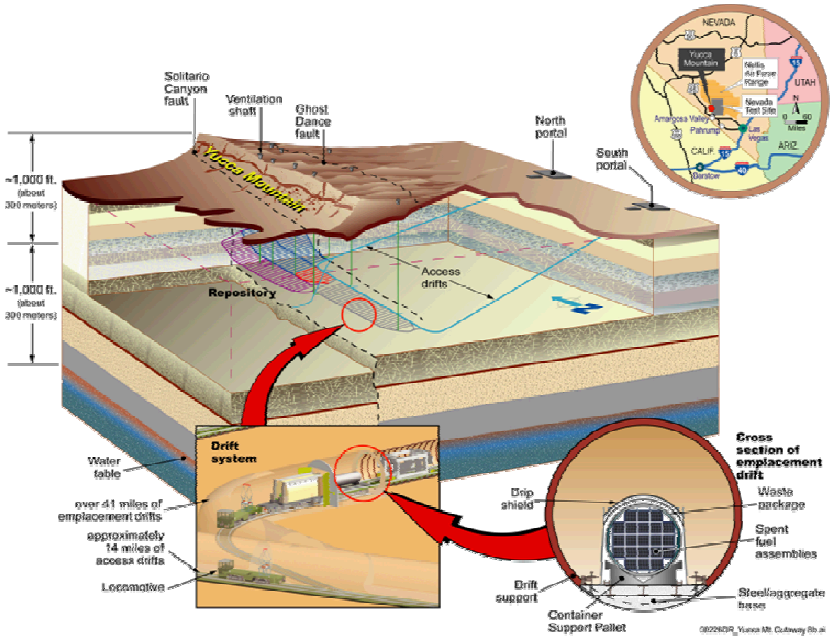
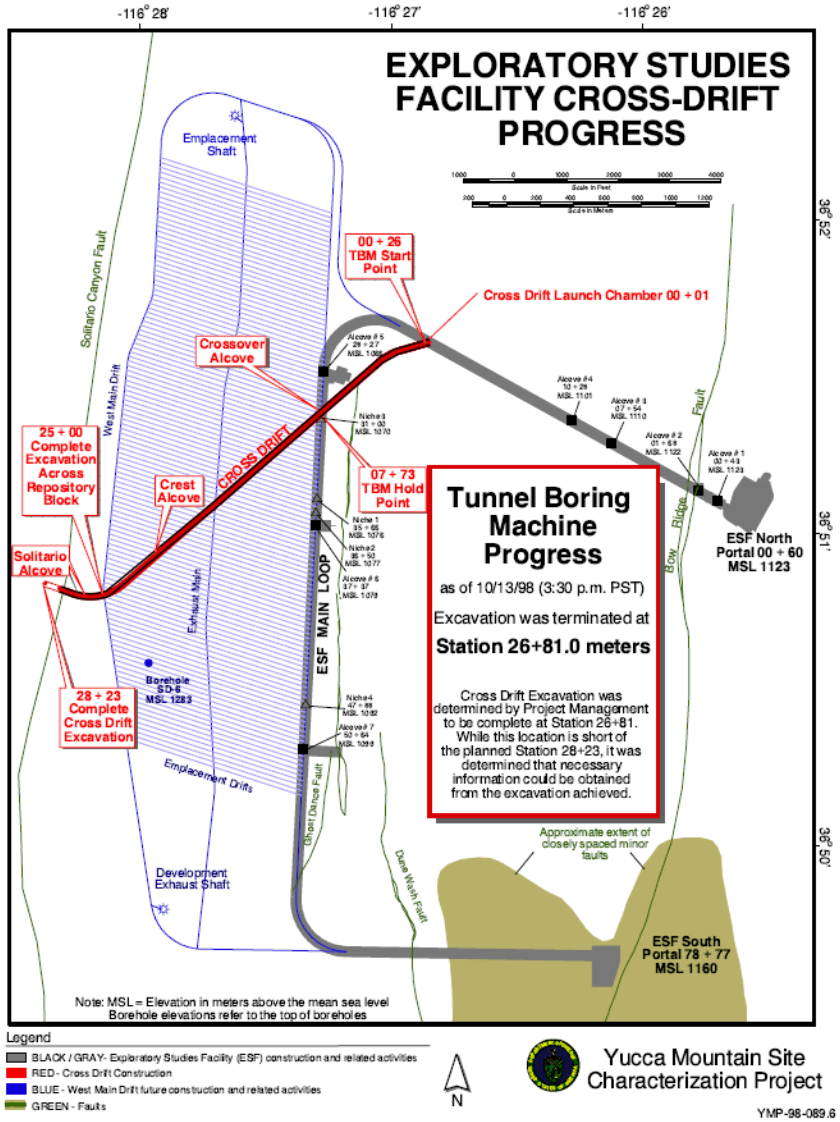
Yucca Mountain Project

- **1988:** DOE Yucca Mt. Site Characterization Plan
- **1991:** State of Nevada granted the DOE the permits necessary to proceed site characterization activities
- **I994 (September):** DOE began excavation of the Exploratory Studies Facility using a tunnel boring machine.
- **1997 (April):** ESF main tunnel (8m in diameter and 8km long) was completed.



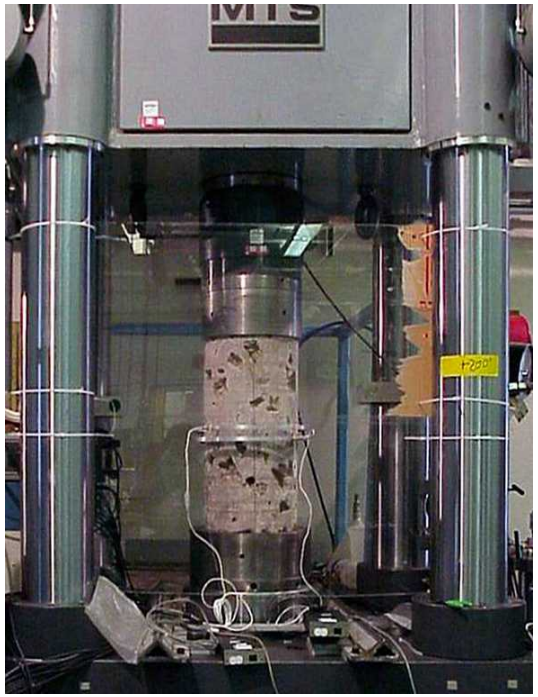
Site Characterization

- 10CFR§ 60.15 Site characterization
- Unless the Commission determines with respect to the site described in the application that it is not necessary, *site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced*.
- Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.



Laboratory Experiments

- Determine basic T-H-M properties and variabilities of rock
- Attempt to understand deformation and failure mechanisms
- Provide baseline data for extrapolation of laboratory to repository scale T-H-M properties

Mechanical and bulk properties in support of ESF design issues, HLWMC1994 by Price et. al.

Rock Mass Classifications

- Identify significant parameters influencing the behavior of a rock mass and relating those parameters to engineering applications based on experience
- Enable effective communication for the conditions of rock
  - **RQD** (Rock Quality Designation) by Deere

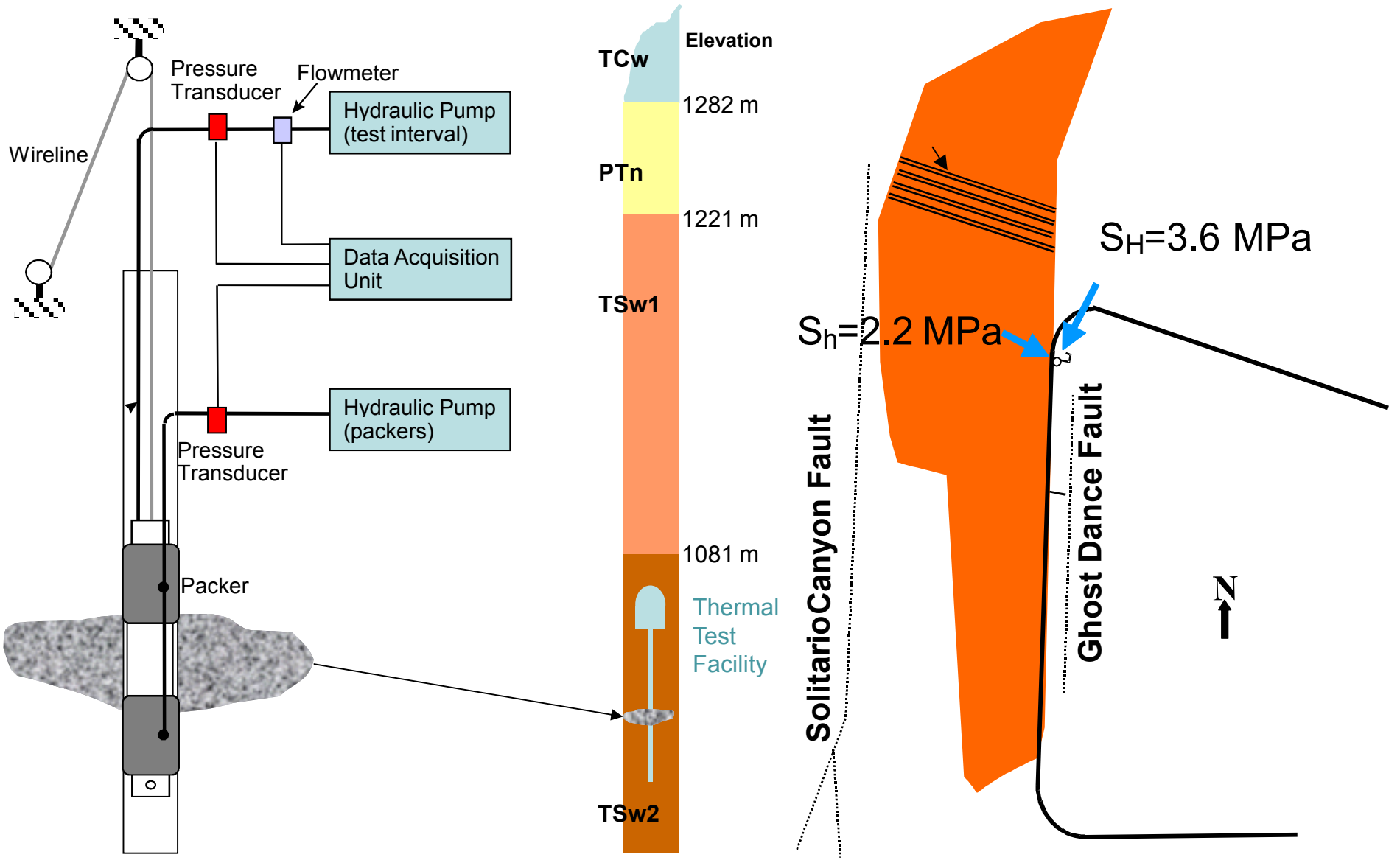
    % of good (>10 cm) rock vP, P, F, G, E
  - **Q** (Rock Tunneling Quality) system by Barton

    $$Q = \frac{RQD}{J_n} \times \frac{J_r}{J_a} \times \frac{J_w}{SRF}$$ vP, P, F, G, vG
  - **RMR** (Rock Mass Rating) by Bieniawski

    $\sum P_{i=1 \text{ to } 6}$ A, B, C, …, G

Rock-mass classification of candidate repository units at Yucca Mountain, Langkopf and Gnirk, SAND82-2034

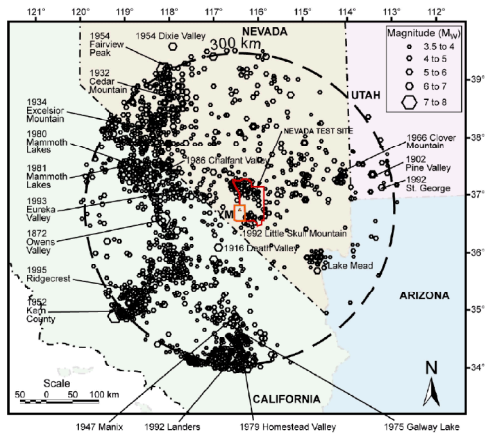
Hydrofrac In Situ Stress Measurement

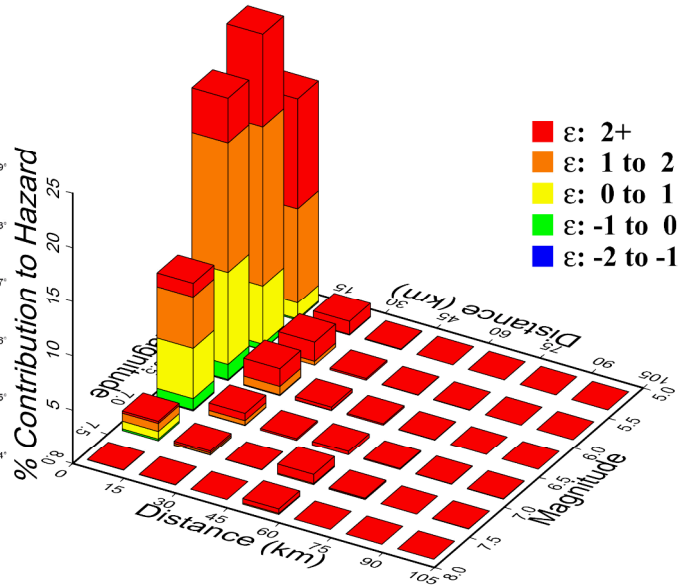


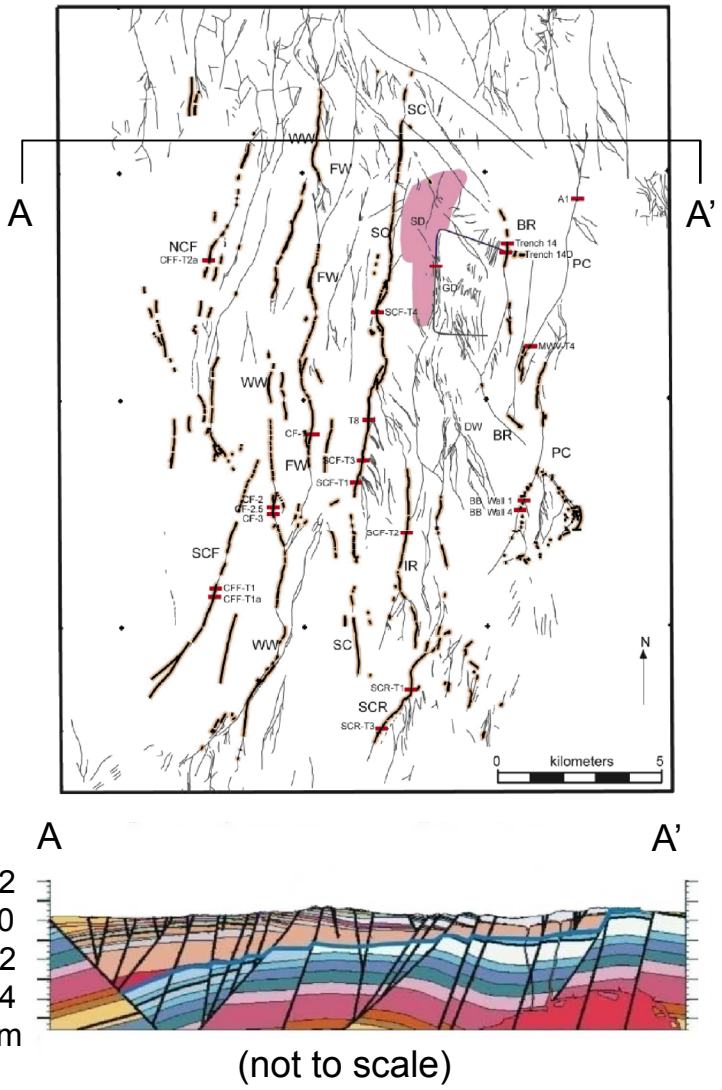
Initial stress measurements in the Exploratory Studies Facility Yucca Mountain, Lee and Haimson,1999

Seismicity

- Site characterization
- Seismic source characterization
- Ground motion characterization
- Hazard calculation and results
- Deaggregation of hazard results

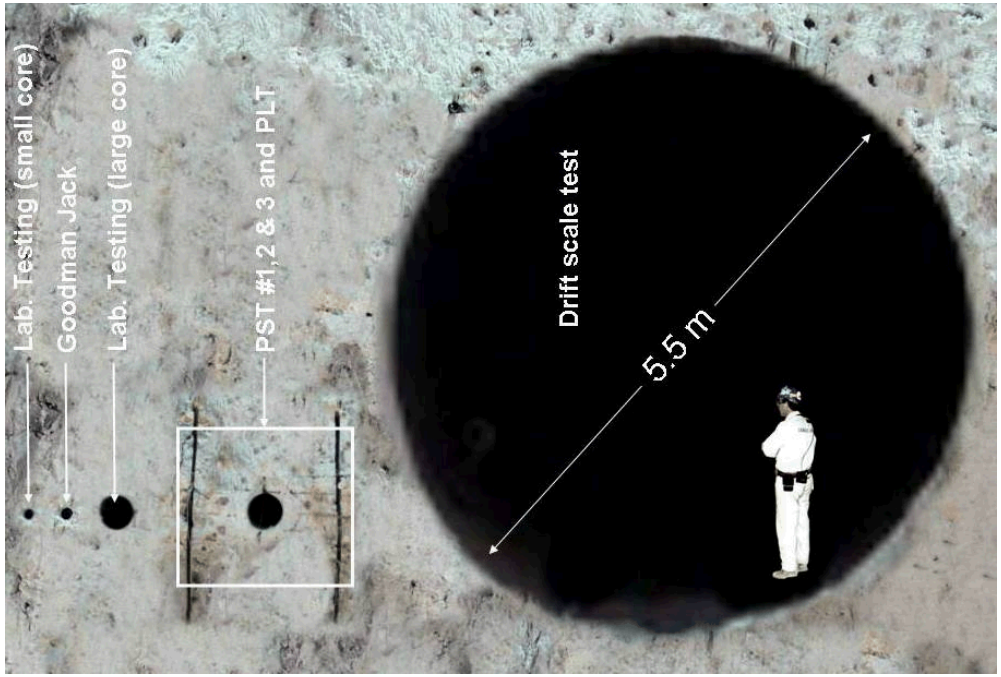


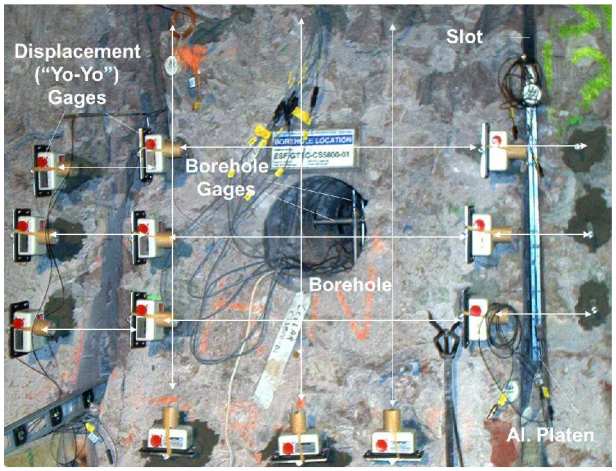


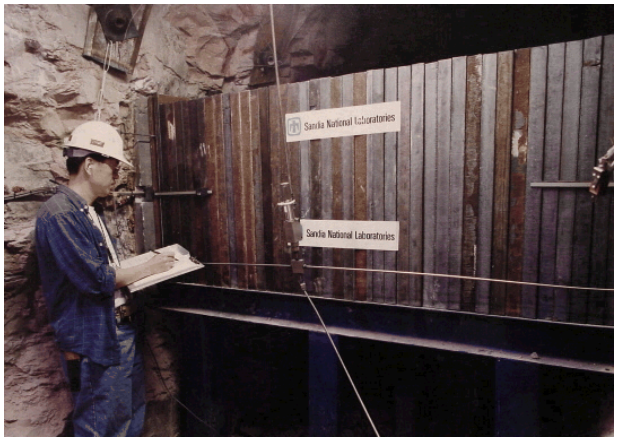


Deformability Measurements

- Rock mass deformability measurements for different scales
  - Uniaxial compression test for core scale
  - Goodman Jack test for borehole scale
  - Pressurized Slot Test (PST) for block scale
  - Plate Loading Test (PLT) for block scale



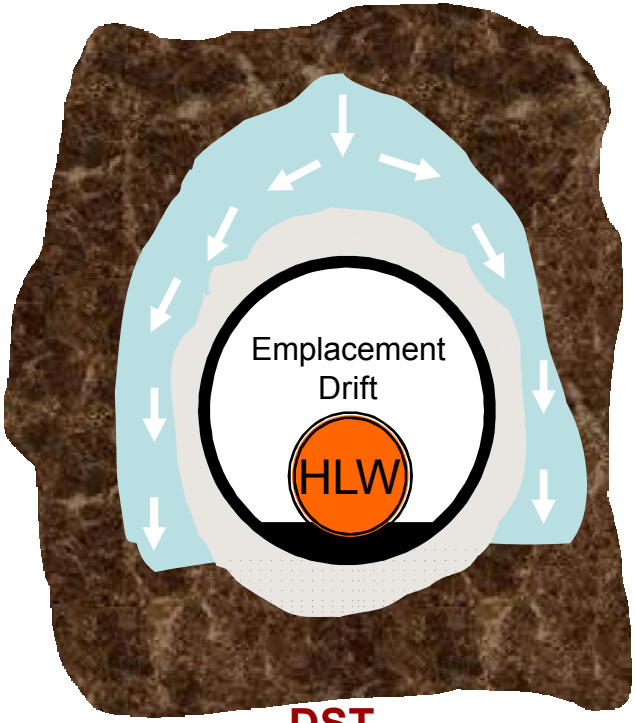




Rock-mass deformation modulus testing at YMP in lithophysal stratigraphic units, USRM 2003 by Howard et. al.

Heater Tests

- Evaluation of coupled **T-H-M-C** behaviors surrounding the emplacement drift
  - Vaporization barrier created by boiling water prevents water from seeping into the drift
  - Diversion of water around the drift reduces seepage onto the waste package
  - Thermal stress creates slab failures in the crown area of the drift at high temperature



SHT

LBT

DST

The Yucca Mountain Project Drift Scale Test, USRM 1998 by Finley et. al.

Summary

- 10CFR§ 60.15 requires in situ exploration and testing be conducted at the depths that wastes would be emplaced
- Laboratory experiments provide baseline data for material properties and failure/deformation mechanisms of rock
- RQD, Q and RMR enable effective communication for the conditions of rock
- Hydraulic fracturing estimates In situ stress at the site
- Goodman Jack, PST, and PLT measure deformability of the rock mass for different scales
- Heater tests (single, large block, drift scale) provide coupled T-H-M-C behaviors unique to the HLW repository project.